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To my Parents
ACKNOWLEDGMENTS

I thank my mom and dad for being supportive of my education and helping me get to where I am today. The inspiration for this document even came from being brought up around the construction industry and the growing technologies of the business. My dad gave me the idea so I took it and ran with it, thank you mom for keeping us both sane. I’d also like to thank my dog, Kylie, for providing me with a great distraction while trying to produce all of this to graduate.
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Integrated project delivery (IPD) is a growing trend within the construction industry. Similarly, sustainable construction and building information modeling (BIM), both of which involve aspects of IPD, continue to become more mainstream within the industry as well. As a result traditional separation design and construction management is beginning to overlap. Collaboration calls for these discipline lines to be crossed and for all parties to become involved in the design of the building which can lead to more efficient design and construction results. This integrated collaboration requires for an examination of the potential liability spread within the contract language for contract documents available. This study examines current available design and construction documents and provides recommendations for their use in integrated project delivery projects.
CHAPTER 1
INTRODUCTION

Introduction

Building design technology is evolving from two-dimensional Architect conceived documents to three-dimensional integrated building information models. Integrated Project Delivery (IPD) has emerged as a much needed collaboration among contractual parties within a construction project. Current technologies, such as Building Information Modeling (BIM) now allow for the sharing of information, by allowing access and input from multiple parties involved in a construction project. Likewise sustainable construction tenets call for the input and sharing of information from various participants in the construction process. These participants include owners, tenants, builders, subcontractors, and suppliers. With the industry progressing to more of a collaborative environment with details being provided by more parties than just the architectural and engineering firms, the question with regard to who is liable for the final design needs to be addressed contractually.

Problem Statement

Construction projects are focusing more and more on the use of integrated design principles (Young 2007). Building Information Modeling and sustainable design are examples of construction processes that are dependent on the collaborative techniques involving multiple parties providing input and having access to the design process. As construction moves towards more collaborative methods it is vital to consider the options for contractually delivering the project. There is a need to better understand the responsibilities and liabilities of all parties participating in a collaborative construction delivery project.
**Sustainable Design**

Owners are becoming more aware of the impacts construction have on the local and global environment. They are often drawn to sustainable design due to its focus on the environment, building performance, and healthier indoor conditions. Organizations around United States such as the U.S. Green Building Council (USGBC) and Green Initiative Green Globes are advertising the positive effects of green design. Sustainable, or green, buildings are the physical expression of a sustainable built environment. They emphasize reductions in energy use, renewable energy resources, recycling and reuse of materials, indoor air quality improvements, and environmentally sensitive land use. One way to measure the sustainability of a structure is through one of the certification programs developed by organizations like the USGBC. The Leadership in Energy and Environmental Design (LEED) certification process provides a framework to identify and implement green design, construction, operations, land use and maintenance solutions. Green construction emphasizes the importance of collaboration of all parties. Design charrettes center on the sharing of ideas from building performance goals to local community connectivity. Information is passed from the charrettes and certification process through to the final design.

**Building Information Modeling**

Building Information Modeling is a new technology that combines three-dimensional modeling with cost and scheduling dimensions directly attached to the model. Materials, costs, labor, and scheduling or sequencing may be directly linked within the virtual software. There are plug-ins, additional third party software, available for energy modeling, light studio modeling, quantity take-offs, and costing data, just to name a few. According to the Smart Market Report released by McGraw-Hill Construction (Young 2007) nearly half of BIM users in the market today operate over 60% of their projects using BIM. Wide-spread organization use is
growing across the industry. Project modeling allows companies to foresee problems and reduce the number of change orders needed on each project. It allows design professionals to take advantage of many design enhancements which lead to efficiency gains in both design and construction. The model becomes a tool in which information is shared and stored. Designers are able to download design components or blocks that contain information such as size, cost, electrical or water usage. For different construction elements this information is usually supplied by the manufacturer yet purchased and installed by the contractor. The model becomes a way for all parties to see building elements in real time and in a single format.

**Contracts**

With this new confluence of data many mistakes can be prevented; however, problems arise when responsibility for the mistakes is questioned. According to the American Institute of Architects (AIA) Documents, the Architect is not responsible for the means and methods of the construction, though they are responsible for creating the specifications which establishes the framework for the means and methods the contractor employs. BIM raises concerns about the level of detail being produced per phase and its use by others. Contractually the design professional does not want to be responsible for any error or omission in detail which causes construction problems leading to additional costs. With IPD the liability with contractual obligations may not always be clear. Agreements used per project need to be specifically detailed to include all participants’ responsibilities. With sustainable construction and BIM becoming more mainstream, contract language may be defined to cover performance obligations including model creation and the level of detail per phase for the model as well as sustainable certification specifications for desired building achievements.

Two commonly used construction contract documents are the AIA documents and ConsensusDOCs created by the Associated General Contractors (AGC). These documents are
continuously being revised in response to the market change. The industry shift towards IPD has required new contract documents need to better suit the IPD delivery method. Obstacles must be overcome and responsibilities assigned as part of conforming to use the new technology. Benefits of the technology will follow utilization.

BIM and sustainable construction introduces new problems with design and construction risk compared to traditional design. New terms need to be defined within the contract documents describing party responsibilities. The industry is changing and it is important to acknowledge the shift in collaboration to an integrated project delivery. Companies need to be aware of where the industry is headed and knowledgeable about the changing contractual agreements and intertwining services.

Using BIM and sustainable design as context, this study reviews current contractual options for an integrated design project. American Institute of Architects and Associated General Contractors contract documents are analyzed and suggestions are made with regard to best case scenarios for each of the contracted parties.
CHAPTER 2
REVIEW OF LITERATURE

Overview

The industry is shifting towards Integrated Project Delivery (IPD). Change is inherent in the construction process; therefore, contracts (and construction documents) are constantly amended as new technologies continue to emerge. The construction process is not black and white. Traditionally design-bid-build projects have been constructed and contracted using the available American Institute of Architects (AIA) documents. Now design-build projects are emerging with the growth BIM and sustainable construction which emphasizes more collaborative building design and construction methods. Contract terms need to be modified to accommodate for this collaboration. Coordination between phases and parties involved is growing. Innovative technology like Building Information Modeling (BIM) is increasing in use. Within BIM multiple parties contribute to the three-dimensional model while providing other benefits like scheduling, estimating, clash detection, and sequencing which also requires an integrated design process.

Building Information Modeling

Architecture students are often limited to two-dimensional elevations, sections, and wire frames. The extent of the students understanding of computer modeling is creating a simple static rendered model. BIM expands this static model to another level. It uses software like Revit, VICO, ArchiCAD, and Vectorworks (Gleeson 2005). These are all parametric modeling tools that use design objects by modeling each component with component and performance attributes. With experienced BIM user groups the traditional design phases are streamlined and integrated. Depending on the level of detail involved in the model, the separation between the schematic design, design development, construction documents, and construction administration
phases may no longer take place in a linear fashion because the contractor must become involved to formulate the means and methods of construction. To accommodate for this streamlining the AIA has released new documents focused on integrated design. These documents set requirements and authorize uses of BIM content by identifying five levels of development. The AIA documents establish protocols for model ownership, conflict resolution, storage, viewing, and archiving (Zeiger 2008).

Unfamiliar designers may struggle implementing the BIM software packages such as Revit. Depending on the level of detail the modeling process can hinder the design progression by forcing earlier design decisions than compared to traditional linear design. When creating a high-level detailed model, components must be considered within earlier stages. Not all users have problems with the packages. To create a detailed three-dimensional model, pieces cannot be ignored and left to a later date for a decision; otherwise, the model would not be whole. Each component must be created; modifications can take place at a later time. BIM software is capable of linking detailed product information to the model, tracking project costs, and providing material take-offs. All of this information could be stored in one place in the digital model.

There are some concerns with any new technology. Initial expense and training can be costly for design and construction firms (Young 2007). At first new technologies may hinder communications as opposed to enhancing them. Not all team members will be up to speed and using the same software advancements thus potentially causing problems with communication and exchange of information during construction. The biggest concern is the blurring of boundaries through sharing work on a model. With two-dimensional drawings a set of construction documents was created and then any outside information was then added through
shop drawings and as-builts. A working three-dimensional model would not allow for the separation of changes. The project could be controlled by a third party who is managing the model instead of the Architect as in traditional two-dimensional drawings. By implementing the integrated project delivery, more time to design the project and a collaboration of more skills within the project is necessary. The insurance and liability coverage will need to be adjusted to accommodate for these changes. This collaboration across disciplines is especially necessary when green building becomes involved in order to provide the specialized skills to develop the structure. Efficiency and cost saving for sustainable construction come within the collaboration of ideas and modeling.

The benefits can out way the concerns. The project workload will be front-loaded facilitating continuity and quality control thus leading to a satisfied owner. The overall project schedule may be compressed and the project cost can be streamlined earlier. This is great for owners in that potential conflicts may be resolved virtually as opposed to during the physical construction process.

Design responsibility in integrated project delivery is moving forward. IPD creates a collective final project through the extension of the design process. The design responsibility has grown past the design professional alone. In the past as stated in the Integrated Project Delivery: A Guide it is stated that each participant will handle tasks consistent with registration requirements per their field of specialty. That would greatly limit collaboration to produce the best project.

Within the contract the risk allocation for design responsibility needs to be defined. The contract must contain means to clearly define and achieve legitimate and legal commercial expectations of parties relative to risks anticipated at the point of contract formation. There is
increasing potential professional liability risk exposure, but the final project design must be a project collaboration and influenced by all parties (Hatem 2008). Traditionally the Spearin Doctrine has been the reigning implied warranty that the owner issues final and detailed (prescriptive) design documents to the constructor (Mitchell 2008). Based on that concept the owner is in control of the design development process. In typical design-bid-build the constructor has no influence in the design development process. The contractor must build in strict conformance to the furnished project design. However, the contractor is often involved in the correction and clarification of design documents when they are inconsistent or not within proper building codes or ordinances. This is typically the only point when the contractor has an opportunity to influence design in the traditional model. IPD delivery methods allow for the contractor, and all parties for that matter, to contribute to design as it develops. The IPD documents must include risk allocation provisions for defective design to alter application of the Spearin Doctrine and its implied warranty. Legal case studies are further discussed in Chapter 4.

**Model Progression Specification (MPS):** Building Information Modeling and its building element representation has led to a false impression of detail and precision in the design process. Builders may take the model into the field and expect every piece to be detailed within, though that particular level of detail may not have been achieved by designers yet. BIM will perform multiple functions: costing, scheduling, performance simulation, code checking, and visualization. All these components lead to further integration of the construction process. Building Integration Modeling has been brought to the forefront of technology and the future because of its capabilities and the shift towards IPD and the growing sustainable construction sector. Integrated Project Deliver is used often in sustainable design and BIM capabilities make the design process within sustainable construction easier. In 2004 Model Progression
Specification began to develop the concept and its integration into contract documents. The AIA National Documents Committee then integrated BIM into the new E202 BIM Protocol Exhibit and AGC released the 301 BIM Addendum. With MPS in mind, the collaboration began with IPD and needed to be developed addressing two principles:

- The requirement “that phase outcomes – milestones and deliverables – be defined succinctly” so that team members “understand the level of detail at which they should be working, and what decisions have (and have not) been finalized.” (See Integrated Project Delivery: A Guide, http://www.aia.org/ipdg, p 23)

- The idea of assigning tasks “on a best person basis, even when that differs from traditional role allocations. (Integrated Project Delivery: A Guide, p 13)

Responsibilities would be determined on a case by case basis. The party most qualified in creating that piece of the model would be responsible as designated within the contract. All designations for completion and collaboration would be made early in the design process along with the detail and dimension accuracy. This document is still in its first phase so more development is necessary, but it is a strong place to begin with integrated project design and building information modeling collaboration.

At the center of MPS is the Level of Detail (LOD) definitions. These are descriptions through which BIM elements can logically progress from the lowest level of conceptual approximation to the highest level of representational precision. There are five levels to describe the levels of progression.

100. Conceptual

200. Approximate Geometry

300. Precise Geometry

400. Fabrication

500. As-built
These five sections are then defined by which type of modeling is being used. Examples would be Design & Coordination, 4D Scheduling, Cost Estimating, Code Compliance, Sustainable Materials, etc. Task Assignments to each part of each model is another area being developed. A number of different parties have input on each component. To address this multiplicity of input, the AIA Documents Committee developed the concept of “Model Component Author” (MCA), who is responsible for creating the three-dimensional representation of the component, but not for other discipline-specific information linked to it. It is likely that handoffs of the MCA will occur throughout the process as the project moves through the various phases, but this concept is still being developed and not clearly defined within the E202. By utilizing the level of detail definitions discrepancies can be avoided during construction and integration across the specialties. The level of detail should be defined within any contract that is used in conjunction with the BIM technology to clarify the IPD process. All though any contractual agreement may be used, the AIA documents clearly indicated the LOD in the standardized document available for BIM use.

Model Progression Specifications were created by VICO to be used as a language to define every element and task in the construction process. This would allow for a coordination point and provide a framework for growth. In essence, it creates a checklist from the schematic design to the 3D model to cost and scheduling. BIM should be standardized across the industry, so definitions must be set and detail level used per specification (100 – 500) by project shall stay consistent. The VICO services team created a process to set these standards.

- Step 1: Organize current processes and determine typical deliverables and process steps
- Step 2: Define framework and definitions by the 5D process you plan on implementing
- Step 3: Collect information from the database and work team experiences
- Step 4: Build standard 5D content and use it on a project (VICO 2009)
Because there will be multiple contributors, each project needs a Model Component Author to keep track of the collaborative model according to the AIA. This person can change throughout the construction process on a best person basis. During the integrated project delivery, depending on the discipline control, responsibility may shift. The 301 BIM Addendum takes a similar approach though only one person will be responsible for the collaboration of information and models throughout the construction process.

**Computer-Aided Green Design**

To produce a sustainable design collaboration is necessary. Parties from multiple disciplines are must work together to achieve energy efficiency, construction waste management, green material use, and innovative design. One party will not be knowledgeable in all areas of the project because of the specialization each organization strives for to be successful today. The scope of work is often too large for one company to be great in every expertise needed. The common argument against this collaboration is that it requires “too many chefs in the kitchen.” One manager must assume responsibility over the collaboration and the owner tends to shy away from the job. The new contract documents released recently were created to accommodate for all parties to be involved cooperatively.

Sustainable design and organizations like the U.S. Green Building Council (USGBC) and Green Globes provide accreditation programs to measure green construction. With Building Information Modeling, these certification programs like Leadership in Energy and Environmental Design (LEED) can provide a baseline to measure effects of implementing the new technology with Integrated Project Delivery services. BIM can provide feedback on cost and payback period potential for strategies implemented. Drawings can be coordinated, material pricing and budget pricing organized, and a real time visual analysis of any design change can be kept. Green buildings represent efficiency through the integration of design and environmental
control systems and possible long term financial payback. BIM integration could change the design profession and bring more complete design and coordination to the industry while mainstreaming architectural practices. It is a tool for efficient, expanded, and improved services.

The design process starts with initial decisions about standard costs and schedule. Using BIM to streamline the decision-making process, sustainable buildings could be designed within the standard costs and schedule. Plug-ins used to create daylighting studios could be utilized by the architect instead of contracting the lighting design out to a consultant. Readily available computer renderings and documentation could lead to quicker approvals. BIM design allows for multiple concepts to be explored quickly in the model. The final concept is then more effective and the least expensive.

The BIM software packages such as Autodesk’s Revit and Architectural Desktop, Graphisoft ArchiCAD, Vectorworks ARCHITECT, and Bentley Architecture allow high-performance design executed with a coordinated team effort. The team must understand the holistic design process. Revit is just one of the software packages that enable this process with LEED and new BIM technology. BIM creates a design platform for sharing information across disciplines. The architect works with the mechanical and electrical engineer on the building envelope and HVAC design to minimize the heat load, thereby to reducing the cost to the owner over the life of the building. These design decisions include a look at both initial ideas and operation and maintenance after construction is complete. BIM-based design provides many capabilities: complete construction documents, material quantification, linking submittal information to master specifications and LEED specifications, linking the model to the energy model, and building assessment of each product and its life-cycle information (Gleeson 2005). Design professionals no longer design just to create two-dimensional drawings. They need to
take advantage of all the enhancements which lead to large efficiency gains in both design and construction.

There are multiple options for software use out there, but the detail and accuracy of each is different. RevitMEP is one of the programs that is still being developed for better use within LEED accreditation and sustainable design. “If you don’t understand what’s happening behind the scenes, you can get some really misleading data out of the software,” one new user said about the software (Gleeson 2005). Bentley is another provider of BIM software though it is thought that the majority of tools within it are not as advanced as other software options out there currently. One capability it does have that others do not is the ability to exchange data back and forth with other software tools. You can choose the option to selectively re-import modifications to a model. These are just a few examples of the development going on today, with advancements taking place quickly to keep up with the industry.

Another emerging issue is the ownership of the virtual model once the design and construction is complete. The owner wants to take full ownership for this work while traditionally the architect retains copyright to its own designs. The new contract documents released from both AIA and AGC have addressed this problem and agree that each party will keep rights to its contributions to the virtual model though it can be used for operation and maintenance after construction is complete.

**Contractor’s Guide to Building Information Modeling (BIM)**

Building Information Modeling has been slow to take off in the industry because of the level of collaboration required between teams. As cited within the Interoperability Smart Market Report released in 2007, Contractors are far behind the curve in adoption. A significant number of Architects and Engineers use the technology, but for interoperability all parties must be involved (Young 2007). To address this problem, the AGC released the *Contractor’s Guide to*
BIM which was the first of its kind – created before any architecture or engineering guide was created. It was written by multiple contractors to educate them about BIM tools, benefits and applications. It touches on five main topics: 2D conversion versus 3D design, basic software tools and collaboration, the BIM process, responsibilities within the process, and risk management.

From the start, the Guide addresses the issue of “who should pay for the model?” It is suggested that the benefits and marketing advantages will offset the cost over time after implementation. The new technology will pay for itself with all of its advantages after the initial learning curve is passed.

The two-dimensional conversion from the architect’s documents to contractor construction model can be time consuming but worth the benefits. Though not all architects are implementing BIM use, if contractors have the software the conversion can still be made. If three-dimensional design is performed by the architect, time and money are saved and the contractor can immediately jump into using that model. This idea contradicts the theory that the construction model is different from the design model, but the AGC believes that the contractor does not need to start from scratch if the model is provided.

Another issue discussed in the Guide is the number of models produced. Multiple models will be made by different disciplines, but is it necessary to create a full-blown model for everything to be combined? The simple answer is “no”. Partial uses are beneficial for certain aspects of coordination, scheduling, and estimating; and, this approach can be less overwhelming, especially when a company is first implementing BIM.

Guidelines for how to get started with BIM are laid out for the contractor’s use. A team set-up along with software costs and hardware requirements are just some of the details
discussed. It even includes an Appendix with BIM tools describing their different uses.

Responsibilities and risks management must also be addressed when setting up the team. Core responsibilities generally remain the same even though the design process is a collaboration. Contractors are still responsible for organizing the onsite construction effort.

The Guide does not specifically address all the legal issues presented by BIM integration, though it gives procedural suggestions. Disclaimers of reliance should be created by each party involved, and each party’s ability and right to rely upon the model must be openly discussed and decided upon before implementation. The risk allocation and responsibility remains the same as for two-dimensional drawings (Khemlani 2006).

The content provided in the Contractor’s Guide to BIM is relevant not just contractors, but architects, owners, and engineers could benefit as well. There are, however, many barriers keeping BIM from growing more rapidly in the construction industry. There is the fear of risk, change, and the unknowns; the initial investment cost; time needed to learn the new software; and, the lack of support from senior leadership. The list goes on, but BIM will overcome these to be fully utilized in the construction industry and provide all its benefits.

**BIM in the Industry**

An evaluation of Building Information Modeling use across the industry uncovers implementation problems along with perceived and quantified benefits. A statistical survey done by Dr. Carrie Dossick at the University of Washington found that cost growth was reduced by 5%, schedule slips were reduced by 4%, and the total rework was reduced by 65% with BIM implementation. These statistics were taken from 93 projects that all utilized BIM. The reduction in total rework is quite significant, though Architects may feel they are losing control because decisions must be made early on and the design process is compromised. The uses for
BIM as described by the National BIM Standard (NIBS) Committee are quite extensive (Table 2-1).

BIM’s estimating capabilities are also limited though. It can quantify components, area & volume of spaces, and material quantities. On the other hand take look at the scenario of a concrete structure. It can calculate the volume of concrete and surface area of formwork but not the tonnage of reinforcing steel. Another example would be for an interior partition wall. It can provide the area of drywall and paint but not the number of studs needed to build the wall.

Contractors are still behind the curve on BIM integration. Only a few early adopters are leading the way in the industry. For BIM to be successful though, widespread implementation needs to happen. The Contractors feel like they need the designers to use the technology, even though conversions can be made during this transition period. Environmental News Record (ENR) reported in 2007 that only 30% of design firms were using BIM tools on projects. That number will probably have grown significantly in the last two years through with the expansive talk about its use. The new technology does create a new position within the Contractor’s organization – project modeler. This position will become essential in the efficient use and implementation of the new technology. One of the leading users of BIM is Turner Construction. They cite repeatable successes, significant process improvements, positive subcontractor relationships, accurate and detailed 3D models, and an enabler for additional BIM services like scheduling and eDocs as their design validation (Reinhardt 2007). Known successful users of BIM can answer a few questions to help their fellow builders with implementation:

- What has led to their success?
- What characteristics do these companies share?
- How do they analyze a building for BIM use?
- What are they doing with BIM that others are not?
With the responses to these basic questions, the users all agreed on a few concepts. BIM leads to early assessment of the project during the Request of Proposal Review, MEP coordination utilizes the technology, and clash detection within the building is one of the primary uses. Other benefits were the owner’s reaction, the integrated project delivery, and the implementation process. Clash detection was not the only software benefit; other aspects included scheduling, estimating, material tracking, and operations and maintenance model creation.

A Survey was completed by the Center for Integrated Facility Engineering (CIFE) back in November of 2007. The goal was to evaluate BIM use through all phases of construction by parties including the Owner, Architect, and Contractor/Construction Manager. Responses would provide quantitative and qualitative impacts as well as incentives and hindrances from BIM use. The General Services Administration (GSA) sponsored this survey since all of their current and future projects must be completed using BIM technology.

Some of the increased qualitative benefits found were an increase in broad scale use and receiving a competitive edge while the quantitative data was limited. Nearly 80% of responders do not track the quantitative impact. The users are spread out all over the country, with no one region leading the way significantly. Half report that BIM lead to new business and increased their marketing success. From 2006 to 2007 the use during design increased significantly though the pre-project planning did not increase between the years. Within that use, over 24% of the respondents worked on over four projects using BIM during the current year. On the other hand, over half were not currently using BIM on any projects. The new technology did improve their capabilities significantly in the development of the construction documents. The CIFE also learned that in 2007 more than half of respondents felt that using BIM lowered overall risk.
distributed with a similar contract structure. Now keep in mind these are users of the new technology. The ones that are not using are more afraid of the risk platform out there, in particular the Architect responsibilities crossing into their idea of means and methods of construction. On the other side of the spectrum, nearly 60% of advanced users are now using BIM to improve the submittal process and fabrication off-site and using less contingency on a project. Another worry of new users is the implementation time and process. Most respondents noted that employees received minimal training. Any training done was one-on-one with another employee who already knows the software. Training was also noted as the largest impediment to the industry integration. The CIFE use unbudgeted change to indicate the owner’s risk in the project. It was noted that nearly a quarter of organizations that participated noted greater than a 10% improvement, while a large number of organizations still do not track this information.

Some interviews were also conducted by the CIFE with respondents who use BIM for visualization. It was found that all interviewees use or will use BIM for clash detection on project coordination. Few of the users attempted estimates or quantity take-offs using the software though. Not many users trusted to software. Problems listed with BIM included extremely sensitive software to inconsistency and errors, central control of the model, and the fear of sharing information with other parties involved. Multiple models can lead to contradiction and error and updating for changes is critical however not always completed. Most designers are not BIM savvy either so they do not want to take responsibility for control of the model. One critical factor cited to lead to success using BIM was defining the process, responsibilities and level of detail. Lawyers state the definition should be put in the contract. Clear objectives should be set and used for modeling decision-making.
An overview of the survey provided that there was perceived value for all stakeholders. The greater involvement and participation was the greatest value. The benefits can be seen by the Owner, Architect, and the Contractor. Responders also claimed that early completion was of value due to the large amount of information available to the owner, aiding in the decision making process leading to faster decisions. Non-users of BIM cited a few reasons for not joining the group: Owners and the designers are not qualified in the technology and the technology is too difficult to use. They are choosing to stay behind the curve because their organization is not prepared for the change. No request by the owner or need by the owner accounts for nearly 50% of respondents reasons for not using BIM. Contractual and regulatory impediments are also on the list of excuses for non-use (Kunz & Gilligan 2007).

**Sustainable Construction**

Half of all annual greenhouse gas emissions come from buildings. The majority of buildings that our generation’s future will be working and living in have not even been built yet (Middlebrooks 2008). Think about the impact that could be made to reduce the carbon footprint and climate change taking place in our environment. The carbon footprint which creates the change in climate is the total amount of greenhouse gas emissions released by a structure and its construction.

With the development of Building Information Modeling and model-based design many new tools have been developed. BIM-based design tools now enable the mechanical engineer to simulate, analyze, and document the design from the start. Greener buildings can be created and lead to healthy, resource-efficient construction. Green design is still not a requirement, though the demand for it is growing from owner demand, environmental stewardship, and government regulations and incentives. For instance, the Energy Policy Act (EPA) in 2005 released financial incentives for sustainable buildings using renewable energy and energy efficiency varying based
on the location of construction. There are multiple standards and ratings systems out there, but one that has been growing in influence and popularity is the United States Green Building Council’s Leadership in Energy and Environmental Design rating system. LEED has 69 points possible to achieve different levels of certification and about 25 of those points can be received just from the building-system design. The industry is evolving and changing, taking all parties towards integrated project design and BIM which both facilitate sustainable design.

Building Information Modeling enabled whole-building analysis, faster decision-making, and better documentation of the structure. It allows for “live” viewing and automatic coordination of all the plans and quantity take-offs needed for estimating and construction. This results in highly coordinated construction documents with minimal errors and omissions. The model allows for construction sequencing, digital fabrication, and facilities management among other benefits.

The greatest benefit of BIM and sustainable design is the building analysis. For successful green construction design professionals need the ability to retrieve insight on the building’s performance through design analysis and optimization. Designers can analyze performance in early stages of design. This technology leads to evaluating design alternatives quickly and allows for better decisions to be made. The more information known, the best choice that can be achieved. Among other advancements BIM also facilitates the calculations needed to optimize the building performance.

The benefits from BIM integration into sustainable design are endless. It provides a wealth of information along with the ability to create drawings and details directly from a model. Efficiency is improved along with the documentation used for green certification. Material quantities are directly obtainable from the model which can be used to determine percentage of
material reuse, recycling, salvage, and regional material. Visualization with the three-dimensional rendering and lighting can also be done.

The design process is greatly influenced by the new technology. The mechanical engineer uses the architectural model to check design and for model coordination. There is less redundancy between specialties, more efficiency with the architectural geometry already created. The mechanical engineer can then define the heating and cooling spaces and zones and add any other pertinent information such as heating loads in specific rooms. This new information is then exported and used as an accurate representation of the thermal model for the project. This file can then be imported to an analysis package and calculate the energy usage and heating and cooling loads. No manually entered data will be needed like in current models and processes. These results are then viewable as a report and attached to the model for future use like sizing of the equipment. There are still some problems with the analysis packages with linking to a neutral file format but tighter integration is on the horizon. The design process can now be a collaboration on one single BIM platform between the mechanical/electrical/plumbing engineer, structural engineer, and architect. Because BIM modeling allows for accurate heating and cooling loads early on in the design indoor air quality, thermal comfort, and overall energy usage can all be improved (Middlebrooks 2008).

In a perfect world one adjustment in the design would reformulate the building’s predicted energy performance and lead to optimization. Daylight use, energy performance, material procurement and use, and building cost would all be considered without the individual analysis needed. BIM is making this concept become closer to a reality. There are a few setbacks included though. The initial cost to integrate BIM is high but the benefits that could be produced may compensate for the cost. It would reduce errors, streamline costs, and improve
performance. Virtual elements would have individual information attached to each and real-time cost estimating could be done. Multiple databases have the capability to be attached either RSMeans or a cost database created for your own company from historical costs could be used. This process could also optimize construction sequencing and procurement.

Prior to the introduction of three-dimensional modeling and design setting up an energy model was time consuming and costly. Now the model can be provided by the architect and the conditions must just be applied. Building performance modeling opens up the entire building construction industry. The problem with green design is a nearly complete model is needed to make decisions, so in the standard design process after the model is done the design has usually already been developed and only small changes can be made because it would be too time consuming and costly to make larger ones through the set of construction documents. BIM makes the late change possible. You do not have to coordinate across all the plans and the early-stage simulations also provide potential. Time and effort required is reduced to set up the energy models.

Material tracking is yet another advancement in modeling. Each surface and volume can be quantified without long calculations. The model has the capabilities of storing libraries with information and details about each material like recycled content and environmental impact scores from life-cycle assessment. This information could even one day be provided as a standard from the building product manufacturer already formatted to be attached, though it is not a standard today. Inventory management is also another possibility. Items could be labeled with a barcode and scanned as they come on site so all materials are tracked.

LEED documentation for certification can also be streamlined. Currently documentation requirements are in PDF format for portability and security. Sharing BIM information could be
used to satisfy those requirements. The ability to link individual elements in a 3D Acrobat file is being pressed for development currently to incorporate the model use. The future of LEED may not even require a PDF file. When originally setup LEED submissions used XML technology to package submittals and allow for downloading straight to a database. Paper submissions were never a standard-use practice within the system. As BIM evolves a more direct data-flow capability will be explored between the two systems. The theory is that information needed for documentation could come straight from the BIM software. This possibility is quite likely too with the partnering of the USGBC and Autodesk back in November of 2006 (Malin 2007). Both green design and BIM are on growth curves, why not bond them between each other and become mutually supportive.

Project integration allows designers to consider building in greater detail earlier in design which enables for a more thorough design process and new level of coordination and collaboration. Sustainable design is a major trend emerging within construction and requires change in the industry. It requires more information early on in the design. Building information modeling facilitates the integrated project delivery linking the design and analysis necessary.

**Green Projects and BIM Integration**

The new integrated project delivery method aims to solve problems causing waste and inefficiency, leading to sustainable construction. The current structure of legal documents is just now beginning to adequately address integrated project delivery and the relationships between all parties involved. The relationships are being restructured among professionals to reformulate the processes of designing and building. In reformulating the relationships between parties, the ecological design process will benefit and expand.

The IPD documents available today enable Green Building and Building Information Modeling to grow. With both technologies expanding rapidly, the contract evolution must
include both concepts and manifest the ability to support each one. The contract has accommodated for the integrated design process, now Green Building must utilize all technologies available like BIM. The LEED credits and submittals are a strong baseline to identify where BIM could be put to good use within the process. The USGBC provides a LEED Project Checklist identifying each credit compiling the accreditation possibilities in one glance (See Appendix B).

Case Law in a New Context

With the new emergence of Building Information Modeling new legal and contractual considerations need to be made. Design and the means and methods of construction can cross lines into responsibilities of other parties when the legal responsibility may still fall elsewhere. The use of BIM causes fear that assumptions will be made about the responsibility for design under the contractors and visa-versa with the means and methods under designers. The traditional roles of the architect, contractor, and subcontractor are being mixed.

The application of past cases will still hold in these new cases. In 1918 the Supreme Court decided on one of the most important documents to date: United States versus Spearin. This case set the bar for allocation of responsibility caused from defective design and construction. Under the Spearin Doctrine it states an implied warranty is created that the owner will provide adequate information in plans and specifications to ensure proper construction so responsibility will not fall on the contractor for defect if the plans are followed. Also to follow that litigation, the Contractor’s incurred extra costs due to other parties must be reprimanded. As decided in Alaska Department of Natural Resources Versus Transamerica, “if defective specifications cause the contractor to incur extra costs in performing the contract, then the contractor may recover those costs that result from the breach of the implied warranty.”
The Spearin Doctrine now must cover Building Information Modeling. The courts claim with respect to the Spearin protection scope that “the warranty of specifications can be vitiated by the involvement of industry or the contractor’s participation in the drafting and development of the specification absent superior knowledge on the part of the government” (Haehn Mgmt. Co. v. United States, 15 Cl. Ct. 50, 56 (1988), aff’d, 878 F. 2d 1445 (1989)). To further support this idea courts supports in the Aleutian Constructors versus United States case when it stated that “when defendant has provided specifications to change them in accordance with plaintiff’s ideas, plaintiff assumes the risk that performance under its proposed specifications may be impossible” (Aleutian Constructors v. United States, 24 Cl. Ct. 372, 378 (1991)).

To contradict the above dicta, the Florida Court of Appeals ruled in favor of the contractor in the case of Atl. Nat’l Bank of Jacksonville versus Modular Age, Inc. where design error would not fall within their responsibility though the wall system constructed failed. The court decisions discussed lead the industry to think that in court design liability will fall on multiple factors: roles and responsibilities of parties must be agreed upon along with the content necessary and the various levels of development. And last the rights of reliance on the model set must be determined.

The introduction of this new technology is not a legal problem. Building Information Modeling just calls for the application of long standing principles to new content. The possibilities BIM brings for the future out ways the harm that it will cause within the legal system. Responsibilities per profession must be practiced with a standard of care. Each party is responsible for their own actions and must “exercise care of those ordinarily skilled in the business” (Nelson v. Virginia, 368 S.E.2d 239, 243 (Va. 1988)). This concept will apply to all parts of the project including project administration, construction management, and BIM.
United States v. Spearin, 248 U.S. 132 (1918)

To summarize the Spearin case the contractor agreed to build a dry-dock in a Navy shipyard. The contract documents required movement of a sewer on-site which later broke due to unknown conditions on the site. The area flooded causing damage to the current work and delay. The contractor refused to continue work until the government would take responsibility for the current and future damages and costs associated with this problem. The government revised the plans to fix the problem and proceeded to get another builder to complete the work. The contractor brought a suit to recover costs spent on the project and damages for termination of the contract. The court awarded both to the contractor. The government breached the implied warranty held within the plans provided and annulled the contractor’s contract with no justification.

An implied warranty existed for safe working conditions on-site provided by the plans for construction. The plans provided should have been adequate to relocate the sewer per specifications. This warranty still holds even with general clauses for the contractor to check the site and plans for errors and assume responsibility for their work. The parole evidence rule also relies upon the implied warranty for reliance implied by law. The party cannot contradict the written terms of the contract by admitting outside evidence, in this case the conditions of the site.

A breach of contract occurred upon the annulment. The government had no justification for the annulment. They also took no responsibility for the working conditions on the jobsite and to ensure safety in the future as construction continued which is a fair justification for the contractor to stop work. Damages for the breach of contract were sought for compensation for all losses due to breach. This compensation included expenditures on work and any projected profit.
The court affirmed the award by the court of claims in favor of the contractor. The government breach of implied warranty exists due to inadequacy of the sewer in the construction documents provided by the government. Damages would be awarded properly to compensate the contractor for the annulled contract.

**Alaska Dep’t of Natural Res. V. Transamerica Premier Ins. Co., 856 P.2d 766, 772 (Alaska 1993)**

To summarize the Transamerica case a problem developed in the project due to plan defects leading to extra costs. A tort claim was brought against the designers for economic loss. The insured filed against the owner (the state) as to not being held liable for the designer’s fault and the insurer also filed against the state. As a result it was found there was no breach of covenant of good faith and fair dealing of the contract which led the insurer to seek administrative remedies. The personal damages claim by the insurer was dismissed and the remand of consequential damages claim for the insurer was affirmed.

The claim was the nature of duty owed to the insured was broken. The duty of care needed to be taken to prevent negligent performance. If this is not done, then it allows to sue in tort. The duty of professional care is not a contract. The tort claim was made for bad faith breach of the contract. This case found the remedy would be in contract, not tort, if the facts were there. The claim for personal damages was dismissed due to the two-year statute of limitations. The contractor was determined as not legally responsible for the defects from inadequate furnished plans.


To summarize the Jacksonville Bank case, the contractor agreed to build a lodging facility. The suit alleged the walls constructed did not meet the standard building code. The claim was made that the contractor was in breach of contract for not meeting building code. The court
decided the architect was at fault, not the contractor. The architect is responsible for code compliance even if they delegate the inspection and compliance to another party.

The claim made was a breach of contract for nonperformance by the contractor. The architect was found responsible for plans and specifications to meet the building codes. The third parties contract delegation of performance was also contested. The architectural duty cannot be avoided by passing responsibility of insurance elsewhere. The inspection responsibility delegation does not enable the architect to not comply with the building code.

**Risks of Leadership in Energy and Environmental Design (LEED) Certification**

Green building practices involve trial and error (Connors 2008). By practicing sustainable construction, one must face liability with the contractual obligations. Performance to achieve a particular level of certification may be set upon signing of the contract between the owner and contractor. Contract documents should set out clear goals and responsibility, often the quality of plans and specifications is in question. Contracts are signed before drawings and specifications are one hundred percent complete. Lawsuits focus on errors and omissions, differing site conditions, and lack of constructability. Applying performance to meet certification specified legal principles concerning design and performance specifications must be analyzed (Connor 2008). Some relevant cases not previously mentioned include: Gogo vs. Los Angeles County Flood Control District, 45 Cal. App. 2d 334 (1941); Souza & McCue Construction Company vs. Superior Court of San Benito County, 57 Cal. 2d 508 (1962); and Neal & Company, Inc. vs. United States, 19 Cl. Ct. 463 (1990). All mentioned cases deal with damage awards due to defective specifications, performance or breach in contract. New green building liability clauses are likely to be developed soon.
Table 2-1. BIM benefits

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<tr>
<th>Agent/Owner</th>
<th>Architect/Engineer</th>
<th>Contractor</th>
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<tr>
<td>Laws &amp; Regulations</td>
<td>CAD Software</td>
<td>Specifications</td>
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<tr>
<td>Building Regulations</td>
<td>Drawings, Calculations</td>
<td>Specification Sheets</td>
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<tr>
<td>Building Specifications</td>
<td>Architecture, Engineering</td>
<td>Classification Standards</td>
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<td>Estimating, Accounting</td>
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<tr>
<td>Knowledge Database</td>
<td>BIM</td>
<td>Procurement</td>
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<tr>
<td>Best Practice Knowledge</td>
<td>Visualization</td>
<td>Product Databases</td>
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<td>Own Practice</td>
<td>3D Models</td>
<td>Price Databases</td>
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<tr>
<td>Briefing</td>
<td>Simulations</td>
<td>Construction Management</td>
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<tr>
<td>Functional Requirement</td>
<td>Comfort</td>
<td>Scheduling</td>
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<td>Estimators</td>
<td>Ventilation, Heating</td>
<td>Logistics, 4D</td>
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<td>Conditions</td>
<td>LCC</td>
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<td>Requirements</td>
<td>Insulation</td>
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<td></td>
<td>Fire Usage</td>
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<tr>
<td>Demolition/Refurbishment</td>
<td>Environment</td>
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<td>Rebuild</td>
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<td>Demolition</td>
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<td>Restoration</td>
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<td>Facility Management</td>
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<td>Leasing, Sale, Operation</td>
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<td>Maintenance</td>
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<td>Guarantees</td>
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CHAPTER 3  
METHODOLOGY  

Approach  

As Integrated Project Delivery (IPD) revolutionizes the construction industry, the effects of collaboration across specialties must be examined through contract document relationships. This report will examine relationships between: 1) Owner/Contractor, 2) Owner/Architect, 3) Architect/Consultants, 4) Architect/Contractor, and 5) Contractor/Subcontractors. Contract documents examined for relationship between parties is limited to the prime contract between Owner and Architect, prime contract between Owner and Contractor, contract between Architect and Consultants, and contract between Contractor and Subcontractors. Contracts between second and third tier contractors are not part of this review, and neither are Purchase Orders or Purchase Agreements between Contractor and material suppliers or fabricators.

Effects of collaboration across specialties through contract documents relationships and integrated project delivery will be examined. First, thorough research into the contract documents that have been developed to-date and their usage with each party in the construction process will be explained. This initial task is to identify documents with language that address mainstreaming industry strategies building information modeling (BIM) and sustainable design and determine if the contract is a primary or secondary contract. Secondly, the effects of IPD within the contract documents and responsibilities within party collaborations will be explicitly discussed as they are presented in the industry today. This task will review “consideration” for the creation and management of any level of detail, three-dimensional model, i.e. is the Architect responsible for building the model in its entirety, or do contributors to the BIM model like consultants and contractors need to maintain their own model and updates. Post-construction rights to access the model need to be determined. Design copyright among parties involved in
creating the model must be distinguished. Thirdly, the benefits of Building Information Modeling within IPD will be examined using the Leadership in Energy and Environmental Design (LEED) certification template as a baseline in sustainable construction. BIM integration into a sustainable construction project and the documentation process will be defined to detail the advantages and disadvantages of implementing this new technology. The responsibility of each piece of the virtual model and copyright for design will be designated from a logical construction process perspective. The goal is to preemptively clarify potential ambiguities, and prevent mistakes, thereby avoiding judicial resolution on questions of risk and liability.

Contract document language related to reliance and responsibility will be examined within the American Institute of Architects (AIA) documents and Associated General Contractors (AGC) documents available to-date. Recommendations will be given on BIM integration and use according to the results of the data analysis and literature review of sustainable construction within an Integrated Project Delivery process utilizing Building Information Modeling. Evaluation of BIM use in the industry currently will distinguish the pros and cons in the technology, as well as implementation problems and perceived and quantified benefits. Specifically the uses by the Architect and Contractor along with the benefits each use brings will be discussed.

A summary of the recommendations for the future implementation of Integrated Project Delivery within sustainable construction and the perceived benefits of using building information technology software to efficiently design and construct the buildings of future generations will be included. Contract documents available will be considered and their past use examined and compared. Party involvement for collaboration and coordination to be successful within the integrated process will be researched and discussed.
Contract Analysis

Construction documents have evolved over the years. The American Institute of Architects has been creating and updating documents for over 120 years to back when the first document was released in 1888, the Uniform Contract, to be used between the Contractor and Owner. The first general conditions for construction was published in 1911, with the latest revision the 16th edition of the general conditions being released in 2007 (AIA 2007). A separate set of documents recently released for similar purposes is the ConsensusDOCS created by the Associated General Contractors. This document was also released in September 2007. Both documents serve to provide a solid basis of contract provisions enforceable by law.

American Institute of Architects (AIA) Documents

The AIA Documents are changing. Since the earliest drafts were completed in 1911 and released the AIA’s flagship document has been the General Conditions of the Contract for Construction, the A201. This document describes the architect’s role in administration of the construction contract. The A201 establishes the legal relationships between parties to the agreement and is modified by the supplementary conditions found in the specification book. In conjunction with the A201, the B141 Standard Form of Agreement Between Owner and Architect with Standard Form of Architect’s Services takes on a new format to encourage interaction and communication between the Owner and Architect, showing the first signs of support for integrated project delivery.

Revisions released in 1997 for the A201 General Conditions will mostly address the most common grey area: dispute. Three major changes are being made:

- Mediation is now required prior to arbitration, in order to defuse disputes before they escalate. The arbitration and mediation provisions are separate so that either can be deleted without affecting the other.
• A mutual waiver of consequential damages keeps a lid on the amount involved in any dispute by excluding indirect or incidental damages. Both owner’s and contractor’s claims are limited to amounts directly arising from the other’s breach.

• Termination for the owner’s convenience is permitted, with appropriate payment to the contractor. “Opt-out” provisions of this kind have been used by federal agencies, and permit the owner to withdraw from a contractual relationship that proves workable.

One of the biggest issues between architects and contractors is the allocation of responsibility for incidental design. Incidental design is an error or omission within the construction contract documents that result usually result in added construction costs. This particular area is where Building Information Modeling and Integrated Project Delivery enters and can cause even more discrepancies, and thus questions arise. In the 1997 set of documents integrated building modeling was not specifically addressed. It was still a new idea when the ten-year revision cycle for this set of revisions to the AIA documents was being passed. There is a new provision in the A201 that spells out procedures and gives a detailed allocation of responsibility.

The B141 document was also revolutionized with the new revisions from 1997. These changes were brought on by the Practice and Prosperity Initiative which by AIA definition “recognizes that architectural services extend well beyond building design and construction, that they are based on long-term relationships, and that they place architects in facilitator/integrator roles” (Ellickson & McCallum 1997). Eleven conceptual principles were addressed in the modification:

• Allow the architect to provide an expanded range of services over the life of the project
• Enhance the link between fee negotiation and the services to be provided by making clear to the owner the value of services being negotiated and how those services can be compensated
• Offer clear descriptions of services
• Evidence a tone and character that are positive, comprehensive, inclusive, proactive, and educational
• Demonstrate the value-added nature of the architect’s services
• Clarify the owner’s role, responsibilities, and obligations
• Provide for conflict avoidance and resolution
• Permit flexible selection of compensation and project-delivery methods
• Describe known project assumptions in detail, including scope, budget, site, and schedule
• Provide a means of managing costs through the life of the project
• Provide some familiarity to users of AIA documents and preserve links to related documents such as the A201

The goal of the new revisions was to document the new responsibilities that the architect would be taking on within integrated design. This new revision varied from the old in three major ways: It is in the form of a three-part document “kit” rather than a single, free-standing document. It requires an active dialogue between the architect and client that will establish a better understanding up front of what the architect is responsible for. It enables the architect to offer the client an expandable range of services. The new B141 brings back the construction administration aspects of the architect’s responsibilities that were lost over time as builders were involved. The architects were in a sense disconnected from the construction site (Ellickson & McCallum 1997).

The new three-part format allows for more tailoring to specifics of each project: An Agreement Form with general information including terms and conditions. A Scope of Services provided by the Architect. And a Supplemental Attachments A Form for modifying or adding to the Scope of Services.

The Agreement Form is instrumental in stimulating communication between all parties involved so that any and all assumptions and expectations are laid out on the table. The first
The article contains Preliminary Project Information. Multiple fill-in blanks require specific information about the project including size, location, proposed use, budget, and parties involved.

The Scope of Services will be similar to the 1987 version but new project specific versions will be released. The AIA has developed scopes for interiors work, design services without construction administration services, and contract administration services without design services. The new Scope of Services will contain a detailed description of the services to be provided by the architect. With this responsibility clearly spelled out, it removes some of the disagreement about services provided.

The Supplemental Attachments A Form is provided to allow more customization to the document already developed. The intention is to provide enough flexibility within the standard document to accommodate most users.

**Integrated Project Delivery**

While relying on familial agreements, Integrated Project Delivery joins all parties involved in the process together to share goals, liabilities, and rewards. The IPD may include the owner, architect, constructor, and major consultants. The new documents create possibilities for collaborative green design to emerge. Using the integrated design process accreditation through national organizations like the U.S. Green Building Council (USGBC) can be achieved.

Two types of integrated project delivery agreements have been released by the AIA within the 2008 revisions to ease integration of design and construction. The first agreement is reportedly a transitional agreement, created within the use of older documents including: B195 – an owner-architect agreement, A195 – an owner-contractor agreement with a guaranteed maximum price, and A295 – a shared “general conditions” document. Unlike the traditional AIA agreements, B195 and A195 do not include a Scope of Services; instead, this is spelled out
in the A295 General Conditions which establish the collaboration process between the owner-architect-constructor team (Fig. 3-1). The AIA says the A295 documents “writes up a process for early involvement on the part of the contractor, working with the architect through design development, providing constructability reviews, and developing a guaranteed maximum price.” The A295 establishes a collaboration process for the owner, architect, and contractor. Early involvement by the contractor is necessary so they can work with the architect through the design development. The contractor can also provide constructability reviews throughout the process. Then after all this detail has been completed the guaranteed maximum price (GMP) can be established.

The more revolutionary approach is the Standard Form Single Purpose Entity (SPE) Agreement for Integrated Project Delivery – C195. By using this agreement all parties waive claims against each other, except for willful misconduct. A limited liability corporation is formed between the designer and builder for the project. The owner establishes common goals for the project. The AIA documents change the phasing of the process: conceptualization phase, criteria-design phase, detailed-design, and implementation-documents phase (Table 3-1). The conceptualization phase includes key consultants and subcontractors being brought in, the architect scheduling design services, and the contractor preparing the overall project schedule. The criteria-design phase includes the architect performing a code review and presenting design alternatives as well as taking in environmental considerations, the digital model is started, the contractor work with subcontractor and suppliers begins, and the owner approval of the design documents and cost estimate is passed. The detailed-design phase includes selection of major components and systems, construction coordination is initiated, and the contractor can now propose the GMP with thorough documentation to the owner. Lastly, the implementation-
documents phase includes production of construction documents including shop drawings and subcontractor submittals and all design information which should be in the digital model by now and will be used by the owner later for operation (Novitski 2008). Because this document is new territory though, liability is a big concern among insurance providers and clients. The industry is watching to see how they react.

This set of revisions released by the AIA included the C196 – Owner & the SPE and the C197 – Non-owner & the SPE (Fig. 3-2). These contracts state that the owner is a full partner with all parties in managing the design and construction process. There will be collaborative and unanimous decision making between all parties and all parties are motivated to achieve goals mutually agreed upon. Disputes will be settled through provisions set in the contract, not in court. These new documents will provide contractual structure to secure funding along with design and construct the project. It pays attention to detail including insurance application liability limitations and payment to each party, profit options through incentive compensation, and what happens at the end of the project (AIA 2009).

**AIA E202 BIM Protocol Exhibit**

The AIA released the new E202 BIM Protocol Exhibit just recently in 2008. This document is a hands-on working tool for all project participants. It defines the responsibilities of model elements, which is authorized to modify and use the model, who will manage it, and ownership. There are many benefits that come with the implementation of this new technology. At each project phase all elements will be defined and responsibilities allocated. Management will be assigned per project phase of the model. Ownership and right of use will be clarified. From project-to-project this process will be easy to modify and all common terms can be defined to prevent any confusion or misinterpretation (AIA 2009).
**ConsensusDOCS**

AGC has developed over 70 new documents to be used for construction called the ConsensusDOCS that offer better protection for subcontractors compared to other contracts. They assign rights, responsibilities, and risks based on industry best practices. The new documents were named to represent the collaboration across the fields – Designers, Owners, Contractors, Sureties, and other stakeholders. Of the new documents, thirteen of them are related to subcontractor relationships and the agreement of equitable terms about risk exposure, timely payments, and retainage reduction. The risk is spread more equally.

The ConsensusDOCS were developed because agreements currently used are often full of amendments and modifications designed to offload risk and protect one more powerful interest. Now parties are freed up to focus on positive project outcomes and less on watching their backs. All of the new documents were released on September 28, 2007, though their use is voluntary.

The current shift in the construction industry is forcing a need for more collaboration in the contract. These new contracts are the groundwork for greater protection of all interests and taking a “project-first” approach (Zind 2007).

The new Consensus Standard Contracts tend to expand power of or protect interests of a particular group’s constituency. They represent a consensus on best practices to achieve project results, reflect changes in technology such as Building Information Modeling and provide more choices in dispute resolution. To create these documents, a three-year exercise was done with all parties invited to be involved. Interestingly enough, the AIA declined to participate with multiple thoughts: 1) No new program needs to be created; 2) The people should have a choice; And 3) It is hard to see the value in only one set of contract documents creating a monopoly.

The AGC produced the ConsensusDOCS with an emphasis on communication and collaboration between parties. It takes a balanced approach to risk allocation and provides an
opportunity to reduce transactional costs, time of negotiation, and the number of potential disputes (Vermilyeu 2007). A specific document was created for IPD: ConsensusDOCS 300 – Tri-Party Collaborative Agreement. It creates a core team between the owner, designer, and constructor to make project decisions (Fig. 3-3). This agreement enhances collaboration while keeping the design phasing traditional (Table 3-1).

**ConsensusDOCS 301 BIM Addendum:** The 301 BIM Addendum was released shortly after the original ConsensusDOCS were published for use. This addendum is a result of the new growing technology in the industry. It clearly defines roles and risks of BIM contracts, while allowing attachment to any governing contract to aid structure for BIM collaboration. The purpose of the 301 BIM Addendum is to gather and record an agreement on the assignment of responsibility and rights with respect to a range of legal issues that may arise during BIM-based projects. It clarifies responsibilities.

In order to setup this document an execution conference with all parties must take place within thirty days of contract signing. In this conference the subsequent digital models are defined as well as their purpose and degree of detail. Additionally, the designer of each digital model is determined at this conference. The owner is also required to designate and pay for a single entity to manage information and maintain the federated model of the linked models. The addendum does not say specifically who this entity needs to be, just that it needs to be decided and designated. The dimensional accuracy must also be decided on, e.g. ¼” tolerance. There are options within the document that determine levels of accuracy, from no representation of accuracy to each contributor represents his contributions are accurate and take precedence over measurements called out or inferred from drawings for dimensional accuracy. As for risk allocation each party is held responsible for its own or its subcontractors contributions to a
model. The consequential damages and standard of care all refer back to the governing contract to which the addendum is attached. To determine intellectual property rights and exchange of limited-term licenses for parties to use their partners’ models shall be created in the addendum. Each party retains copyright authority to their own contribution. The BIM 301 Addendum is a tool to utilize BIM on a project start to finish. It allows the contractor to more closely integrate project delivery with owners and designers.

Figure 3-1. AIA integrated project delivery contract document relationships
Figure 3-2. AIA single purpose entity contract document relationships

Figure 3-3. ConsensusDOCS integrated project delivery series 300
Table 3.1. Construction document phasing

<table>
<thead>
<tr>
<th>AIA B195, A195, A295 Transitional Agreements And AGC ConsensusDOCS</th>
<th>AIA C195, C196, C197 SPE Agreements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Schematic Design (SD)</strong></td>
<td><strong>Conceptualization Phase (CP)</strong></td>
</tr>
<tr>
<td>establish general scope</td>
<td>key consultants and subcontractors</td>
</tr>
<tr>
<td>conceptual design, scale, and relationships</td>
<td>brought in</td>
</tr>
<tr>
<td>among components</td>
<td>architect schedules design services</td>
</tr>
<tr>
<td></td>
<td>contractor prepares overall project</td>
</tr>
<tr>
<td></td>
<td>schedule</td>
</tr>
<tr>
<td><strong>Design Development (DD)</strong></td>
<td><strong>Criteria-Design Phase (CDP)</strong></td>
</tr>
<tr>
<td>more detailed drawings illustrating new aspects of project</td>
<td>design alternatives presented</td>
</tr>
<tr>
<td>floor plans are clearly defined with accurate dimensions</td>
<td>digital model started</td>
</tr>
<tr>
<td>check for compliance with building codes</td>
<td>check for compliance with building</td>
</tr>
<tr>
<td>work with engineers to design mechanical, electrical and</td>
<td>codes</td>
</tr>
<tr>
<td>structural components</td>
<td>contractor begins working with subs</td>
</tr>
<tr>
<td></td>
<td>and suppliers</td>
</tr>
<tr>
<td></td>
<td>owner approves design documents</td>
</tr>
<tr>
<td></td>
<td>and estimate</td>
</tr>
<tr>
<td><strong>Construction Documents (CD)</strong></td>
<td><strong>Detailed-Design Phase (DDP)</strong></td>
</tr>
<tr>
<td>detailed working drawings and specifications</td>
<td>selection of major components and</td>
</tr>
<tr>
<td>actual construction cost established by contractor</td>
<td>systems</td>
</tr>
<tr>
<td>these documents become part of the contract</td>
<td>construction coordination begins</td>
</tr>
<tr>
<td></td>
<td>GMP set</td>
</tr>
<tr>
<td></td>
<td><strong>Implementation-Documents Phase (IDP)</strong></td>
</tr>
<tr>
<td></td>
<td>produce construction documents</td>
</tr>
<tr>
<td></td>
<td>including shop drawings and</td>
</tr>
<tr>
<td></td>
<td>subcontractor submittals</td>
</tr>
<tr>
<td></td>
<td>all information attached to design</td>
</tr>
<tr>
<td></td>
<td>model</td>
</tr>
</tbody>
</table>
CHAPTER 4
RESULTS

After researching contract documents available throughout the construction industry in the United States, three main documents (AIA Transitional, AIA Single Purpose Entity, and AGC ConsensusDOCS) emerged specifically managing details needed to be defined within an Integrated Project Delivery (IPD). First, the American Institute of Architects (AIA) Transitional Agreements: B195 – Owner-Architect Agreement, A195 – Owner-Contractor Agreement (Guaranteed Maximum Price), and A295 – General Conditions (Scope of Services). The AIA also released the AIA Single Purpose Entity (SPE) Agreements: C195 – Standard Form Single Purpose Entity Agreement, C196 – Owner and the Single Purpose Entity, and C197 – Non-owner and the Single Purpose Entity. The last document discussed was released by the Associated General Contractors (AGC): ConsensusDOCS 300 Tri-Party Collaborative Agreement. All these documents were recently released for public use to define contractual obligation within the collaboration. With the U.S. General Services Administration (GSA) requiring Building Information Modeling (BIM) on all projects now the documents needed revisions to reflect industry trends with building information modeling and sustainable construction.

To start, the shift to Integrated Project Delivery has caused construction phasing to evolve under the creation of the AIA SPE agreements. With the blurring of lines between disciplines and the team work of contract participants the SPE agreements use a four-phase system in place of the traditional three-phases the AIA Transitional Agreements and ConsensusDOCS utilize (Table 3-2). The traditional document phasing includes schematic design (SD) with general scope and conceptual design, design development (DD) with detailed floor plans and preliminary mechanical, electrical and plumbing design, and construction documents (CD) with detailed
working drawings and specifications. The four-phase system includes the conceptualization phase, criteria-design phase, detailed-design phase, and the implementation-documents phase. Conceptualization includes architect design services and overall project schedule by the contractor. Criteria-design includes design alternatives, the beginning of any digital modeling and owner approval of design documents and estimate. Detailed-design includes selection of major components and systems, the beginning of construction and defining of the guaranteed maximum price (GMP). Lastly, the implementation-documents include shop drawings and submittals and attachment to any digital model.

Dispute was another issue for concern by participants in the past and the settling of any outstanding issues. All three documents specifically define how dispute resolution will be handled prior to any litigation. The transitional agreements require mediation and/or arbitration prior to the pursuit of any litigation against parties involved in the contract. The AIA SPE agreements waive claims by any participants in the contract. Provisions to settle any dispute will be detailed within the document. The ConsensusDOCS provides options for the dispute resolution.

Teamwork among all contracting parties is key for IPD to be successful. The three agreements (both AIA and sole AGC document) discussed all approach teamwork and decision-making with the collaboration in mind. The AIA Transitional agreements establish the framework necessary for the collaboration on the project. The AIA SPE agreements enable the owner to set common goals for the team to achieve. The ConsensusDOCS were created through the collaboration of multiple organizations to best allow for efficient teamwork with a “project first” approach.
Risk allocation per party’s contractual obligation can vary depending on the documents used. The AIA Transitional agreements tend to protect a single party within the shared “General Conditions” document – A295 more than spreading out the risk evenly. This agreement is closest to past AIA documents used for traditional design-bid-build projects. With IPD, risk falls on parties who did not previously have to manage it. For this reason, the other two documents, the AIA SPE agreements and the AGC ConsensusDOCS 300 Tri-Party Collaborative Agreement, share risk for the project design and construction. The SPE agreements place the owner in a position to share equally in risk for the project. The ConsensusDOCS spread the risk across all stakeholders.

The newest releases by the AIA and AGC attempt to define terms for use and implementation of Building Information Modeling. The structure of each document varies significantly. The AIA released the E202 BIM Protocol Exhibit which is a stand-alone document to define BIM risk. The AGC, on the other hand, released the 301 BIM Addendum to attach to another governing contract that is being used for the project (Table 4-2).

Each document assigns responsibility for model components and the level of detail to be achieved per element to avoid confusion. At creation of these contracts authorized use and modification personnel shall be identified. The management of the model will vary by contract. The AIA E202 BIM Exhibit states that a model manager will be defined by phase of the project. The responsibility will move from person to person as construction progresses through the phases. The AGC 301 BIM Addendum states the owner will designate one single entity to manage and maintain the federated model throughout the project.

One final additional requirement the AGC 301 BIM Addendum defines the Execution Conference. This conference must be completed within thirty days of signing the governing
contract. At this meeting all participant responsibilities are defined with the detail level for each element. The list of authorized personnel for model use and modification will also be assembled at this time.

Table 6-1. AIA vs. Associated General Contractors (AGC) contract benefits

<table>
<thead>
<tr>
<th></th>
<th>AIA Transitional Agreements</th>
<th>AIA SPE Agreements</th>
<th>AGC ConsensusDOCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design/Construction Phasing</td>
<td>traditional phasing</td>
<td>phasing change for integration</td>
<td>no phase change</td>
</tr>
<tr>
<td>Dispute</td>
<td>requires mediation/arbitration prior to pursuing litigation</td>
<td>all parties waive claims against each other - settled within provisions stated</td>
<td>provided choices in dispute resolution</td>
</tr>
<tr>
<td>Teamwork</td>
<td>establishes collaboration</td>
<td>owner establishes common goals</td>
<td>&quot;project first&quot; approach</td>
</tr>
<tr>
<td>Risk Allocation</td>
<td>shared &quot;General Conditions&quot; document</td>
<td>Owner equal party in sharing risk for project design</td>
<td>risk spread more equally across stakeholders</td>
</tr>
</tbody>
</table>

Table 6-2. BIM contract options

<table>
<thead>
<tr>
<th></th>
<th>AIA E202 BIM Protocol Exhibit</th>
<th>AGC 301 BM Addendum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>Stand-alone contract for BIM risk definition</td>
<td>Attachment to separate governing contract</td>
</tr>
<tr>
<td>Responsibility</td>
<td>Define responsibility of model elements including authorized personal to modify/use</td>
<td>Define digital model and party responsibilities/ level of detail per element</td>
</tr>
<tr>
<td>Model Management</td>
<td>Assign a model manager per phase of construction</td>
<td>One single entity to manage and maintain the federated model designated by owner</td>
</tr>
<tr>
<td>Execution Conference</td>
<td>none</td>
<td>Required within 30 days of signing contract</td>
</tr>
</tbody>
</table>
CHAPTER 5
CONCLUSION

Integrated Project Delivery (IPD) using Building Information Modeling (BIM) creates a problem with design and construction risk within the construction process. Defining terms within the contract documents and the party responsibilities needs to be standardized in the industry. This standardization could mean that only one main contract document remain in the future yielding the best results and collaboration among the creators. Change is coming and for every organization to be on the same page, the topics emerging need to be discussed in detail. Companies are implementing this new technology without knowing what the outcome will be while keeping an optimistic attitude towards the limitations being presented. With the U.S. General Services Administration (GSA) making BIM mandatory for all new projects companies are forced into integrated project delivery arena. The building construction industry will follow this lead to join an economically stable sector of the construction industry.

Sustainable Construction

A baseline case study to illustrate the benefits of Building Information Modeling in Integrated Project Delivery and sustainable construction, the Leadership in Energy and Environmental Design (LEED) certification system was incorporated in this study. Each credit for the LEED checklist was examined looking at the submittals necessary to earn the points toward the certification (Appendix B). Out of the 62 possible credits achievable, BIM use could provide aid in the submission process for at least 53 of the credits. Sustainable design efficiency could be improved significantly using Building Information Modeling for the submittal process. The benefits for organizations using the new technology is described in detail credit by credit in Appendix A and the BIM aid in LEED submissions.
Currently, the most benefits brought about from BIM use can be seen in a few major credits. For starters, the Energy and Atmosphere credit one – Optimize Energy has the most potential. Energy modeling is a big portion of receiving this credit. The modeling process can be tedious when a complex model must be created to simulate the energy consumption. With BIM use, the model will already exist if at least a second level of detail is reached within the model and could be used for the energy model. A second set of credits that could be easily compiled using BIM is the low-emitting materials credits within Indoor Environmental Quality. With the BIM model detailed to level four to utilize the attachment of submittals directly, the totals could easily be tabulated. Lastly, the regional materials and recycled content of material used could also be tracked through level three and level four detailed models. With the level three tracking, the design could be managed to predict the materials being used to be scoped within the construction specifications and the level four detail would be the submittal tracking process as noted above.

The collaboration between specialties within the industry is the future for green construction. The partnership between the U.S. Green Building Council (USGBC) and Autodesk suggests the idea that the submittal process could be changed to directly attach the BIM model created with plug-ins and the XML capabilities already setup within the LEED submission process.

**Case Law Application**

As for the legal issues arising from the new BIM process and integration of parties to create the model, the case law states that no major changes will occur. The current cases being used to back litigation will continue to be used and just applied in a different context. The dilemma most parties believe exists is the responsibility of design and construction error and where that falls with the collaboration throughout the design and construction process. The risk
should not fall on any one party through the use of BIM technology. The risk should still fall within the current organization allocation. Architects will be responsible for design. Contractors will be responsible for the means and methods of construction. The final model created from the Building Information Modeling can be used by the owner, but the copyright for the design will still fall on the Architect.

The most significant case referenced in construction is the United States versus Spearin – defining implied warranty within the contract. This implied warranty for defects within design and construction should not change once Building Information Modeling is implemented. Talking with Architects who are implementing the technology now, they say BIM is expanding their liability platform. The Architect is required to further define the project requirements through BIM leaving less responsibility and liability in the hands of the installing Contractor. Because the stages of integration are still initial, the use of BIM can infer that everything has been coordinated when that is simply not plausible or possible. From firsthand experience one Architect felt that using BIM was much more time consuming because the Architect becomes involved in the process. It is not just the design given to the Contractor any longer, which the Architect feels compromises their decision making abilities and control. It seems that conflict is created when integration is required yet not all parties involved are incorporating the new technology within their organization. The transition is still taking place on a wide-spread scale which causes hesitation. The case history should reassure the Architects that even though the process is being expanded to include them in more elements, there are still only responsible for the design and not the means and methods of construction. Their contributions to the model will be defined in the contract and separate them from any further risk they may fear.
Contract Documents

After researching the history of contracts available for use in the multitude of construction projects, it was found that the evolution of the industry has not surpassed the contracts available. There are multiple options available to the Owner, Architect, Contractor, and Subcontractor. The American Institute of Architects has provided the leading contracts for many years now, releasing new revisions every ten years to the industry. The newest set of releases was revised with integrated project delivery and Building Information Modeling technology. The contracts needed to change because the relationships within project delivery are changing. Disciplines are crossing lines to collaborate and construct the best project possible. With the direction construction project teamwork is heading, the AGC also released a set of contracts created with the intention to keep the “project first” called the ConsensusDOCS. Both sets of documents have their benefits to the different parties involved (Table 4-1). The addendums released specifically for the use of BIM on a contract directly address what needs to be performed for the project to be successful. The risk involved with using BIM is eliminated with the terms defined within the contract prior to implementation. The sole problem with the new contracts is the requirement of all parties involved to be using the BIM technology, which is not the case with all projects going on currently in the industry. It is inferred within the documents that all parties involved will be using the new technology. The use of the technology is growing every day and will be standardized across the industry eventually, especially with GSA requirements in place currently.

AIA Documents versus ConsensusDOCS

Among the documents available today, the newest emergence is the ConsensusDOCS. Though the AIA documents have evolved over the years, their newest IPD documents were released during the same year as the AGC documents. The new ConsensusDOCS represent who best bears the risk as opposed to who will have to pay for it. When these documents were
created, multiple organizations became involved including subcontractors and owner’s representatives. The AIA declined to participate. Both the AIA and AGC wrote the new releases/modifications with the changing industry in mind including the emergence of Building Information Modeling and IPD.

The ConsensusDOCS require (Table 4-1) dispute mitigation, mediation and parties at contract signing to decide to use arbitration or litigation as a last resort. The AIA A201 General Conditions revision released is similar unlike before when all initial claims were subject to an initial decision by the architect prior revisions in the twentieth century, parties moved to mediation or arbitration. The A201 now requires the same process as detailed in the ConsensusDOCS. Another key improvement mainly benefitting the subcontractor – the contractor-subcontract agreement does not require the subcontractor to indemnify the contractor, owner, and architect for all claims. Indemnity “to the extent caused by the negligent acts of omissions” of the subcontractor is stated in the ConsensusDOCS (Korman 2007). It also provides for a limited waiver of consequential damages and a limited mutual waiver with the owner for liquidated damages.

Other revisions made to each documents include the payment security for subcontractors. The documents have a new requirement that that contractor is required to pay each subcontractor within seven days after payment is received from the owner. The AGC abandoned the “pay-if-paid” clause and the AIA 1997 revision largely eliminated it. The new AIA documents still places more risk on the subcontractors than its older version while the AGC diminishes the subcontractor risk.

One groundbreaking aspect about the creation of the ConsensusDOCS by the AGC is the participation of the owner associations. It is logical for the owners and their representatives to
become involved considering the growing frustration with over-utilized, heavily modified standard-form documents that do not resemble the original text. The owners have emphasized that dialogue and communication are more important than power. This idea pushed the risk allocation formulas to the forefront to create a framework for the contract communication. The ConsensusDOCS promote communication and dialogue in order to avoid litigation. The focus for the owner currently must be communication with the integrated project delivery per project.

Other differences from the AIA documents include the requirement of the project owner to provide the prime contractor with evidence of project financing before start and anytime upon request during construction. Without this proof of financing, there is grounds for the contractor to suspend work. The AIA requires the contractor to make an affirmative showing of need before the owner is obligated to provide the financial information, leaving the contractor with less ability to stop work due to financial information. The ConsensusDOCS make an effort to balance parties’ decision-making authority and responsibility along with liability exposure. The AIA A201-2007 leaves the project architect with greater authority for decision-making than in prior documents. This revision also places more responsibility on the contractor for failure to catch design errors and omissions – leaving the architect with less responsibility (Vermilyeu 2007). To compare, the ConsensusDOCS try to remain “risk-neutral” while the AIA A201 places the risk on the contractor’s side but with less responsibility for authority.

Companies seem to not be utilizing the new documents available (Young 2007). The shift is cause for concern for these companies. Any company president may not want to change to the new agreement that is formulated with specific detail for integrated project delivery if their current agreement still functions fine. The governing contract used needs to incorporate IPD and the best way to include IPD is to use the new documents available. The risk will be reduced with
the new agreements released in 2007 by the AIA and AGC. Alongside these new governing contracts the BIM Addenda should be attached to manage modeling risk when BIM technology is used. Because the AIA documents are the most familiar within the industry it seems they will be used more often and provide the strong foundation for the industry to expand upon.

**Building Information Technology**

The new problems introduced by Building Information Modeling within the construction industry are part of the evolution of a technology. Change always includes problems that must be overcome. All parties involved are afraid of the new risk involved with BIM and the integrated project delivery required for the technology to be successful. The standard separation of specialties can no longer operate for the project to be successful using Building Information Modeling. The list of benefits includes plug-ins for external modeling like daylighting, energy, and sustainable design, visualization, central storage of project information, decision-making process shift, reduction in change orders, and models for operation and management after construction is complete. This list just begins to quantify the benefits. The liability and risk parties are worried about can be resolved with the emergence of new contract documents to incorporate the BIM technology – defining terms, party responsibility, and level of detail within each model element created. Both the AIA documents and the AGC documents have encompassed the concerns presented in the past like dispute resolution, risk allocation, model management and responsibility for parties involved in the process (Table 4-1). These organizations have created an agreement centered on integrated project delivery and the contractual obligation, per party, involved in the collaboration (Table 4-2). BIM will require use of these agreements to define terms and responsibility for the project level of detail and creation relieving risk on contracted parties, especially new to the technology use.
Conclusion Statement

With construction moving towards collaborative methods a better understanding of the responsibilities and liabilities for all parties taking part in the new relationship must be clear. Contractually there are more options available to define the risk and responsibility for each participant. The Integrated Project Delivery agreements by the AIA and AGC both lay out a framework to create the relationship and communication necessary for the project to be successful.

When the new technology is being utilized, this study recommends the use of the AGC 301 BIM Addendum created under the ConsensusDOCS. Though the AIA has released a similar agreement, the AGC document encompasses more of the details necessary to clearly layout the progression of the project. With the AGC 301 BIM Addendum an execution conference is required to be completed within thirty days of signing the governing contract. This addendum can be attached to any contract but is recommended to govern the project alongside the AGC ConsensusDOCS 300 Tri-Party Collaborative Agreement. It is recommended that disclaimers of reliance be created by each party and each party’s ability and right to rely on the model and its level of detail should be openly discussed. Within the AGC 301 BIM Addendum all these terms are defined during the execution conference. The AGC addendum also defines one entity to govern the model for the entirety of the project which would limit the confusion on responsibility for the federated model and authorization to modify it. The AIA E202 BIM Protocol Exhibit allows for the responsibility of the model to be passed to multiple parties throughout the phases of construction which could cause discontinuity and confusion. It would be best to have one outside party take responsibility for the federated model throughout the entire project from preconstruction design phases to post-construction facilities management. This party could then hand off the model at the end to the owner for use in operation and maintenance of the structure.
The ConsensusDOCS also seem to be the best document to govern an integrated design project. When created, the AGC took a “project first” approach which allows for all parties to benefit equally throughout the construction process. With the risk spread more equally across the stakeholders more care will be taken to make the right decision the first time around because it will affect all parties involved in construction including the participant making the decision. The AIA Single Purpose Entity agreements provide a similar structure to the project party relationships, but strays from the traditional construction design phasing which could cause problems for any company that has not experienced the new phasing yet. Change may not be welcome within any organization involved in the process leading parties to feel it would be easier to stay with the traditional phasing.

Implementing IPD in the construction process leads to efficient and accurate design of the project. All parties benefit especially the owner. Decisions about design can be made early and alternatives can be explored with less limited options. Utilizing collaboration early in design allows the structure to include input from different specialties on efficiency and constructability which is key in a construction process like sustainable design. Integrated design principles are allowing construction processes such as Building Information Modeling and sustainable design to utilize collaborative techniques involving multiple participants providing input and access to the design process. For these new contractual relationships to be successful party involvement must be clearly defined. This new territory in construction collaboration is where owners like the General Services Administration (GSA) are forcing the industry to head. With GSA requiring BIM on all projects and sustainability laws increasing, architects and contractors may need to branch out and implement new processes.
Future Research

To learn more about the construction focus on IPD the use of new contract documents available should be monitored in conjunction with projects utilizing the construction processes, BIM and sustainable design. The best way to discover the benefits of integrated design principles is first-hand experience with construction projects contracted with the AIA or AGC agreements released specifically for IPD. Current information found on studies of the new agreements are still preliminary. With the collaborative contracts being released in 2007, companies are just beginning to collect quantifiable data of benefits from use of the IPD agreements (Kunz & Gilligan 2007).
BIM Use in LEED Submittals

Each credit for a LEED certified building must be documented and submitted to the USGBC for approval. Building Information Modeling can be used for submission to the Council. The LEED strategy and objectives for the structure can be addressed earlier in the design process using the digital construction of the building. From scheduling to clashing and material use, BIM could be a useful tool in planning the certification of the project in more detail.

The LEED-NC Registered Project Checklist provides a blank list to develop ideas for BIM integration. On it each credit has been marked where BIM could be integrated into the submittal documentation to aid in the design process. BIM use within each credit and the components being considered include anything from material lists and logs to schedule to energy efficiency design using the digital construction model to simulate savings. Some aspects of the Building Information Modeling advantages may be overlooked due to the growing technology and information available about the software capabilities.

LEED Components and BIM Integration

Below the pieces to each credit will be discussed and where BIM can be integrated into the process. Each credit will be identified along with submittals required to achieve that particular credit. The responsibility for that specific portion of the modeling will also be distinguished. Contract to contract responsibility may change depending on the relationships between parties, yet the designation below is the most logical (See Appendix B).

Sustainable Sites

- SS Prerequisite 1: Construction Activity Pollution Prevention
Create an Erosion and Sedimentation Control (ESC) Plan during the design phase of the project. With this plan project drawings must be submitted and confirmation of National Pollutant Discharge Elimination System (NPDES) Compliance. BIM Aid: yes.

The model created through the BIM process will be used in the submission of the Erosion and Sedimentation Control Plan during the design of the project. The compliance documents will need to be kept by the contractor though early submittals will be done using the model. Responsibility: Designer

- SS Credit 1: Site Selection

Confirmation that site does not meet and of the prohibited criteria and a description of any special circumstance and non-standard compliance path. The development footprint on the project site that has been impacted by any development activity should be established. BIM Aid: yes.

BIM would incorporate the site and surroundings into the model and confirm that the specific site meets all of the standards. The footprint on the site can be explicitly examined and its impacts on the surrounding area. The site selection takes place early in the pre-construction phase. Responsibility: Designer

- SS Credit 2: Development Density & Community Connectivity

Using option 1 site vicinity plans including project site and surrounding buildings along with a list of sites and square feet of all the building in the density radius must be included. Option 2 includes a listing of business names and business type. BIM Aid: not significant.

In order for BIM to be a significant aid for this credit the entire area surrounding the structure would need to be modeled which is just not plausible. Now in the future as more and more buildings shift over to using BIM and the operation and maintenance shifts to using it also, entire cities may be modeled and could be combined to create a large scale model of the city. This process will not occur far into the future though especially with the ownership and accuracy of each individual model being put into the question. Responsibility: none

- SS Credit 3: Brownfield Redevelopment

Contamination confirmation by ASTM E1903-97 must be submitted or as defined by local, state, or federal government agency along with a narrative describing the site contamination and remediation. BIM Aid: not significant.

Site contamination and remediation is also an existing site condition which would increase the complexity of the model significantly if all of the components were added. The as-builds of the old structure could be helpful but with BIM being a new technology they will not be in three-dimension. The only part of BIM that may aid in this credit would be the scheduling of the remediation which may impact construction. This factor could be added in during the collaboration of all the modular pieces. Responsibility: none
• SS Credit 4.1 Alternative Transportation: Public Transportation Access

Site vicinity drawing showing project and rail station with pedestrian access or showing project and bus stations with multiple routes must be included. BIM Aid: not significant.

Site vicinity drawings with the locations of the rails and pedestrian access along with the bus stations and their routes being added into the model would be also add additional work that is not necessary at this time. Maybe further down the road when BIM is more standard across the field and other disciplines are using it as well, this option may be considered. This idea goes back to the modeling of a significantly large area that is not necessary for construction. Responsibility: none

• SS Credit 4.2 Alternative Transportation: Bicycle Storage & Changing Rooms

Project Drawings to show bicycle storage and shower/changing facilities or covered storage submitted. BIM Aid: yes.

This submittal includes drawings with the location of bicycle storage and shower/changing facilities on site. The model would easily display these categories and their location in perspective to the building. Decisions would be made on the placement of these structures during the design phase of construction. Responsibility: Designer

• SS Credit 4.3 Alternative Transportation: Low emitting & Fuel Efficient Vehicles

Total parking capacity and preferred parking designations must be disclosed. BIM Aid: yes.

To comply with this credit the total parking capacity and preferred parking designations must be shown. With BIM’s capabilities to quantify each piece to a model, this number could easily be distinguished in the model. Responsibility: Designer

• SS Credit 4.4 Alternative transportation: Parking Capacity

Compliance path for site parking capacity must be submitted. BIM Aid: yes.

Again with this credit the compliance with site requirements for parking capacity must be accurately displayed and the BIM model will quantify these values automatically. The particular compliance path must be decided during the design process. Responsibility: Designer

• SS Credit 5.1 Site Development: Protect and Restore Habitat

Submittals include the project site area, project building footprint and a narrative describing the projects approach to the credit. BIM Aid: yes.

Submittals include the project site area, project building footprint and a narrative describing the projects approach to the credit. All these pieces will be created within the building model, possibly including the current site conditions around which the approach would be decided. Due to compliance taking place within construction and the scheduling
factor which will affect the site development and its protection/restoration, this model and narrative will be created by the contractor. Responsibility: Contractor

- **SS Credit 5.2 Site Development: Maximize Open Space**

  The project site area, project building footprint area, copy of site/landscaping drawings dedicated to vegetated open space, and a possible narrative for special circumstances must be included. BIM Aid: yes.

  The site and landscaping drawings which will be modeled in BIM must be submitted to achieve this credit. The area of the project site and building footprint must also be displayed on these drawings. With a model encompassing the site, all of these components will definitely be within the submitted documents. Responsibility: Designer

- **SS Credit 6.1 Stormwater Design: Quantity Control**

  Pre-development and post-development site runoff rates and quantities must be submitted. These values are used in the design of the system to be implemented. BIM Aid: yes

  The system design and its quantity control will be modeled into the BIM process using the pre-development and post-development site runoff rates and quantities. These decisions are all made during the pre-construction phase of the project. Responsibility: Designer/Engineer

- **SS Credit 6.2 Stormwater Design: Quality Control**

  Structural controls with description of pollutant removal of each control and the percentage of annual rainfall treated along with narrative for special circumstances to be included. BIM Aid: yes.

  The system design and its quality control will be modeled into the BIM process describing the structural controls and pollutant removals for each control. The decisions for which controls to use are based on the percentage of rainfall treated. These decisions are all made during the pre-construction phase of the project. Responsibility: Designer/Engineer

- **SS Credit 7.1 Heat Island Effect: Non-Roof**

  Submittal includes SRI of each paving material, total area of site hardscape, total area of hardscape to be shaded within five years, total area of installed SRI, and total open grid paving. BIM Aid: yes.

  The heat island effect for non-roof structures will all be displayed and designated on the model along with their descriptions and specifications such as the SRI value of each paving material and total area. The percentages of each material can be easily quantified since BIM keeps track of the quantity take-off of all materials. Responsibility: Designer

- **SS Credit 7.2 Heat Island Effect: Roof**
Area of SRI compliant roofing materials, list of installed roofing materials and their SRI values, and total area of Green Roof for submission. BIM Aid: yes.

The heat island effect for the roofing material will be designated in the model with its materials and all other installed roofing components. The total area of the roof will be easily quantifiable and comparable to all materials used for the roof components. Responsibility: Designer

- **SS Credit 8: Light Pollution Reduction**
  
  Submit project lighting drawings interior and site with location and type of fixtures and provide confirmation that maximum candela is not exceeded. BIM Aid: yes.

  The specification of each component installed in the lighting system will be modeled in the project along with its specifications stored in the descriptions. The maximum candela will need to be quantified with the lighting totals. Responsibility: Lighting Designer

**Water Efficiency**

- **WE Credit 1.1 Water Efficient Landscaping: Reduce by 50%**

- **WE Credit 1.2 Water Efficient Landscaping: No Potable Water Use or No Irrigation**

  The projects design case Total Water Applied (TWA) in gallons and the total non-potable water supply available for irrigation purposes. The design of the system will be completed prior to construction. BIM Aid: yes.

  The design system for the building must be completed and created within the model to examine the compliance with the Total Water Applied and the total non-potable water supply available for irrigation purposes. The system can be examined within the structure and its functionality with other components. Responsibility: Designer/Engineer

- **WE Credit 2 Innovative Wastewater Technologies**

  Plumbing construction drawings must be submitted. BIM Aid: yes.

  The plumbing within the building must be submitted for compliance with this credit. In the submission include all fixtures and flows. The model will store the specifications for all components within the plumbing system unless they are not loaded into the model. Responsibility: Designer/Engineer

- **WE Credit 3.1 Water Use Reduction: 20% Reduction**

- **WE Credit 3.2 Water Use Reduction: 30% Reduction**

  Submissions include number of building occupants, project design case, project calculated baseline, non-potable water usage for sewage conveyance, and a narrative describing reduction strategies. BIM Aid: yes.
The submission includes number of building occupants, project design case, project calculated baseline, non-potable water usage for sewage conveyance, and a narrative describing reduction strategies. The model for the plumbing system should already include all of these components except the narrative which can be derived from the model. Responsibility: Designer/Engineer

**Energy and Atmosphere**

- **EA Prerequisite 1: Fundamental Commissioning of the Building Energy Systems**

Commissioning requirements incorporated into the construction documents along with documentation of OPR and BOD for review. Commissioning plan and a summary report must be submitted. BIM Aid: yes.

The commissioning requirements that are incorporated into the construction documents and the model must also be updated throughout the construction process to document compliance with the OPR and BOD. Responsibility for each piece of the commissioning process will be created by the designer on the owner’s behalf. The updating throughout the process though must be done by the contractor since they will be on site during construction. Responsibility: Plan/Designer:Compliance/Contractor

- **EA Prerequisite 2: Minimum Energy Performance**

Design to comply with both mandatory and prescriptive provisions of ASHRAE Standard 90.1 with calculation submissions necessary. BIM Aid: yes.

The energy performance of the systems designed to be implemented within the building must be submitted to prove compliance with both mandatory and prescriptive provisions of ASHRAE Standard 90.1 with calculation submissions necessary. The model has the capabilities to perform many of the calculations automatically after the system has been placed within the model. Responsibility: Designer/Engineer

- **EA Prerequisite 3: Fundamental Refrigerant Management**

Confirmation on project for no use of CFC refrigerant or a phase-out plan including dates and refrigerant quantities as a percentage of the overall equipment. BIM Aid: not significant.

This particular credit will achieve no significant aid from utilizing the BIM process though the specifications of the systems being used in the building can be input into the model. The phase-out plan could be adapted from the schedule and model integration and maybe even the use of the model following construction completion for operation and maintenance but that is on a case by case basis. BIM is not necessary for submission. Responsibility: none

- **EA Credit 1: Optimize Energy Performance**

Submittal Template provides detailed tables and calculations to automatically generate percent savings and points achieved. BIM Aid: yes.
At the level of use of BIM today this credit would aid with energy modeling though it
could not perform all the calculations alone without a plug-in. In the future these tables
could be automatically generated from the mechanical systems that have been modeled in
the building software. The specifications of each system would need to be put into the
model and the mechanical software still seems to have some bugs in it making this
particularly challenging and time consuming. Responsibility: Engineer

- **EA Credit 2: On-Site Renewable Energy**

  Provide the on-site renewable energy sources used along with a description of the source of
  the annual energy cost information and appropriate values and costs. BIM Aid: yes.

  On-site renewable energy sources used along with their specification and description for
  annual energy cost information must be submitted. With the modeling, all of this
  information should be input into the specifications for each material and source within the
  building. Responsibility: Designer/Engineer

- **EA Credit 3: Enhanced Commissioning**

  Provide the name of the Commissioning Authority, firm, and experience information,
  confirmation that the six required tasks are completed, and a narrative describing the
  results of the commissioning design review, implementation of the systems manual and
  training, and the plan for the review of the building operation in 8-10 mos. BIM Aid: yes.

  The results of the commissioning design review and the plan review of the building
  operation should both be incorporated into the building model to clearly illustrate
  compliance with both. The responsibility of commissioning can fall between multiple
  parties though the main responsibility should fall in the hands of the commissioning agent
  to see that all requirements are met. Responsibility: Contractor/Commissioning Agent

- **EA Credit 4: Enhanced Refrigerant Management**

  Submittal includes the HVAC&R equipment types with size, refrigerant, and refrigerant
  charge. BIM Aid: not significant.

  As stated above the use of BIM for the submittal about mechanical equipment and its
  refrigerant specifications would be an insignificant aid to the submittal process for this
  credit. That information can be imbedded within the model but is not necessary and the
  calculations performed by the current software do not take into account the type of
  refrigerant being used for pollution purposes. When the software is developed further and
  the bugs worked out it will be provide a significant impact on the mechanical design
  process though. Responsibility: none

- **EA Credit 5: Measurement & Verification**

  Submit a copy of the Measurement and Verification Plan. BIM Aid: yes.
The Measurement & Verification Plan will be embedded within the structure and its components so the model will be a strong aid in measuring these aspects. The model could also be used after construction is complete as the as-built documents which would also aid in the operation and maintenance. Responsibility: Contractor

- EA Credit 6: Green Power

Option 1 includes providing the name of the green power provider and contract term and option 2 provides the name of the REC vendor. BIM Aid: not significant.

The BIM process will not provide any aid in receiving the credit for green power. Both options include external components which will not be modeled into the building. The designation of its use could be included in the energy specifications but that would only be for future operation and maintenance knowledge. Responsibility: none

Materials and Resources

- MR Prerequisite 1: Storage & Collection of Recyclables

Plan for reduction of waste generated by building occupants including collection and storage of materials for recycling including paper, corrugated cardboard, glass, plastics, and metals. BIM Aid: yes.

A plan for the reduction of waste generated onsite and recycling must be included in the design to meet the prerequisite for materials and resources. Designation can be clearly defined within the model for compliance with this requirement. Responsibility: Designer

- MR Credit 1.1: Building Reuse: Maintain 75% of Existing Walls, Floors & Roof
- MR Credit 1.2: Building Reuse: Maintain 95% of Existing Walls, Floors & Roof
- MR Credit 1.3: Building Reuse: Maintain 50% of Interior Non-Structural Elements

Confirmation that project is renovation/addition that meets the square footage requirements and a table of existing and reused square feet. BIM Aid: yes.

The submittal for building reuse must include square footage requirements as well as tables including the reused materials. The reused material could be easily quantified with the BIM take-off capabilities along with the total square footage comparisons. The materials would just need to be designated and modulated correctly within the model to define the correct characteristics. Responsibility: Contractor

- MR Credit 2.1 Construction Waste Management: Divert 50% From Disposal
- MR Credit 2.2: Construction Waste Management: Divert 75% From Disposal
Submittal includes construction waste calculation tables with type/category and location of landfill/receiving agent and the quantity of waste diverted in tons along with a narrative of the construction waste management plan. BIM Aid: yes.

This submittal includes construction waste calculation tables with type/category and location of landfill/receiving agent and the quantity of waste diverted in tons along with a narrative of the construction waste management plan. All of these components should be included within the model upon the planning and scheduling of construction for the project. Responsibility: Contractor

- MR Credit 3.1: Materials Reuse: 5%
- MR Credit 3.2: Materials Reuse: 10%

Tables of salvaged/reused materials, source/vendor, and cost for the total project will be submitted along with a narrative of reuse strategy. BIM Aid: yes.

To achieve this credit tables of salvaged/reused materials, source/vendor, and cost for the total project will be submitted along with a narrative of reuse strategy. The salvaged materials will be designated on the model to be reused for construction along with for scheduling purposes throughout construction. BIM will aid in keeping track of all the parts and pieces to be used to achieve this credit. Responsibility: Contractor

- MR Credit 4.1: Recycled Content: 10% (post-consumer + ½ pre-consumer)
- MR Credit 4.2: Recycled Content: 20% (post-consumer + ½ pre-consumer)

Submit calculations for total recycled content value as defined in accordance with ISO 14021 not including mechanical, electrical, plumbing components, and specialty items. BIM Aid: yes.

Submission includes calculations for total recycled content value as defined in accordance with ISO 14021 not including mechanical, electrical, plumbing components, and specialty items. The material totals will be included in the quantity take-offs for the building and all specifications and material designations will be attached to each material for clarification. The model will greatly simplify the process and management of each material. Responsibility: Contractor

- MR Credit 5.1: Regional Materials: 10% Extracted, Processed & Manufactured Regionally
- MR Credit 5.2: Regional Materials: 20% Extracted, Processed & Manufactured Regionally

Submit calculations for the percent of local materials used as a part of the total material cost. BIM Aid: yes.

Each material can be specified with a description throughout the building model prior to material use the submission of calculations for the percent of local materials used and
obtained with travel distances. With growth into the use of BIM this credit will make it more efficient. Responsibility: Contractor

- MR Credit 6: Rapidly Renewable Materials

Calculate the percent of rapidly renewable materials as part of the total materials cost within Divisions 2 -10. BIM Aid: yes.

The rapidly renewable materials will be designated within the model and researched as construction progresses to include the most possible in the building. The contractor will be responsible for the supply of materials throughout the building so responsibility for this credit and its calculations cannot be placed on the designer. Responsibility: Contractor

- MR Credit 7: Certified Wood

Calculate the percentage of FSC-certified wood material as a total of the new wood material cost. BIM Aid: yes.

Like the rapidly renewable materials credit, the FSC-certified wood use will be determined by the contractor upon purchasing materials for the construction of the building. The calculation of the percentage of the total new wood will not be able to be completed until the contractor has ordered and installed a large amount of the wood components within the building. Responsibility: Contractor

Indoor Environmental Quality

- EQ Prerequisite 1: Minimum IAQ Performance

Submit the design narrative describing the project’s ventilation design for mechanically or naturally ventilated buildings. BIM Aid: yes.

The project’s ventilation design for the mechanically or naturally ventilated building must be submitted for compliance. The BIM model will include both of these systems as they are a major component of the building design. Responsibility: Designer

- EQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control

Confirm parameters have been met for one of the option requirements to control smoking. BIM Aid: yes.

The drawings must confirm the compliance with either of the options for this credit. The model would be sufficient to prove compliance. Responsibility: Designer

- EQ Credit 1: Outdoor Air Delivery Monitoring

Confirmation of the type of ventilation system and installed controls and a narrative describing the project’s ventilation design and CO₂ monitoring system. Project drawings to
document location and type of installed sensors and natural ventilation components included. BIM Aid: yes.

The ventilation system and installed controls for the CO₂ monitoring system must be submitted for confirmation along with the sensor location. All of these components should be created and placed in the model during the design process. Responsibility: Designer

- **EQ Credit 2: Increased Ventilation**

Prepare calculations to demonstrate the design ventilation rates for each zone are above the minimum rates required. BIM Aid: not significant

The calculations for this submittal are going to have to be prepared separately from what the model will provide so simply using the model will not provide any significant aid to achieve this credit though future development of software plug-ins could produce this information. Responsibility: none

- **EQ Credit 3.1: Construction IAQ Management Plan: During Construction**

Provide a copy of the IAQ plan along with photos to prove implemented construction practices and list all filtration media installed during construction and confirm replacement prior to occupancy. BIM Aid: yes.

The list of all filtration media needed can be created by the model if the details have been logged in. The implementation of the plan will need to be supervised by the Contractor during construction though along with the photos for documentation. Responsibility: Designer/Engineer

- **EQ Credit 3.2: Construction IAQ Management Plan: Before Occupancy**

Perform building flush-out and air quality testing to demonstrate contaminant maximum concentrations are not exceeded. BIM Aid: not significant.

To achieve this credit a flush-out and air quality testing must be performed prior to occupancy to demonstrate the maximum concentrations have not been exceeded. These requirements are all field related so the model would be of no significant aid to achieve these credits. Responsibility: none

- **EQ Credit 4.1: Low-Emitting Materials: Adhesives & Sealants**

Provide a list of each indoor adhesive, sealant, and sealant primer product used on the project and each indoor aerosol adhesive product. BIM Aid: yes.

The list of indoor adhesive, sealant, and sealant primer products used on the project will be attached within the production of the model. This is very specific information to detail in the model and should be included. It must be designated on the level of detail that will go into the model. Responsibility: Contractor
- **EQ Credit 4.2: Low-Emitting Materials: Paints & Coatings**

  Provide a listing of each indoor paint used on the project. BIM Aid: yes.

  The list of each indoor paint used on the project will need to include information detailed for the model. The quantities can be derived from the model if the level of detail is reached in the BIM process up to the as-builds. Responsibility: Contractor

- **EQ Credit 4.3: Low-Emitting Materials: Carpet Systems**

  Provide a listing of each carpet and carpet cushion and confirm compliance with the CRI Green Label Plus testing program. BIM Aid: yes.

  The list of each carpet and carpet cushion used in the building to confirm compliance with Green Label should be produced from the model. The level of detail is high but achievable. Responsibility: Contractor

- **EQ Credit 4.4: Low-Emitting Materials: Composite Wood & Agrifiber Products**

  Provide a listing of each composite wood and agrifiber product installed in the building interior. BIM Aid: yes.

  The list of each composite wood and agrifiber product installed in the building interior should be detailed in the model produced. That level of detail can be achieved by submission for this credit. Responsibility: Contractor

- **EQ Credit 5: Indoor Chemical & Pollutant Source Control**

  Submit construction drawings to highlight the location of the entryway systems and confirm required systems along with mechanical drawings highlighting chemical usage areas, room separations, and associated exhausted systems. BIM Aid: yes.

  The model could be used in place of the construction drawings to highlight location of entryway systems to confirm the required systems. The mechanical will be implemented into the model so the level of detail needed will be present. Specific areas such as chemical usage areas, room separations, and associated exhausted systems can be highlighted in the model. Responsibility: Designer/Engineer

- **EQ Credit 6.1: Controllability of Systems: Lighting**

  Provide a listing of the total number of workstations and lighting controls for individual and shared multi-occupant space control along with a narrative describing the project’s lighting control strategy. BIM Aid: yes.

  The list of the total number of workstations and lighting controls for individual and shared multi-occupant space control can be produced from the model in quantities and location to detail the compliance. Responsibility: Lighting Designer
• EQ Credit 6.2: Controllability of Systems: Thermal Comfort

Provide a listing of the total number of workstations and thermal controls for individual and shared multi-occupant space control along with a narrative describing the project’s comfort control strategy. BIM Aid: yes.

The list of the total number of workstations and thermal controls for individual and shared multi-occupant space control can be produced from the model in quantitative take-off and location to detail the compliance. Responsibility: Designer

• EQ Credit 7.1: Thermal Comfort: Design

Submittal documentation with data regarding seasonal temperature and humidity design criteria and a narrative describing the method used to establish the thermal comfort conditions for the project and how the systems design addresses the design criteria. BIM Aid: yes.

The documentation needed for this submittal includes data regarding seasonal temperature and humidity design criteria which will be attached to the mechanical components installed in the model as well as any natural ventilation that may be included in the system. The BIM process will provide the information needed to detail compliance for this credit. Responsibility: Designer/Engineer

• EQ Credit 7.2: Thermal Comfort: Verification

A narrative describing the survey planned for validation of the thermal comfort conditions and specific description of the provisions for creating a plan of corrective action will be submitted. BIM Aid: not significant.

As for submission to receive this credit the model will not be a significant aid. A narrative describing the survey planned for validation of the thermal comfort conditions and specific description of the provisions for creating a plan of corrective action will be submitted. When actually measuring the thermal conditions after occupancy, the model could be put to use for the system that has been set in place. Responsibility: none

• EQ Credit 8.1: Daylight & Views: Daylight 75% of Spaces

Submit glazing factor calculations or a computer simulation or the daylight measurement method. BIM Aid: yes.

The computer simulation of the daylight measurements necessary for submission to receive this credit can be produced from the model created. The glazing factor calculations would have to be done separately if necessary. Responsibility: Lighting Designer

• EQ Credit 8.2: Daylight & Views: Views for 90% of Space
Submit the template calculation spreadsheet to demonstrate overall access to views and provide copies of the applicable project drawings showing the line of sight from the interior spaces through exterior windows in both plan and sectional views. BIM Aid: yes.

The model can be used to demonstrate overall access to views to create the spreadsheet and provide proof showing the line of sight from the interior spaces through exterior windows in both plan and sectional views. Responsibility: Designer

Innovation and Design Process

• ID Credit 1-1.4: Innovation in Design

Submit proposal with intent, requirements for compliance, submittals, and design strategies to meet. BIM Aid: yes.

The submission for this credit could also be supported with a three-dimensional model and then the scheduling added in the BIM process to support the intent, requirements for compliance, submittals, and design strategies that need to be met. Responsibility: varies

• ID Credit 2: LEED Accredited Professional

Submittal documentation includes the name of the LEED AP, LEED AP’s company, brief description of role, and copy of the LEED AP Certificate. BIM Aid: not significant.

The submittal of documentation for the name of the LEED AP, LEED AP’s company, brief description of role, and copy of the LEED AP Certificate will not be produced by the model so the BIM process will provide no significant aid in achieving this credit. Responsibility: none
## APPENDIX B

### LEED CHECKLIST NC 2.2

<table>
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<th>Sustainable Sites</th>
<th>LEED-NC Version 2.2 Possible Credits</th>
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<th>Responsibility</th>
<th>Not Used</th>
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</thead>
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<td>Construction Activity Pollution Prevention</td>
<td>X</td>
<td>X</td>
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<td>C1</td>
<td>Site Selection</td>
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<td>C2</td>
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<td>C3</td>
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<td>Alternative Transportation: Public Transportation Access</td>
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<td>C4.2</td>
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<td>C4.3</td>
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<td>Stormwater Design: Quantity Control</td>
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<td>Water Efficient Landscaping: Reduce by 50%</td>
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<td>Measurement &amp; Verification</td>
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<td>C1.1</td>
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<td>Construction Waste Management: Divert 75% from Disposal</td>
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<td>Materials Reuse: 5%</td>
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<td>Recycled Content: 10% (post-consumer + 1/2 pre-consumer)</td>
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<td>C4.2</td>
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Total out of 62: 53, 16, 14, 2, 22, 9
LIST OF REFERENCES


BIOGRAPHICAL SKETCH

Before attending the University of Florida, Betsy attended the University of Central Florida to play collegiate volleyball for the Knights. Lacking a degree similar to architecture or building construction, Betsy transferred to UF after only one year in Orlando. The University of Florida provided her with a Bachelor of Science in building construction. They presented a strong undergraduate program with a valued appreciation by peers within the Gainesville community. The two-year upper division program provided a background for insertion into the industry throughout the country. The combined degree program offered an accelerated option to pursue the Master of Science in building construction, limiting the education to two semesters. This availability led her to pursue that degree and become one step ahead of her colleagues that graduated beside her the year prior. Now, she will continue into the industry to work for a mid-size General Contractor with an entry level project management position.