



CIFE CENTER FOR INTEGRATED FACILITY ENGINEERING

**Applications of BIM and Hurdles for
Widespread Adoption of BIM
2007 AISC-ACCL eConstruction Roundtable
Event Report**

By

Timo Hartmann & Martin Fischer

**CIFE Working Paper #WP105
Revised - FEBRUARY 2008**

STANFORD UNIVERSITY

COPYRIGHT © 2008 BY
Center for Integrated Facility Engineering

If you would like to contact the authors, please write to:

*c/o CIFE, Civil and Environmental Engineering Dept.,
Stanford University
Terman Engineering Center
Mail Code: 4020
Stanford, CA 94305-4020*

Applications of BIM and Hurdles for Widespread Adoption of BIM

2007 AISC-ACCL eConstruction Roundtable

Tuesday, April 17, 2007

New Orleans, LA

Event Report

Timo Hartmann and Martin Fischer

CIFE, Stanford University

timo@stanford.edu, fischer@stanford.edu

Executive Summary

This report summarizes the presentations, discussions and findings from the 4th eConstruction Roundtable organized by AISC and ACLL. The purpose of the Roundtable was to identify and address process issues with respect to BIM implementation (see Appendix A for the agenda of the Roundtable). It brought together participants from all main parties in the design and construction supply and value chains including, for the first time, representatives from the legal, insurance, and surety sectors (see Appendix B for a list of participants). The first part of this report summarizes the presentations of representatives of the different disciplines of the AEC industry. It summarizes how each of the disciplines are using Building Information Models (BIM) and describes the obstacles to a wider BIM implementation experienced by the participants. The second part describes the insights from a panel discussion and two breakout sessions.

Many participants noted the increasing use of BIM in their disciplines during some project phases. They identified the lack of knowledgeable practitioners who are ready to move the industry into the BIM age as a major bottleneck. Thus, the AEC industry and companies need to establish far reaching education and training programs. Additionally, though the focus of the Roundtable was on process issues with respect to BIM implementation, there are still a number of technological issues that hinder the wider utilization of BIM.

Objectives of the Roundtable

The American Institute of Steel Construction (AISC) and the American College of Construction Lawyers (ACCL) organized the eConstruction Roundtable 2007 with the objective to discuss the implementation of Building Information Models (BIM) across the construction industry. Furthermore, the AISC-ACCL intended to address the specific hurdles faced by the different members of the AEC community in widespread deployment of BIM. The invited participants represented the different parties involved on AEC projects: Lawyers, Insurers, Owners, Designers, Contractors, and Suppliers (see Appendix B for a list of participants). The focus of the event represented a substantial shift compared to previous years. While prior Roundtables focused on the structural steel supply chain, this Roundtable created an open forum for industry groups to explore the impact of the Roundtable on the entire AEC community.

To identify and discuss the hurdles to broader BIM use, the Roundtable was organized into four different sections. First, Professor Martin Fischer from the Center of Integrated Facility Engineering (CIFE)¹ at Stanford University set the stage. Then, representatives of the different industry groups presented the use of BIM, initiatives of their organizations, and the hurdles from their point of view. A panel discussion with the different presenters followed these presentations. After lunch hurdles and solutions were discussed in two breakout sessions. Please refer to Appendix A for the agenda of the workshop. This report first summarizes the presentations, discussions, and findings of each of the sections of the Workshop. In two additional sections, this report then critically analyses the discussions and findings and relates them to some of the latest research efforts in this area.

¹ CIFE's website <http://cife.stanford.edu> provides more information about the work of CIFE.

Martin Fischer: BIM and the AEC Industry Today

In his initial address the facilitator of the Roundtable, Professor Fischer, addressed the current situation of the AEC industry with relation to the use of BIM. This section summarizes Professor Fischer’s presentation.

In past years the AEC industry has spearheaded a number of projects that utilize BIM. Many of these projects are able to realize

- 20-30% higher productivity in the field,
- a reduction of Requests for Information (RFI) and Change Orders (CO) by a factor of ten or more,
- a dramatically higher engagement and buy-in of all important stakeholders, and
- the consideration of significantly more design options from more perspectives with a similar budget and time schedule than traditional methods.

Often engineers on these projects realize these benefits with relatively simple technological means. Professor Fischer showed an example of a construction project from Egypt, where a 3D model of the facility was used to generate a detailed bill of materials and list of detailed construction tasks, which were stored in a Microsoft Access database. Furthermore, the presentation showed that some project teams were able to realize benefits utilizing BIM in all phases of a project. Figure 1 shows an overview of how these projects have applied BIM. However, all the projects have used BIM only for one of the phases. The main hurdle that the AEC industry needs to overcome is the integration of BIM across the different phases and across the different participants of a construction project.

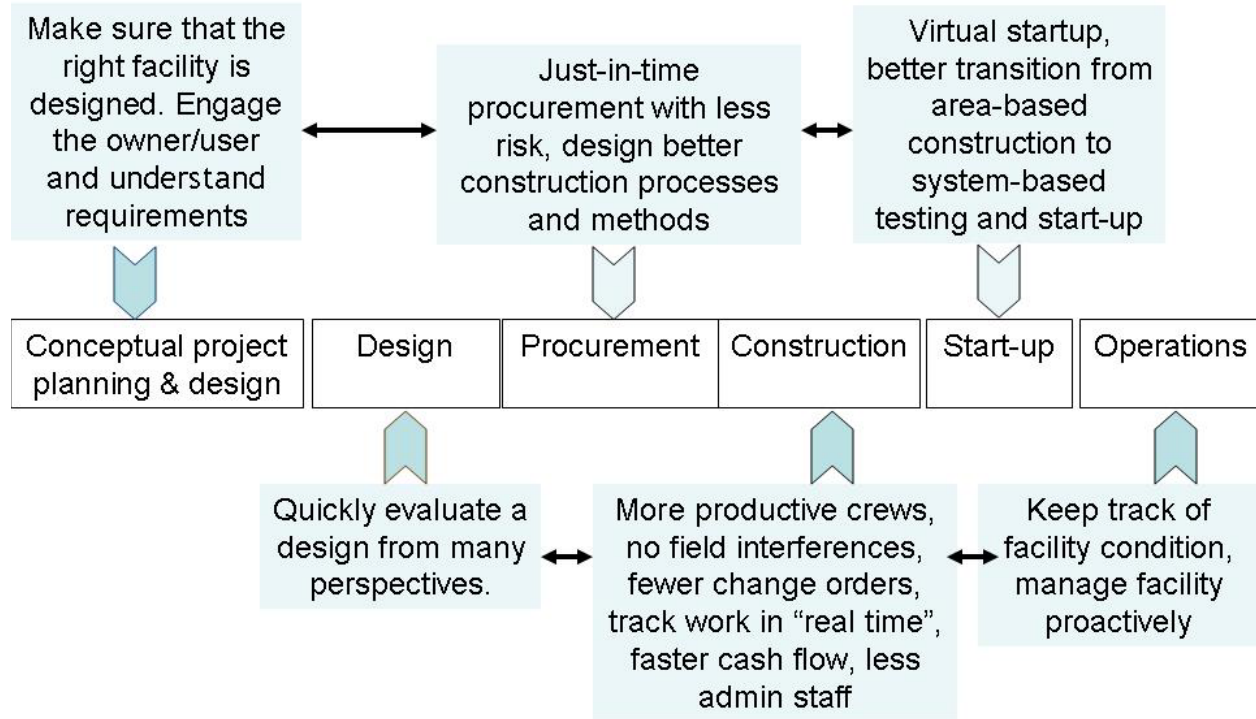


Figure 1 - BIM applications in the different phases of an AEC project

Professor Fischer, finally, summarized the purpose of the Roundtable:

- discussing the barriers to a broader BIM implementation,
- coordinating strategies to address these barriers, and
- focusing on the process of BIM implementation instead of BIM technology.

He concluded his initial address by stressing that all participants are convinced of the benefits of BIM and reminded everybody that it is, therefore, not necessary to promote the benefits of BIM by presenting success stories. Ideally, he hoped that he will not “hear a single good thing about BIM” throughout the workshop.

BIM from the Perspectives of AEC Stakeholders

In the next session of the Roundtable representatives of the different disciplines of the AEC industry presented their viewpoints on BIM. The session started with a presentation by John Cross (AISC) representing the steel industry. He was followed by Patrick J. O’Connor (ACCL) representing the construction lawyers, Markku Allison (AIA) representing the architects, Lorna Parsons (Victor O. Schinnerer & Co., Inc) representing the construction insurers, Charles Hardy (CURT) representing the owner community, David Hanson (AGC) representing the general contractors, Mark Anderson (Environmental Systems Design) representing the MEP designers, and Joe Burns (Thornton & Tomasetti) representing the structural engineers followed. The main points of the discussion are summarized in Table 2. In general, most of the different AEC stakeholders have used BIM in one or another way. However, a vertical integration between the different parties on a construction project has generally not occurred so far. This is, according to the speakers at the eConstruction Roundtable, mainly due to

- missing software applications that support a BIM approach,
- missing BIM trained personnel, and
- missing legal and insurance frameworks that support a collaborative project delivery framework.

The rest of this section summarizes the different viewpoints of the various AEC stakeholders according to the presentations at the Roundtable in detail.

AEC stakeholder	Current Situation	Obstacles
Steel Industry	CIS/2 data model: integrates structural design, scheduling and fabrication Silo solution of the steel industry that needs to integrate with BIMs used by other parties	Software vendors do provide sufficient support for the CIS/2 data model The steel industry does not have a collaborative mindset, and there is a prevailing fear of change Problems with legal frameworks, financial risk, business models and practices, legacy practices, interoperability
Lawyers	Contracts are based on a court	Lawyers need help to understand

	<p>decision 100 years ago, thus lawyers need to change the contracting paradigm to integrate BIM</p> <p>Help the construction industry to create an atmosphere of collaboration instead of blame</p> <p>Keep up with current technological developments</p>	<p>who has which responsibilities</p> <p>Lawyers need help to understand what needs to be done to create a BIM framework for the AEC industry</p>
Architects	<p>So far architects have not heavily invested in BIM</p> <p>Architects need to understand the need to shift to a more integrated practice</p> <p>The AIA has established education programs for architects</p>	<p>Lack of awareness of practicing architects</p> <p>Agreements between AEC stakeholders</p> <p>Legislative obstacles</p> <p>Lack of Architects educated in/with BIM</p>
Insurers	<p>Industry is highly positive about BIM</p>	<p>Do not know yet how to price insurance and write policies as historical data is missing</p> <p>Lack of good contracts to regulate collaborative use of BIM on construction projects</p>
Owners	<p>Owners are focusing on project delivery factors beyond cost</p> <p>BIM is already impacting the industry by enabling collaboration and information</p>	<p>Missing BIM training, staff, and software</p> <p>In the existing business model, the parties maximize their profits by “doing as little as possible”</p> <p>No legal change has happened so far</p>
General Contractors	<p>Contractors have started to use BIM without help of the AGC for marketing, planning, and construction</p> <p>In the last year, the AGC started to support BIM efforts</p> <p>Developed a collaborative agreement</p> <p>Developed an electronic communication agenda</p> <p>Developed an AGC/XML exchange protocol</p>	<p>Final BIM model will need input from everybody</p> <p>Tracking time and cost</p> <p>Complexity of software</p> <p>No models from the designer</p> <p>Aggregation of multiple BIMs</p> <p>Way to manage tolerance</p> <p>Missing legal and insurance frameworks</p>
MEP Designers	<p>3D modeling for coordination, construction documentation and marketing</p> <p>Client driven approaches</p>	<p>Existing software often not ready for “Prime Time”</p> <p>Cost of software training</p>

Structural Engineers	BIM enables worldwide distributed work	Need to integrate with MEP BIM, as MEP BIM has the biggest impact on steel fabrication
	Working software packages	Problem aligning tolerances and fit
	BIM enables immediate gratification and feedback during analysis	Codify the standard practice
	Integrated modeling and analysis	No budget for BIM

Table 2 - Summary of the stakeholder presentations describing the current situation of BIM implementation and the main obstacles for a broader use of BIM

Viewpoint of the Steel Industry – John Cross

The steel industry has realized for quite some time that the transfer of information between the stakeholders in the supply chain is key to improved productivity. Therefore, the industry has developed the CIS/2 model to enable the exchange of information between the structural design, scheduling and fabrication of steel². The steel industry has already realized significant benefits from data exchange with CIS/2. To further improve productivity the steel industry needs to move beyond this silo solution for data exchange and integrate with the information of other AEC disciplines as well.

The steel industry sees a number of main obstacles to such an integration of the AEC industry utilizing BIM models. First, the existing software packages do not support the CIS/2 standard sufficiently for the data exchange that is needed by the members of the steel industry to integrate their work. Second, by nature, the steel industry has not a collaborative mindset and is very averse to change. Finally, the AEC industry has to solve problems with respect to legal frameworks, financial risks, business models and practices, legacy practices, and interoperability.

Viewpoint of the Construction Lawyers – Patrick J. O’Conner, Dwight Larson, and Chris Noble

In general, the lawyers working in the AEC industry try to keep up with the latest technological developments. Lawyers intend to help the construction industry to create an atmosphere of collaboration instead of blame. However, currently, legal decisions for the AEC industry are based upon a 100 year old court decision. This court decision focused on the warranty of the rights of the individual stakeholders of a project and did not focus on a collaborative assessment. To be able to help with widespread BIM adoption, construction lawyers need to keep up with the current technological developments to understand the requirements for a legal BIM framework. In particular, lawyers need to understand the responsibilities of the different stakeholder in the new process.

Viewpoint of the Architects – Markku Allison

So far, architects have not invested heavily in BIM technology. However, lately a broader understanding that the architectural practice has to shift to a more integrated practice has developed among architects. The AIA has established a number of educational programs for its members, including the organization of panel discussions, industry summits, and conferences, as well as the provision of a number of documents such as position statements and reports

² Information about the CIS/2 standard can be found at <http://cis2.org>.

through its integrated practice knowledge community³. The AIA sees BIM as one of the enablers to such an integrative practice.

There are a number of obstacles to the transformation that the architectural profession is facing. First, practicing architects need to develop a greater awareness of the possibilities that BIM offers them. This problem is mainly caused by a lack of BIM educated architects. Second, on a broader industry level, all AEC stakeholders need to agree on a general BIM-based project delivery approach that is supported by a legal framework.

Viewpoint of the Insurers – Lorna Parsons

In general, the insurance industry is highly positive about BIM. However, there are still a number of liability related issues about how to share data, how to use, and who owns the BIM model that need to be addressed. Collaborative Design (which is aided by the use of BIM software) is a harder problem. Collaborative Design potentially provides a better quality project that has a much higher chance of being delivered on-time and on-budget. This is extremely attractive to insurers since it means there would be fewer claims. One obstacle the insurance industry sees with respect to writing insurance policies is that, currently, there are no standard contracts that regulate the BIM supported collaborative project delivery approach. Liability typically flows from the provisions of the contract. To make matters more complicated, many of the suggested collaborative contracts assign liability for errors to the group instead of the individual firms. There are no historical precedents to tell us how the courts will react to these contracts. Since insurance policies are created and priced using historical data as a basis, the insurance industry needs to collect a sufficient amount of historical financial data to be truly comfortable insuring collaborative design efforts. In the absence of data, the insurance industry tends to be conservative with both coverage and price.

Viewpoint of the Owners – Charles Hardy

In the last couple of years a number of owners have started to focus on factors beyond construction cost like quality or life-cycle cost of the facility. The owner community has realized the potential of BIM to manage projects that include such objectives. So far, BIM has already impacted the industry as it enables better collaboration and information sharing. The Construction Users Roundtable (CURT) has published two whitepapers that describe the focus and vision of a BIM-based project delivery approach⁴.

The owner community sees a number of obstacles towards a broader BIM implementation in the AEC industry. First, the AEC industry lacks staff knowledgeable in BIM, BIM-focused educational programs, and mature BIM software. Second, with the current project delivery processes, benefits for the different stakeholders of a project are theoretically maximized by doing “as little as possible”. Thus the processes are not structured to support AEC stakeholders in using BIM. Integrated project delivery methods are changing this, but are in formative stages. Finally, no activities in the legal arena have moved to support a BIM-based project delivery approach.

Viewpoint of the General Contractors – David Hanson

General contractors have already used BIM without the help of the AGC for marketing, planning, and construction for a number of years. To support their members, the AGC,

³ The AIA website contains information about the AIA Initiative integrated practice. <http://www.aia.org>.

⁴ CURT’s website at <http://www.curt.org>.

therefore, has started to develop collaborative agreement documents, an electronic communication agenda, and the AGC/XML electronic data exchange protocol⁵. However, so far, most general contractors that use BIM have not “seen a BIM from the architect or designer” yet. Despite the use of self-produced BIM models so far, general contractors are aware that an effective and efficient utilization of BIM will need a collaborative effort with input from all disciplines.

General contractors see a number of obstacles for a more integrated BIM approach on construction projects. First, it is not possible yet with the existing BIM solutions to track time and cost at the same time. Second, the existing BIM software is too complex to be used by most project managers. Third, as mentioned earlier, general contractors do not receive any BIM models from designers yet and have to develop their own BIM from the traditional design deliverables. Fourth, existing BIM solutions do not offer functionality to manage tolerances of the information contained in the BIM. Finally, missing legal and insurance frameworks impede the use of BIM on construction projects.

Viewpoint of the MEP Designers – Mark Anderson

The MEP supply chain started to use BIM for coordination, fabrication and construction, documentation, and marketing. However, so far, BIM designers use BIM only if the client requires it. MEP designers see a rising demand from the owner community, and design companies have lost jobs in the past if they could not show their ability to use BIM to design MEP systems.

The main obstacles for a more widespread use of BIM among MEP designers are that most of the existing BIM software applications are not ready for “prime time”. Additionally, the MEP designers struggle with the timing and cost of software training.

Viewpoint of the Structural Engineers – Joe Burns

BIM enables structural engineers to distribute their design work worldwide. A couple of factors enable this. First, a number of working software packages support the work of structural engineers. Second, BIM models enable the immediate gratification and feedback during the analysis of structures, and, therefore, enable integrated modeling and analysis.

The main obstacle to a more widespread use of BIM by structural engineers is that there is no integration between the structural engineers and the MEP designers. This, in turn, hinders the direct exchange of the structural design models with the steel fabricators, as the fabricators need the direct positioning and sizes of the penetrations between the MEP system and the structural steel. Furthermore, the standard BIM practices need to be codified, and BIM modeling needs to be integrated into the budget for structural engineering.

Panel Discussion

The panel discussion that followed the presentations about the different viewpoints of the various AEC stakeholders focused mainly on the following issues:

- The utilization of BIM in the US industry and how it compares with the use in Europe.

⁵ AGC website at <http://www.agc.org>.

- The position of the legal and insurance community to the fact that practitioners on projects already collaborate with BIM without a legal and insurance framework.
- The need of the legal and insurance community to understand BIM technology in detail to write contracts and insurance policies.
- The thoughts of the participants to new forms of contracts already used by owners such as Sutter Health.
- Why insurance policies have not yet been adjusted, although projects with good BIM use promise (have demonstrated) financial risk reductions.
- Where the interoperability movement is headed.

The following subsections briefly discuss these points.

Utilization of BIM in the USA and Europe

Martin Fischer and Joe Burns summarized the situation in the European construction industry with respect to the utilization of BIM. In general, they stressed that, while the Finnish AEC industry is world-wide leading in the use of BIM, the rest of the European industry does not differ much from the US industry in the utilization of BIM models. There are some companies and projects that apply BIM, but the use is also still very fragmented and not well integrated.

Plans of the Legal and Insurance Industry to react to the Increasing Use of BIM

The representatives of the legal AEC community agreed that they need to catch up with the technological and process developments of project deliverable methods. Most of the existing contracts used in construction have been developed 30 years ago. Thus, these contracts do not adequately cover the exchange of design and construction information, not even for the delivery of fast track projects. However, practitioners do use these new methods, working around the legal issues as best as possible.

The legal community works on these issues. Patrick O'Connor informed the Roundtable participants about an electronic protocol document the AIA is developing and planning to publish around October 2007. However, he also again stressed the point that the legal community needs to understand who has which rights and benefits while working with BIM.

Can Lawyers Write New Contracts without Technological Knowledge?

A number of participants of the Roundtable were concerned about how lawyers could write new contracts without "getting their hands dirty" by gaining a deeper technical understanding of BIM. However, Patrick O'Connor disagreed with this standpoint. He believes that it is more important to understand the processes behind the use of BIM, instead of the BIM technology itself, since contracts have to be written in a standard form that covers more than only the use of BIM technology. Additionally, it is not wise to write contracts covering technological features in detail, as technology is changing too fast to be covered through detailed legal agreements. It is important that all stakeholders on a project are comfortable with the legal agreements, especially with respect to the defined tolerances.

A number of participants of the Roundtable then started discussing whether new contracts are needed at all. These participants stressed that there will be multiple BIMs on a projects. Thus

the main question is whether the contractual relationships or the content and the scope of the deliverables will change.

Sutter Health Care Project Agreement in California

Dean Reed of DPR Construction asked whether the panel was aware of the integrative form of agreement that was developed by Sutter Health Care on its hospital projects in California. In general, most of the participants were aware of these new forms of contracts used on the West coast. Specifically, the agreement has already been shared with AIA and has been distributed through the community of construction lawyers.

Insurance Policies and BIM – Increase or Reduction of Financial Risk?

From the standpoint of the insurance industry it is not yet clear how beneficial the exchange of information with BIM will be. The cost of exchanging information needs to be lower than the gains of sharing information electronically. Thus more historical data has to be collected to rewrite adequate policies. As an example of the benefits of new project delivery methods that are often not clear cut, Lorna Parsons mentioned design-build projects. On these projects the insurance industry has observed a significant reduction in claims, however, the claims that remain tend to be three to four times higher. Thus insurers will need some time to collect the required historical data to adjust their policies.

Another problem for the insurance industry is that on projects that use BIM the responsibility lines blur and thus it is hard to adjust the policies of the various stakeholders of a project.

At the moment the introduction of BIM on projects is seen as a black hole that increases the financial risk from the viewpoint of the insurance industry. BIM supports collaboration and the experience with a collaborative method, like for example design-build, has not been entirely positive for the insurance sector. Thus the insurance industry will rewrite policies in the future, but only when enough historical data is available from BIM projects to assess the financial risks adequately. From the standpoint of the insurance industry interoperability sounds good on paper, but more maturity is needed.

Latest Developments of Interoperability in the AEC Industry

During this discussion, Kristine Fallon mentioned that it is necessary for the AEC industry to move away from data models owned by software vendor. Currently, the available commercial software applications cannot support all physical, analytical, and manufacturing subsets of data needed by the AEC industry. Therefore, a broad implementation of BIM is also still a technological and not only a contractual and process challenge.

Therefore, according to Chuck Eastman, the BIM community needs to develop two levels of language: one language to describe the BIM implementation and data models and one language to describe the BIM working processes and that can be used within contracts. Additionally, level of detail and tolerance issues need to be solved as many liability concerns due to interoperability issues depend on “how deeply the different parties can drill into the model to get valuable information that people use to build the job” (Kim Hurtado).

The Breakout Sessions

Two break-out sessions followed the panel discussion. In the first breakout session the participants were organized into three groups that each contained representatives from general contractors, steel fabricators, designers, architects, lawyers and insurers. The three groups then discussed the main obstacles towards a more widespread BIM implementation in industry. In the second breakout session the participants were distributed again into three groups. The first group consisted of the steel fabricators and general contractors, the second group of designers and architects, and the third group of lawyers and insurers. In this second break-out session the participants discussed how the AEC industry jointly can overcome the main obstacles. The key points of the outcomes of the breakout sessions are summarized in Table 3.

	Group 1	Group 2	Group 3
Obstacles	<p>One leading group should take charge of this to avoid many well-meaning groups creating chaos</p> <p>Need guidelines for project set-up to guide BIM implementation early in the project</p> <p>True interoperability</p> <p>Overcoming entrenched attitudes</p> <p>Licensing agreements to share data and data uses</p>	<p>Owners need to invest in BIM</p> <p>Responsible person laws (although one should never watch two things being made: laws and sausage)</p> <p>Who can author reviews and change the model</p> <p>Industry consensus documents, present norms of information presentation</p> <p>“Show me the risk,” tell the contract writers what one should really be concerned about</p> <p>Better articulation of rewards</p> <p>Availability of competent modelers</p>	<p>Making BIM work for all sectors of the industry, large and small firms</p> <p>Inaccurate perceptions of value and costs for different stakeholders</p> <p>Commercial reality</p>
Solutions	<p>Address interoperability challenges</p> <p>Become proficient in making models (before sharing models)</p> <p>Establish metrics</p> <p>Develop guidelines</p>	<p>Interoperability (direct digital exchange throughout the whole process from design to fabrication)</p> <p>Design-assist role for structural steel fabricators for integrated teams to leverage BIM</p>	<p>Continue discussion about moving forward collaboratively (Roundtable)</p> <p>Organize lessons learned, metrics, case studies to develop a risk and rewards program, guidelines, standards, best practices</p>

Table 3 - Results of the BreakOut sessions

Analysis of the Findings of the Roundtable

This section analyzes the discussions at the eConstruction Roundtable. First, we summarize the main hurdles and assess whether the solutions that have been developed in the breakout sessions will likely be able to overcome the hurdles. We also identify and discuss the main drivers for BIM in the industry.

Analyzing the Hurdles

It seems that the main obstacles towards a more widespread utilization of BIM in the AEC industry are twofold. First, and foremost, it seems to be a people problem. Multiple speakers during the Roundtable mentioned that they need to keep up with the technological development and that knowledgeable personnel is missing due to a change averse mindset. Thus, in general AEC practitioners still do not see much value in collaboratively working together on a project. Additionally, it seems like the legal and insurance community has been ignorant about collaborative developments in the AEC industry. We see that professional associations like for example the AIA, the AGC or CURT have developed educational programs for its members and others. However, most of the individual members of these organizations that are targeted with deploying these efforts have not yet embraced these services to their full extend.

Second, issues with the technology seem still to be a major obstacle to a more widespread utilization of BIM. The problem speakers mentioned most often during the presentations in the Roundtable was that existing software does not support data exchange. Furthermore, a number of participants of the workshop mentioned that stand-alone applications to support BIM-based analyses tasks are often not ready for “prime time”.

Surprisingly, the participants of the Roundtable did not discuss many process issues, despite process issues being the main motivation for organizing the Roundtable.

Overcoming the Obstacles: Drivers and Laggards

According to the presentation and discussions at the Roundtable there seem to be two main drivers of BIM in the AEC industry: the general contractors and the owners. Representatives of the owners mentioned that the owners’ focus is slowly changing from being purely cost driven towards other business drivers, like quality or sustainability. Also it seems as if owners are financing most BIM approaches at the moment. However, they are only willing to pay for BIM throughout a “grace period” to support other parties to develop the required knowledge. We expect that companies from all areas of the AEC industry that will work together with owners will now start to develop the necessary expertise that will be required later while the owners still pay for it. Thus, companies who utilize BIM now will not only gain competitive advantage for the future, but may also be partly financed for their corporate learning efforts.

General contractors are the second driver for BIM in the AEC industry seems. On one hand it seems that general contractors such as DPR Construction work closely together with owners such as Sutter to implement BIM on projects. On the other hand, contractors have been utilizing BIM to support construction planning for a number of years. Participants reported that many general contractors successfully and routinely use BIM on projects “without ever having seen a single BIM from the designers”. Thus, even if general contractors had to remodel BIMs from two-dimensional drawings, they realized a number of benefits and an overall return on

investment. Finally, it seems that contractors often do not utilize BIM-specific software that has previously been developed, but implement BIM utilization using several existing software applications that are available.

The participants representing the design and architectural community at the Roundtable generally see themselves more in a reactive role. These Roundtable participants generally reported that BIM efforts at their companies only started on projects where the client requires BIM. In general, there seems to be a general fear among designers and architects to be left behind in the BIM movement. However, architects and designers are generally aware of the development, but they do not seem to actively drive the BIM movement.

Finally, insurers and lawyers seem to struggle with the new form of collaborative project delivery enabled by BIM. Lawyers openly admitted that they are behind the industry movement and need to keep up. To do so, they will need the help of the other AEC disciplines. Similarly, insurers are still reluctant to change their policies until they have a better understanding of the consequences of BIM implementation on AEC projects. Thus the rest of the industry needs to help lawyers and insurers by providing case studies and other historical data for a better legal and financial understanding. Overall, it does seem that the industry moves towards BIM without having well defined legal or insurance policies developed. Thus companies who plan to wait for such legal or insurance frameworks might be left behind the fast technological developments.

Surprisingly, it seems that the representatives of the design, architectural, legal, and insurance sectors do not seem to see benefits of the use of BIM for their own practices. Contrary to this, we believe that designers and architects could use BIM profitably without the collaboration with others, for example, in the area of drawing production and updating. BIM enables a better storage of all design data within a 3D model of a facility. 2D plans and drawings can be automatically generated from this 3D model, including details. Designers can integrate changes in the design easily, while drawings and details are updated automatically. It seems that such a BIM-based drawing production process would ensure that sets of plans would remain internally consistent. This approach would save time during drawing review and promises less liability problems due to inconsistent drawing sets. CIFE researchers have observed that a number of design companies have applied the BIM-based drawing production process beneficially on a number of projects⁶. Similarly, we expect that lawyers would be able to use the representation power of BIM to mitigation law suits, while insurers could use BIM to understand projects better and reduce their financial risks.

Theoretical Insights

This section will try to explain some of the discussion results from the workshop in the context of recent academic research in the area of construction management. First, we will draw on research of the diffusion of technologies within the AEC industry to explain some of the reported experiences of the Roundtable participants. Second, we will draw on research about trust and contracting to help understand some of the discussions about contractual issues better.

⁶ Hartmann, T., J. Gao and M. Fischer (to be published). Areas of Application of 3D and 4D Models on Construction Projects. Submitted to the Journal of Construction Engineering and Management, March 2007; a preliminary copy of the article can be obtained from the author of the report, timoh@stanford.edu

Diffusion Research: Systemic vs. Incremental Innovations⁷

The nature of the AEC industry is fragmented. Engineers independently work in their own disciplines and results are combined in the end. There is very little interaction between the disciplines during this process. According to Taylor, therefore, in the AEC industry the introduction of systemic innovations that will radically change the work processes of all participants works well within each of the disciplines. However, as soon as the boundaries between the different disciplines are crossed and multiple disciplines need to change their working processes, the adoption of such systemic innovations becomes much more challenging. Taylor concludes that technologies that will change processes across various disciplines need to be integrated incrementally in small steps.

Taylor's research can explain the accounts of the participants of the Roundtable well. Participants who seemed to use BIM technologies for some time successfully introduced small-scale and very well-defined technological process changes that worked across the boundaries of the disciplines. Other parties who focused on developing industry-wide data models, processes, legal frameworks, or insurance policies only reported minor successes at best.

Trust "and" Contracts vs. Trust "or" Contracts⁸

Edkin and Smyth (2006) use concepts from relational contracting as a baseline to understand new forms of contractual agreements on British construction projects. These concepts explain how disputes between parties are resolved using a scale that ranges from trust-based to contract-based conflict resolution methods. If there is mutual trust between parties conflict resolution is achieved by the two parties through mutual management of their relationship. At the other end of the scale, contracts are needed in the case of missing trust between parties to regulate conflicts by litigation involving third parties such as arbitrators or courts. According to the theory of contractual relationship management, the most effective relations between parties are those that are managed relationally with trust among the parties. Relations that are managed using contracts as the key driver hinder parties to proceed effectively with their work and, therefore, increase costs due to transactions. At worst, contractual relationship management causes parties to intentionally "do things knowingly less efficient than possible", even though both parties will not maximize the benefits that may result from the relationship.

Edkin and Smyth's findings match well with the discussion about contractual relationships during the Roundtable. Representatives of the legal community often stressed that they want to help the AEC industry to work more collaboratively on the basis of trust by developing new contracts. According to Edkin and Smyth, new contracts can only solve one part of the problem. To move towards more collaboration, the different AEC disciplines need to start developing trust between each other, without necessarily relying on contracts. Some statements from some general contractors stressed this fact. For example, construction contracts have not been yet established that are able to regulate the collaborative working style that is needed on

⁷ This section is mainly based on the work of John Taylor at Stanford University with partial funding from CIFE. His Ph.D. Thesis can be downloaded free of charge at http://crgp.stanford.edu/publications/dissertations/Taylor_2005.pdf.

⁸ This section is based upon the 2006 article by Edkins, A. J., and Smyth, H. J. titled "Contractual Management in PPP Projects: Evaluation of Legal versus Relational Contracting for Service Delivery." *Journal of Professional Issues in Engineering Education and Practice*, 132(1), 82-93.

fast-track projects. Nevertheless, fast-track projects have been managed successfully over the last 20 years by establishing mutual trust between the different parties.

Appendix A – Roundtable Agenda

Breakfast	8:00	
ASIC Welcome and Introduction	8:00-8:10	Luke Faulkner
Agenda and Goals	8:10-8:30	Martin Fischer
Presentations		
AISC	8:30-8:50	John Cross
ACCL	8:50-9:10	Patrick J. O'Connor
AIA	9:10-9:30	Markku Allison
Insurers	9:30-9:50	Lorna Parsons
Break	9:50-10:00	
CURT	10:00-10:20	Charles Hardy
AGC	10:20-10:40	David Hanson
MEP	10:40-11:00	Mark Anderson
Structural Engineer	11:00-11:20	Joe Burns
Panel Discussion	11:20-12:00	Presenters
Networking Lunch	12:00-1:00	
Break Out Session 1	1:00-1:50	Breakout groups
Findings	1:50-2:15	Presented by group
Break 2	2:15-2:30	
Break Out Session	2:30-3:10	Break out groups
Findings	3:10-3:30	Presented by group
Findings and Conclusions	3:30-4:00	Martin Fischer

Appendix B – Roundtable Participants and Breakout Session Assignments

Name	Company	Email	Group BS 1	Group BS 2
Aaron White	Walter P. Moore	awhite@walterpmoore.com	3	1
Barry Butler	Design Data	barry@dsndata.com	1	2
Bobbie Angelo	Chaparral Steel	bangelo@chapusa.com	2	2
Bob Smith	Akerman Senterfitt Wickwire Gavin	robert.smith@akerman.com	1	
Brad Vaughan	Black + Veatch	vaughanpb@bv.com	1	1
Brian Lowe	Nucor-Yamato Steel	blowe@nucor-yamato.com	1	2
Brian Williams	Fabtrol	bwilliams@fabtrol.com	3	2
Chris Noble	Noble & Wickersham	cn@noblewickersham.com	2	3
Chris Traybig	Bechtel Corp.	ctraybig@bechtel.com	1	1
Chuck Eastman	GA Tech	charles.eastman@coa.gatech.edu	2	1
Charles Hardy	GSA	charles.hardy@gsa.com	2	
David Hanson	Walbridge Aldinger	dhanson@walbridge.com		2
David Ratterman	Stites & Harbison	dratterman@stites.com	1	3
Dean Reed	DPR Construction	deanr@dpr.com	2	2
Dwight Larson	Mortenson	Dwight.larson@mortenson.com	1	2
Erleen Hartfield	Thornton Tomasetti	ehartfield@thettgroup.com	3	1
Ivan Jivkov	JITECH	ivan@jitech.ca		2
Jim Dome	Barton Malow	Jim.dome@bartonmalow.com	1	1
Jim Groton	Sutherland Asbill	Jim.groton@sablaw.com	1	3
John Bailey	Prospect Steel Co.	johnb@lexicon-inc.com	2	2
John Cross	AISC	cross@aisc.org	3	3
Joseph Burns	Thornton Tormatti	jburns@thorntontomasetti.com	2	
Ken Loomis	Cives Steel Co.	kloomis@cives.com	2	2
Kerry Slattery	Southern Illinois Univ.	kslatte@siue.edu	1	2
Kim Hurtado	Hurtado, S.C.	khurtado@hurtadosc.com	3	1
Kristine Fallon	Kristine Fallon Assoc.	kfallon@kfa-inc.com	1	1
Lorna Parsons	Victor O. Schinnerer & Co., Inc	Lorna.m.parsons@schinnerer.com	2	3
Mark Anderson	Env. Systems Design	manderson@esdesign.com	3	1
Mark Holland	Paxton & Vierling	mholland@pvsteel.com	1	2
Markku Allison	AIA	mallison@aia.org	3	1
Matt Gillies	Stites & Harrison	mgillies@stites.com	1	3
Mike Alianza	Intel Corp.	mike.allianza@intel.com	3	1
Nicolas Mangon	Autodesk	nicolas.mangon@autodesk.com	3	
Patrick J. O'Connor	Faerge & Benson	POConnor@faegre.com	3	3
Pete Carrato	Bechtel Corp.	pcarrato@bechtel.com	2	1
Rex Lewis	Puma Steel	rex.lewis@pumasteel.com	3	2
Rich Sghiatti	Liberty Mutual Security	Rich.sghiatti@libertymutual.com	3	3
Rob Stevenson	Flad & Associates	rstevenson@flad.com	1	1
Robert Lipman	NIST	robert.lipman@nist.com	2	2
Ronald B. Sinopoli	Barton Malow Co.	ron.sinopoli@bartonmalow.com	3	2
Simon Parkinson	Fabtrol	sparkinson@fabtrol.com	1	2
Stacy Scopano	Tekla	stacy@scopano@tekla.com	1	
Tom Faraone	AISC	faraone@aisc.com	1	1

