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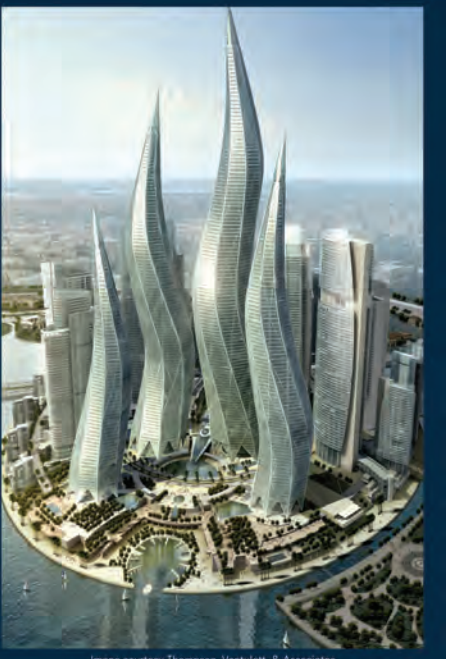

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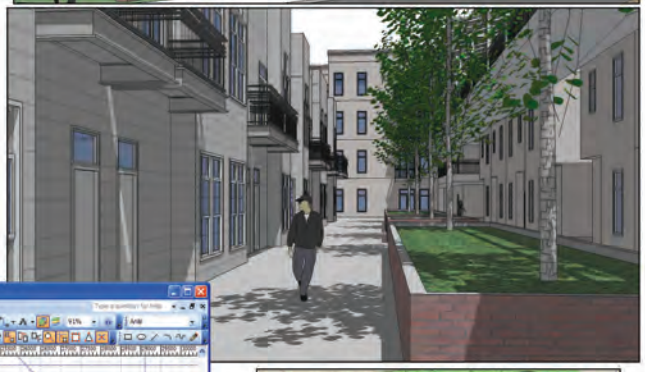

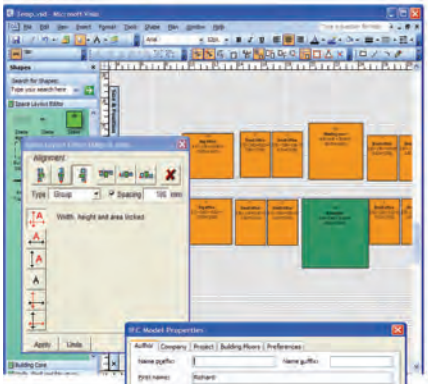

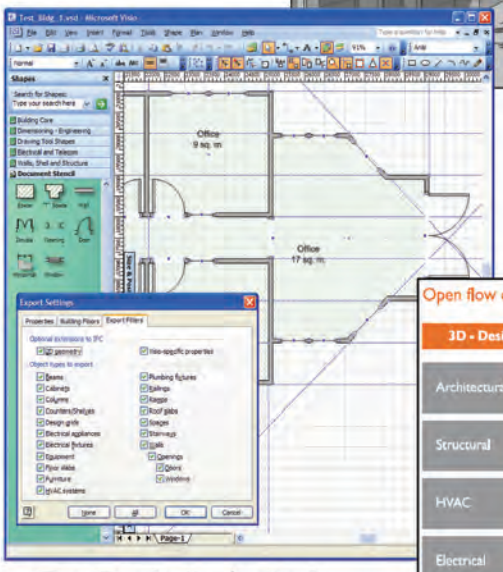

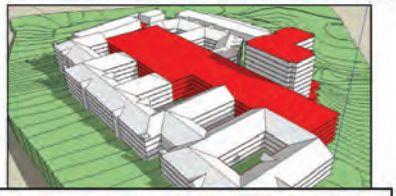

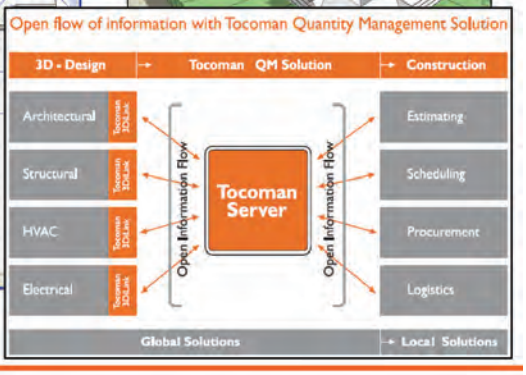

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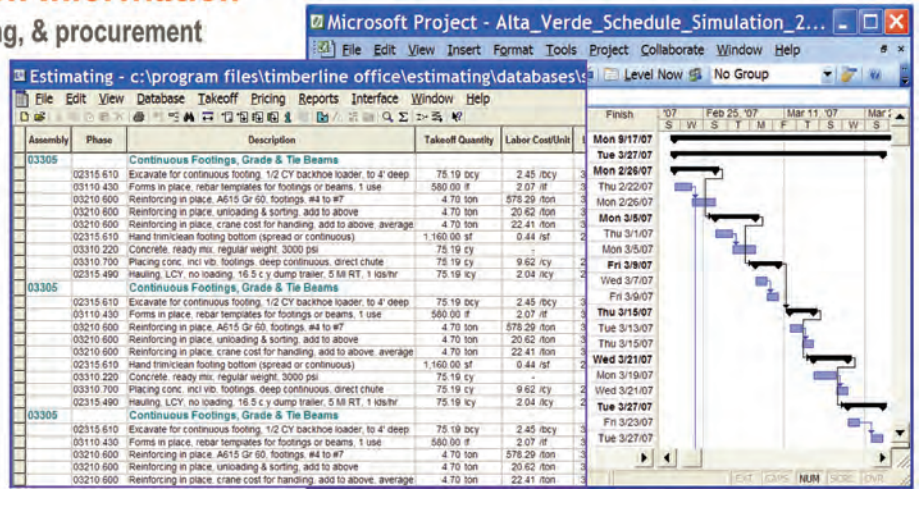

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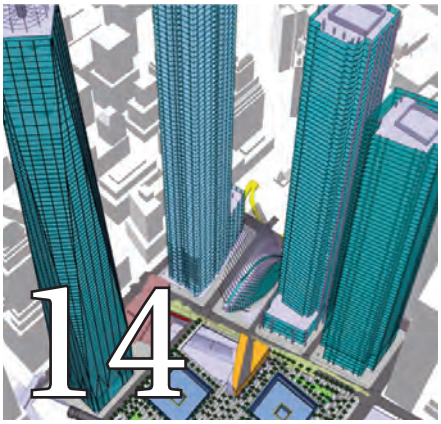

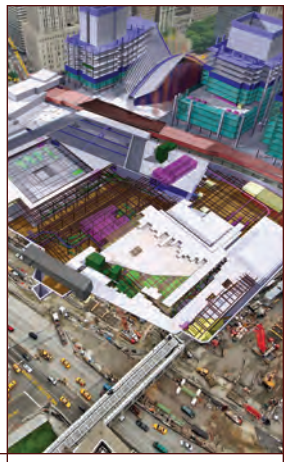

On the cover:
This BIM model image is overlaid with projected 4D WTC site construction progress. Courtesy and Copyright ©2009 LMCCC and Gehry Technologies, Inc.

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Henry L. Green, Hon. AIA

THE CONSTRUCTION INDUSTRY IS AT A CROSSROADS. AS WE here at the National Institute of Building Sciences (Institute) and the buildingSMART alliance™ (bSa) place an emphasis on building information modeling (BIM) and its interrelationship with other building industry practices to achieve successful projects, we are also working with Congress to promote high performance buildings. The two goals truly work hand in hand. One direct benefit of engaging BIM in the use of advanced construction practices is its ability to help achieve buildings that yield greater levels of performance and durability.

In September, the Institute and bSa were proud to host a presentation on Capitol Hill for the High Performance Building Congressional Caucus Coalition that provided a perfect example of BIM benefits in action. Commander James Dempsey of the U.S. Coast Guard gave a wonderful demonstration showing how the Coast Guard uses BIM for the construction, use, maintenance and operation of its facilities. His article in this month's edition of the *Journal of Building Information Modeling* highlights how BIM can be used as the framework for decision making in facility asset management. His presentation, as well as those of buildingSMART International President Patrick MacLeamy and buildingSMART alliance™ Executive Director Deke Smith, is available on the Institute's website at www.nibs.org/enews/BIMHPBbriefing.html.

BIM is becoming the platform for work in many areas of design and construction. The ability to share information at all stages of the construction process helps owners to gain the greatest possible efficiencies and savings throughout the life cycle of their facilities. Simply addressing the potential for system conflicts during the design phase of the project and finding scheduling problems during the construction phase can mean substantial savings in overall costs by eliminating the need for redesign of systems or modification of equipment during installation.

To improve the sustainability of our built environment, we need to be mindful of the many attributes that must be measured to fully develop high performing structures. BIM plays an important part in this effort, assuring information is available to be shared and not lost through the design, construction, acquisition and occupancy phases of a structure. What better way to gain an understanding of the benefits of BIM than by attending industry events, such as the buildingSMART alliance™ International Conference?

The Institute and bSa will host the buildingSMART alliance™ International Conference this December 7-10, in conjunction with the National Institute of Building Sciences Annual Meeting and Ecobuild America. A number of sessions will show how BIM can be used as an essential business tool to streamline costs and improve overall building performance. There will be programs that highlight the value of BIM through project demonstrations and workshops, as well as a BIM Aquarium and BIM Pavilion. The bSa Board will host its Annual Meeting during the Conference to discuss how to further advance the utilization of BIM and achieve even greater interaction between BIM and integrated project delivery techniques. The buildingSMART International will hold meetings and User Groups will convene at the event as well.

In addition, the Institute is sponsoring the International the High Performance Building Conference being held during Ecobuild. A full program of sessions will address high performance building and energy efficiency, green building, LEED and sustainable design; and sustainable sites and infrastructure.

By engaging the minds of practitioners in the construction industry, as well as the many tools now available to streamline processes and improve performance, we can implement a true transformation on both the industry and our future. Improved life cycle performance, measured deliverables and saving are the result of a full understanding of the many complex elements of a structure and how each are interconnected. Staying abreast of these exciting changes is imperative to their being successful. The *Journal* is a great resource to keep you up to date and so is the building SMART alliance™ International Conference.

I hope to see you there in December.

Henry L. Green, Hon. AIA
President

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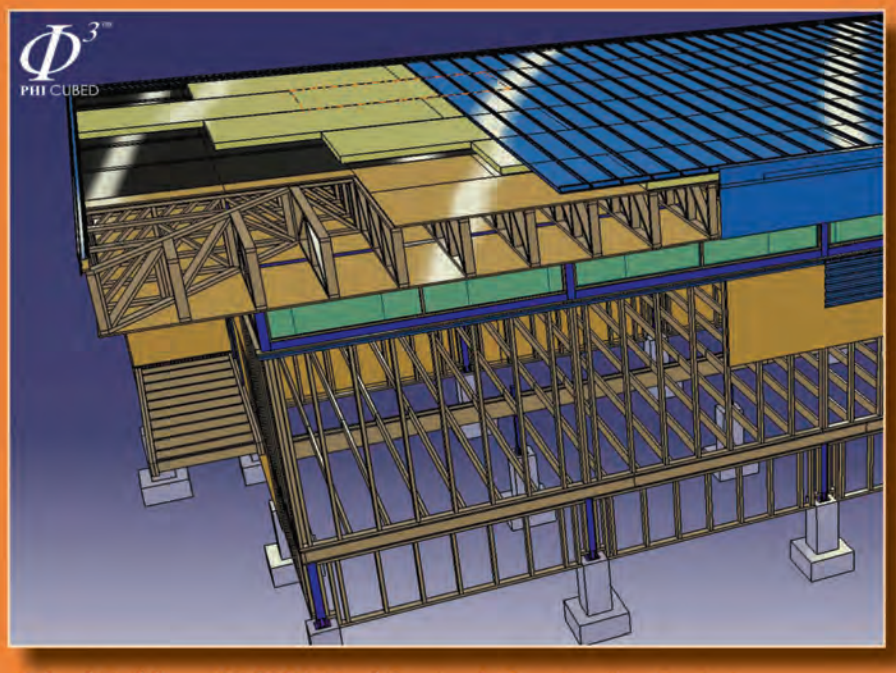

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Dana K. Smith, FAIA

The advent of the new Alliance portal is at the heart of this improvement in communication. Project sites based on the portal will be where the standards work is accomplished.

I OFTEN GET QUESTIONS RELATED TO how people can get more involved in the buildingSMART alliance™ and developing the *National BIM Standard*®. Up until now, it has been a bit difficult to answer since many of the projects were coming to us already resourced with subject matter experts and funding. While we still expect many projects to follow that same path, we now have the ability to get more people involved at various levels. The advent of the new Alliance portal is at the heart of this improvement in communication.

Project sites based on the portal will be where the standards work is accomplished.

Let's walk through some of your options together. First, please remember that as a member of the Alliance you are already contributing to support the very important work of worldwide experts, all focused on open BIM standards. Even if you are not actively participating, your funds are supporting these essential efforts.

The new public website (www.buildingsmartalliance.org), supported by the portal, will now give you far more insight into what efforts are underway. Status information will be provided directly and instantaneously by the project managers. This is your opportunity to get a real-time glimpse into the work being accomplished.

If you are new to the Alliance, you should first familiarize yourself with the public website to become familiar with the vision, mission and strategic goals of the Alliance. You will find a wealth of information there, especially under "Resources," including help in finding an Interest Group in your area or someone to speak at a meeting or conference from our speaker's bureau. You should also review the material on the Whole Building Design Guide® (WBDG) site (www.wbdg.org) under the "BIM" tab, which links to other material on that site and externally. The WBDG site has more than 2.5 million unique document downloads a month and one of its largest growth areas is the number of .EDU addresses.

Another source of information is the buildingSMART International site (www.buildingsmart.com). Visiting there will give you a look at the work in progress at the international level, much of which can be quite technical. The buildingSMART International site's name will be changing soon, however, there is a link from our front page to the site.

Should you wish to get actively involved in a project on our site, there are various levels—observer, reviewer or subject matter expert. You can also get involved as a project manager on a new project. Subject matter experts are the ones doing the actual work on a day-to-day basis and require the greatest investment of time. We owe so much to these experts, who volunteer their time to give back to the industry.

If you want to work on a new project, look at the projects requiring resources. If you are a subject matter expert in one of the areas, contact the project manager directly. If you have the necessary skills they need, they will grant you access to the project. Please remember that project managers try to have a balance from the sectors defined in the Institute's enabling legislation, which includes not only architects but engineers, contractors, insurers, unions, manufacturers, legal, housing, vendors, owners, consumers, state and federal government, codes and standards, and testing.

As mentioned earlier, some projects are run by other organizations or agencies associated with the Alliance so subject matter experts may already be selected. However, expert observers and product reviewers are often needed in most cases. Having the NBIMS consensus process put in place will ultimately help enforce the broad-based industry involvement as well. The process, along with a balloting and voting module, will be added to the portal site in the near future.

All members have access to the portal. If you are involved with a specific project, you can see the work of that project and participate in the development effort. The portal will only allow you to see projects with which you are associated. If you want to see the entire project list, just visit the public site.

All members who have become NBIMS Project Committee members will be eligible to vote on all balloted items. Of course, if you are a Project Committee member, it is important that you be involved in the projects and understand what is being proposed for the standard.

If you have a problem that you do not see being addressed by the Alliance, please complete a "Project Creation Form" request, which can be found on the website under "Starting a New Project."

If all else fails and you still have questions, please do not hesitate to contact me. This is important work and there is plenty to be accomplished. The Alliance is certainly not doing it all. In fact, often we are pointing the direction to where the work is being accomplished and helping to ensure it all comes together in the end.

I am looking forward to meeting you or catching up with you at the buildingSMART alliance™ International Conference in December. The Conference is a tremendous opportunity for you to witness firsthand all of the issues being discussed. Please feel free to come and chat.

Dana K. Smith, FAIA

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David Morris

The *National BIM Standard*® has identified a balloting process and "The Rules of Governance" are in the final stages of review and acceptance. This will clear the way for reviewing sections as "standards candidates" and will allow multiple sections to develop simultaneously.

THE NATIONAL BIM STANDARD® (NBIMS) version 1.0, first released in 2007, was the first comprehensive attempt to establish a vision for standardized data exchanges and processes for building information modeling (BIM). Since 2007 the industry has made many strides forward in BIM adoption but little attempt has been made to adopt the precepts put forth in the NBIMS.

Through his leadership, Alan Edgar has made strong efforts to move the NBIMS revision process forward. Unfortunately, recent changes in his work-related duties preclude Alan's further. The building SMART alliance™ would like to express its sincere gratitude for Alan's effort and wishes him the best in his new responsibilities at OSCRE.

As the new Director of the NBIMS project, I would also like to express my personal gratitude for Alan's assurance that "while he was no longer able to direct the process he would be willing to assist in any way he could" (time permitting).

In spite of current economic conditions, these are exciting times for the built environment.

Software programs are making quantum leaps forward; owners, designers and contractors are adopting BIM processes as the norm rather than the exception; and for the first time in forty years, construction sector productivity is increasing. The challenge of interoperability and data exchanges between stakeholders remains a primary impediment to the evolution of model intelligence over time, versus handoffs and recreated models.

The NBIMS and the U.S. *National CAD Standard*® can play a key role in improving interoperability and data exchange. To do so it, is imperative that the standard go through a revision, consensus and adoption process. The *National CAD Standard*® is in the initial stages of the first major update in many years. It will address issues such as object naming conventions, and parametric CAD programs that do not use layers. The *National BIM Standard*® has identified a balloting process and "The Rules of Governance" are in the final stages of review and acceptance. This will clear the way for reviewing sections as "standards candidates" and will allow multiple sections to develop simultaneously. Both standards will be developed with close ties to each other to avoid gaps, overlaps or contradictory clauses. The U.S. *National CAD Standard*® will continue to address CAD and graphics program issues and the BIM Standard will focus on non-CAD data exchanges and process standardization.

The task of taking the current visionary position of NBIMS version 1.0 into a true BIM Standard will not be a small one, or something that can be accomplished behind closed doors. To ensure widespread acceptance and adoption will require an open collaboration between multiple segments of the industry. The challenge will be to maintain order and forward progress during the process. To that end, a structure and deliverable schedule with attainable goals will need to be established. A series of sections for the standard will be identified and projects will be created to engage team members in content creation. As each section is deemed ready for consensus it will undergo a balloting process and, if accepted, will enter the standard.

Who should be involved moving forward? I think everyone with an interest in BIM agrees that standard information exchanges of data that are program neutral are key to ongoing success in the process.

People or organizations who wish to participate in the revision process are encouraged to join the buildingSMART alliance™ and when you join, identify that you wish to be on the NBIMS Project Committee. If you are already a member of the buildingSMART alliance™ and would simply like to join the NBIMS or NCS Project Committee, then please select the join/support tab on the front page and then select "join" or go to the bSa website (www.buildingsmartalliance.org/index.php/support/application) and select to join the respective project committee. If you have content items, please add those to the portal under NBIMS and Planning Committee – Version 2 Content.

The upcoming year will be a busy one for NBIMS; our goal is to have the draft document ready for balloting by mid-year and a completed release ready by the end of the third quarter. The process can only succeed with the dedicated input, oversight and assistance of many participants from various industry segments.

In conclusion, the U.S. *National BIM Standard*® revision process is alive, moving forward and needs your help to make it an excellent document that will improve interoperability, data exchanges and process.

David Morris
Chair, U.S. National BIM Standard®
Project Committee

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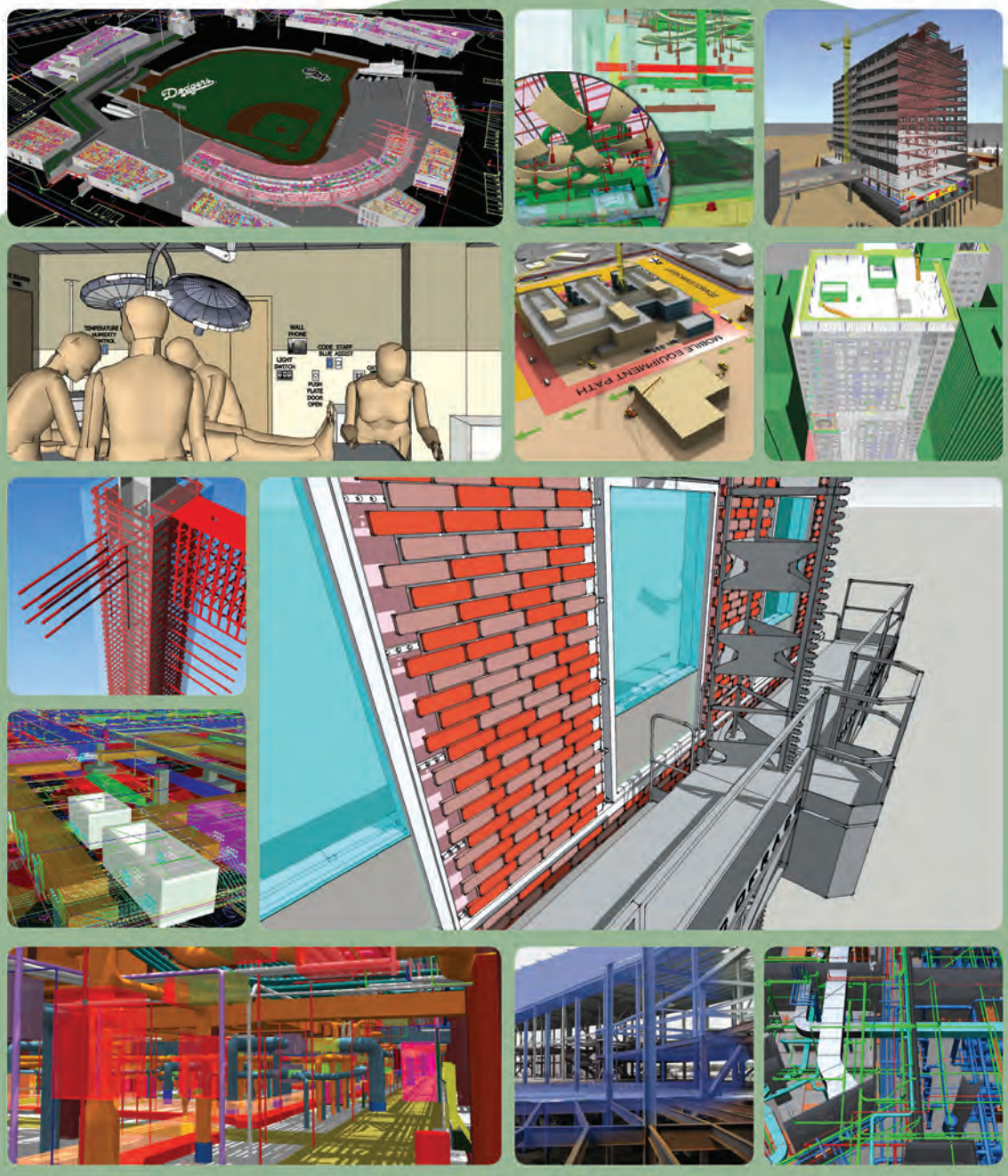

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Building what's next

Mark Butler

The BIM Task Team is working to pull together file naming information to work better for projects using BIM tools, but I wish we could do 20 times that to help out those firms who are implementing these new tools.

WE HAD A REALLY GOOD DISCUSSION at our monthly NCS Steering Committee meeting recently, which asked the question: "How will the NCS stay relevant as people move to BIM?"

Last issue I wrote about NCS staying relevant because you still need to plot your model and NCS is the industry standard for that. That is all true. I believe that stuff, but that is not really the issue here. As firms are implementing new BIM tools, there are questions about where NCS fits in that process, and if not NCS, then what?

Speaking from my own experience…

My firm has been happily chugging along using NCS for several years. Over that time, the standards issues had sort of faded away. We began implementing a BIM package two years ago. There are enough differences between the way things worked in CAD and these new tools that there are a lot of areas that either NCS covers that are sort of moot (like layers) or that NCS does not directly address. Many firms are using an "out-of-the-box" approach to implementing these new packages. I don't like the idea that the vendors are in effect setting the standards (not the standard, because each vendor does things differently). That is not exactly the optimum consensus based approach that we are striving for.

The BIM Task Team is working to pull together file naming information to work better for projects using BIM tools, but I wish we could do 20 times that to help out those firms who are implementing these new tools.

The problem is in the timing. The reality is that with the way we are currently revising the NCS, it takes a lot of time to publish the standard. Being inside this process for several versions now, I know that it would be miraculous to deliver a new version of the NCS in less than, say, 18 months. However, in 18 months tons of firms will have implemented new packages, really without the advantages of having a standard to follow.

It is a different flavor of relevance. It might push us into describing a different delivery model. I don't know what that model is yet, but it needs to be able to react much more quickly than the model we are using today. This is a question that the NCS Steering Committee will be working to address.

I want to talk a little about the mechanics of standards. The *National CAD Standard*® depends to a great extent on volunteers. There are lots of volunteers giving lots of their time and talents to support a process that is known, documented, fair and transparent. Over the past year, the National CAD Standard Steering Committee has been spending time on improving the mechanics that will carry us into the next version. There has been a terrific redo of the website that will support a much improved balloting process, and we are in the throws of testing all the ins and outs of that process during the fall months of 2009 with hopes of opening the ballot process for NCS Version 5 sometime around the first of the year.

What will the next version of the NCS contain? Well, I don't really know. The mechanics are that the content comes from the people who are members of the project committee, and everyone who owns a copy of the NCS is invited to participate as a member of that committee. There are some requirements about how long you need to have been a member, but by and large the content comes from the industry.

Ballot items are proposed by committee members, those items are then reviewed by other committee members who have previously volunteered to be on specific task teams, then it's pushed back to the overall project committee for a comment period, and then it's voted on. One of the task team's main purposes is to vet the ballot items in their particular areas of expertise. Using this overall process, over the course of several months the next version of the NCS (Version 5) will take shape.

There are a couple other task teams that have a different focus than reviewing ballots. These are teams like the Implementation Task Team, the Compliance Task Team and the BIM Task Team. These teams have a research role, investigating ways to help firms implement the NCS, determining tests for compliance and coming up with the first concrete steps in "BIM-ing" the NCS.

We really have our work cut out for us. We have to get NCS Version 5 published, and we need to rethink the delivery process for going beyond Version 5. If you are a member of the project committee or the buildingSMART alliance™, thank you for your time and interest. And if you have any awesome ideas on how to set and publish standards instantly while getting the best input from all the knowledgeable folks in the industry, I would LOVE to hear from you!

Mark Butler
Chair, U.S. National CAD Standard Project Committee
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BIM as a Risk Management Platform Enabling Integrated Practice and Delivery

By Robert Harvey, PE, Tarek Bahgat, David Gerber, Ph.D., James Kotronis, and David Pysh

WHILE BUILDING INFORMATION MODeling (BIM), sometimes more accurately described as virtual design and construction (VDC), is rapidly gaining traction in the architecture, engineering and construction industry (AEC). The industry is far from capturing the full value of BIM/VDC and the innovative practices emanating from BIM that will stimulate a much discussed industry transformation. Still lacking is:

- The integration of multiple domains and project stakeholders;
- Early access to information in support of the decision making process; and
- The ability to manage and mitigate project risks.

The broader value of BIM will require collaboration among all project stakeholders, early and continuous management of project risks and value planning, and engineering. This article describes value planning, coupled with an ongoing Risk Management Program at The Lower Manhattan Construction Command Center (LMCCC). It involves the use and implementation of BIM/VDC to facilitate risk modeling and management on the reconstruction at the World Trade Center (WTC) site, and is an example of the extension of BIM into a truly integrated practice. It is a revealing case of the potential applications of BIM that will collectively result in broad industry change.

BACKGROUND

The LMCCC was established by executive orders of the Governor of New York State and the Mayor of New York City in November 2004. It is charged with coordination and general oversight of all Lower Manhattan construction projects south of Canal Street. These projects are worth more than $25 billion. The Command Center's mission is to facilitate all construction activities, and mitigate their impacts on each other and on the community, while communicating with the public about the work and its impact. The LMCCC team works with project sponsors to help streamline design and construction schedules, negotiate priorities, coordinate logistics and plan the movement of construction workers, materials and equipment to the area.

Within its Charter, the LMCCC facilitates the coordination of design, construction and logistics among the stakeholders involved in the development of the WTC site. Aspects of the program involve redeveloping 10 million square feet of office space in 5 iconic towers, 1 million square feet of retail, an intermodal transportation hub, the 9/11 memorial and museum, and a performance art center. The overall WTC program occupies approximately 16 acres and has an aggregate budget of approximately $15 billion dollars.

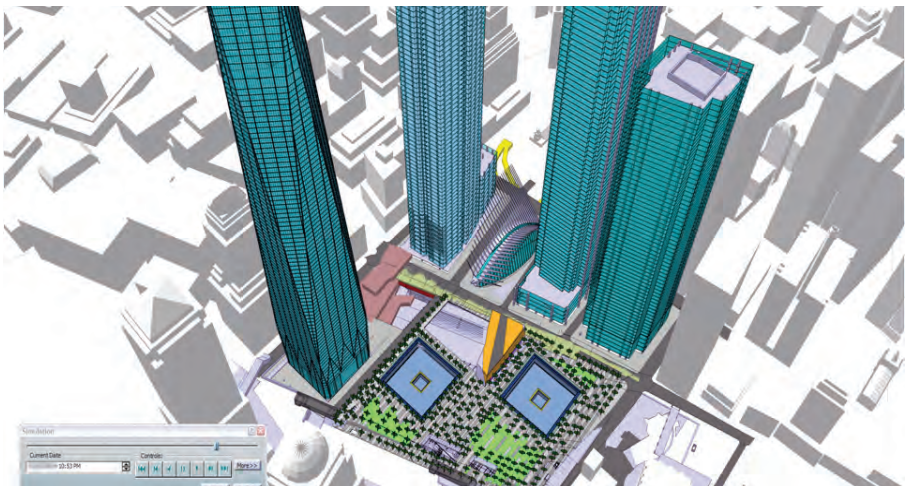
THE PROBLEM

The WTC mega project has an ambitious master plan that involves different program spaces that are all interconnected spatially and functionally. Each of the aspects mentioned above has a program sponsor, a bi-state agency (The Port Authority of New York and New Jersey, and the land owner), state and city agencies, and private developers. The design and construction are carried out by each of these agencies within the confines of the master plan. When the LMCCC embarked on the design, construction and logistics coordination for the WTC site in 2006, coordination between the different project sponsors was taking place bilaterally but an overall integrated coordination between all the stakeholders was lacking.

In response, the LMCCC established the Construction Coordination Room (CCR). Its goal was to bring all stakeholders to the table to evaluate and assess the risks associated with the interfaces between the projects and facilitate the prioritization and resolution of these interfaces, with key focus on the program schedules.

The LMCCC established a Risk Management Process (RMP) to continuously adjust against agreed-upon risks. The RMP was designed to track the project risks and the mitigation plans and decisions needed to maintain progress and avoid schedule delays. (Early on, the RMP process revealed major scheduling coordination and reconciliation issues that may have had major schedule impacts on the program.)

To validate and structure the process, the LMCCC planned a two-week Risk Based



A BIM model image illustrating the increase in level of detail and a 4D time marker of the WTC component of the LMCCC program.

Value Planning workshop, and solicited the input of 22 outside experts in different aspects of design and construction. The assembled team was tasked to assess the program scope, the timeframes, the logistic and construction interfaces between the projects, and provide a structured risk assessment and risk analysis, as well as mitigation scenarios that could reduce regional cost impacts, increase benefits, and established an optimal schedule for the program.

The greatest challenge to the workshop success was providing the experts with a quick understanding of the program scope, design drawings and construction schedules. The design documents amounted to tens of thousands of drawing sheets at different design stages, and the combined project schedules amounted to approximately 20,000 activities, again at different development stages. The review and understanding of these documents is a monumental task that would require months but we only had two days to accomplish it, at the beginning of the two-week workshop.

THE SOLUTION

The Gehry Technologies (GT) team was brought in to develop and maintain 3D and 4D models for the entire site. GT was selected to support the program and use their strategic consulting experience, tactical technological and process implementation experience, and digital project technology and product infrastructure. While some of the stakeholders relied on 3D modeling for some of the aspects of their projects, LMCCC's RMP and perpetual ongoing coordination required the development of an integrated practice focused on schedule and project controls bi-directionally linked to these models. The challenge was to rapidly model and simulate the program through extending BIM technology into the risk management platform and process. The GT project team has been part of the LMCCC, managing the incorporation of 3D, 4D and 5D implications for over 2 years.

The process that the LMCCC implemented included the creation of an expansive and expanding set of low-level detail BIM models for each of the architecture, civil and engineering concepts. This included new, old and temporary structures. Prior to the initial risk management workshop, the LMCCC team and GT were required to develop a VDC model for the entire program consistent with the project's work breakdown schedules and program schedules provided by the stakeholders. Information provided by the stakeholders ranged from 2D documents, PDFs, 2D CAD drawings and in, some cases, 3D models. The team's approach to the modeling focused on optimizing the model level of detail and size by focusing on the inter-project interfaces and detailing elements which were understood to have significant scheduling impact. The team then incorporated the project staging and phasing plans and the logistics plans as provided by the project sponsors into the master model. Where plans were not available, the team utilized the schedule logic to represent the most effective constructability approach.

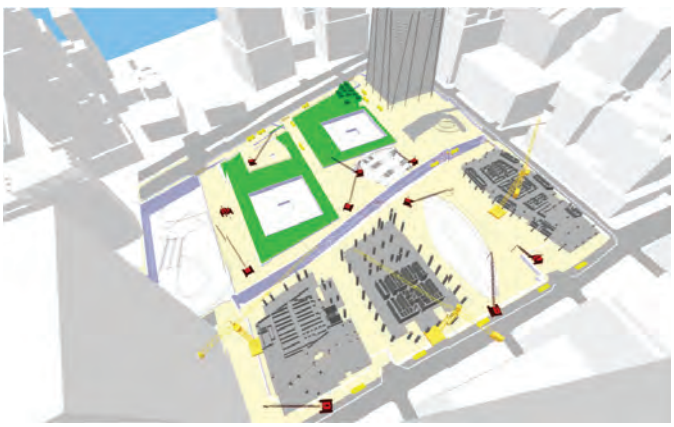
The LMCCC developed a summary schedule representing approximately 20,000 activities resulting from integrating the schedules for all the projects in the program. The team then developed 4D models representative of the project schedule and integrated them with the site logistics and staging plans provided by stakeholders. The 4D model was used to facilitate the project review process and provided the team with a clear understanding of the project inter-dependencies. This provided unprecedented visibility into the nuances of the schedule coordination.

The process of reducing the complexity and quantity of the tasks was, and is, essential to the workshop coordination process. Through the 4D model, the team facilitated the risk identification and quantification processes necessary for the LMCCC to make informed and mitigated decisions to complete the projects.

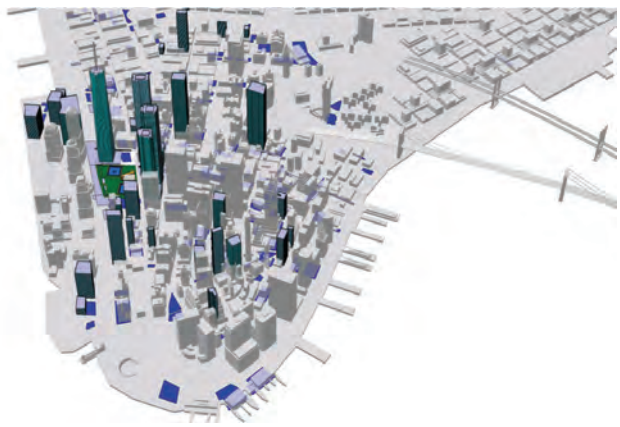
With the 3D and 4D models linked by the team, workshops were held incorporating all of the project stakeholders. These included world-class architects, engineers, construction professionals, risk modeling professionals, and project finance experts. All were enabled by the team to utilize the technology platform to gain a fundamentally better understanding of the coordination issues. This GT platform helped the team enable the stakeholders to come up with realistic assessments of the project and interactive visualizations of "what-if" scenarios and mitigation alternatives collaboratively…in real time and with look-ahead scenarios.

CONTINUING PROCESS

For the past two years, the ongoing development of WTC RMP has continued. Through the management of this VDC model, the team continues to facilitate follow-up risk workshops so the risk program is continuously updated and synchronized with the current project schedules.



A BIM 3D and 4D model image illustrating the modeling of construction activities and resources for sequence analysis and risk analysis.



A BIM model image illustrating the scope of the LMCCC program and projects south of Canal Street.

All images are courtesy of/and are copyrighted to: LMCCC and Gehry Technologies, Inc.

The LMCCC monitors the progress and the team provides coordination visibility through the capturing of preset vantage point images of the actual site progress as compared to the master risk model and linked schedules.

The extension of BIM data into a true 4D risk management model provides a periodic release of a master schedule for the WTC site. The work process for each cycle progressively evolved to be more refined and includes a higher level of detail in the individual BIM project models. From the models and schedules, GT enumerates the construction-related activities parameterizable as the key driving activities in the model. For at least half of these activities, the driver dates are interpolated out over a series of model elements happening serially.

What the team has found is that, for the most part, these series are all perfectly linear but, in some cases, the series are accelerating or weighted. A parametric risk management modeling platform allows dates to be changed easily as long as the activity names and geometric scope stay linked. This provides bi-directional optimization between 3D and 4D, enabling a true integrated practice model and risk management process.

Scripting has allowed the process of mapping and managing the thousands of BIM objects to schedule activities, but the process is directed towards engaging the knowledge professionals use for comparing several schedules that are derived from the master schedule. The master schedule is understood as the deterministic schedule, the LMCCC produces its Logic Adjusted Schedule by evaluating schedule clashes and adjusting the construction logic to resolve these clashes. LMCCC incorporates the risks involved in the construction and logistics by ranging the durations on the construction schedule and developing a probabilistic model for higher fidelity in completion dates developing the probabilistic schedules—all of which are compared to one another to reveal the variances between the current and previous iteration of the schedule. The BIM model facilitates the CCR meetings and the risk management process; providing a higher fidelity visibility into the spatial understanding and conflict discovery and resolution for the stakeholders.

The result of the process has enabled a set of project outcomes with tangible and measurable results. These include the advantage of enhanced look-ahead modeling and planning, enabling LMCCC to quickly evaluate trade off decisions and understand their impacts. The 3D and 4D modeling has produced an increased amount of fidelity in the model and scheduling process, and, through the iterative process, an ever-increased level of detail and conflict resolution. Through the simple artifact of the process and accurate visualization of multiple projects in time, there has been community benefit and, even more importantly, stakeholder collaborative benefit.

The LMCCC team is demonstrating the ability of BIM to be applied to mega projects through the technological facility to accommodate thousands of objects and thousands of associated tasks. We are witnessing the team deliver BIM at scales encompassing the city and the extension of BIM into an integrated practice for risk management and mitigation. While the core value of BIM is in coordination and visibility, the team and the GT process have begun to reveal the future for BIM implementations, namely, that of optimization for complex risk mitigation and analyses.

The ongoing LMCCC process illustrates that, while we are clearly still in the infancy

Through the simple artifact of the process and accurate visualization of multiple projects in time, there has been community benefit and even more importantly, stakeholder collaborative benefit.

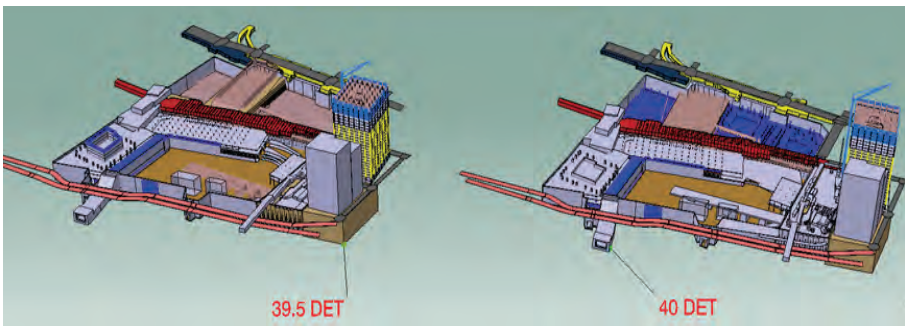
of BIM and the development of integrated practice, BIM is being extended to incorporate multiple stakeholders for the consumption of not only 3D but ever-more importantly, 4D and 5D, enabling a true risk management model practice.

CONCLUSION

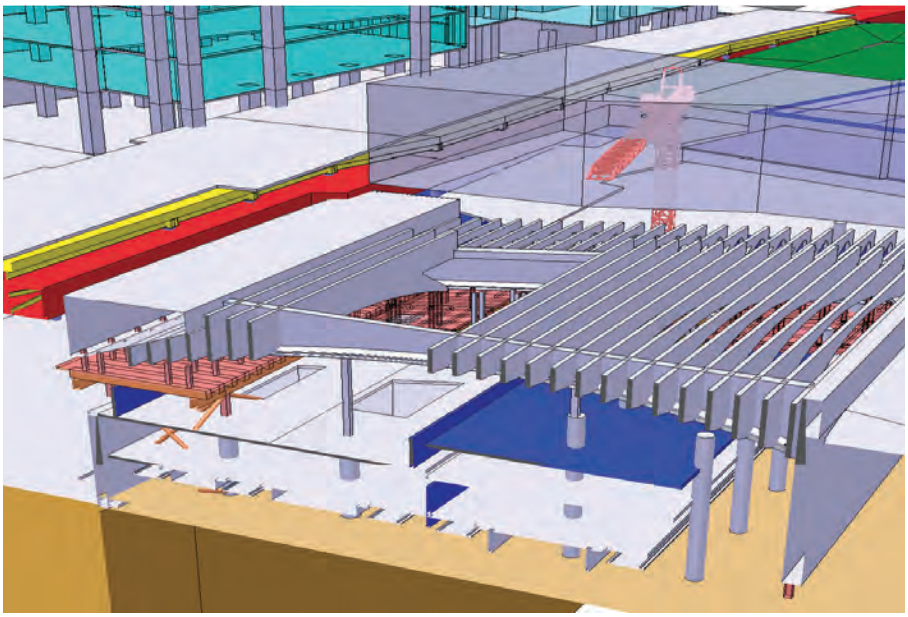
The LMCCC project is a prime example of the value BIM can have in managing multi-party iterative processes; reinforcing the value of collaboration, risk management and mitigation; and finally, for value planning. The BIM component of the LMCCC project brings collaboration, high fidelity simulation, and ultimately risk mitigation through visibility of complexity and scale. It is an example of allowing for the real-time optimization of timing of the necessary program functionalities and what may be referred to as value planning as opposed to reactive value engineering.

All of the technical integration and process invention has lead Bob Harvey, Executive Director of the LMCCCC, to conclude: "for the first time in the history of mega projects, we are inventing and conducting an integrated process that combines value planning methods and risk management processes, facilitated by the virtual construction model and 4D simulations." ■

Robert Harvey is the Executive Director of LMCCC; Tarek Bahgat is the Vice President of GT and Managing Director of GTUAE; Dr. David Jason Gerber is the Vice President of GT, Assistant Professor USC School of Architecture; James Kotronis is the Director of GT New York; and David Pysh is the Senior Project Consultant, GT New York.



A side-by-side comparison of schedule based optimization and risk assessment.



PATH Construction Complexity. A BIM 3D and 4D model image illustrating the complexity of the sequencing of construction activities and resources of the PATH terminal at the WTC site.

Performance Specifications for Building Information Exchange

By E. William East, Ph.D., PE.

DISCUSSIONS OF BUILDING INFORMATION MODELING OFTEN center on building geometry. The most widely described uses of building information to date have been for collision detection and progress visualizations. *Engineering News-Record* reported recently that one hour spent in design coordination activities results in ten hours of saved field re-work. Attaching geometry to Critical Path Method schedules creates "4D" models, useful in reducing on-site conflicts due to trade scheduling and material handling.

The majority of information needed by the owner, construction agents, and ultimately, the facility manager, does not directly concern the geometry of the building. Equipment lists, for example, provide the list of equipment and equipment types listed with their room number and some limited sets of properties. Other equipment properties may be found in the specifications, a decidedly non-geometric representation of building information.

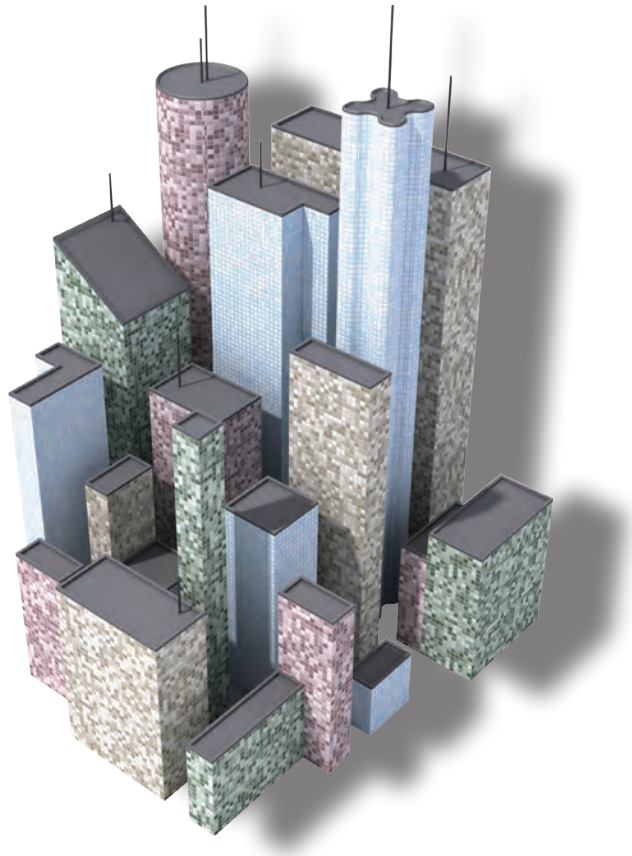
The worker installing a pump, for example, does not need to know a detailed geometric representation of that device. They do, however, need to have the installation instructions from the manufacturer and information about the inflow and outflow piping and the status of the powering electrical system.

A brief list of information currently exchanged in a variety of different documents and messages in many proprietary formats, follows:

Commissioning Plans	Cost Estimates
Daily Reports	Equipment Lists
Floor Plans and Drawings	Fabrication Drawings
Insurance	Invoices
Manufacturer Product Data	Operations & Maintenance Manuals
Photographs	Progress Schedules
Quality Control Documentation	Requests for Information
Room Data Sheets	Safety Inspections
Spare Parts Providers	Specifications
Tests and Certifications	Warranties

Table 1. Typical contract deliverables.

None of the public building information modeling specifications reviewed by me distinguish between the requirements for building information deliverables and the technology that is required to deliver such information. One example of the lack of separation is the requirement that as-built models be accurate below the tolerance of the completed construction. Finished walls may, for example, be ¼ inch out of vertical alignment across the face of a long wall, therefore requiring the as-built deliverable to be accurate within ¼ inch is an untestable requirement.



For the purposes of operations and maintenance activities, in another example, the geometric location of water values within a building needs only to be within the listed room number and within two feet of the as-installed location.

The separate specification of information requirements and accuracy from means and methods is the essential characteristic of open competitive bidding. By defining requirements, vendors specializing in specific means and methods can compete in the marketplace to deliver the best value product at the least cost to the owner. While the use of performance specifications related to physical components of the building is well understood, examples of performance specifications for the delivery of electronic information is not found in current contracts.

The most basic performance specification for the delivery of electronic information is the ASCII file format. This format, now embedded in every software system in the world, defines the computer coding required for representation of alphabets, numbers and commonly used symbols. The ASCII requirement is so well embedded within computer software that contracts no longer specify that text information be represented in ASCII format.

An electronic format more closely tied to the construction industry is the Standard Data Exchange Format (SDEF).

SDEF is a Critical Path Method scheduling data exchange format used for over 15 years by the Corps of Engineers and others (http://140.194.76.129/publications/eng-regs/er1-1-11/entire.pdf). SDEF cost-loaded CPM schedules are submitted, in a non-proprietary format, to assist in determining contractor payments.

DRAFTED SPECIFICATIONS

The first demonstration of performance specifications for building information deliverables was conducted in July 2008 at the National Academy of Sciences (www.buildingsmartalliance.org/news/20080723.php). Three new specifications were presented, and several widely used commercial software systems demonstrated their ability to comply with these requirements.

The first of the performance specifications required project planners to provide space programming, and blocking and stacking diagrams in a neutral file format to allow the information to be used by designers and others downstream in the process. This specification was based on the requirement of the *GSA BIM Guide*, but removed the agency-specific requirements to allow the format to be used across the entire industry. The open standard format for this information exchange is called the Spatial Compliance information exchange (www.buildingsmartalliance.org/projects/scie).

The second of these specifications extends design quality-control deliverables to allow designers to demonstrate that they have met their contractual obligation to coordinate the designs provided by various consultants. This specification requires designers to provide a hard- and soft-collision report and identify any significant collisions not addressed in the subject deliverable. While BIM software may be used by the designer to perform this collision detection report, CAD vendors may also collate the results of "light-table reviews" to arrive at a similar set of collision information. The objective here is the result of the action, and not that a specific set of software was or was not used. The open standard format for this information exchange is called the coordination view information exchange (www.buildingsmartalliance.org/projects/cvie).

The third performance specification required contractors to provide equipment lists, warranties, spare parts suppliers, submittals and maintenance plans in a format that would not end up in building's boiler room. The Construction Operations Building information exchange (COBie) is currently gaining both national and international attention due to demand to eliminate the waste associated with creating, reproducing, processing and archiving paper documents (http://wbdg.org/resources/COBIE.php).

Public agencies currently have COBie requirements listed in the BIM sections of their specifications that are incorrect. The COBie specification presented in July 2008 clearly states that the COBie specification replaces those sections of current Operations and Maintenance Manual specs that require delivery of paper handover documentation. Since COBie is a performance-based specification for information delivery, it does not matter if COBie data has been produced manually in a spreadsheet form or automatically via export from BIM software. Demonstrations of software certified against an internationally accepted update to COBie will be conducted at the National Institute of Building Sciences Annual Meeting, in conjunction with Ecobuild America, December 7-10 in Washington, D.C.

One of the primary drivers of waste in the design and construction industry is the lack of reliable methods for contracted information exchange. The development of performance specifications...is the only approach that will allow market forces to drive the innovations needed to eliminate such waste.

IN PREPARATION

I am leading a team to extend the initial COBie data set to begin to capture additional facility management information in a format that can be re-used. The Equipment Layout information exchange (ELie) project has a goal of providing a common layout for piping schematics. ELie takes into account work already accomplished by the process plant industry, as well as information to describe building blocking and stacking diagrams contained in COBie. A demonstration of work on ELie will be held at the Institute's Annual Meeting.

The second project to extend COBie is the Specifiers' Properties information exchange (SPie) (http://wbdg.org/references/pg_spt.php). SPie is currently working with specifications software firms, manufacturers and trade associations to begin to develop open standard property sets for materials, products and equipment. The initial set of these properties, created by the Specifications Consultants in Independent Practice in conjunction with the Construction Specification Institute, is currently available on the Whole Building Design Guide's Product Guide. A demonstration of work on SPie will be held at the Institute's Annual Meeting.

Given the Department of Defense's interest in reducing its energy footprint, my team is also working on a longer term project to transform the exchange of energy-related building information exchanges into a full energy management control cycle. The current phase of this effort, the energy information exchange (ENERGie) format, will extend early design energyanalysis efforts funded by the General Services Administration into the design stage. A demonstration of work on ENERGie will also be held at the Institute's Annual Meeting.

As with previous efforts, each of these new exchange specifications are aligned with the buildingSMART Industry Foundation Class schema and that portion of the IFC model represented in COBie. Reports that automatically identify deviations between submissions and these formats are also fully interoperable between IFC and ifcXML.

FUTURE SPECIFICATIONS

With many of the contractual deliverables identified in **Table 1**, it is possible to identify a significant amount of wasted effort required by all parties to produce the contracted information and also by those who would use the information once delivered to the owner. The current way cost estimates are exchanged, for example, requires repeated counting of "door knobs, light bulbs and carpet areas" throughout the average 67 year life of an army building. Exchanges of site photos and construction punch lists would be greatly enhanced by identifying the context of the files and transactional information.

The AGCxml project (http://buildingsmartalliance.org/index.php/projects/agcxml) has begun to develop message wrappers within which project information may be supplied and consumed across the World Wide Web. AGCxml is a good start and will continue as the performance requirements for the information contained within these wrappers is specified. The content will include both specific information to be transferred and references to other building information that allow the transaction to be placed within the larger project context. Use of AGCxml will depend on the development of an ecosystem of web service-oriented software tools.

CONCLUSIONS

One of the primary drivers of waste in the design and construction industry is the lack of reliable methods for contracted information exchange. The development of performance specifications for the delivery of consistent, computable building information is the only approach that will allow market forces to drive the innovations needed to eliminate such waste. These innovations will come both in the software we use to perform and transmit our work, and in the types of services that will be needed to coordinate and manage such transactions.

We are at the early stage of completing a variety of different information exchange formats. While the work to develop these formats does not proceed as quickly as one would like, once it is completed, the specifications can be directly applied without reliance on proprietary means and methods.

To accomplish this hard work, your help is needed. Please sign up with the buildingSMART alliance™ to contribute to these existing projects and to start new projects to develop performance-based specifications for the delivery of building information in your subject matter area or customer domain. ■

Acknowledgements: The views expressed in this article are those of the author and not the policy of the U.S. Army Corps of Engineers or the Engineer Research and Development Center.

E. William (Bill) East is a Research Civil Engineer at the Engineer Research and Development Center, for the U.S. Army Corps of Engineers. East is a registered Professional Engineer and recipient of the 2008 American Society of Civil Engineers Government Civil Engineer of the Year Award. He is also the primary author of the Construction Operations Building information exchange (COBie) format and is the Projects Coordinator for the buildingSMART alliance™.

AIA-TAP BIM Repeat Award Winners: Strengths and Opportunities

By Major Patrick Suermann, PhD, PE, LEED AP, and Tammy McCuen, LEED AP

IN 2005, THE AMERICAN INSTITUTE OF Architects Technology in Architectural Practice (AIA-TAP) recognized its first annual BIM Award winners. After five installments, these award winners have come to represent the very best BIMs in the world. Of this elite group, some firms have been honored more than once, making them the "best of the best." This article will discuss three repeat award winning firms and the evaluation of each using the *National BIM Standard*'s® *(NBIMS) Interactive Capability Maturity Model (I-CMM)* as a basis for objective analysis of their information management maturity strengths and opportunities. *Note: You can start using the I-CMM to evaluate your own BIMs right now! Visit:* www.buildingsmartalliance.org/docs/BIM_CMM_v1.9.xls

The three "best of the best" firms highlighted here are Morphosis, KieranTimberlake, and Mortenson Construction. Each firm's approach and project execution in BIM differs, but all represent a common characteristic of innovation and creativity.

MORPHOSIS

Morphosis was recognized with awards in 2005 and 2008, for federal projects in San Francisco and Eugene. In 2009, Morphosis received two awards, a Citation in the "Creating Stellar Architecture Using BIM" category along with the top "Jury's Choice" honor. Both awards were for a new academic building in New York, the Cooper Union for the Advancement of Science and Art. In an interview with Marty Doscher, Morphosis IT Director, he discussed the firm's approach to architecture and its signature style of complex structure and cladding assemblies. Morphosis uses BIM as a tool to engage and educate clients and constructors using model information about the design and structure.

Morphosis believes using BIM as a tool to optimize building performance and streamline the construction schedule is well known. Doscher encourages architects to use BIM as a tool to **optimize architecture**. The Morphosis philosophy is that BIM is as much about making 'architecture' an expression of art and the conveyance of poetic architecture as it is about the technical information within the model. BIM affords architects the opportunity to push the boundaries, improve design, and test out many design alternatives instead of using BIM solely for drawing production. Particularly interesting is the Morphosis belief that architects should not just use BIM as a way to optimize "the box" but rather as a way to improve the "DREAM."

Cellophane House, KieranTimberlake. Photo © Peter Aaron/Esto.

Doscher noted that over the last few years there have been both advances in the technology and an increase in contractors adopting BIM as they see its value in construction. He did point out that there appears to be a lag in the evolution of traditional business processes necessary to work more effectively in BIM and that this should be addressed by organizations such as buildingSMART alliance™ in the near future.

KIERANTIMBERLAKE

KieranTimberlake won two awards in 2007 for "Loblolly House" and another in 2009 for the Cellophane House. In an interview with David Riz, Principal, and Marilia Rodrigues, Associate, both from KieranTimberlake, they noted that while Loblolly House was a revolutionary project

Wayne L. Morse U.S. Courthouse, Courtesy of Morphosis Architects.

built with revolutionary software, they felt that the Cellophane House project represented greater adoption, knowledge and comfort levels with the BIM process. Riz noted that Cellophane House was revolutionary because it pushed the capabilities of a structural aluminum framing system beyond what was thought possible, allowing the house to be rapidly assembled and disassembled.

The project was fabricated directly from the BIM, assembled in modules and stacked into a 5 story showpiece hosting over 500,000 visitors in six months. Although the superstructure went together in less than a week, a model handoff data error led to a 1" discrepancy that had to be ameliorated on site, which led the team to question, "how do you truly collaborate when 40 percent of your project team is not using the same software?"

MORTENSON CONSTRUCTION

Winning one award as a contractor from the world's leading architectural organization is a tremendous honor. Winning four times is staggering. However, Mortenson can take pride in their accomplishment as the only contractor to ever accomplish this feat. They have won four AIA-TAP BIM citations or honorable mention awards.

In an interview with Derek Cunz and Ricardo Khan, Mortenson's approach to projects in BIM revealed innovation in construction and facility management. Focusing on two specific research facilities which have won awards, the 2007 award winner, Benjamin D. Hall Interdisciplinary Research Building at the University of Washington (UW) and the 2009 honorable mention winner, Research II (or R2) facility at University of Colorado – Denver (UC-D), helps provide an insight to Mortenson's information management approach over time.

University of Colorado at Denver – Health Sciences Research II. Photo courtesy of Mortenson Construction.

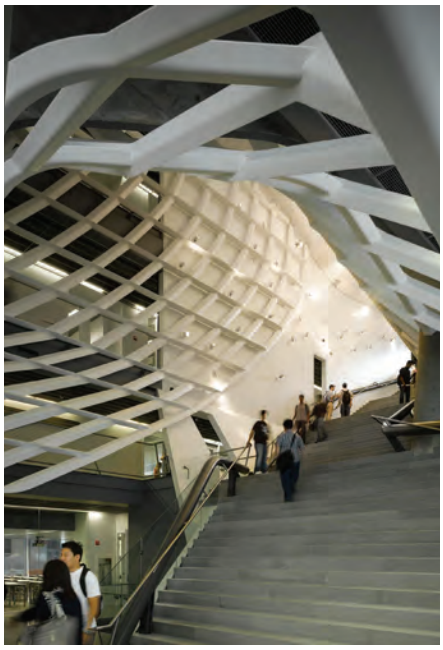
The Interactive BIM Capability Maturity Model			
Morphosis I-CMM 2008 Score -- Wayne L. Morse U.S. Courthouse			
Area of Interest	**Weighted Importance**	**Choose your perceived maturity level**	**Credit**
Data Richness	84%	Data w/Mostly Authoritative Information	5.9
Life-cycle Views	84%	Includes Constr/Supply & Fabrication	4.2
Change Management	90%	Full Awareness	3.6
Roles or Disciplines	90%	Plan, Design & Construction Supported	5.4
Business Process	91%	Some Bus Process Collect Inco	2.7
Timeliness/Response	91%	Most Response Info Available in BIM	4.6
Delivery Method	92%	Network Access w/Basic IA	2.8
Graphical Information	93%	3D – Intelligent Graphics	6.5
Spatial Capability	94%	Spatially Located	2.8
Information Accuracy	95%	Full Computed Areas & Ground Truth	7.6
Interoperability/IFC Support	96%	Full Info Transfers Between COTS	5.8
		Credit Sum	**51.8**
		Maturity Level	**Certified**

The Interactive BIM Capability Maturity Model			
Morphosis I-CMM 2009 Score – Cooper Union for the Advancement of Science and Art			
Area of Interest	**Weighted Importance**	**Choose your perceived maturity level**	**Credit**
Data Richness	84%	Completely Authoritative Information	6.7
Life-cycle Views	84%	Includes Constr./Supply & Fabrication	4.2
Change Management	90%	Limited Awareness	2.7
Roles or Disciplines	90%	Plan, Design & Construction Supported	5.4
Business Process	91%	Some Bus Process Collect Info	2.7
Timeliness/Response	91%	Limited Response Info. Available in BIM	3.6
Delivery Method	92%	Network Access w/Full IA	3.7
Graphical Information	93%	4D – Add Time	8.4
Spatial Capability	94%	Spatially Located	2.8
Information Accuracy	95%	Full Computed Areas & Ground Truth	7.6
Interoperability/IFC Support	96%	Full Info Transfers Between COTS	5.8
		Credit Sum	**53.6**
		Maturity Level	**Certified**

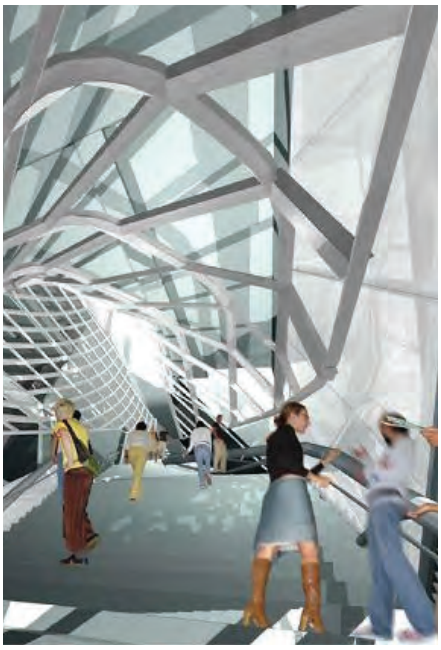
The UW facility was a Design-Build-Operate-Maintain (DBOM) facility investment by Mortenson. The researchers leasing space in the facility reimburse Mortenson's capital construction expenditure, so long-term sustainability was integral in the facility's BIM creation. Differing from this project, the UC-D facility focused on superior value for the owner in a traditional project. Rather than focusing on maximizing leasable space, the team focused on integrating the design and construction models to ensure superior quality for the complex placement and installation of the structure and MEP systems in the facility, resulting in a more productive construction project.

THE NBIMS I-CMM

In chapter four of the NBIMS, Version1 – Part 1, the concept of evaluating information management maturity is discussed via



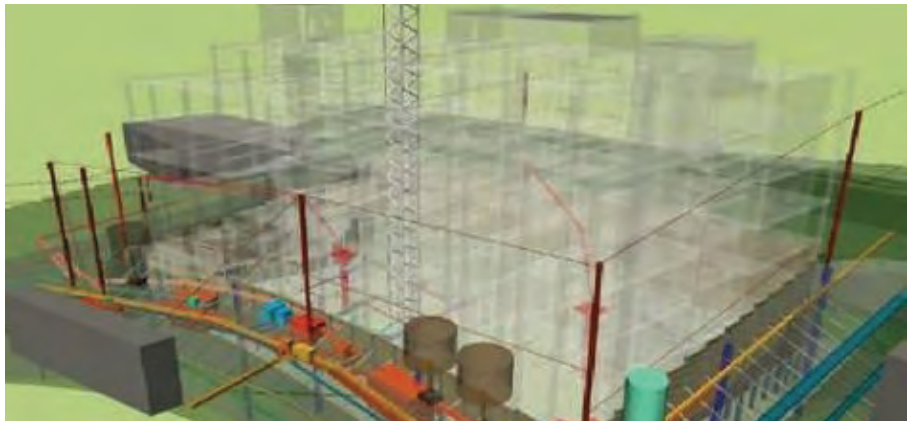
Cooper Union for the Advancement of Science and Art. Photo © Roland Halbe.



Cooper Union for the Advancement of Science and Art, as modeled.

The Interactive BIM Capability Maturity Model			
KieranTimberlake I-CMM Score 2007 - Loblolly House			
Area of Interest	**Weighted Importance**	**Choose your perceived maturity level**	**Credit**
Data Richness	84%	Data w/Limited Authoritative Information	5.0
Life-cycle Views	84%	Includes Constr./Supply & Fabrication	4.2
ITIL Maturity Assessment	90%	Limited Awareness	2.7
Roles or Disciplines	90%	Partial Plan, Design & Constr. Supported	4.5
Business Process	91%	Separate Processes Not Integrated	0.9
Timeliness/Response	91%	Limited Response Info. Available in BIM	3.6
Delivery Method	92%	Single Point Access No IA	0.9
Graphical Information	93%	4D – Add Time	8.4
Spatial Capability	94%	Not Spatially Located	0.9
Information Accuracy	95%	No Ground Truth	1.0
Interoperability/IFC Support	96%	Limited Info Transfers Between COTS	3.8
		TOTAL	**36.0**
		Certification Level	**Minimum BIM**

The Interactive BIM Capability Maturity Model			
KieranTimberlake I-CMM Score 2009 - Cellophane House (Note: This was a temporary project that was disassembled, so the score may represent a higher level of information management maturity than warranted.)			
Area of Interest	**Weighted Importance**	**Choose your perceived maturity level**	**Credit**
Data Richness	84%	Completely Authoritative Information	6.7
Life-cycle Views	84%	Includes Constr/Supply & Fabrication	4.2
Roles or Disciplines	90%	Partial Ops & Sustainment Supported	6.3
Business Process	91%	Some Bus Process Collect Info	2.7
Timeliness/Response	91%	Most Response Info Available In BIM	4.6
Delivery Method	92%	Web Enabled Services – Secure	7.4
Graphical Information	93%	4D – Add Time	8.4
Spatial Capability	94%	Spatially Located	2.8
Information Accuracy	95%	Full Computed Areas & Ground Truth	7.6
Interoperability/IFC Support	96%	Full Info Transfers Between COTS	5.8
		Credit Sum	**62.7**
		Maturity Level	**Certified**



Benjamin D. Hall Interdisciplinary Research Building at the University of Washington. Photo courtesy of Mortenson Construction.

the "Capability Maturity Model" concept. Starting in 2007, before the NBIMS was published, the NBIMS testing team validated the NBIMS I-CMM by employing a panel of practicing professionals as scorers. The panel ensured consistency while using the tool to score the 2007 AIA-TAP BIM award winners like KieranTimberlake and Mortenson Construction. The double-blind approach resulted in a valid tool, worthy of publication for the NBIMS, and adoption by industry stakeholders. Within this article are the results from the NBIMS I-CMM evaluation of the projects featured.

It is important to note that a higher score only represents a higher level of information management maturity—not a better design. All the projects were already AIA winners, and they all stand alone on their own merit. The data shown in each of the charts in this article is from the National Institute of Building Sciences.

In summary, the firms highlighted here—Morphosis, KieranTimberlake and Mortenson—have demonstrated continued BIM execution and received recognition from the AIA TAP BIM Awards committees over the last five years. In addition, results from the evaluations using the NBIMS I-CMM indicate that, overall, each of these "best of the best" firms' information management approaches has improved in some areas. However, there is still room for improvement in other areas as firms seek to optimize the benefits of BIM across all categories.

As BIM becomes less "revolutionary" and more deeply entrenched in the industry, information management approaches will advance through interoperability, resulting in improved sharing, collaboration, and analysis capabilities. ■

Major Suermann is a graduate of the U.S. Air Force Academy with a B.S. in Civil Engineering. Recently, he successfully defended his dissertation and received his Ph.D. in Design, Construction, and Planning at the University of Florida as the first ever Rinker Scholar at the M.E. Rinker, Sr. School of Building Construction.

Tammy McCuen is an Assistant Professor of Construction Science at the University of Oklahoma, College of Architecture. Her research and teaching emphasis is in BIM and the information exchange necessary between the members of an integrated BIM team.

Cellophane House, KieranTimberlake. Photo © Peter Aaron/Esto.

Loblolly House, KieranTimberlake. Photo © Halkin Photography, LLC.

The Interactive BIM Capability Maturity Model			
Mortenson Construction I-CMM Score 2007- Benjamin D. Hall Interdisciplinary Research Building			
Area of Interest	**Weighted Importance**	**Choose your perceived maturity level**	**Credit**
Data Richness	84%	Completely Authoritative Information	6.7
Life-cycle Views	84%	Includes Operations & Warranty	5.9
ITIL Maturity Assessment	90%	Limited Control	4.5
Roles or Disciplines	90%	Operations & Sustainment Supported	7.2
Business Process	91%	All BP Collect & Maintain Info.	7.3
Timeliness/Response	91%	Real Time Access w/Live Feeds	9.1
Delivery Method	92%	Web Enabled Services-Secure	7.4
Graphical Information	93%	4D – Add Time	8.4
Spatial Capability	94%	Integrated Into a Complete GIS	8.5
Information Accuracy	95%	Computed Ground Truth w/Full Metrics	9.5
Interoperability/IFC Support	96%	Full Info Transfers Between COTS	5.8
		Credit Sum	80.1
		Maturity Level	**Gold**

The Interactive BIM Capability Maturity Model			
Mortenson Construction I-CMM Score 2009 - Research II (Note: This traditional project scored slightly lower than the 2007 submission which shared more information over time because of the DBOM approach)			
Area of Interest	**Weighted Importance**	**Choose your perceived maturity level**	**Credit**
Data Richness	84%	Limited Knowledge Management	7.6
Life-cycle Views	84%	Includes Constr/Supply & Fabrication	4.2
Change Management	90%	Limited Integration	6.3
Roles or Disciplines	90%	Partial Ops & Sustainment Supported	6.3
Business Process	91%	Some BP Collect & Maintain Info	6.4
Timeliness/Response	91%	All Response Info Available in BIM	5.5
Delivery Method	92%	Full Web Enabled Services w/IA	6.4
Graphical Information	93%	4D – Add Time	8.4
Spatial Capability	94%	Spatially Located	2.8
Information Accuracy	95%	Full Ground Truth – Int Spaces	3.8
Interoperability/IFC Support	96%	Full Info Transfers Between COTS	5.8
		Credit Sum	**63.4**
		Maturity Level	**Certified**

A Coast Guard Plot to Make Better Facility Decisions

By Commander James J. Dempsey, PE

HOW DO WE BEST SPEND THE PROVERBIAL NEXT DOLLAR? AS a Coast Guard facility engineer, I would have loved to have been able to prove to my Commanding Officer that our preventive maintenance efforts were absolutely the right thing. He accepted my argument that, "an ounce of prevention was worth a pound of cure," but also complained that my spending limited his ability to do more "fun" things.

As an Executive Officer of the Coast Guard's version of a mid-sized A/E design office executing an annual construction budget in excess of $25 million, I lived the pain of a thousand cuts defending my resource decisions. These experiences are well known to all facility asset managers and are the driving force behind a Coast Guard plot, ten years in the making, to develop a stable, systematic decision-making framework to answer this perennial dilemma.

This is ultimately a BIM story, but in the context of a means to an end. Adlibbing from Winston Churchill: "BIM'ing may be the worst form of integrated facility decision-making, except all the others that have been tried." The plot's emphasis is having a mission-based, integrated decision-making framework **(Figure 1)** in which "mission" is any ultimate objective from providing services to profit making, based on the laws of demand and supply.

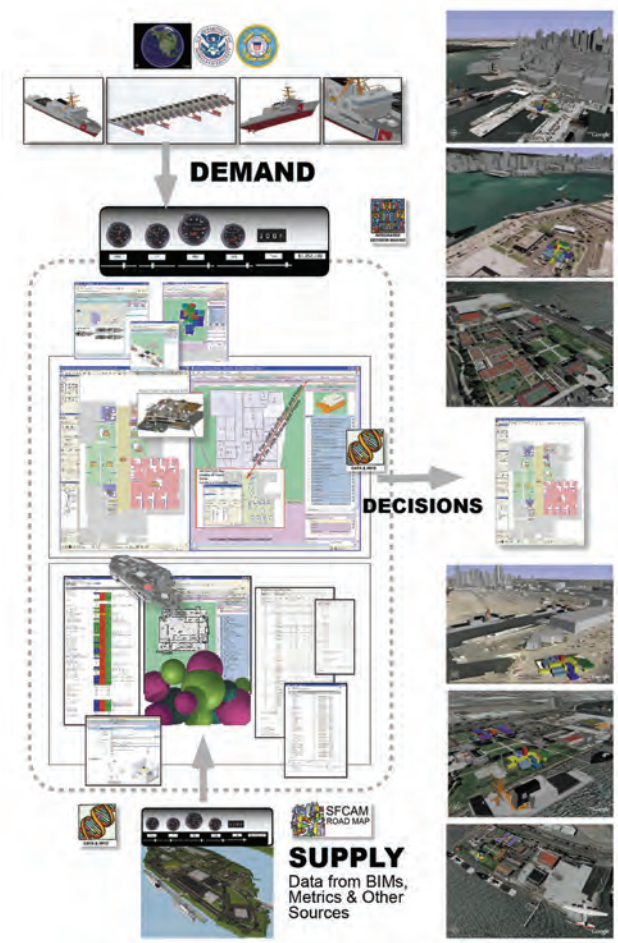


Figure 1. Mission-based integrated decision making.

In the Coast Guard, we have eleven legal authorities to perform missions. Legal authorities are essentially business lines given to us by Congress. They range from maritime search and rescue, enforcement of laws and treaties, environmental protection, law enforcement and national defense. The Coast Guard is the steward of more than 10,000 buildings, occupying over 29.5 million square feet of building space. We manage over 430 developed real property sites located throughout the United States and its territories.

The average age of a Coast Guard building is 43 years and the combined replacement value of buildings and infrastructure is estimated to be in excess of $12 billion dollars.

Changing the way this organization does business requires a plot. Justifying sustainable facility investment strategies should be easy with so much critical infrastructure. Don't facilities have an unquestionable role in mission execution? So why do facility investments compete poorly against other critical needs. This is certainly not a problem unique to the Coast Guard, but the solution requires more than traditional tools and methods.

Our framework for integrated facility decision-making begins and ends in a Coast Guard facility. BIM is a foundational technology that can virtually manage the configuration of our large facility portfolio from a mission-based systems perspective to individual system components. BIM can also document and simulate the cause and effect facility decisions will have on mission outcomes. This decision model, although still largely on the drawing board, has been defined by successive development waves over the last ten years. As each successive wave has worn away more opposition, it has also affirmed my opinion that BIM-based technologies are the only practical means to deliver real, mission-based decision-making after trying all other traditional methods. If it happens in the real world, it can happen virtually in BIM and in this form we use the word "plot" to chart a navigational course for our business transformation efforts.

The emerging framework has seven specific elements **(Figure 2)**. The Coast Guard legal authorities (business lines) are translated into mission objectives (1), which are then used as planning factors for the provision of logistical systems including facility assets. This is known as integrated project delivery (IDP) in the industry. In the Coast Guard, our vision of IDP extends to the complete sphere of time, space and scope of the organization. From this, operational requirements (2) are documented and are used to establish logistical requirements and, consequently shore facility configuration standards (3). Facility investment decision-making

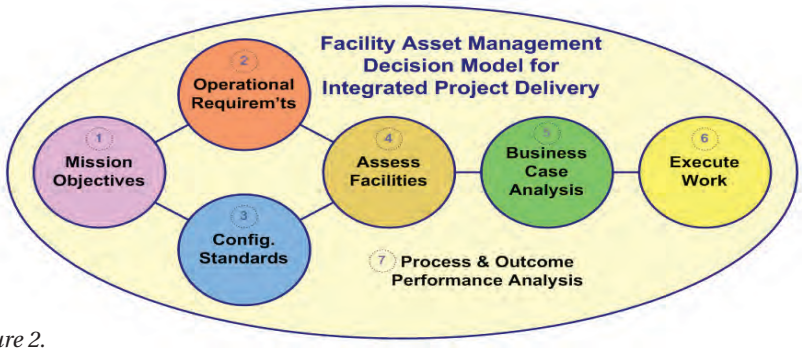


Figure 2.

is then bounded in terms of objectives, and resource decision-making becomes a function of continually optimizing sustainable, mission-effective facility solutions at the lowest total ownership cost, considering both current and future demands.

This process is attentive to facilities as part of a broad, mission-based system as well as to explicit life-cycle considerations. Decision-making must be performed in a fully defined configuration management system whereby physical and functional standards are used to establish measurable facility configuration requirements to govern all investment, planning, design, construction and facility management processes. Facility assessments (4) are conducted to identify any facility discrepancy as a gap between a standard and the facility's actual configuration. The convention for discrepancies is also used as a fundamental building block for activity-based costing and for contract work descriptions addressing needs from recapitalization to basic maintenance and facility operations. Next a business case analysis (5) is used to rationalize risk-based decision-making using business case pro formas and common financial analysis techniques. Finally, work is executed (6) and the performance of these efforts, as well as the facility portfolio, are evaluated (7).

In order to support objective, fully auditable decision-making, the Coast Guard is developing a series of metrics. These metrics are separated into two general perspectives; a mission perspective and a stewardship perspective. It is intended that these perspectives be universally available to decision-makers at all levels and are sub-divided as follows:

Strategic Mission Perspective: A Mission Essentiality Index (MEI) has been developed for executive level decision-makers in order to direct investment decisions based on enterprise-wide mission needs. This process differentiates individual facilities and uses both physical and functional mission perspectives.

Tactical Mission Perspective: A Mission Dependency Index (MDI) is used to determine the relative mission importance of a facility from the local Commander's perspective using operational risk management, including probability and severity, but changing it to address facility interruptiblity, relocatability and replacability.

Physical Stewardship Perspective: A Condition Index (CI) is used to judge the relative depletion of a facility component's useful life based on established configuration standards. The CI determines the severity and timing of maintenance needs from a life-cycle management perspective.

Functional Stewardship Perspective: As a counterpoint to condition-based analyses, facilities must also be functional. The Coast Guard is seeking to adopt a suitable index to provide this perspective to include sustainability and energy conservation. This introduces the use and utilization perspectives.

The decision-making fulcrum bringing this together is a concept known as affordable readiness. In simple form, each facility is scored with a combined mission/stewardship metric. Related financial liabilities are determined using a facility's estimated present replacement value and the relative importance is determined using the combined perspective. Likewise, the effect a corrected discrepancy has on the facility can be quantitatively measured and an entire portfolio of corrected discrepancies within a specific business case can be compared to competing business cases. The business case selected should have the greatest contribution to affordable readiness, which is derived from a mathematical summation of the different metrics within a BIM-described facility context.

Continued on page 41

BIM for Electrical Construction:
Benefits and Current Trends

By Salman Azhar, Ph.D.

THE ELECTRICAL CONSTRUCTION INdustry traditionally rELies on 2D and 3D drawings to layout, design, estimate, and install power and communication systems in buildings. With the advent of building information modeling (BIM), electrical contractors have begun to experience its potential benefits. The scale of BIM adoptability in the U.S. electrical construction industry, however, and its impact on electrical design and construction, are still unknown. Keeping these objectives in mind, this research study was carried out with the support of National Electrical Contractors Association (NECA). The necessary data was collected via two questionnaires sent to NECA members from January to April 2009. The purpose of the first questionnaire was to gather data about the current status of BIM adoptability in the U.S. electrical construction industry while the second questionnaire collected information about BIM benefits and opportunities for electrical contractors.

The first questionnaire was completed by 185 NECA member companies. Though the survey targeted companies of various types (main job function) and sizes (in terms of annual revenue), the majority of responding companies were medium to large in size with their major focus on electrical construction. Results from these companies, which were located all over the United States, indicated that 38 out of 185 responding companies (21 percent) are using BIM technology in their projects. The following information is collected from these 38 companies.

When asked about the most valued BIM features for electrical construction, the following responses were obtained: clash detections (83 percent of users), visualization of electrical design (78 percent), space utilization (67 percent), partial trade coordination (53 percent), shop drawings review (42 percent), virtual mock-ups (39 percent), shop fabrication process (36 percent), walk-throughs (36 percent), design validation (31 percent) and energy analysis (14 percent).

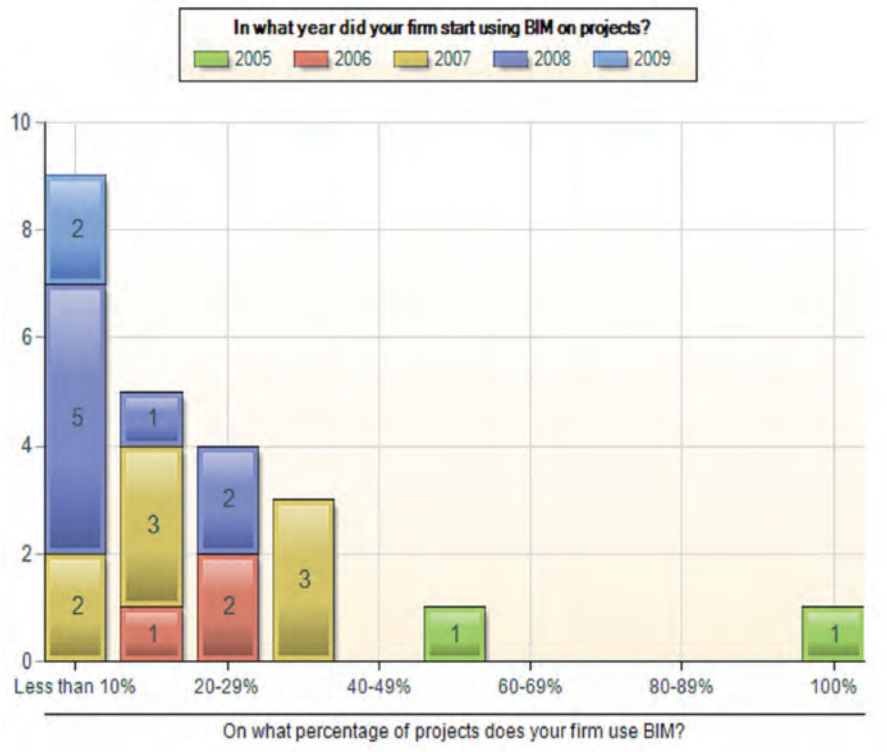


Figure 1. Year of BIM Adoption and Percentage of BIM-based Projects.

The next question asked was about the electrical components. These percentages show components which are typically modeled: branch and feeder conduits (92 percent), electrical rooms (89 percent), cable trays and other supports (86 percent), equipment panels (84 percent), lighting fixtures (76 percent), underground conduits (73 percent), junction boxes (49 percent), specialty lighting supports (46 percent), hangers (46 percent), outlets and switches (32 percent) and cables (22 percent).

Next, data about BIM benefits and implementation costs was collected. As a whole, the majority of respondents indicated that BIM technology is significantly helping to improve the process of delivering a facility. When asked about overall effects of BIM on the projects' performance, 70 percent of respondents reported "some-to-significant" time and cost savings. Furthermore, 64 percent of the respondents indicated that BIM helped to improve the quality of work put in place, while 18 percent indicated that the use of BIM nearly eliminated rework.

As far as the BIM implementation costs are concerned, a wide range of responses were received, ranging from $2,000 to $50,000, with the average falling just under $13,000. These costs are subject to a number of factors such as organization size and the level of implementation. Given the fact that 70 percent of survey respondents experienced some cost savings, it can be inferred that BIM technology has the potential to payback quickly.

The last part of the first questionnaire was focused on companies that are currently not using BIM (79 percent of respondents). When asked why not, the top five responses were:

- Do not know about BIM (64 percent);
- Lack of technological experience/expertise (24 percent);
- Existing software not compatible (13 percent);
- Too expensive (11 percent); and

- Not required by customer or design team (8 percent).

The second questionnaire was sent to those 38 companies which were using BIM at the completion of first questionnaire. The purpose was to collect more specific information about BIM benefits and opportunities for electrical contractors. Twenty-three (61 percent) companies responded to this questionnaire.

The first question inquired about the percentage of companies' projects for which a building information model was developed. As per results, most electrical contractors used BIM for less than 10 percent of projects (9 respondents). The "between 10 to 19 percent of projects" option received 5 responses; 4 respondents selected 20 to 29 percent; while 5 respondents indicated that 30 percent or more of their projects are developing a model **(FIGURE 1)**. It is also found that the companies who adopted BIM earlier are using this technology on a higher percentage of projects and vice versa. As companies adopt new technology, time and experience are typically required to obtain a positive outcome. With the exception of one electrical contractor who experienced a significant loss, survey results indicated that 15 of the 23 respondents found that the BIM technology helped to make the project more profitable. Six respondents either did not answer this question or they were not sure.

This study also identified the effect of BIM on the numbers of RFIs and Change Orders (COs) generated over the project life cycle, compared to similar projects in the respondents' companies. Based on 23 responses, it appears that 14 electrical contractors were able to reduce the amount of RFIs, 6 contractors reported no change, while the remaining 3 experienced more RFIs than a similar project that did not use BIM. Almost similar results were obtained for change orders. When this data was analyzed with respect to the BIM experience, a positive correlation was found between the "Less Number of RFI's/COs" and "More Years of BIM Experience". Hence, it can be inferred that the more BIM experience the companies have, the more benefits they achieve.

At the end, the impact of BIM on the overall business was assessed by examining how the key performance indicators (KPIs) have changed since the adoption of BIM. The respondents were asked to consider changes in quality control (regarding the amount of necessary rework), cost, timely completion, safety and productivity. Given the options, ranging from "negatively" to "positively" effected, respondents rated the impact of BIM on each of these KPIs. Interestingly, there was no "negatively" responses selected for any KPI, while "slightly positive" responses dominated four out of the five KPIs, as shown in **TABLE 1**. It was found that BIM has the most effect on quality control, followed by productivity, cost, schedule and safety.

In a nutshell, BIM is still an emerging technology in the electrical construction industry. About 21 percent of surveyed companies are currently using BIM, and are reporting positive savings in time and cost for the project, while improving the work put in place, thereby decreasing rework. For those 79 percent of companies not using BIM, the major reasons are unfamiliarity with BIM technology, followed by a lack of technological experience. While BIM may not be an appropriate business venture for all electrical contractors, as it requires substantial investment and training, it certainly does provide many benefits to its users. ■

Salman Azhar, Ph.D., is an assistant professor at the McWhorter School of Building Science at Auburn University, Auburn, Alabama. *This study was funded by the National Electrical Contractor Association (NECA).*

Answer Choices							
	Negatively	Slightly Negatively	No Change	Slightly Positive	Positively	Weighted Score	Rank
Point Value	**-2**	**-1**	**0**	**1**	**2**		
Quality Control/ rework	0	2	1	9	11	29	1
Cost	0	2	6	14	1	14	5
Timely Completion	0	3	5	12	3	15	4
Safety	0	1	9	9	4	16	3
Productivity	0	2	3	13	5	21	2

Table 1: Effect of BIM on Project's Key Performance Indicators (KPIs)

Building Information Models and Model Views – Part 4

By Richard See, AIA

PART 1 OF THIS SERIES (PUBLISHED IN THE FALL 2007 ISSUE of JBIM) provided some history about building modeling and building information modeling (BIM), and ended by introducing Information Delivery Manuals (IDMs) and Model View Definitions (MVDs) as parts of a process for realizing software interoperability in targeted building industry processes. Part 2 (Fall 2008) provided more detail about a standard process and toolset for developing BIM-based solutions for the building industry called the IFC Solutions Factory. Part 3 (Spring 2009), looked at the IFC Solutions Factory artifacts for a project organized, funded, and managed by the U.S. Government Services Administration. In summary, we walked through the development and deployment process depicted in **Figure 1** (first introduced in part 2 of the series).

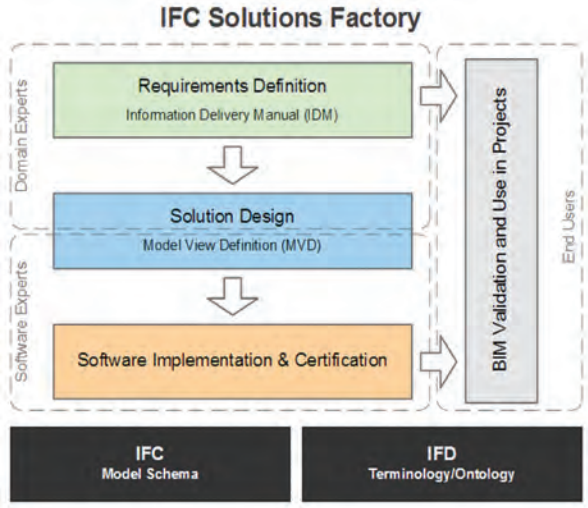


Figure 1.

In this, the final part of this series, we will look more closely at building industry concepts that are included in existing and forthcoming IFC model views used to share data between BIM enabled software applications. Review of these key concepts will give the reader a much better understanding and appreciation for how BIMs are structured and why the relationships between objects in a BIM are just as important as the objects themselves. This is one of the key differences between a 3D model and a BIM. Concepts we will review include property definition, type definition, association, assignment, placement, shape representation, voiding, connectivity, containment and aggregation.

SPATIAL CONTAINMENT

One of the most important and most easily understood concepts for structuring BIMs is spatial containment. As the name implies, this concept enables the BIM authoring application to represent a hierarchical structure for spatial containment. While there are some options (e.g. a building element can be contained by any space, building story, building, or site), this concept captures a top-down view of the spatial containers and building elements in a project. For example, a project could contain one or more sites, each of which contains one or more buildings, which in turn contains one or more building stories, which contains one or more spaces, which contains or are bounded by various building elements as shown in **Figure 2 and 3**.

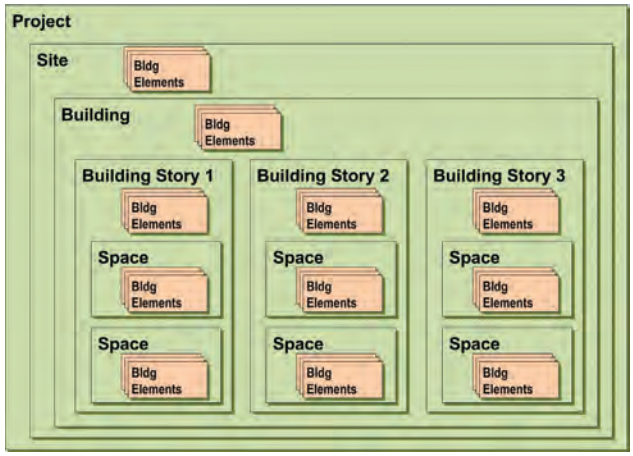


Figure 2.

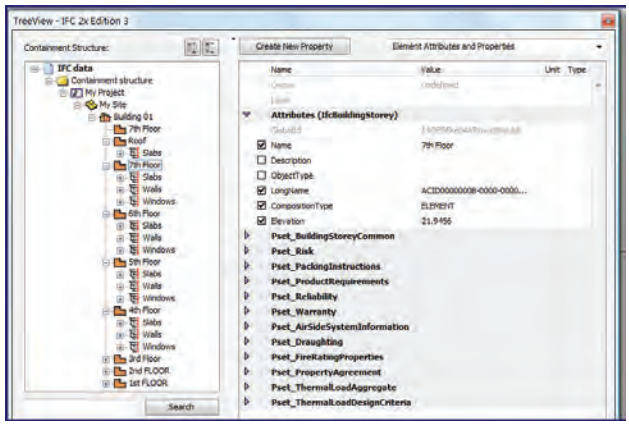


Figure 3.

As spatial containment involves essentially all physical and spatial entities in a building model, it is represented as a web of relationships between these entities. This concept is not only important to BIM authoring applications, but also to applications used in design analysis, engineering, construction, and facilities management.

ASSOCIATION

Our industry is diverse and contains many specialized disciplines. The myriad of different types of information these disciplines use in their processes are just as diverse. The generalized and fundamental concept used to support this diversity in the IFC standard is that of association. That is, a series of specialized relationships that capture the association between an object

(e.g. a wall) and other common industry concepts including class association (e.g. wall type), classification, constraints (e.g. client program, building code, geometric relationship, or budget), documents (that further define the object), libraries (for many purposes), materials, and properties (associated through membership in a class/family or instance), shown in Figure 4 and 5.

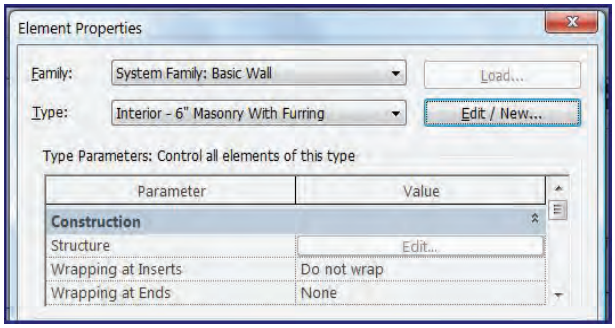


Figure 4.

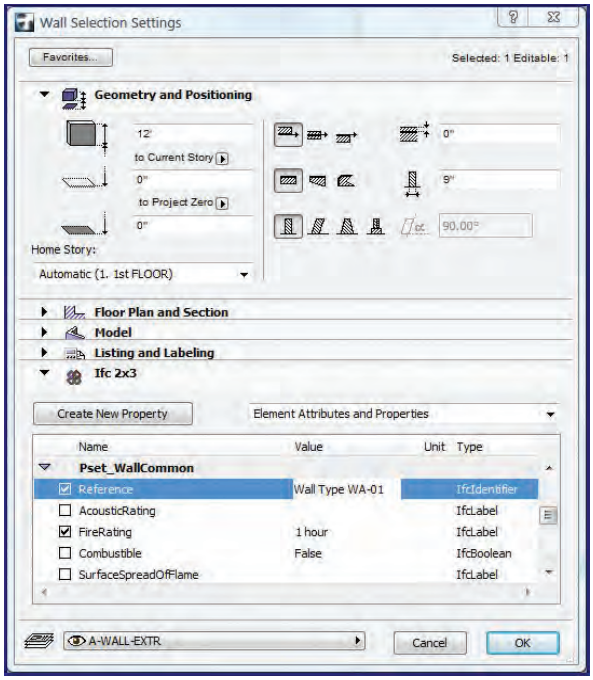


Figure 5.

The reader will recognize all of these as common industry concepts associated with elements and assemblies in building projects. Capture of this information in a project model, such that it can be shared and reused in several applications, is one of the true leaps forward enabled by BIMs and model-based processes. As with spatial containment, these associations are not only used in BIM authoring applications, but also in analysis, engineering, specifications, take-off/estimating, construction, and facilities management.

PROPERTY DEFINITION

At least one of these association concepts is worthy of emphasis. Property association is another of the basic and most easily appreciated concepts in a BIM, because each of us can cite dozens of examples of both common and specialized properties that we associate with objects in BIMs (e.g. walls, doors, windows) to support our end user processes, shown in **Figure 6**.

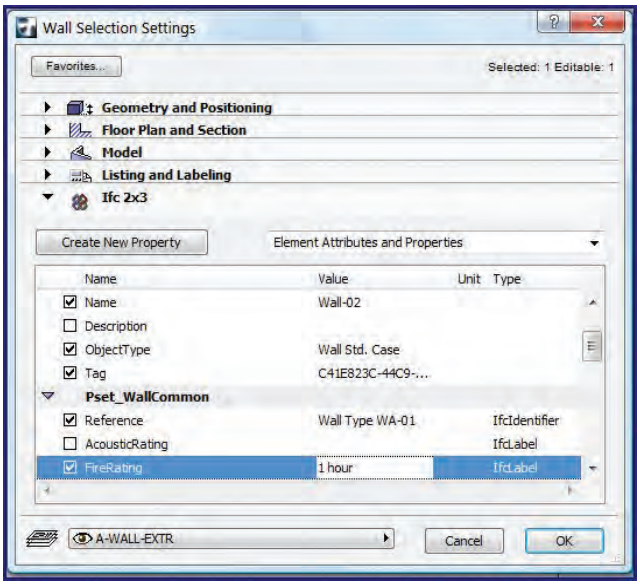


Figure 6.

TYPE DEFINITION

As buildings can be viewed as a design process for which the manufacturing quantity is one, we need to be as efficient. Standardizing components and assemblies in a design supports efficiency in the construction and operation of a building. Thus standard type definitions (e.g. wall, door, or window types) are common in our projects. They have also been reflected in the tools we have been using over the past few decades (e.g. block definitions AutoCAD, cell definitions in Intergraph and Bentley products, and shape masters in Visio). More recently, these take the form of design element libraries used in the project (e.g. object family in Revit and object library in ArchiCAD), shown in **Figure 7**.

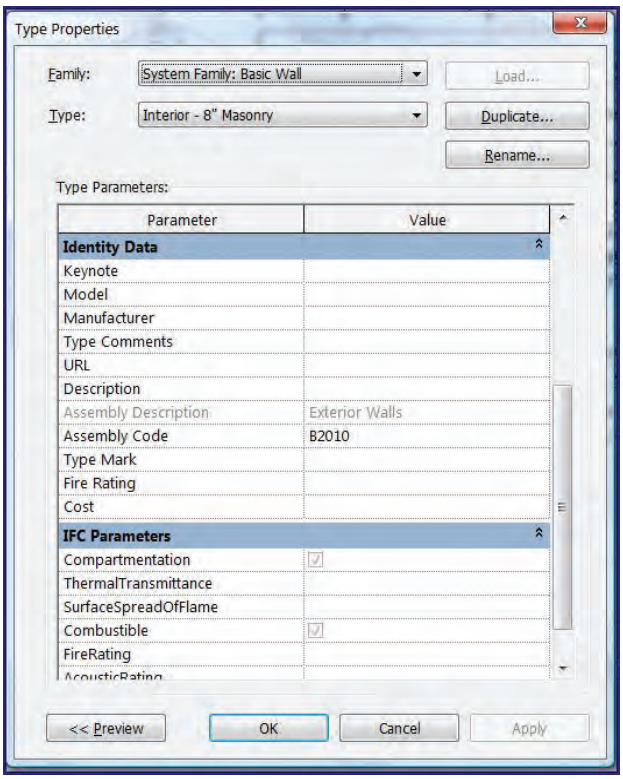


Figure 7.

In such definitions, the type is defined once and then referenced by any number of instances. A change to the type is immediately propagated to all of the instances by reference. This enables changes in the type throughout the design and construction process that would otherwise be cost prohibitive.

As type definitions are important to the way we structure and manage projects, they must be included in the information model for that project/building. This takes the form of a relationship between an object instance and the type definition that defines it (and is shared by many instances).

ASSIGNMENT

Our industry uses many high level concepts that are orthogonal to the building elements and spatial containers. These include: project actors (or participants) and their roles/responsibilities in the project, controls (or constraints) like client program, budget, schedule, codes, and standards of all types, groups like systems, zones, and sections, processes in design, construction, and operations, assemblies, and resources like labor, materials, equipment, and services.

Assignment is becoming increasingly supported in BIM authoring applications, and is arguably even more important to applications that perform analyses on the BIMs created in these apps.

These are related to building elements, spatial containers, and each other through the concept of assignment. Common examples include membership of a space in one or more spatial zones (e.g. daylighting, HVAC, or occupant department), membership of a building element in a system (e.g. ducting, VAV box, or air terminal in an HVAC system), and membership of a building element in a building section (e.g. a section used for takeoff, estimating, procurement, and construction processes).

Assignment is becoming increasingly supported in BIM authoring applications, and is arguably even more important to applications that perform analyses on the BIMs created in these apps.

SHAPE REPRESENTATION AND PLACEMENT

The most visible and assumed concepts for representing objects in a BIM are physical shape representation and the placement (or location) of the object, shown in **Figure 8 and 9**. Our industry has arguably been doing a good job in communicating size, shape, and location of objects in building design for decades (most recently in CAD drawings). However, these representations have been disjointed and uncoordinated in the way we have communicated over the time. We have all experienced conflicting representations in our projects because coordination between these representations is done manually, by humans, and is thus error prone. One of the true advantages of BIM tools and processes is automated coordination between the various representations we use (e.g. plans, elevations, sections, specifications, cost estimates, and energy analysis).

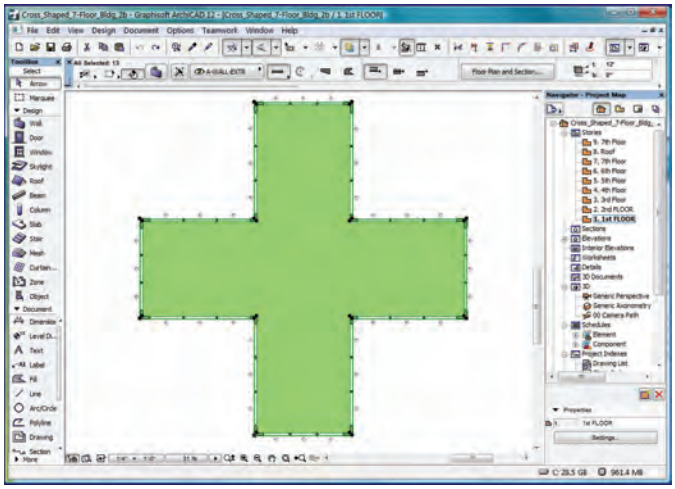


Figure 8.

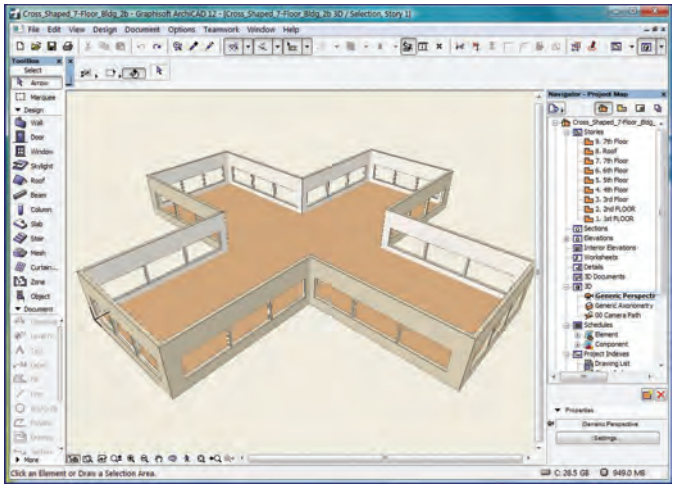


Figure 9.

To realize this benefit, a BIM format must be capable of capturing multiple representations (geometry [shape], symbolic, and analytical) in a coordinated manner. For shape, the key coordination concept is that of placement. That is, an object is seen to have one 3D placement (that can be projected for use in any 2D view).

The challenge in exchanging multiple, coordinated shape representations is that it requires standardization of the various representations (e.g. plan, 3D, sketch, detailed, and rendered) and the mechanism for coordinating them. The buildingSMART alliance™ has spent more than a decade adapting such standardization work done in the manufacturing industries through the Standard for Exchange of Product models (STEP), for use in representing building designs. This includes standardization of various types of geometry, symbolic representation, feature definition (e.g. openings, slots, bumps, etc), and geometry relationships (e.g. embedding, filling (e.g. window in an opening in a wall), aggregation, relative placement).

It should be obvious to all of us that building elements and spatial container geometry is important to a broad cross section of the software used in building industry projects—and thus shape representation and placement of those shapes are central concepts in the exchange of BIMs among software applications.

End users should become active in helping their software providers to understand which of these will deliver real value to building industry projects and require support in the software applications they use.

CONNECTIVITY

In many types of analysis, the connections between objects can be as important as the objects themselves. Examples include structural design/analysis, MEP design/analysis, accessibility and egress analysis, and code checking. The required connection information can be physical (e.g. connecting two structural elements) or spatial (e.g. a door connects the spaces on either side, and a space boundary connects a space to a bounding element like a wall or slab—through which energy is passed when there is a difference in temperature.

In a BIM being exchanged between the design and analysis applications, in these end user processes, the connections are represented as relationships that connect the objects. These relationships carry information that define the nature and characteristics (properties) of the connection. The ability to capture them in the BIM enables BIM-based analyses that required creation of separate models before BIM.

AGGREGATION AND NESTING

Many of the common concepts in building projects are actually assemblies or aggregations of other, lower-level elements. Examples include stairs and ramps (which aggregate flights, landings and railing), and roofs (which aggregate structure, slabs, attic space, vents and other elements). Similarly, the representation of a piece of equipment may be as a single high-level object, or as a composition of several component parts. In other cases, we use hierarchical structures which nest like objects. Examples include cost estimates, in which some cost elements sum several nested cost elements, and construction schedules, in which summary tasks sum several nested tasks.

This may seem similar to the grouping and system definitions described under assignment, but they are different in that that aggregation object is defined by the sub-elements rather than simply including them in a group.

Support for aggregation and nesting in BIM exchanges enables a great deal of flexibility in the representation of objects in BIMs, and in the use of those objects by many applications. It also supports the design refinement process which enables the project team to add more detail to objects over time, thus developing a BIM with greater and greater levels of detail that enables an expanding list of possibilities for reuse of that information in other applications.

CONCLUSIONS

I hope that this series has helped raise the level of awareness in our industry about the value of sharing data between software applications (a.k.a. interoperability), the degree to which possibilities have been extended through the industry adoption of BIM, and the choices enabled for end users through basing these data exchanges on an open industry standard for BIM like IFC.

End users who are using BIM should become familiar with the industry processes, exchanges, and Model Views being defined by the buildingSMART alliance™ and others. End users should become active in helping their software providers to understand which of these will deliver real value to building industry projects and require support in the software applications they use. Support for smart, cross-product use of BIMs such as automated quantity takeoff for estimating, energy analysis, and owner program validation will only become available after a broad cross section of the industry require support for these processes in the software products they use.

In this article series, we have reviewed a process that has been proven to make these things possible. It is now up to the building industry to decide if they are important and valuable. ■

Richard See is an architect that has been developing BIM processes and software solutions for 25 years. He is Managing Director of Digital Alchemy, Chairman of the BLIS Consortium, Model View Definition (MVD) Leader for buildingSMART International, Leader of the Models and Implementation Guidance (MIG) committee in development of the U.S. National BIM Standard®, member of the Technical Advisory Committee for buildingSMART International, and MVD lead in the Technical Committee for the buildingSMART alliance™ (North America).

A Modest Proposal for a Transdisciplinary Curriculum for the Design, Construction, Management and Maintenance of Architecture

By Lamar Henderson, RA, and Nancy L. Jordan, Ph.D.

TO DATE, THERE IS AN IMPRESSIVE body of literature—studies, essays, reports, manifestos, blogs, etc.—that have attempted to analyze and propose solutions to the existing pedagogic issues in architectural education. Historically, most departmental-based courses of study at the university level (graduate or undergraduate) have emphasized a narrow curriculum. Typically, each department owns and teaches a separate knowledge set and each member of that department owns and teaches an even more narrow knowledge subset.

Yet, real-life architecture demands that practitioners have a more multifaceted knowledge-base and ability—not just in design, but also in fields such as engineering, energy management, economics/finance, technology/information systems, construction management, building maintenance, and environmental science. Unfortunately, the standard of narrow and separate precludes practitioners leaving the university with the complex skills necessary to meet the current and future job requirements in architecture.

THE SHIFT

BIM is an acronym not only for the term building information modeling, but it also represents a paradigm shift in the way we think about buildings and their design, production and maintenance. This new paradigm is the synthesis of many emerging trends within the larger global culture of architecture. Currently, building professionals are in the process of transitioning from an analog tool system to a digital tool system.

This system is still in the process of its own evolution. As we better understand our needs, we will be able to design those needs into the software. Furthermore, we are not only concerned with the adoption of this new (in-process) tool system, but also with understanding and implementing the social and cultural strategies of a different design, construction and management process for the built environment. Thus, the paradigm shift not only encompasses the software, but also the skill-sets necessary to implement this new paradigm.

THE BIM PARADIGM

In order for building professionals to practice within this new paradigm, they need to understand the properties and skill-sets used by practitioners throughout the life cycle of a building project. Not only do professionals need to be educated in the traditional skills related to project design, engineering, construction, management and maintenance, but they also need to have additional skill-sets to practice within this paradigm. These skill-sets include knowledge of data management, information technology, energy and material conservation, integrated building design, systems thinking, life cycle analysis, the design processes, business and marketing skills, and project finance. As this new paradigm evolves and grows, additional knowledge and skills will become applicable to the design process in the future.

In addition, this paradigm requires a collaborative design process. Due to the growing complexity for building, it will be impossible for any one professional to have all the knowledge and skill-sets. All building professionals will need to learn to have respect for and value the skills of others, as well as their own skills.

Thus, the BIM paradigm necessitates the development of an educational program that prepares building professionals for an ever-evolving profession within a collaborative work culture.

CURRICULUM FRAMEWORK

Many undergraduate programs in colleges and universities today have been formed in reaction to marketplace competition and as a direct path to employment. These programs (narrow in scope) are most concerned with teaching students the essential facts that they will need to know in order to perform in their chosen occupations. Yet other professions, such as law and medicine, prefer to educate their students in carefully planned graduate programs after selecting their students from undergraduate programs in the liberal arts. Why is this?

A liberal arts undergraduate education provides students with more than facts. While emphasizing a well-rounded curriculum in the humanities, history, the social sciences, math, science, and the creative arts, it teaches students to think independently and flexibly, solve complex problems, inquire, conduct research, collaborate with others, and adapt to our ever changing world. Students discover new perspectives and at the same time, come to understand our shared inheritance—the cultural ties that bring us together. Knowledge is considered for its own sake and for how it shapes our world.

Most importantly, a liberal arts education prepares students for leadership in their chosen professions and would provide pre-architecture students with much stronger foundations from which to construct

their knowledge and abilities as they pursue an advanced degree in architecture.

What then would a graduate program that teaches the skills necessary to practice in the much more complex BIM paradigm look like? It might consist of a core program taken by all students. This core program would create an environment in which the students would continue to practice using the tools that they learned from their undergraduate liberal arts education while learning all aspects of the life cycle of the building process.

This core program would be a prerequisite for specialized study as well as for a terminal degree—for those individuals seeking a generalist degree. Specialized study would continue after the core program for those seeking certification and licensure in specific professional areas (as required by state licensing boards and other certification programs), such as architecture, interior design, etc. Most importantly, as the BIM paradigm continues to evolve, courses and internships could be added, changed and dropped to insure flexibility, and to make sure that graduates leave with the tools necessary to be innovative leaders in the life cycle of the buildings that they design.

TEACHING FOR THE FUTURE

As the building profession has become more complex, students need more complex abilities and knowledge to be not only successful, but to become leaders within the industry. Courses need to be more than the transmission of facts because learning and building are intricate and multidimensional, creating and expressing different realities. The point where learning and architecture (the life cycle of building) connect should be dynamic. Both architecture and learning are, by nature, constructive, creative and social. Due to this, classrooms within the BIM paradigm need to be places of inquiry, fostering different views and capitalizing on the constructive, creative, and social nature of building and learning.

Thus, learners in this model would need to be responsible for their own learning by setting their goals, solving their problems and developing their skills. They would also need to learn in social, collaborative and experience-based classrooms. Teachers would need not only to be experts in their particular areas of expertise, but to be facilitators of learning. Their classes and course content should be dynamic—like the learning and building for which they are responsible—evolving and changing depending on the needs and interests of their students.

The teaching role in this paradigm would be more complex. Not only would the teacher serve as expert, but also as participant, inquirer, facilitator and learner. The classroom would become a workshop. Students would be active contributors and collaborators. Together, teachers and students would learn new ways to respond, create, and think about architecture and build smarter for the future.

RESEARCH

Since the BIM paradigm is a very recent transition from the historical practices of building design and maintenance, the research opportunities to explore the new paradigm are enormous. One of the most critical aspects of any research program is the ability to develop useful and productive research programs. Since the staffing of the program will contain practitioners, their insights from practice can provide specific topics for research.

A high-quality research program should use multiple research designs and tools. Research from this program should inform

Not only do professionals need to be educated in the traditional skills related to project design, engineering, construction, management and maintenance, but they also need to have additional skill-sets to practice within this paradigm.

theory and practice, be used in teaching, used in the design process, and contribute to the knowledge of the building field. Tools to do modeling, simulation, and analysis for the life cycle design of buildings would need to be developed.

A research design might involve the development of digital "scientific instruments" to support the study of the life cycle of buildings. For example, these instruments might analyze and evaluate "what if" scenarios and strategies for resource and energy conservation designs. Another research design might use qualitative research methods. These methods are best suited for capturing multiple realities and describing complex social realities. If we are to more fully understand the life cycle of buildings, these methods will be useful. In addition, conducting research which investigates the development of collaborative skills—specifically oriented for the building professionals—might contribute to improving and changing how building professionals work collaboratively to build in the BIM paradigm.

CURRICULUM WITHIN THE UNIVERSITY

The proposed graduate program can only work within a major university with a strong liberal and academically diverse curriculum. Since the proposed curriculum is a graduate program within a research university, existing curricula related to the building industry will need to be merged into the new program. A core faculty will be needed to develop the core curriculum. Hopefully, faculty from other disciplines would be willing to develop appropriate courses for this new curriculum, thereby reducing the number of new hires.

The focus of the post-core classes will be project workshops which would be taught by a team of practicing professionals. These workshops would apply the knowledge learned by the student in specific building projects. The various professional organizations which support the building industry would be active participants in the development of the curriculum, as well as providing industry support. Through these professional organizations, it would be hoped that donations from the industry would support the development of the program.

CONCLUSION

The evolution of the BIM paradigm and its adoption by the building industry suggests that the education of building professionals has to be redesigned. The collective and evolving knowledge of this paradigm can provide a framework from which a comprehensive program of education—which accommodates the future needs of the industry—can be built. If we are to design sustainable architecture for its life cycle, the pedagogic framework constructed here for educating building professionals begins, hopefully, a conversation to rethink how we educate building professionals. ■

The authors would like to thank Professors Mark Clayton-Texas A&M, Chuck Eastman-Georgia Tech and Karen Kensek-USC for their helpful comments.

Lamar Henderson is an architect who has practiced as a sole proprietor, in a collective, as well as starting a design/build firm. He taught for ten years in the School of Architecture and Planning at the Catholic University of America. He has been an active member of the National Institute of Building Sciences, contributing to the Facility Information Council, IAI projects, and CAD Layering Guidelines, and as a member of the Education Project in the buildingSMART alliance™.

Nancy Jordan has a Ph.D. in education from New York University. She is currently self-employed with two businesses: 1) Jordan's Teach to Learn Consulting (www.jordantlc.com) which specializes in professional and curriculum development for teaching learners of all ages and levels (kindergarten to university) in the areas of inquiry-based learning, assessment, collaborative learning, research design, critical literacy, and the teaching/learning connection; and 2) Walls with Panache, which uses faux finishing techniques and products to design and finish walls, floors, cabinetry, and furniture in homes and commercial settings.

buildingSMART alliance™ Interest Groups Update

By David Jordani, FAIA

BUILDINGSMART ALLIANCE™ INTEREST Groups are local grass roots organizations of building industry professionals—architects, engineers, building owners, contractors, subcontractors, educators, attorneys, and facility managers—who share an interest in exploiting technology to enhance the quality and improve the efficiency of the built environment.

BOSTON

The most recent McGraw Hill SmartMarket Report showed the northeast United States lagging in the adoption of BIM. The *Boston BIM Collaborative* assembles innovative and forward-thinking firms in the New England construction industry for monthly discussions on ways to improve the industry through construction technologies and methodologies, such as BIM and IPD.

Meetings are sponsored by a participating firm and are held in The Plumbing Museum, located just outside of Boston. In planning its first two meetings, the *Boston BIM Collaborative* has drawn interest from architects, construction managers, engineers and subcontractors from all across Greater Boston. The inaugural meeting featured guest speaker Michael Cannistraro, P.E., Vice President of Engineering for J.C. Cannistraro, LLC, who explained how bringing the subcontractor team on board early enables the "Full Dimension of BIM." The group discussed how firms are currently tying 4D scheduling, 5D cost validations and 6D facilities management directly into the model, and exchanged ideas about the business value of BIM.

The most recent meeting of the *Boston BIM Collaborative* was mid-November. Attendees discussed BIM Standards and ROI derived from BIM projects.

MINNEAPOLIS

After a summer hiatus the *Minnesota BIM Breakfast Club* (BBC) started its third year of monthly meetings. The BBC is a growing group of about 85 people—primarily local architects and engineers, but also a nice cross section of contractors, educators, attorneys and representatives from risk management. The BBC has been meeting monthly for two years; it's a great group that usually draws about 40 people to each meeting.

The September BBC focused on the growing number of BIM Standards and Guidelines that are being developed by owners to articulate their deliverables requirements and expected use of BIM. We looked at several examples and discussed their impact on project delivery and contracts.

The October meeting looked at the exchange of model data between design and construction project stakeholders. We reviewed the Model Progression Specification with a presentation from Vico Software and discussed the variances of modeling requirements for designers vs. the construction team.

AIA Minnesota, a Society of the American Institute of Architects, hosts the monthly sessions for the BBC.

WASHINGTON, D.C.

The D.C. buildingSMART alliance™ Interest Groups, also known as the Renaissance Club, met in November to discuss technology trends affecting architecture and LEED**.** The focus of the presentation was on SMART buildings that use integrated, IP-based, networked systems to facilitate ease of use for multiple services, increased operational efficiency, cost savings, and perhaps in the future, LEED points for integrated technology. Christopher Pollock, LEED AP and Senior Associate of Shen Milsom & Wilke, LLC, and Robyne Hamilton, Assoc. AIA and Associate of SMW, presented the concepts using case studies from SMW's portfolio of projects completed in the United States and abroad. ■

David Jordani is the President of Jordani Consulting Group.

Join the Alliance:

You are Critical To Our Success

PLEASE GO TO THE WEB SITE WWW. buildingsmartalliance.org and join the Alliance and make an investment in your future. We encourage you to join as an organization as the switch to BIM is organizational and this would send a strong message not only to your organization, but also to the industry. However, if you are not able to do that, then please join as an individual.

Joining as a sponsor will have the biggest impact on the industry and will provide you the opportunity to help guide the Alliance by being included on the Board of Direction. Sponsorships over $25k provide access to all chapters worldwide. Therefore, if you are multinational or considering being so in the future, this might be your best investment.

Our approach is to make the vast majority of our products available at no charge to the end user. This is because it is our goal to be as inclusive as possible and to achieve a faster market penetration of all phases of the industry. However, we cannot do that without resources and that is where you come in. Since you understand what we are trying to accomplish, your support will help others learn. It is estimated that there are upwards of 10 million people involved in the facilities industry. There is no telling how many we need to engage fully in order to succeed, but the number is quite large. We plan to do this with the support of industry associations, government agencies, as well as individuals.

The various products that we are currently providing after just one year in operation include the following. We need your support to first simply sustain these products:

- This *Journal of Building Information Modeling* magazine;
- *National BIM Standard*® Development;
- International standards development (ifc, IDM, MVD & IFD Library);
- Support to buildingSMART International;
- Sponsorship of Alliance projects and project promotion. This supports projects such as COBie, Smart Market Report and BIM Storm;
- Presentations, workshops and seminars to nearly 100 organizations a year;
- Coordination of Speakers Bureau;
- Coordination with all organizations involved in BIM;
- buildingSMART alliance™ web site;
- buildingSMART alliance™ conference, (which is in December);
- Organizational support for Local buildingSMART alliance™ Interest Groups; and
- General support for the Alliance.
- The *National BIM Standard*® needs substantial expansion. Projects must be completed then go through the consensus process so that they can be incorporated into the standard. This takes staff time and resources to accomplish.

It should be noted that our goal currently is to develop a plan and demonstrate practitioner interest in transforming the industry. However, we do not think that we are going to solve a $400B problem on the backs of the practitioners. It will take significant involvement from those who are spending the $400B, in order to accomplish this. We first have to identify where the funds are being wasted, then provide a plan to fix the problem areas. Once we reach that point then the funding for overall success will be made available. This will not be a quick fix, but will occur through an overall transformation throughout the industry. We have never had a better opportunity to succeed than we do now. However, it will only come if you support the early phases now. ■

It is estimated that there are upwards of 10 million people involved in the facilities industry. There is no telling how many we need to engage fully in order to succeed, but the number is quite large.

Our goal is to expand these products and add additional products. These will only be made possible through a significant increase in membership:

- JBIM Live—an on-line version of JBIM allowing longer articles and timELier posting of articles—more than twice a year.
- Project sponsorship is based on the funding you provide. Many projects are critical to our common good, but are not funded to include any level of collaboration and coordination with others. The Alliance will help support those projects and ensure that multiple organizations can work together.
- New projects that are not funded that need funding will also come directly from you. A list of projects will be created to identify these opportunities. Sponsorship also lets you fund specific additional projects of interest to your organization.

PLEASE JOIN THE ALLIANCE NOW.

For more information on the Alliance and membership fees, please contact:
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Participation in the Alliance primarily identifies you as one of the people or organizations working together for a solution to a significant problem in our industry and allows you to participate in the consensus process leading to national standards.

EVERYONE CAN VIEW AND USE MOST OF THE INFORMATION

buildingSMART alliance™ is coordinating to accomplish the transformation of the facilities industry. Supporters and contributors can actually participate in the development of projects.

The products of the Alliance are the results of many projects that are being developed or coordinated by the Alliance. Most of the work is being sponsored and in many cases paid for by external groups. In some cases, you must adhere to membership requirements of those external groups in order to participate directly on those projects. However this is not the case on all projects. In some cases, we have reciprocal agreements with organizations and in other cases, we offer discounted Alliance memberships.

Participation in the Alliance primarily identifies you as one of the people or organizations working together for a solution to a significant problem in our industry and allows you to participate in the consensus process leading to national standards.

There are several levels of participation on each project based on how projects are being developed. Institue projects such as the U.S. *National CAD Standard*® and the *National BIM Standard*® are open to all members (with some additional requirements, such as purchase of the NCS) and need your help in the development of ballot items as well as participation in the consensus process. In many cases, the members of a project are selected by the organization sponsoring the project and come to the Alliance fully staffed and funded. In those cases, Alliance members can be observers and/or reviewers of the products of those groups. Members can also sign up for RSS feeds so that they are notified if a project of interest changes.

Support from you is at the heart of our success. You are the ones who actually get the work done. We appreciate each and every annual contribution. To become a member, simply determine your level and go to www.buildingsmartalliance.org to sign-up online.

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Number of participants allowed per contribution level:

- Less than $1,000 – 1 member
- $1,000 – 15 participants may be registered from your organization
- $2,000 – 25 participants may be registered from your organization
- $3,000 – 40 participants may be registered from your organization
- $4,000 – 55 participants may be registered from your organization
- $5,000 – 75 participants may be registered from your organization
- Over $5,000 – 100 participants may be registered from your organization

SUPPORTERS AND CONTRIBUTORS ARE ELIGIBLE FOR:

- Participation in bSa projects at various levels.
- The dissemination of no-cost products and information to the building industry:
  - Journal of Building Information Modeling;
  - *National BIM Standard*® development;
  - buildingSMART alliance™ web site;
  - Annual conferences;
  - Support to buildingSMART International;
  - Support for Alliance projects and project promotion;
  - Coordination with all organizations involved in BIM;
  - Presentations, workshops and seminars to nearly 100 organizations a year; and
  - Central staff support for the Alliance.
- A 20 percent discount off attendee registration fees at all Ecobuild America and AEC Science & Technology events.
- Access to the electronic copy (PDF) of JBIM as soon as it is published—weeks in advance of the printed copy.
- All contributors at the $1,000 and above are listed on the Alliance web site.
- Scholarships are available on a per case basis reviewed by the Board of Direction. Please contact the Executive Director to apply.

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Continued from page 27

The plot must be communicated in terms of operational effectiveness, mission achievement and, ultimately, affordable readiness. This makes the story exciting but it is BIM that makes it real. BIM provides the intelligence to keep track of all of the individual facility components and systems while relating them in ways that immediately confer a universally recognizable mission-based context. Impressively, BIM can do this as a rapid time-series of still frames so fluid it can look as if one is simulating decision-making in a movie. Movies like these will not likely win any Academy Awards, but they certainly will provide an editable means to play-out a thousand plots of how to spend that proverbial next dollar. ■

Commander James J. Dempsey, PE, is a career military officer with over 18 years of facility asset management experience with the United States Coast Guard.

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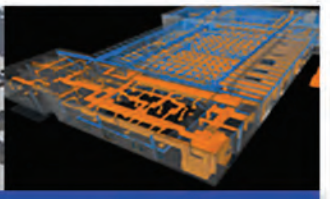

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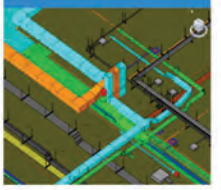

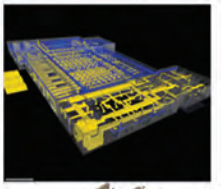

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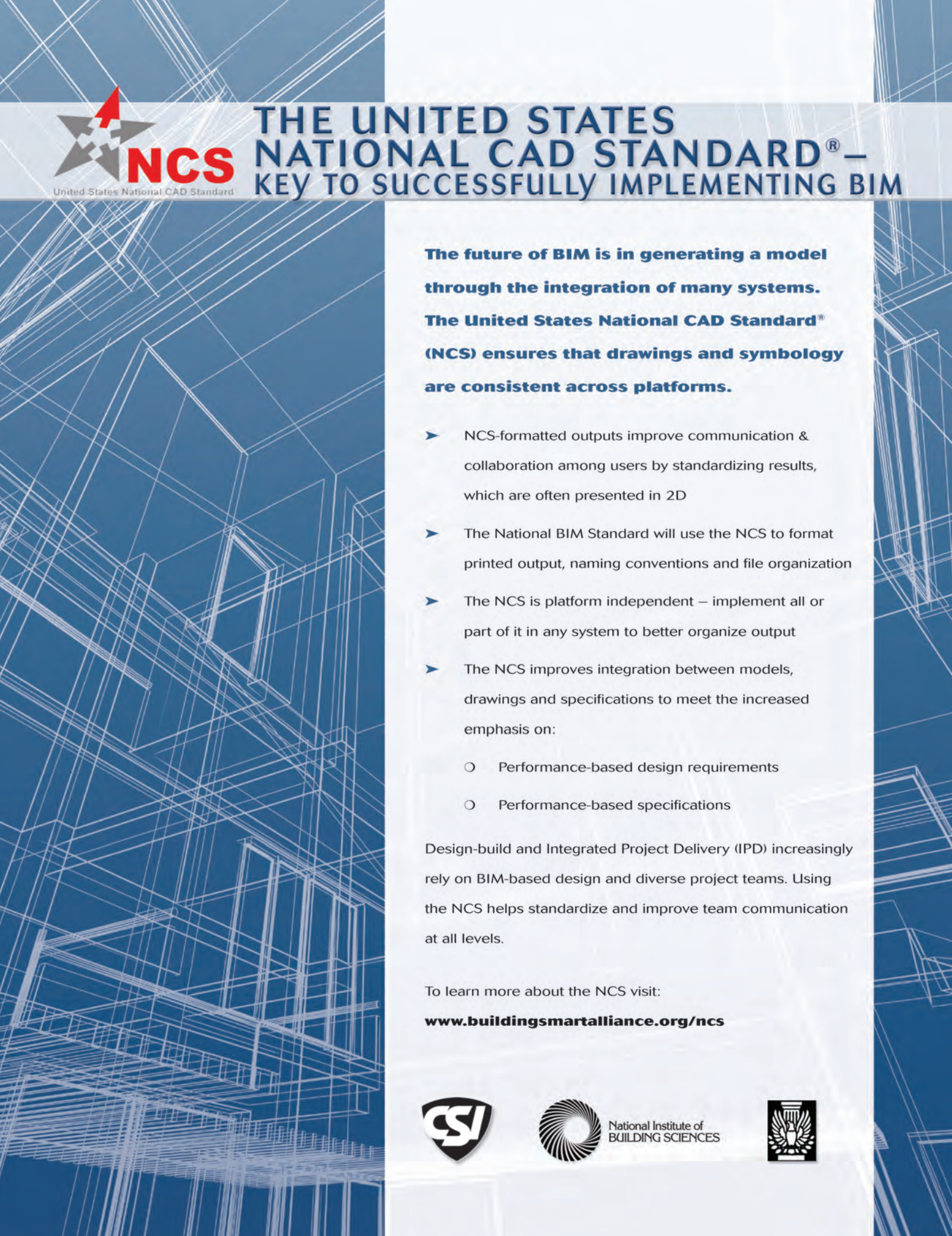

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