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BIM Enables Success on WTC Mega Project

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.

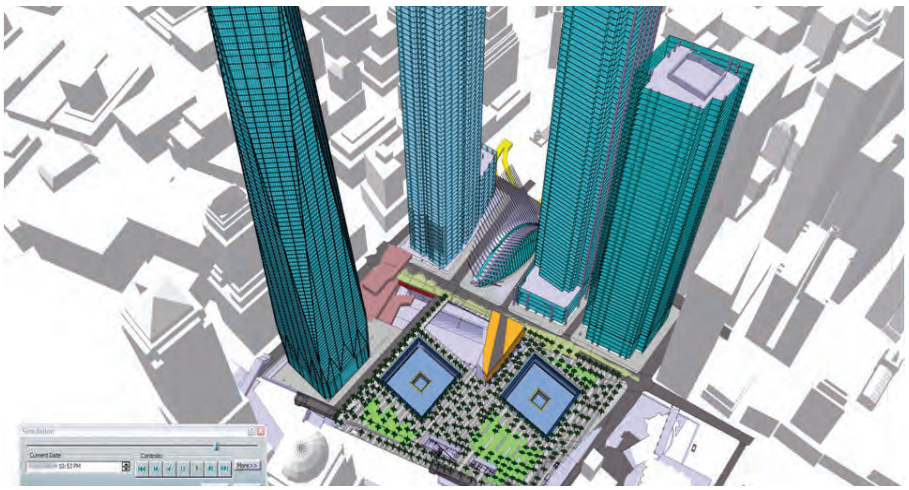
THE PROBLEM

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.

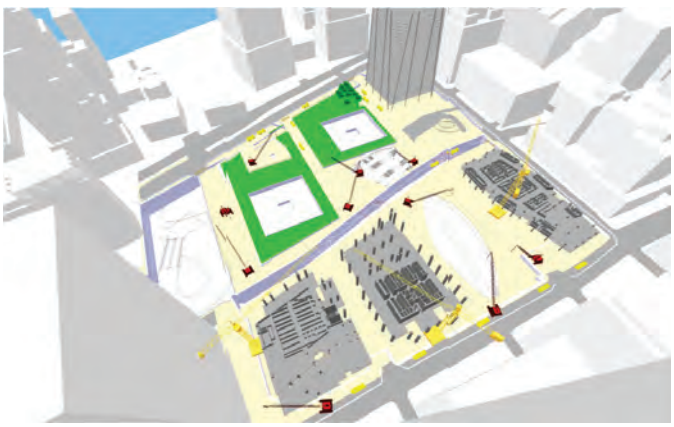
The LMCCC developed a summary schedule representing approximately 20,000 activities resulting from integrating the schedules for all the projects in the program. The team then developed 4D models representative of the project schedule and integrated them with the site logistics and staging plans provided 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.

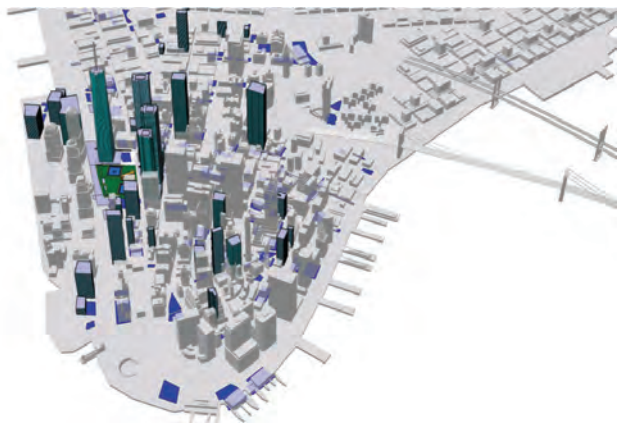
With the 3D and 4D models linked by the team, workshops were held incorporating all of the project stakeholders. These included world-class architects, engineers, construction professionals, risk modeling professionals, and project finance experts. All were enabled by the team to utilize the technology 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.

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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." ■

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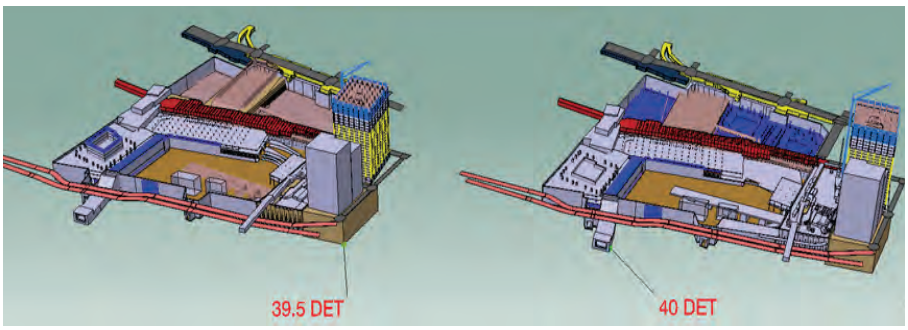
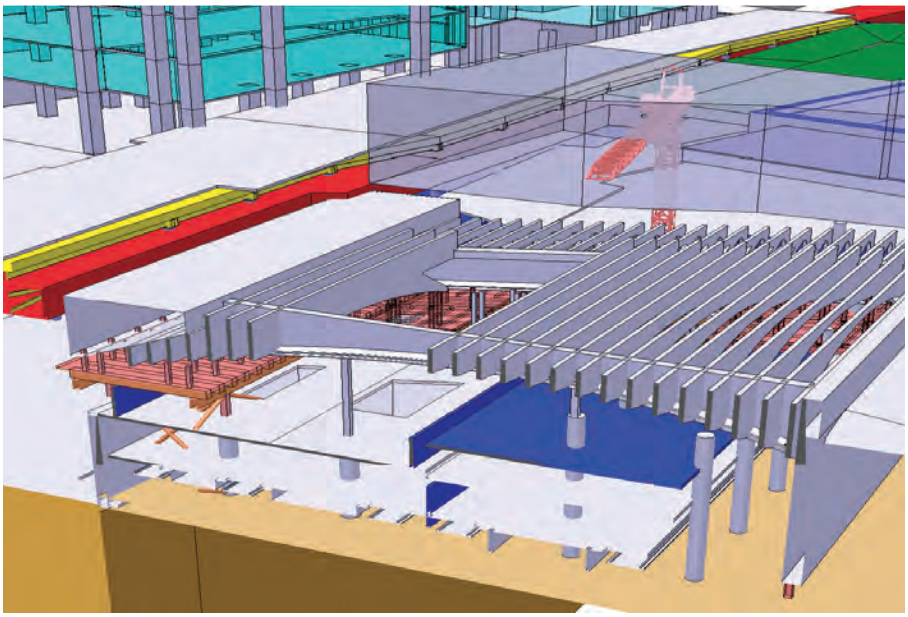


A side-by-side comparison of schedule based optimization and risk assessment.



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.