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Collaborating Through the “Perfect Storm” to Deliver Greater Value Using Virtual Design and Construction

By Dean Reed, Atul Khanzode, and John Mack

“The key, in our opinion, is true and very close collaboration between the people who design and build the facility...it’s the process.”

At a time when the economy is strong and the work is plentiful in most major market sectors, we are on the brink of a major shift in the way projects are designed and delivered. New thinking and technology have converged to create an explosion in the use of virtual design and construction (VDC), which is proving to enhance value and produce greater savings for all project stakeholders.

As an industry we have a tremendous opportunity to innovate and deliver projects with the highest quality, while simultaneously minimizing waste and increasing overall production.

The “Perfect Storm”

According to the most recent annual ranking of the Top 400 contractors by Engineering News-Record (May 22, 2006), many firms experienced record growth over the past year, leading the Top 400 to post a combined revenue of $235.56 billion for 2005, up 12.3 percent over 2004. With the bounty of work in this bull market, however, comes a wave of challenges: escalating material costs, labor shortages, and increased complexity of buildings.

Material price increases have been a major issue facing owners across the country, with some commodities, such as copper, soaring beyond reach at $8,000 a ton. Equally challenging has been the ongoing shortage of skilled labor available to meet rising demand, a shortfall that becomes more pronounced during a competitive market. With the average age of skilled construction workers currently standing at 47 years old, according to the Associated General Contractors, there is a clear need to bring new workers into the industry to meet future demands.

Hand in hand with the skilled labor shortage has come the challenge of finding qualified subcontractors to perform the work in a boom market. On top of the marketplace realities of fluctuating material costs and labor shortages is the heightened pressure for owners to deliver a better, higher quality product to their end users with shorter schedules and lower costs. In addition, the facilities themselves, especially in the advanced technology, biopharmaceutical, and healthcare markets, have grown increasing more complex. Beneath the steel, concrete and drywall lies a maze of mechanical, electrical and process systems.

We are in the midst of a “perfect storm” and, like most companies, we are constantly looking at using the latest tools and alternative project delivery methods, including design-build, design-assist, CM-at-risk, and lean construction, among others, to successfully navigate today’s accelerated business environment and deliver better results for customers.

Experience has taught us that new technology by itself will not produce the dramatic improvements we are seeking. The key, in our opinion, is true and very close collaboration between the people who design and build the facility. In other words, “it’s the process.”

Focus on Collaboration

A common thread woven into the fabric of the most successful alternative project delivery approaches is an emphasis on collaboration. For example, lean construction, which has been adopted by Sutter Health as the cornerstone of its project delivery approach, emphasizes early participation by major subcontractors in the design of the facility. In the lean approach, key design and construction team members must work closely together from the outset to achieve the end goal of saving time and money, while improving overall quality, especially on fast-track projects.

The lean construction methodology focuses on producing maximum value for the customer, looking at both the product and process. When engaging in lean construction, teams — including the owner, architect, builder, and all major subcontractors — begin designing the construction process along with the facility being built. The team looks at each step of the building process and evaluates ways to eliminate waste by promoting a continuous, reliable work flow throughout the project.

The Virtual Solution

Perhaps the solution offering the most widespread implication for improving quality and returning value to the owner on a project is the use of VDC. The application of this technology, within a collaborative approach such as lean, offers strong potential to help mitigate the myriad challenges associated with the current construction boom by im-
proving quality, lowering cost, and shortening project delivery.

Sustaining technologies that have long been the industry standard like two-dimensional computer-aided design (2-D CAD) are quickly seeing competition from newer disruptive technologies like three- and four-dimensional (3-D and 4-D) object modeling that are making it possible for project teams to build facilities virtually before construction begins in the field. These new technologies are also proving to increase productivity at a significantly faster rate than the sustaining technologies. Companies not prepared for this shift will face a steeper learning curve than those companies on the forefront of adopting the new technology and already using virtual 3-D and 4-D (3-D plus time) modeling for coordinating design and construction.

**Designing Both the Process and the Product**

Collaboration and communication are essential ingredients in the successful application of VDC. Project teams work together from the outset to simultaneously design both the product (the building) and the process (how it will be built). Every team member shares a common commitment to build from comprehensive 3-D and 4-D models, which incorporate architectural, structural, mechanical, and electrical details, reflecting the way the facility will be built. And the development of these models is an ongoing process, not a single event, continuously revised throughout construction.

The use of VDC requires that all the players — owner, designers, general contractor, and specialty contractors — be not only technically savvy but also true collaborators. In this interdependent process, technology alone does not solve the problem. Team members must be able to listen and understand each others’ concerns and then use 3-D modeling software to explore, define, and test solutions. Another result of VDC is a more efficient customer-supplier relationship that helps further eliminate waste from the construction coordination process. For example, a 3-D model built by an architect can be then used by the contractor during the coordination process.

While the use of VDC on a given project may narrow the field of qualified subcontractor partners from which to draw, it is only by using prequalified firms, who are fully committed to the process and prepared to use VDC technology, that the owner can expect to achieve greater value.

**Coordination in the Big Room**

VDC implementation requires the use of cross-functional teams of design professionals and builders, who can work together to develop and model solutions in a highly collaborative and interactive environment. The most productive approach is to set up a “Big Room” in which detailers work side-by-side to model and coordinate their designs to support the construction schedule. This approach has proven effective in reducing wait time and promoting rapid decision-making during design and coordination.
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VDC leverages the knowledge and experience of construction superintendents and foremen by allowing them to quickly see and understand what is being designed so they can offer advice on the how the various pieces should fit together for the most efficient fabrication and assembly onsite. Assemblies and components are modeled by the companies responsible for their design and/or fabrication and installation and these multiple models are then coordinated inside one or more integrated models. Ensuring that the models are kept up to date as changes are made is critical to the success of the project. Through constant communication and the collaborative environment supported by the Big Room setup, team members stay focused on maintaining accurately represented 3-D models so that everyone stays on the same page.

Increased Use of Prefabrication = Savings
One of the major sources of savings reaped from the use of VDC is the increased use of prefabrication on various project components. Coordination in 3-D all but eliminates the risk of installation conflicts, boosting the contractor’s confidence to prefabricate more and larger assemblies. An explicit prefabrication program is a key way in which the project team can return value to the owner and reduce project costs by allowing for just-in-time delivery of the prefabricated assemblies, reducing inventory on the jobsite, and reducing the number and skill level of workers needed in the field to install the major system components.

3-D modeling and fabrication of shop drawings is a prerequisite for extensive prefabrication. Subcontractors experienced with either modeling or shop fabrication can identify opportunities to fabricate components and even entire assemblies off site rather than on. These opportunities must be discussed and understood by the design and construction team to secure composite crews, assembly sites, and plan delivery and staging on site.

Increased levels of prefabrication and the fact that components fit in their intended locations lead to higher labor productivity. In turn, increased productivity combined with a drastic reduction in rework of assem-

Photo 11 and Photo 12: The use of virtual design and construction technology allowed the project team to identify clashes virtually before building in the field.
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Coordination in 3-D helped to eliminate the risk of installation conflicts, boosting DPR Construction's confidence to prefabricate more and larger assemblies.

Some of the biggest benefits can be seen in the area of improved work crew efficiency, with the project currently experiencing an overall 20 percent increase in productivity rates over traditional industry standard, with no rework required due to clashes being detected in the coordinated 3-D model. In fact, the team installed more than 75,000 s.f. of prefabricated MEP systems before the first clash occurred in the field (due to an oversight where a clash identified during 3-D coordination was not corrected).

Prefabrication and planning have also allowed Southland to reduce its crew size by a full 33 percent from what was projected when it submitted its Guaranteed Maximum Price (GMP), which had already anticipated improved labor productivity due to lean practices and VDC. If the project, which is more than half way complete, continues according to this to trend, Southland anticipates returning between three and four percent of its total contract value back to the owner. In addition, both the plumbing and electrical contractors have reported labor savings due to extensive prefabrication and increased productivity of their crews.

Best Practices
While VDC is just now proving itself, several best practices have clearly emerged that can point the way for improve its implementation on future projects.

Based on results of implementing lean project delivery and VDC, both DPR Construction, Inc., and Southland Industries are recommending that owners consider applying both sets of practices and technology on their projects. On the 250,000 s.f. Camino Medical Group medical office building and parking structure underway by DPR and Southland in Mountain View, CA, for example, the use of VDC to support the lean project delivery approach has produced significant results.

Blies that conflict in the field achieves the ultimate goal — greater value and return on investment for the owner and the entire project team.

Return on Investment
VDC implementation should be looked at from the perspective that it is a return on the investment by the whole team, with each team member taking responsibility for that return. This starts with the owner and includes specialty contractors, who have been asked to detail their installations in 3-D. To gain the greatest value during construction, the investment in VDC must be made up front when it can have the most influence over the project. In most cases the initial cost of implementing VDC averages approximately one half of one percent of the total construction cost and, if done ideally at project start, can potentially yield a return of more than two or three times the early outlay. The owner, as the primary stakeholder with the money and expectation of gaining the most value, must be willing to make the initial investment in VDC.

The general contractor, in turn, must be knowledgeable and organized enough to drive the process and put the right team together. The team must have the capability to work collaboratively to build virtually and team members must be able to work in what might sometimes seem like a chaotic and ambiguous environment. For its part, the general contractor should enable the virtual building process by acting as facilitator rather than author. The contractor is also responsible for coordinating the hand-off of information from the A/E to the subcontractors, as well as the modeling and coordination work itself, and should develop a workable schedule for the 3-D detailing and coordination process with the A/E and subcontractors to support the construction schedule.

Specialty contractors must also invest significant time and money prior to undertaking a project utilizing VDC technology to train their people so they can be productive from the first day the detailing group comes together to work. It is vital that detailers be fully 3-D capable from day one to maintain an aggressive detailing and coordination schedule.

Results
Though the technology has been available for many years, the use of VDC is now growing more prevalent — offering even more widespread promise for the future as both the technology and its application continue to be refined and improved. With each project that incorporates VDC, there are lessons learned to
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More than 75,000 s.f. of prefabricated MEP systems were installed before the first “clash” occurred in the field.

even more successful and widespread application of the technology in the future. They include:

• Organize and rally the team around specific project and customer goals to be accomplished (i.e., just-in-time delivery of materials, coordination with zero conflicts in the field, X percentage of prefabrication, etc.).

• Prequalify specialty contractor partners for VDC-based project delivery, who are up to speed with 3-D/4-D technology and committed to the collaborative approach.

• Have a defined coordination and conflict resolution process and use weekly coordination meetings to resolve issues rather than find issues.

• Architectural and structural models should be created in 3-D, rather than modeling 2-D design drawings in 3-D. If the model is created as a consequence of design, it is critical that it be kept up to date to reflect any changes in the design.

• Create defined responsibilities among the team members for modeling responsibilities and collaboration.

• Establish technical logistics and protocols at the project outset, including how files will be accessed, managed and shared, as well as drawing protocols.

• Establish a clear process for making and answering design questions from subcontractors.

A Look Ahead
The promise of VDC has already been realized on a number of projects and it seems assured to have an even greater role in facility development in the years ahead. As the software continues to improve and more people become proficient with the tools VDC, coupled with a highly collaborative approach such as lean project delivery, offers a way to create a breakthrough in delivering more value to customers.

Working closely to build virtually before construction offers project teams the ability to deliver savings through increased prefabrication, elimination of conflict-generated change orders, and higher productivity of installation crews. It addresses some of the most pressing current challenges facing the industry, such as the lack of skilled labor, by reducing the need for an ever-increasing skilled labor force and offering the ability to not only have fewer people on the job but less experienced individuals as well.

A Wider Application
The Seattle Science Foundation is currently even discussing the possibility of designing modular healthcare facilities that could be placed anywhere in underdeveloped countries, using the technology. That is just one of a growing number of examples of how a focus on eliminating waste through collaboration and Virtual Design and Construction is beginning to shape the future of facility development and, the hope is, bring continuous improvement to the facility design and construction process. ♥

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Atul Khanzode of DPR Construction, Inc., with 15 years in construction, has focused the last five years on helping DPR leverage advanced technologies to improve critical business processes. He helps DPR project teams implement new technologies such as Virtual Design and Construction (VDC). DPR Construction, Inc., is a national forward-thinking general contractor and construction manager specializing in technically challenging and sustainable projects for the advanced technology, biopharmaceutical, healthcare and corporate office markets. Consistently ranked as one of the nation’s top general contractors, DPR is committed to continuous improvement of the construction delivery process and is sponsoring research at Stanford University to help further develop metrics for the advanced use of VDC.

John Mack is the detailing manager for Southland Industries in Northern California. He has led company-wide implementations of mechanical systems using 3-D modeling over the last 15 years. Southland Industries is a mechanical contractor specializing in design-build-maintain services for commercial and industrial customers. The company’s core purpose is “to build customers for life,” which drives them to develop novel and innovative solutions like VDC and lean construction to meet its customers ever-changing needs.