

**Using Virtual Construction Tools for Pre-Project Planning**

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## Abstract

Preconstruction, or the set of activities that precedes the physical erection of a structure, is the keystone of the construction process that sets the stage for successful projects. This process has evolved from a meeting and a hand shake to a complex process involving teams of individuals working in unison to minimize errors and maximize savings. The construction industry is rapidly incorporating the use of virtual building tools to assist in this process. The following essay provides a glimpse into this evolution and looks at what the future may hold.

The Ancient Pyramids of Giza, the Caravan Bridge in Izmir, Turkey, The Pantheon, the Taj Mahal; all of these amazing accomplishments continue to serve as monuments to the brilliant minds responsible for their design and construction. Construction, whether arising out of the necessity of habitation, the homage to a deity or purely for art, has been an integral part of the advancement of the human race since the beginning of time. As of August of 2013, construction has evolved into a trillion dollar global industry that drives the economies of many countries (US Census). While many of the materials and methods of construction have remained steadfast over the last 2,500 years, technological advances have greatly increased the productivity of preconstruction, resulting in an increased collaboration between trades, reduced design flaws and omissions, and substantial savings to the owner.

Construction is a complex and often lengthy process. Many laypeople are unaware that a project's success or failure is often determined before the first shovel penetrates the earth. This process, preconstruction, is the set of activities leading up to the physical execution of the project's contract documents. These activities include, but are not limited to, the creation of construction documents, such as the set of building plans, the establishment of the project schedule, project cost estimating and subcontractor selection. A mistake in a preconstruction activity, if caught early, results in little added expense or delay to the project. However, if this same mistake is not realized until after the contract documents have been executed, this error or omission could potentially lead to exponentially increased costs and delays in schedule, and can often derail the entire project progress up to that moment. Preconstruction costs are only a small percentage, in the range of 1-3%, of the project costs of a project but, are responsible for establishing

the majority of the budget of the project (O'Neal). The integral steps of the preconstruction phase of the project include project design, estimating, scheduling, subcontractor selection and materials procurement. These activities determine the project costs and flow, ultimately determining if the project will be a monumental success or disastrous failure. Errors in these steps can lead to change orders, costing time and money, which can often result in entering the lengthy and costly litigation process, a process in which neither party wins. When you think back to the time when the great monuments of the world were constructed, it is mind blowing to think of the obstacles they had to overcome during the duration of the projects they undertook. Unlike the building geniuses responsible for the great wonders of the world, today's builders utilize technology that has greatly increased the accuracy with which the programs for the construction of buildings are created.

The invention and advancement of computers has forever altered the history of mankind. In the last 100 years, man has gone from a pencil, paper and traditional drawing tools to advanced computers capable of running a full simulation of the construction of the building in a virtual world. Today, technological milestones are measured in sprint distances compared to marathon distances just thirty years ago. In recent history, many companies have utilized programs such as Microsoft's Excel and Project, Primavera's P3 or P6 and Autodesk's AutoCAD to help them develop a project's design, schedule, estimate and budgets. These advancements not only saved time, but dramatically simplified the overall process of preconstruction, leading to increased savings to the project owner. These programs have aided the designers and project managers to overcome many of the obstacles and challenges they face on a daily basis.

According to survey of construction industry professionals, as can be seen in Charts 1 and 2, some of the most common obstacles to a project occur during the preconstruction phase

(Singleton). With the advancement of technology to incorporate the virtual construction of a project, many of these problems can be eliminated. The implementation of these technologies has also brought about an increased collaboration between the architect, the owner, the general contractor, subcontractors and material suppliers, all of which

leads to substantial savings to the owner. As innovation has led to virtual worlds being created for computer games and movies, this same technology is gaining momentum in the construction industry.

Many companies today are beginning to implement the use of these technological advances. While many of these companies do not utilize the same software programs, they all expect to realize the same benefits before, during and after the project. According to the WM Jordan Construction company website, the company utilizes virtual construction to establish expectations early in a project's planning phase, during the design phase for the submission of shop drawings and clash detection, and after the completion of the project for facilities management. Manhattan Construction Group believes that the use of building information modeling (BIM) “provides early and tangible 3D visualization of projects and, reduces costs by early identification of value management opportunities.”

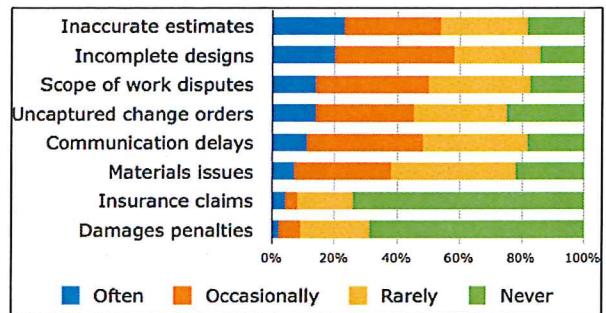


Chart 1 - Project Budget Obstacles, Singleton

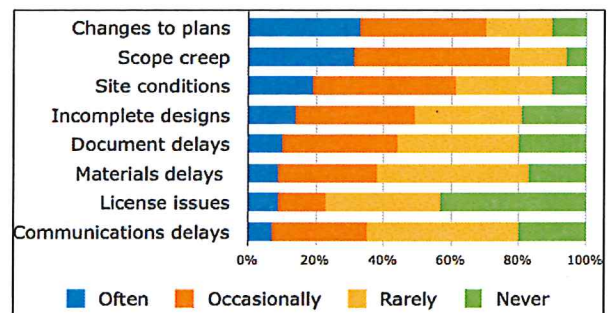


Chart 2 - Project Design Obstacles, Singleton

Some of the other benefits of implementing advanced technology include accelerating schedules, identifying errors and omissions, and increased collaboration throughout the project. No matter if a company prefers Bentley Systems, Graphisoft, Navisworks or any other up and coming platform, BIM provides an opportunity for the architect, builder and

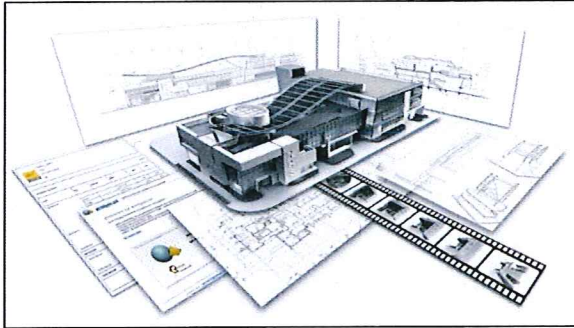


Figure 1 - BIM components, Spiliotis

owner to sit down and discuss crucial elements of the building visually before the design has been completely finalized. The specialty subcontractors and materials representatives can then assist in the finalization of the

placement of the mechanical systems and the materials being used during the project to ensure any potential conflicts between systems is recognized before the project documents are finalized. It also provides them an opportunity to address any items missing from the design that are critical to the completion of their portion of the project. This collaboration is critical in establishing a good working relationship with all the parties involved in the project. BIM also provides an opportunity for project personnel to experience the project in 4D, which adds the element of the schedule to the model and even 5D, which incorporates the budget information in the virtual model. Another current innovation being utilized is the implementation of tablet computers and their accessories. Balfour Beatty, a leader in the construction industry, recently transitioned from paper plans to using Apple iPads and Apple TV to save money on printing expenses; they are expected to save \$5 million on construction documents alone on a single project they are currently working on at the Dallas/Fort Worth International

Airport (Rosoff). By using one of the many emerging, plan viewing tablet applications, or apps, as they are commonly called, the company was able to eliminate paper copies and, when paired with Apple TV, these plans can be displayed on TVs, projectors or video boards of any size for large audiences when necessary. One of these apps rapidly gaining popularity is Plangrid, which can also provide instantaneous updates on plans whenever changes or revisions are made so the parties involved in the project are never working with out-of-date drawings. Programs, or apps, such as Plangrid are expected to shave thousands, if not millions, of dollars off project budgets simply by eliminating the use of paper (Mathis). While there are many other computer programs being utilized by the industry, one cannot help but wonder what is on the horizon for the construction industry.

Several new technological advances may also soon become necessities for construction companies for the successful execution of a project program. An attachment for a tablet that provides 3D scanning of objects may be utilized to scan areas of a building undergoing a remodel or renovation for which LiDAR scanning is impractical. These scans can then be converted to CAD files, providing accurate plans for projects



Figure 2 - iPad compatible scanning accessory - Flaherty

with no existing as-built drawings. They can also be used to update construction documents during these types of projects, converting them to final as-built drawings for each trade or system as the work is completed. Google has

recently announced and will soon release their 'Google Glass,' a futuristic glasses-like

headset, featuring a small digital display, capable of taking pictures and video, providing live video feeds to what the wearer is seeing and sending messages, among other things, may soon be utilized in the industry. As this type of technology advances at a rapid pace, these glasses may soon be the simple virtual reality, intelligent display glasses dreamed of so many years ago. These glasses could be used to provide instantaneous feedback on issues encountered in the field or to provide visual display to multiple individuals when large displays are impractical or unavailable. The ever changing world of computer technology shows no signs of slowing down and one cannot help but be excited for the future of our industry. As someone who is soon to enter the professional world, I see boundless opportunities for the projects I will be undertaking.

As a Project Manager, I would try to implement as much technology in the project planning and execution as possible. Relatively new software, Innovaya Visual, would be the BIM program I would choose to utilize during the preconstruction process. The most attractive aspect of this product is its ability to incorporate data from programs I am currently familiar with in the development of the project BIM. This program is capable of utilizing Microsoft's Excel and Project, Primavera P6, and AutoCAD, as well as others. It also has the capabilities to run clash detection, is linkable to data from RS Means, and includes its own scheduling and estimating platforms, with all data also being exported in platforms commonly utilized by others within the industry (Innovaya). Some companies, such as Exponent Engineering and Scientific Consulting, have tracked savings on projects in which they have utilized BIM and have averaged a 50% reduction in design time, an 80% reduction in estimating time, 60% fewer RFIs, a schedule savings of 7%, and most amazingly, no mechanical, electrical or plumbing change orders. These

numbers represent a dramatic savings to the owner who selects a construction firm capable of creating accurate models. During the preconstruction of the University of California at San Francisco Medical Center at Mission Bay, the general contractor, DPR Construction, and its collaborators claim to have saved the hospital an estimated \$100 million from the budget and approximately 5 months off the schedule, according to Kerry Dolan, in her article 'Building A Hospital out of Bits and Bricks.' Not only did the project see dramatic savings during the preconstruction process, the facility was able to open ahead of schedule, which allowed the owner to generate revenue earlier than expected. Utilizing these innovative technologies will lead to increased collaboration between all parties undertaking the task of completing a challenging project. The early involvement of the often overlooked players in the design phase, the specialty trade subcontractors and material suppliers, provides these parties a platform to convey their concerns and needs, which allows these companies to feel as if they played a greater role in constructing each structure in the safest, most efficient way possible, while delivering quality that exceeds the owners expectations. This increased inclusion will result in a greater sense of pride among all the parties involved and a more positive attitudes of those in authoritative roles, leading to a trickle-down effect reaching all the way down to those responsible the physical construction of the project. I would also attempt to persuade the company to implement the use of a durable tablet computer capable of running applications such as Plangrid and that are capable of connecting to multiple display media. Having the entire set of current plans on a small computer device capable of instant updates and visual displays for those in the field less familiar with reading

plans will help break down some of the technical barriers that exist between office and field personnel.

Preparing future construction management is the focus of several educational programs at institutions of higher learning around the world. The education I have received at Texas A&M University has prepared me for my future within the industry. Introducing students to such preconstruction tools as Microsoft's Project, On Center's On Screen Takeoff, and Primavera's P6 allows these future professionals to easily transition to other, similar programs that are currently being utilized around the industry. Perhaps the most important programs I have been introduced to are Autodesk's Revit and Trimble's Sketchup. These two virtual building tools have shed light on the rapidly developing utilization of virtual building tools in the industry. Just as my knowledge of AutoCAD helped me in learning the nuances of Revit, my new knowledge of the previously mentioned programs will allow an easier transition into the industry than had I not been introduced to them.

A project's success or failure is often determined in behind the scenes meetings that occur well before the first construction laborer steps foot on site. This labor intensive process, preconstruction, can often lead to the loss of the project if the correct steps are not taken. Lots of the work done for projects never gets recuperated if they do not go the extra mile and are awarded the project, technology will provide a shot in the arm for an industry on the upswing. The increasing inclusion of virtual construction tools will drive innovative thinking and early resolutions to complex problems as a result of collaboration, leading to greater efficiency, less wasted time and energy addressing changes in the scope and increased cost savings.

## Bibliography

Dolan, Kerry. "Building A Hospital Out Of Bits And Bricks." *Forbes*. Forbes Magazine, 9 Sept. 2012. Web. 15 Sept. 2013.

<<http://www.forbes.com/forbes/2010/0927/technology-virtual-construction-3d-software-ucsf-hospital.html>>.

"Innovaya Products - Overview." *Innovaya Products - Overview*. N.p., n.d. Web. 5 Oct. 2013. <[http://www.innovaya.com/prod\\_ov.htm](http://www.innovaya.com/prod_ov.htm)>.

Flaherty, Joseph. "This amazing accessory turns your iPad into a 3D scanner." *Wired UK*. N.p., 23 Sept. 2013. Web. 24 Oct. 2013.

<<http://www.wired.co.uk/news/archive/2013-09/23/accessory-turns-ipad-into-3d-scanner>>.

Mathis, Joel. "Plangrid brings iPad to construction sites." *Macworld*. N.p., 6 Apr. 2012. Web. 24 Oct. 2013.

<[http://www.macworld.com/article/1166246/plangrid\\_brings\\_ipad\\_to\\_construction\\_sites.html](http://www.macworld.com/article/1166246/plangrid_brings_ipad_to_construction_sites.html)>.

Rosoff, Matt. "Huge construction firm uses iPads and Apple TV to save millions."

*CITEworld*. N.p., 28 Mar. 2013. Web. 24 Oct. 2013. <<http://www.citeworld.com/tablets/21639/balfour-beatty-dfw-airport-ipads>>.

Singleton, Derek. "Construction Project Management Software UserView | 2013."

Software Advice, 18 Mar. 2013. Web. 05 Oct. 2013.

Spiliotis, Apollos. "What is BIM?." *What is BIM?*. N.p., n.d. Web. 27 Oct. 2013.

<<http://apollospiliotis.prosite.com/1591/595212/portfolio/what-is-bim>>.

"Construction Spending." *Construction Spending*. N.p., n.d. Web. 27 Oct. 2013.

<<http://www.census.gov/construction/c30/c30index.html>>.

"Virtual Construction." *Contractor Using*. N.p., n.d. Web. 27 Sept. 2013.

<[http://www.wmjordan.com/services/virtual\\_construction.html](http://www.wmjordan.com/services/virtual_construction.html)>.

"Virtual Construction « Manhattan Construction Group." *Manhattan Construction Group*

*Virtual Construction Comments*. N.p., n.d. Web. 22 Oct. 2013.

<<http://www.manhattanconstructiongroup.com/manhattan-construction/services/building-information>>.

"Virtual Design & Construction (VDC) in Project Delivery." *Exponent Engineering and Consulting Services*. N.p., n.d. Web. 27 Sept. 2013.

<[http://www.exponent.com/virtual\\_design\\_project\\_delivery/](http://www.exponent.com/virtual_design_project_delivery/)>.

"What is PreConstruction? An O'Neal Perspective." : *O'Neal Inc.*. N.p., n.d. Web. 5 Oct. 2013. <<http://www.onealinc.com/news22.php>>.