Virtual Design and Construction

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Virtual Design and Construction (VDC), sometimes referred to as Building Information Modeling (BIM), is revolutionizing the construction industry. VDC is a term used to describe the application of 3D design and modeling software to enhance the design process, improve coordination, and enhance management of construction. Not since the Critical Path Method of scheduling a project was introduced nearly eight decades ago has a system so significantly shaped design and construction, and this revolution has only begun.

3D design software has been available for architectural and construction management purposes since the late eighties to early nineties. While available for many years, cost of use hindered its acceptance. For example, one of my projects in the early nineties involved the design and construction of a highly advanced facility in which critical elements of a future orbital telescope were to be assembled. The end-user was concerned the satellite vehicle would not fit into the facility. They requested we produce a 3D animated presentation to demonstrate that the facility would house the satellite. The 3D design required to produce the animation cost three times what the 2D design had cost. By the time our team completed the 3D design and rendered that design and animation, all of which was available in the design software, the cost of the design was five times the 2D design. In addition, the rendering and animation required two very expensive computers to run overnight, and that overnight processing was not flawless. Today, the 3D design software can run on most laptops with rendering and animation occurring almost instantaneously. Lower computing cost, ease of use, extensive vendor support of 3D product libraries, and recent advances in things like GPS and Virtual Reality have radically altered the landscape; adoption of VDC throughout the industry has increased rapidly. Following are some examples of VDC's transforming impact on the design and construction industry.

Customer Centered Design

The discipline of design includes discovering and documenting a client's intent. VDC enhances both discovery and documentation. During the discovery phase, as an example, a VDC engineer builds a full 3D model of what is believed to be the client's intent. This model may include such things as furnishings, fixtures, finishes (such as stone or wood), colors, textures, and shadows that are

consistent with anytime of day. With the use of Virtual Reality, the client can walk into and experience the space that has been designed at nearly photographic quality. A similar experience to this was discussed by one of our employers and is described below.

The future – it is not that far away.

One of our employers was contracted to build a surgical room for one of the nation's top surgeons. The room would be housed within a prestigious hospital. It became clear that the surgeon had difficulty imaging the new room using 2D drawings so the contractor's VDC engineer designed the room complete with operating table, control panels for a robotics system used in surgery, and various display monitors. The surgeon slipped on VR gear inside of a VR suite and was immersed in the experience of his surgery room. He approached the operating table, looked around the room, and asked that some of the display monitors be moved further away from the table. The VR engineer, who was in the VR suite, moved the monitors in the virtual world until the surgeon was happy with the result. The surgeon then reached for the robotic controls and asked that they be moved closer. The VR engineer moved the controls towards the surgeon until the surgeon was happy with the result. Had traditional design and construction methods been used, the surgeon's concerns would not have been apparent until after construction was complete. Alterations after construction would have necessitated increased cost to the hospital and delayed completion of the lifesaving and revenue generating surgery room.

Clash Detection

Design evolves through various phases. Architectural drawings often come as one of the first phases, followed by mechanical systems, and then electrical systems. Sometimes in this evolutionary process, one system might be designed in a way that interferes with another system such as ductwork being shown on the drawings in the same location as electrical conduit. Or, maybe two pipes were designed to be installed next to one another, but one pipe has a valve that would not turn completely because it would hit the other pipe. These interferences are called a clash and the only way to find them using traditional 2D methods was the eye and experience of the designer. One of the early uses of VDC was Clash Detection. In the 3D environment, VDC software examines the document for clashes, this includes turning every valve and examining every foot of pipe and ductwork to ensure that one element does not clash with another element.

Production

VDC has allowed some aspects of the work to become an assembly process rather than a process of construction. For example, a sprinkler pipe contractor used GPS techniques to locate in the partially constructed building all the attachment points that would be used for installation of the sprinkler pipe in a large multi-

story commercial building. The sprinkler pipe would hang below a concrete floor poured overhead. At each point, the contractor drilled a hole and inserted the attachment device into the form before concrete was poured. The sprinkler contractor returned after the concrete was poured and took a GPS reading from each of the attachment items because some of those items had shifted slightly during placement of the concrete. Using these GPS points, and other measurements taken of the project, the contractor's VDC engineer drew the sprinkler pipe, including corners, elevation changes, and points of attachment. In the shop, the contractor cut and assembled the pipe into forty-foot segments and shipped those segments to the jobsite. The installation team unloaded the sections of pipe, put each section on a rolling lift, moved the section into its proper location, lifted the section, and bolted it into place. Rather than constructing on the site where safety risks and labor costs are high, most of the labor was done in a controlled, indoor environment at table height. Site work could be thought of as "some assembly required" rather than construction. Similar techniques are being used to assemble and install entire bathrooms in hotels, bedrooms in apartment buildings, and modular specialty rooms for hospitals.

X-Ray Vision

Using Augmented Reality (AR) headsets, it is possible to see what is inside a wall when the AR is connected to VDC. What is seen is not actually inside the wall, but rather is a virtual representation of what is inside a wall. A person sees the wall just like looking through glasses but projected onto the glasses is a virtual representation of what lies inside the wall. What is inside the wall is being created by the VDC model that includes pipes, wires, studs, and all other elements that lie within the wall. This technology can be valuable for organizations who do a lot of renovation and upgrade work, such as universities or hospitals. If a hospital, for example, wanted to convert a room into a new surgical room and the new room was adjacent to an existing surgery room, VDC could help the design and construction team to locate utilities inside the wall. People on those teams would put on AR headsets that were attached to VDC and then could visualize inside the wall the precise location of crucial utilities, such as an oxygen pipe that was supporting life saving equipment in the adjacent surgery room. In this way, the construction crew demolishing the wall would not accidentally break and disrupt oxygen that might be maintaining life in the adjacent room.

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Planning

One of the most important uses of VDC is to aid the construction team in planning the project. VDC allows everyone on the team an opportunity to visualize their portion of the work, see how it interacts with the work of others, and this can be done in a team meeting that promotes discussion and improved coordination. In addition, VDC's tools allow users to schedule every aspect of the project and then the software will build the project virtually before it is built on site. Project teams can run what-if scenarios with the intent of optimized efficiency and reduced schedule. The Ledenhall skyscraper, a fifty-two-story commercial building in the heart of London, was built thirty-two times in the virtual world before the team hit on the most efficient and time saving approach to construct the building. Sometimes, a large custom home takes two years to be constructed, and yet the core and shell of the 610,000 square foot Ledenhall building was constructed in just under twenty-four months.

Some of the VDC methods used by design and construction professionals to innovate and revolutionize the industry have been presented in this article. While this article is not an exhaustive examination of the methods being applied, it is a representation of approaches that have emerged recently and are impacting the industry significantly. There is much more to come, such as robots that are guided by VDC models to assemble our buildings and recreational places of the future – it is not that far away.