The Benefits of Virtual Reality KAUSHAL DIWAN, RAYMOND HUYNH, OCEAN VAN

Virtual Reality (VR) is a technology that is ready for large-scale implementation on projects that fulfill the criteria outlined in this document, which summarizes the results and findings of the VR Initiative implemented on several DPR Construction projects. Based on these findings, DPR is working on a rollout plan that details various technical requirements to successfully implement VR at the project level.



INTRODUCTION

DPR's strategy around technology and innovation is to adopt new technologies that have the potential to increase value for owners and improve the predictability of project outcomes. Many commercial construction projects deploy an array of new or emerging technologies, such as Unmanned Aerial Vehicles (UAVs), 3D printing, laser scanning, digital offsite prefabrication, and 4- or 5-D BIM, etc., to help drive innovation, improve productivity and increase collaboration. None, however, match the promise of VR to transform the way we visualize and consume information on projects.

Once relegated to the gaming and entertainment industries, and decades after unsuccessful experiments with VR in the 1980s

and '90s failed to live up to the hype, VR has made some giant strides forward in recent years.

Today, the technology is coming into its own, with diverse applications being implemented across multiple industries. And the construction industry is beginning to take note. In a survey of construction technology trends conducted by ARC Document Solutions, Inc. (2017), nearly two-thirds (65.3%) of industry participants ranked the growing use of VR applications as the number one tech trend, surpassing UAVs, the 'internet of things" and paperless environments. (http://www.prnewswire.com/ news-releases/arc-document-solutions-survey-identifies-current-construction-technology-trends-300211053.html).

When DPR first began experimenting with the technology back in 2010, the only option was to hire VR developers to build custom commercial applications. Location and cost were major hurdles to overcome before VR could be more widely adopted. Project team members had to physically travel to a VR company's immersive virtual environment room (i.e. CAVE) to step inside the VR simulator. Costs were also considerably higher, requiring the user to pay for the customer VR development and room rental.

As an early adopter, DPR recognized its potential to enhance collaboration and communication among project teams, architects and designers, owners and end users. In 2014, DPR dove headfirst investing time and effort to better understand how immersive visual experiences could help streamline expectations for project delivery and potentially reduce the cost of rework. (Learn more at https://www.dpr.com/media/blog/is-this-virtual-re-alitys-turning-point).

A QUICK ASIDE: VR VS. AR

At this juncture, it is important to make a distinction between VR (virtual reality) versus AR (augmented reality). While sometimes used synonymously, there is a clear difference:

- VR is an artificial, computer-generated simulation or recreation of a real-life environment or situation. It immerses the user by making them feel like they are experiencing the simulated reality firsthand, primarily by stimulating their vision and hearing.
- AR is a technology that layers computer-generated enhancements atop an existing reality to make it more meaningful through the ability to interact with it. AR is developed into apps and used on mobile devices to blend digital components into the real world in such a way that they enhance one another, but can also be told apart easily.





REALITY

AUGMENTED REALITY (AR)

Source: Re-flekt GmbH

VIRTUAL REALITY (VR) Note that there are two types of VR setups, Mobile VR and Console VR. Mobile VR requires a mobile device such as an iPhone, Samsung or Google Pixel, and a headset, such as a Google Cardboard, Samsung Gear VR, or Google Daydream. The VR content in this set up is from a mobile app and the device is turned to landscape mode when viewing in the headset. On the other hand, Console VR requires a VR-ready laptop or computer and a console VR device like Oculus Rift or HTC Vive.

This paper focuses solely on Console VR technologies because it has provided more applications than the mobile VR setup.

Mobile VR Phone Required



Google Cardboard





Google Daydream

Zeiss VR One 🗡



Samsung GearVR

Console VR Computer Required





Oculus Rift

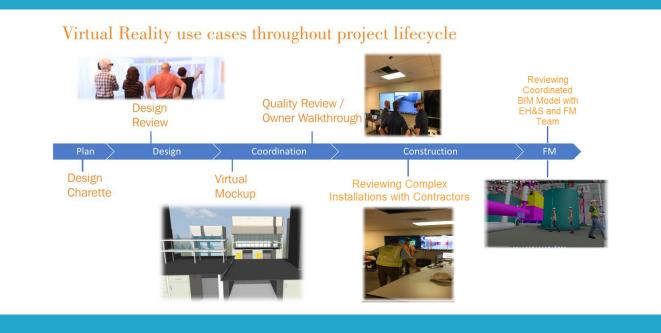
PlayStation VR



Google Cardboard image courtesy of Maurizio Pesce https://creativecommons.org/licenses/by/2.0/legalcode

When, Why & How to Use VR

When is it appropriate to use VR on a construction project? VR technologies can be implemented throughout the entire project life cycle to add value and greater predictability to projects.



Virtual reality use cases throughout project lifecycle. (Source: ICon Lab, Penn State)

DURING PLANNING AND DESIGN

- VR can be immensely useful at the earliest stage of a project to help teams perform an end-user study and gain insight from those who will be using the space. The team is then able to incorporate end-user's ideas and feedback into the design/ drawings.
- Users can provide valuable insights into the moods of various spaces, furniture layouts for offices and lobbies, medical equipment layout for hospitals, workflow of staff, check visual line of sights for nurses and security guards, safe access for facility managers, etc.
- VR also extracts the metadata from users, tracking where users focus their gaze in the virtual space and foot traffic through heat maps. This helps reveal patterns in which users are interacting with the building, that can help influence space utilization and provide data for development and validation of architectural features.



A VR session with doctors and nurses at a medical center project in Tucson, AZ. A project executive for the owner said, "This was much more personal and intimate. I definitely see a great value in being able to walk around rooms, almost touch things, get a sense of scale, walk out of the room into other parts and just get an immediate personal view of the space is fabulous."



The pilot plant operations team for a project in the Bay Area ensures the spacing around process piping and equipment meets user access requirements.

DURING PROJECT PURSUIT/COMMUNITY OUTREACH

- During project pursuit, VR can be used to show how DPR approaches the project and tackles challenges. This helps key project stakeholders better visualize and understand the logistics around their projects, as well as allows for better communication among team members.
- VR can also be used to create excitement with the public and end-users, showcasing the project.



CEO and design consultants of a new biotherapeutics manufacturing facility had an opportunity to walk through their future facility in virtual reality. The session built excitement with the executive team about their new facility, which will develop immunotherapies for the treatment of certain cancers.

DURING COORDINATION/CONSTRUCTION

- VR can be used to create virtual mockups in lieu of physical mockups that enable better visualization of distinguished finish features and complex installations, which are sometimes misinterpreted when only viewed on screen. This immersive VR environment helps to align expectations for installation of complex or high-end finish work among owners, designers and contractors. Some examples where this has proven valuable include:
 - typical patient rooms with complex systems that affect both patients and facilities managers;
 - operating rooms with complicated medical equipment layout;
 - tight working spaces for physicians/doctors/nurses;
 - kitchen/server areas that need to serve thousands of people each day;
 - a main lobby area, where understanding space and direction of traffic is important;
 - working spaces around lab benches in research facilities; etc.
- During the MEP coordination process, facility managers can use VR to review the layout of access panels to gain a realistic sense for their location and accessibility. Facility managers are also able to review equipment access panel locations to determine the most efficient equipment location and orientation for access and maintenance. This feedback can be tied directly into changes in the BIM to be adjusted accordingly.

• During safety planning, DPR's Environmental Health and Safety team can use VR to review the safety tie-off points and coordinate major crane picks over occupied facilities that cannot be typically shut down for construction work. The immersive VR environment in this context allows for an effective way to visualize and communicate the impact of major construction events in existing facilities that could potentially be missed when viewing through traditional methods.



At a hospital project in Virginia, a virtual mockup of an operation room was rendered in virtual reality for surgeons and nurses to review before construction. The VR mockup cost approximately 15 percent of the budget for physical mockup and the VR session resulted in 35 design changes.

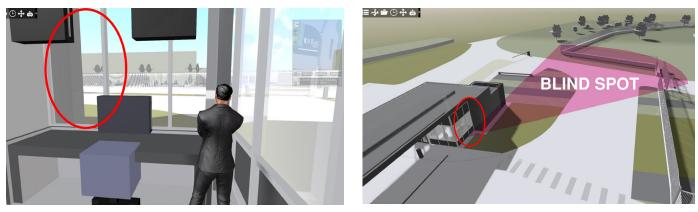
 During site logistics planning, field teams can use VR to communicate the impact and disruption of construction activities to the communities in surrounding neighborhoods, those in adjacent buildings, and those in the same building.

DURING FACILITIES MANAGEMENT AND OPERATION

- The hand-over of a VR model can enable building owners and facility managers to better understand how building systems work. Consequently, it helps them to provide training to building staff and personnel; to provide better maintenance through clear understanding of access requirements, location of equipment, etc.; to create safety plans for areas that cannot be easily accessed (ex: lab spaces, clean rooms, fabrication rooms, operating rooms, nurseries etc.); and much more.
- The final hand-off of the VR model to facility managers also can include metadata that contains the names and properties of equipment as well as operations and maintenance documentation. This further enables facility managers to better inform and train their staff as well as provide valuable building information in the context of where equipment is actually installed.

WHAT IS REQUIRED? HOW TO MAKE VR DELIVER THE MOST BENEFITS

When it comes to deriving the greatest benefit from VR implementation on a project, there are several factors, both tangible and intangible, that play a significant role in the value proposition. They include:



The security team at a data center project in the Dallas-Fort Worth area was able to review the security guard house to review a blind spot issue. The issue was resolved in VR by moving the façade 3 feet, which maximizes the view of the driveway and access gate. Photo courtesy of Piyush Pandey.

THE RIGHT MINDSET

VR is, by nature, a tool used for communication. As such, the success of VR is dependent on a project team's ability to create an environment where people can openly collaborate and contribute to the success of the project. Some of the project environments, tools and delivery methods that can help set the stage for successful implementation of VR on a project include the "Big Room" colocation environment, Integrated Project Delivery and the Design-Build delivery methods. These all foster a project environment that is commonly characterized by:

- A sense of shared responsibility
- High levels of trust amongst team members
- "Problem Solving" mentality versus "Blame" mentality
- Diversity and open mindedness towards trying new technologies and processes





ORIGINAL

REVISED

At a research institute project in Durham, NC, the client had an opportunity to let the CFO review the what the future executive leadership team's suite in VR. This session led to a significant layout revision to the suite as shown above. Fortunately, this effort was done in the early stage of the project so the team was able to revise the floor plan. Images courtesy of Chetan Potdar.

COMPLEX PROJECTS

Projects that are complex in nature and require a lot of cross-functional collaboration between different project stakeholders can derive the greatest benefits from being able to accurately visualize the final product through VR applications.

Examples of DPR project types in which VR has shown the most value to date have included hospitals, clean rooms, labs, data centers, and schools, all of which exhibit complexities in use case, MEP systems design, and stakeholder involvement.



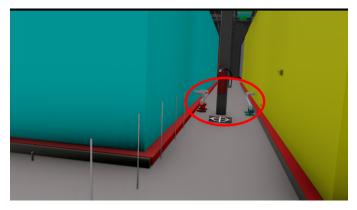
During a VR session at the medical plaza project, the identified window did not provide a clear line-of-sight for ICU nurses to perform a quick assessment of the patient, particularly of the head and chest, and pieces of life-supporting equipment, without obstruction. Photo courtesy of Chidambaram Somu.

SETTING REALISTIC EXPECTATIONS

For VR to have the most benefit to a project team, there needs to be a focus on the specific applications for VR. You wouldn't put the entire model in VR and expect people to find it useful just because they can see the building through a fancy headset, right? We've seen the greatest degree of success from VR when it is used to solve specific user, design or construction challenges. It is instructive to look at specific examples/ questionnaires of what we mean here:

User Challenges – VR can engage the end-user and allow them to provide feedback on an array of areas such as:

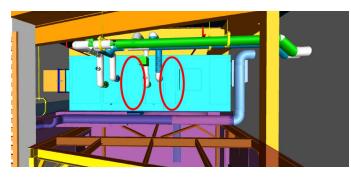
- Do I have enough space to work?
- · Do I have access to critical utilities?
- Am I comfortable when immersed in this space?
- Do I have a visual line of sight?
- · Is it safe to access and comply with safety standards?
- Can pre-manufactured components on equipment be placed more efficiently to work better with the design of surrounding elements?



During a VR session at the same data center project in Texas, the team identified that the mechanical pipes were too close to the structural column, which might cause a tripping hazard to facility engineers. This feedback was incorporated into the design of next phases. Photo courtesy of Piyush Pandey.

Design – VR can help drive a cleaner process during project design by focusing on such questions as:

- When immersed, is the design intent fulfilled?
- Are clearances code-compliant?
- Do finishes look the way designers and owners envision them?
- Am I distracted with a feature that is insignificant when properly visualized?



During a VR session at the research institute project in Durham, the facility engineer had an opportunity to coordinate access to an air handler that was suspended over 11 ft. above ground. The mechanical room space was small and served as a storage room. The team was able to meet the client's needs to have enough space for a 6'-2" engineer to service the air handling unit (AHU), swap out coils, change filters, access to valves and store chairs. Photo courtesy of Chetan Potdar.

Construction – At this stage, VR enhances communication and can reduce rework. Some areas that may be addressed:

- Do we have enough space to install large equipment?
- Am I properly communicating the end result for this installation?
- Are there blind spots that I cannot see in the model or the drawings?
- Can I reduce rework and provide higher quality through better communication with VR?

- Can I provide more accurate costs by visualizing complex assemblies that look simple on paper?
- Can I get buy in from the facility lead, the neighborhoods and the community with plans to mitigate disruptions, through VR?

CONCLUSION

Whether it is during the project pursuit, design development, MEP coordination/installation, safety and site logistics planning, or during the facilities maintenance stage, VR clearly has evolved into a powerful tool with widespread applications. Far more than just a "new technology," DPR views VR as a strategic tool that project teams across the country are increasingly leveraging to add value, increase stakeholder engagement, increase communication, resolve project challenges and ultimately, improve project predictability and outcomes.

Depending on use cases, it does not take an excessive amount of work to render a BIM to VR. And with the necessary, essential VR infrastructure and supporting software in place, DPR teams are increasingly finding that past hurdles they may have encountered have largely disappeared.

So where does a team start when it comes to knowing whether VR is a viable tool to deploy on a new or current project? First, talk to the local BIM /VR professionals. They can help you assess the strategies and applications VR may have on a particular project. Secondly, have a conversation with both the client and the entire project team to assess if VR is the right solution to address specific issues, needs or challenges. And finally, teams should make sure they bring the right mindset, set realistic expectations, and understand the benefits and the best use cases where VR can make a real difference on a project. Given those conditions, VR will only become a more indispensable tool for DPR teams as they continually strive to build smarter, better and faster, both now and well into the future.

For more information about Mobile VR, please refer to the VR Roll-out Plan that is being developed by members of the Tech & Innovation team. While DPR's current efforts are mostly concentrated on applying and implementing VR on various projects, it is important to note that Augmented Reality (AR) is another ongoing corporate initiative that DPR is also researching and piloting on a few projects. We will explore AR in greater depth in future years as its potential applications increase.