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Virtual Reality (VR) Coming to the CRE Industry

*Michael K. Lerg***

*Jeffrey D. Fisher, Ph.D.****

Abstract

Virtual Reality (VR), which allows us to view objects and places as if we were actually there, is expected to have a significant impact on the CRE industry by allowing virtual tours of buildings, campuses, cities and even a planned development project as if it already existed. Users can even make customization decisions in real-time (for example changing decorations, interior finishes, furniture and amenities). This article provides a variety of examples of how the technology has been applied to different types of users to illustrate how readers can best incorporate this new technology into their business.

Virtual Reality (VR) Coming to the CRE Industry

Introduction

The iPhone revolutionized the mobile communications market. It set new boundaries on smart phone capabilities, impacted countless global industries and their economies, and rewrote the meaning of being connected to the information, people and world around us. As impactful as the iPhone has been, the Virtual Reality (VR) Market is expected to grow nearly 5 times faster than the iPhone in the next 3 years ¹, and be worth \$7 Billion by 2018 and \$30 Billion by 2020 ². This growth and proliferation is likely to be disruptive to and create opportunities for the Commercial Real Estate (CRE) industry.

Given all of the media attention focused on the current wave of VR technology about to enter the market, it is difficult to wade through all the hype and find the true value of Virtual Reality (VR). Furthermore, as with the marketing of “3D” a few years back (as in [stereoscopic](#) ³ [3D televisions](#) ⁴), many of the technical terms can be misused or completely repurposed for marketing which can greatly confuse the average consumer. Therefore, the goal of this article is to not only clarify VR’s current “state of the art”, but to provide an overview of this technology and some of the key terminology that we should be familiar with to know how to make the best use of this new technology.

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What is VR?

The primary goal of VR is to provide the user with an immersive experience that makes them feel as though they are somewhere else, whether it be real or fictional, existing, or not. The key word above is “immersive”. In terms of the technology running behind the VR experience, some provide a more immersive experience than others.

Currently there are two primary types of VR experiences:

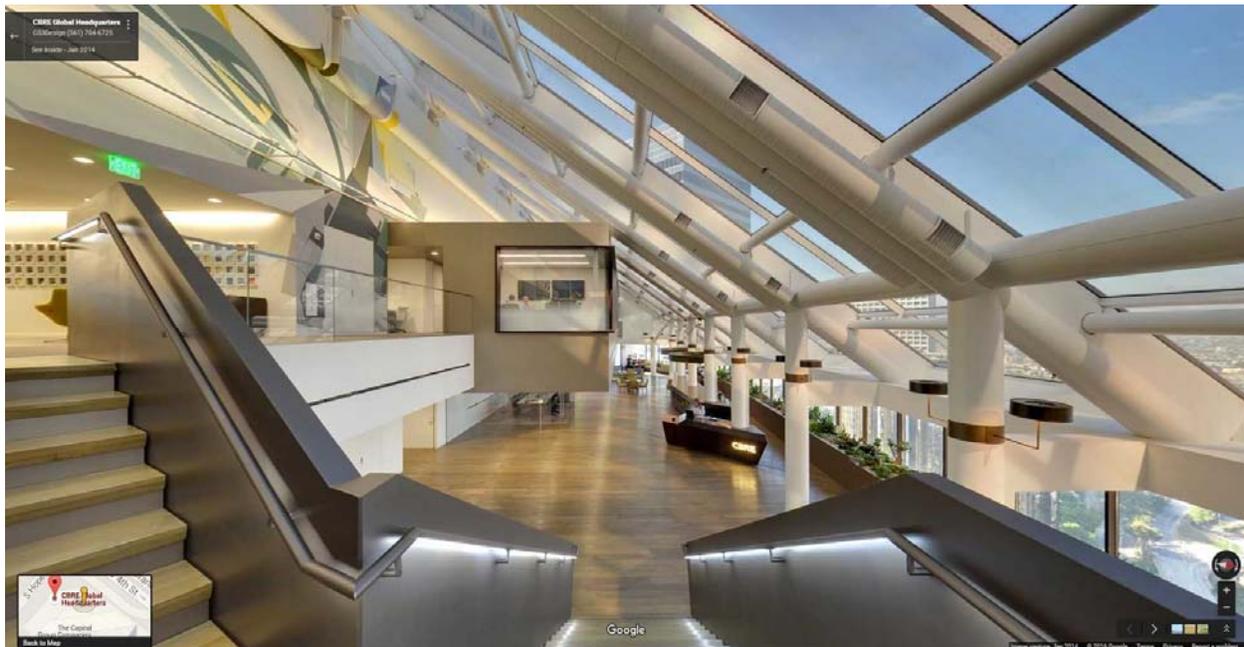
1. Spherical or Cylindrical Panoramic ⁵ images or videos, and
2. Realtime-3D Simulations based on photo-realistic game-engine technology.

The first allows the user to look in any direction from a series of predetermined camera locations or along the path of a moving video camera. This technology is ideally suited for a building or other commercial real estate that not only already exists, but is decorated / furnished and photo-ready for publication. Just as in Google’s “Street View” ⁶, within this type of Virtual Experience, the user can freely look around while inside each spherical image. The user is also able to move from location to location by “jumping” to the next neighboring spherical image. But they cannot seamlessly move from one place to another as with a game-based user experience. This “Street View” type of user experience was originally created over 22 years ago by Apple under the branding of QuickTime VR (QTVR) ⁷. Keep in mind that since these are image or video based user experiences, nothing in the virtual environment can be changed by the user.

<http://goo.gl/maps/l4rhj>

Figure 1 uses the Google Street View type of panoramic technology that stitches pictures together. This is for the CBRE headquarters building in Los Angeles.

Figure 1: Panoramic Picture of CBRE LA Headquarters



In contrast, 3D simulation using gaming technology allows the user to move freely around a building or city and also still view the space from any angle. Furthermore, it can be used to visualize or experience a building or place that does not currently exist such as a proposed development project. It also allows the user to make dynamic changes to the environment such as moving walls, changing windows, changing furniture, etc. Thus, the user can essentially design or customize the future space while standing within it virtually today.

While an image in an article cannot illustrate moving around and changing things in a Realtime-3D application, Figure 2 (below) shows the same CBRE headquarters building, but the image is a screen shot from an interactive and dynamic 3D Virtual Reality Experience created using the PIX platform, which is based on gaming engine technology. What readers should realize is that Figure 2 is NOT a picture that was taken of the space. It is a screen shot from a 3D virtual environment of the space that allows one to move freely around the building. Although Figures 1 and 2 look virtually the same, Figure 1 is based on static photos and Figure 2 is a screen shot of an interactive and dynamic 3D virtual environment. Again, the difference with an interactive 3D application is the things you can do while immersed in the space such as walking to any point in the building and seeing it from any angle, incorporating sound, the ability to change furniture and finishes, the incorporation of data layers, etc. The remainder of this article will elaborate on these capabilities.

Figure 2: 3D PIX Virtual Tour of CBRE LA Headquarters



Using the Realtime-3D PIX platform, this virtual tour allows the user to not only freely look around, but freely walk around, ride the elevator and experience walking in and out of the building's lobby. Embedded within the PIX platform are toolbars that are easily triggered by clicking on the related icon associated with the function that is desired. The top user toolbar has a number of functions including one that allows the user to change the time of day (providing a real-time lighting / shadow study). When the "time of day" function is enabled, a slider bar appears for the user to simply drag a time indicator from morning to night to move the sun through the course of the day. The shading seen in the picture changes depending on the time of day setting (figures 3 and 4 illustrate two different times of day). The toolbar has other functions that allow the user to take measurements, use a laser pointer, view each floor as an isometric illustration (from any angle), give groups of people guided tours, activate a head mounted display (HMD – for example Oculus Rift⁸) or use hand gestures to control the 3D scene using a Kinect⁹.

Figure 3: CBRE LA Headquarters in the Early Morning (9 am)

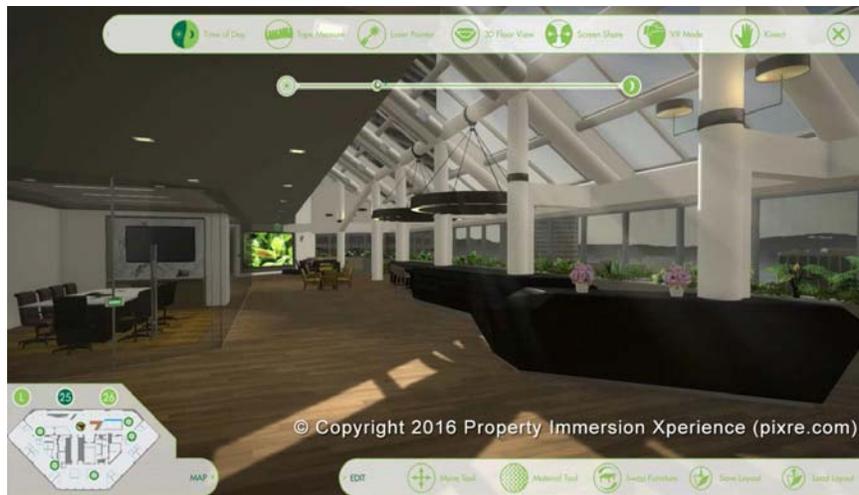


Figure 4: CBRE LA Headquarters in the Early Afternoon (2 pm)



The bottom right bar on the user interface allows the user to move and rearrange the furniture, change its fabric and color, or select entirely new pieces from a furniture library. To move a chair, the user simply needs to enter “edit” mode by clicking on the appropriate button, click on the particular chair in question and then move it by dragging it along the floor using their mouse. The user can also rotate it by clicking and dragging the now visible “handles” on the chair. Figures 5 and 6 illustrate the ability to change textures, change furniture and move furniture. In order to change a surface’s texture, the user can select the countertop of a kitchen to bring up a list or thumbnail images of the various options. Once the preferred image is selected, the new texture is applied. Once configured to the user’s liking, the new configuration can be saved for future viewing and sharing with others such as potential tenants or investors. These capabilities can save time and money in terms of avoiding mistakes on the build out of space, making design decisions more quickly and reducing the time to conclude a lease or sales process by making it easier and faster for the tenant or buyer to evaluate and design the space.

Figure 5: A Normal Day in the Office Layout - CBRE LA Headquarters

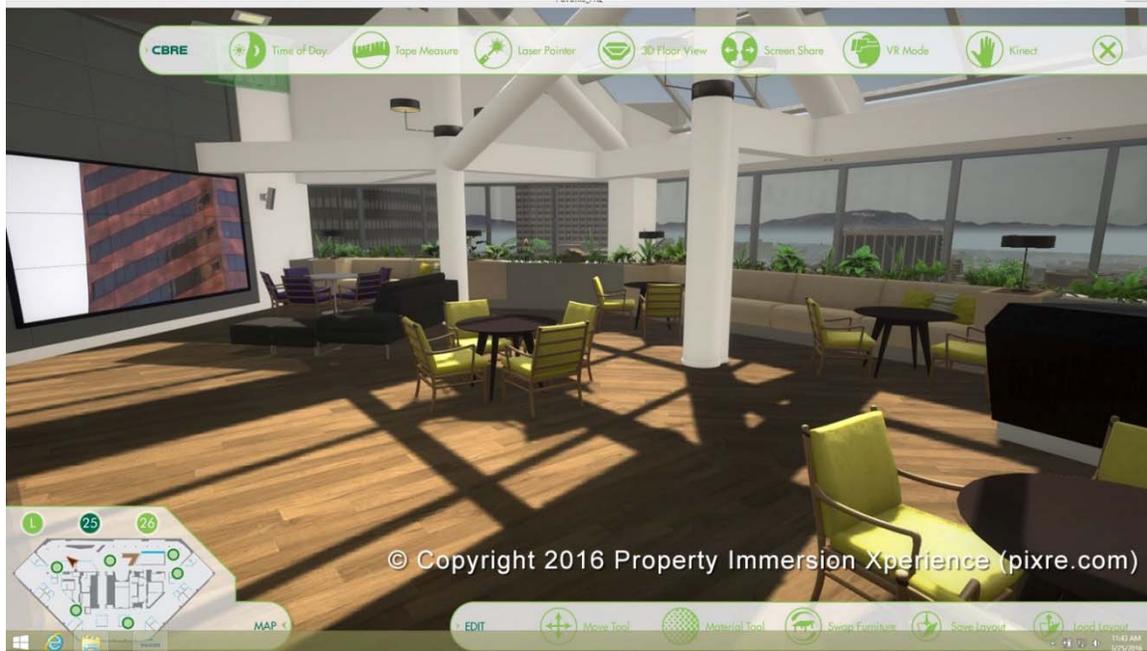
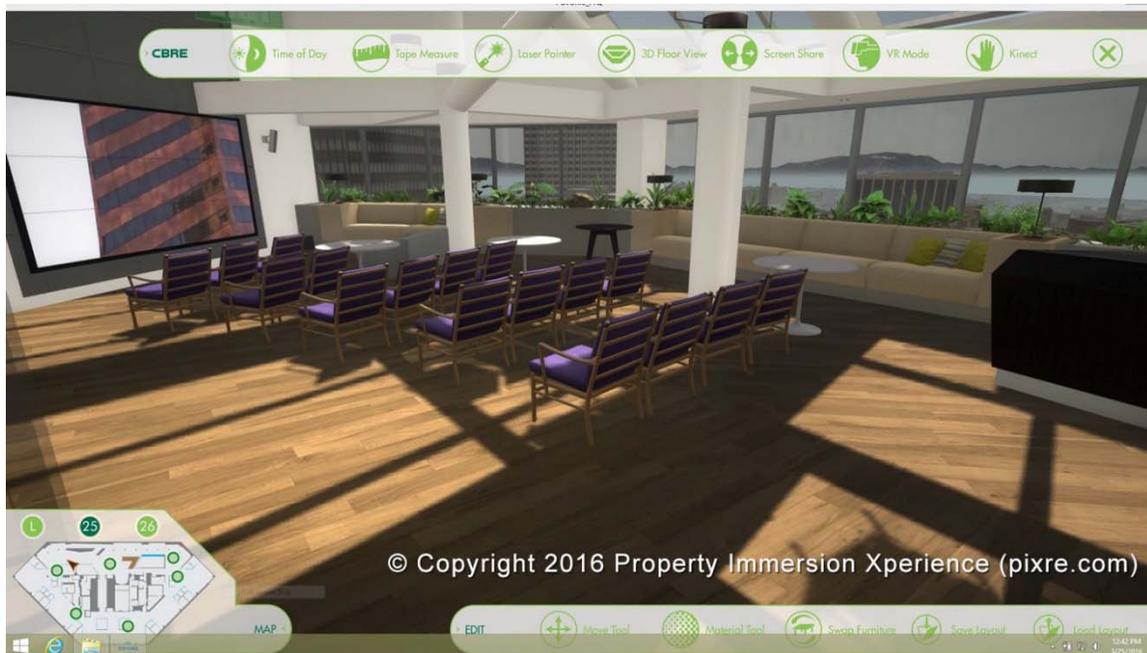


Figure 6: Movies Night - CBRE LA Headquarters



The bottom left Quick-Nav panel allows the user to jump to various locations throughout the building (inside and out), saving the user the time to navigate through the current floor, take the elevator up or down to their destination and then navigate to their point of interest.

When the “Screen-Share” feature is activated, groups of people from around the world can simultaneously be given a guided tour of the facilities. The laser pointers and measuring tapes become key tools in this mode so that the host can point out certain features, or the potential clients can take accurate measurements, and all of the participants can see what each other may be talking about.

This Multi-Player capability allows all of the users to see through the eyes of the guide, or they can each freely walk and look around the virtual environment, completely un-aided. Thus, a broker at one location can be taking a prospective tenant at another location on a virtual tour even though they may be in different parts of the world.

Again, there is both time and cost savings to be realized. Potential buyers or tenants can “see” a range of properties without having to travel to each location. Brokers are able to measure reaction in real time via embedded audio and video capabilities, giving everyone the convenience of not having to be at the space but still see the reaction to the space.

Sound can also be incorporated into the virtual scene. For example, in the above picture at the back of the room, there is a video screen mounted on a wall with sound that gets louder as you approach the screen. This capability can be used to customize and personalize the space for a prospective tenant or buyer. For example, a TV ad or an appearance of the CEO from a potential tenant on a business news show could be playing during their virtual tour.

The above example is intended to illustrate the various kinds of functionality that can be incorporated into a 3D virtual building using the current technology. It clearly could change the way we do business in commercial real estate and what clients and others grow to expect.

Integration with Database and Real-time Data Feeds

A Realtime-3D Virtual Environment can also be integrated with a database that has information about the property. Figure 7 below is a screen shot of virtual downtown Raleigh, NC where the realtime-3D scene was integrated with a database of space for lease from CBRE. When pointing to a building that has space listed for lease, the information shown in the exhibit pops up. This can include information about the space such as the size, asking rent, etc., in addition to the broker contact information.

Within each virtual scene, the individual assets (for example chairs, tables, granite countertops, fixtures and appliances) can be tied to the supply chain information available from the supplier. In this way, when a potential tenant or buyer adjusts a space to match their desired preferences they are able to get information related to the costs, timing and availability of the specific changes that they wanted quickly. This has an ability to significantly reduce the amount of time for a prospective buyer or tenant to reach a decision. This integrated data can even be “real time” with continuous updates into the virtual environment. In fact, virtual environments can even incorporate live security camera feeds so that when you activate a virtual camera in the virtual scene, you can see what it is currently capturing in the actual building from the real video camera.

Figure 7: Integrated Real Estate Listing



Swapping Buildings

Just as furniture can be swapped within a building using the VR technology, entire buildings can be swapped to show what they would look like at a particular location where an existing building is to be torn down or renovated. Figure 8 shows the original hair salon that exists in the location, where Figure 9 shows a McDonalds that is swapped in place of the hair salon. If the property data sets are incorporated, the impact on foot traffic and retail sales can also be simulated.

Figure 8: Downtown Raleigh, NC – Original Hair Salon

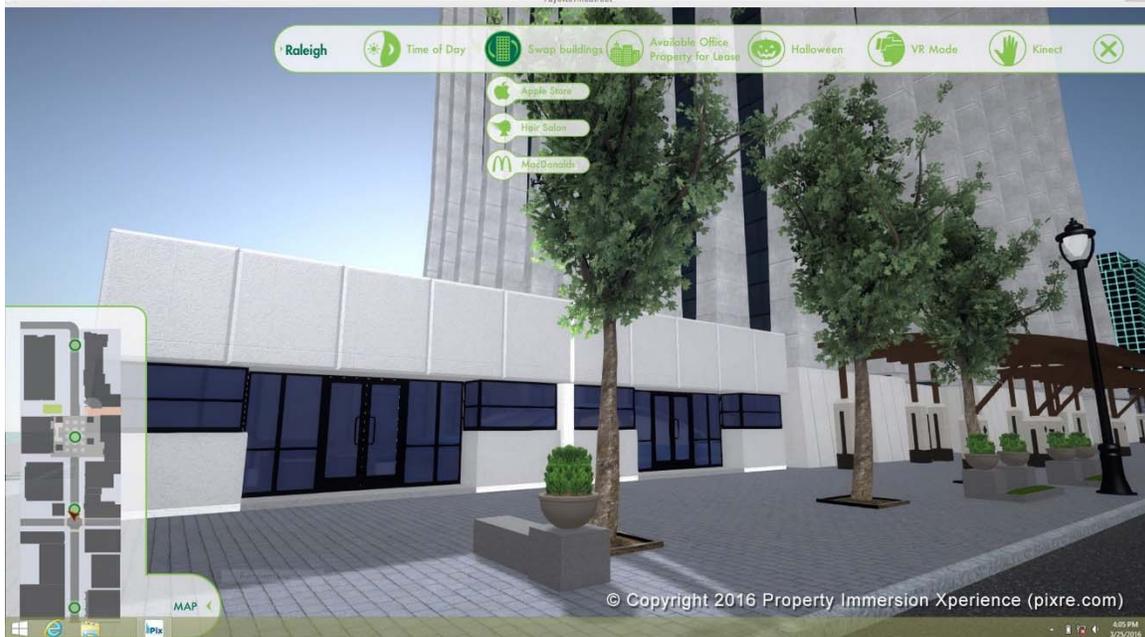


Figure 9: Downtown Raleigh, NC – Building Swap McDonald's



Integrating Marketing

Also, marketing such as having a billboard, pre-recorded or even live video screen incorporated within a virtual environment of existing buildings that already exist but can provide advertising opportunities that don't exist elsewhere – as depicted in Figure 10 below. This is particularly useful in a city or college campus scene where the clients of the virtual environment are seeking sponsorship of its development through advertising revenue and increased web traffic by awarding certain participants with a prepaid gift card. A more subtle approach can also be taken using product placement. Examples include having a certain company's vending machines on every corner or each hallway, or having only one car brand's automobiles driving in the virtual environment.

Figure 10: Downtown Raleigh, NC – Integrated Marketing



Recent Revolution in VR Making this Possible

Until recently the costs associated not only with the hardware and software required to develop and distribute a VR experience, but also to create the Virtual Environment was too costly for the Commercial Real Estate market. The technology was not readily available “off-the-shelf”.

That has now changed due to four key factors:

1. The game engines that used to cost almost \$1M to license per project are now available on a monthly subscription of just \$75 / month per developer ¹⁰.
2. The increasing processing power due to Moore's Law ¹¹ (doubling of processing power every 18 months) has made the hardware smaller and more affordable.
3. The Graphics Processing Units¹² (GPUs) are now providing higher levels of realism at an increasing rate of 4x performance every 3 years. ¹³
4. Advances in the use of the “cloud” and improved data compression and internet connectivity to deliver content whenever needed and wherever needed.

Gaming Engines

Let's look at each of these factors individually. First, although game-based technologies are being used, this is certainly not just a game! The US Military spends billions of dollars every year advancing the use of game-based technologies for visualization of "Big-Data", as well as simulation and training of its personnel on virtual ships, nuclear submarines and aircraft, as well as many of its weapons and communications equipment. Some people refer to these applications as "Serious Games" – since if this training fails and you make a mistake in the field real lives are on the line.

In parallel, the gaming market has grown exponentially over the years, supplying an ever growing source of revenue to the game engine companies. For example, 20 years ago the annual revenue generated by the gaming industry surpassed the movie industry. As clear proof that the trend has continued, John Cameron's movie Avatar¹⁴ (2009) grossed \$77M on its opening weekend. Star Wars VIII (2015) grossed just under \$250M on its opening weekend.¹⁵ However, in 2013 the game Call of Duty: Ghosts racked up over \$1 billion in sales in its first day in stores.¹⁶ Of course, this is a video game. But think of what the future generation of clients will expect that grew up playing these games! And one could even incorporate some "game" aspects into a virtual building. For example, a version of your virtual property can be decorated for various holiday themed events for your current or prospective tenants – like a virtual scavenger hunt, which could be used to address the clicks-to-bricks challenge the retailers increasingly face.

What this means to the CRE industry is that we can access the same technology that has been developed using billions of dollars, to now create photo-realistic simulations of real estate, at the mere cost of \$75 / developer / month (in this case based on using the Unity3D game engine), which has over 4.5 million registered developers.¹⁷

Moore's Law

As for Moore's Law and the increasing processing power, some theorize that the industry is beginning to reach the physical limits of processors at an atomic scale. However it has been shown by Ray Kurzweil that Moore's law was in effect over 100 years ago (50 years before it was documented).¹⁸ Despite the theoretical debate, it is still a huge factor in the miniaturization of the hardware inside the upcoming Head Mounted Displays (HMDs),¹⁹ which include but are not limited to the individual displays for each eye, the built in motion tracking, image processing and countless other electronics. In the past, some HMDs for the military cost over \$100k each. The Oculus Rift which is soon to be released will cost just \$600.

Graphics Processing Units

The performance rate of current Graphics Processing Units (GPUs) are not limited, as the new chips are scalable and can provide massively parallel processing. Their processing power has been greatly accelerating at a rate of 300% every 4 years. Most new computers have dedicated graphics cards designed to optimize the use of game-based applications.

The Cloud

There is increasing availability of cloud processing²⁰. By 2020 5G Wireless Networks will increase bandwidth for wireless internet by up to 1,000x the speed of current 4G networks. In combination these advances will allow the virtual user experience to be processed on a series of servers at

another location and then stream the resulting 4k video resolution for each of your eyes within the HMD... in real-time... This will make the issue of local processing power obsolete; in just the next 4-5 years, your smartphone will likely be as capable as today's super computers.

Considerations for Success

Given the variety of potential VR experiences, it is important that one focuses on their project's objectives before choosing a particular VR solution (the integration of specific hardware, software and delivery method). Below are some topics to consider for determining which technology will be best suited for a project:

1. Does the property already exist?
2. Is it photo ready?
3. Is this a short-term / 1-time project where you only want to depict the property in its current "as-is" state?

If the answer to these questions is yes, then Spherical or Cylindrical photo or video based panoramic scenes may be your best option to provide a VR-based experience at a lower cost.

However, if the property does not yet exist, is currently in the design or construction process, a user wants to start their sales or leasing process prior to completion, and they would like to provide their clients with the option to select and depict numerous finishes and amenities, then using a Realtime-3D technology is required. Even if a space exists, is there a desire to give clients the ability to virtually walk the space as if they were really in it to provide them a much better idea of how they would be able to utilize the space than just looking at a view of the space from a fixed location? Only interactive and dynamic game-based technology allows this experience.

Targeted CRE Uses

In our experience, most people cannot look at 2D construction documents and develop an accurate 3D mental image of a building's design. When combined with all of the choices a client has to make regarding finishes, lighting, amenities, furnishings and decorations, the issue becomes compounded exponentially.

Just as Building Informing Modeling (BIM) enhances traditional Computer Aided Design (CAD) files with data for each object to reduce the design and documentation iterations between the various stakeholders – Virtual Reality (VR) can also help accelerate the design, renovation, and sales or leasing cycles.

- **Architects and Design Firms** can benefit from an iterative review of the virtual experience with their clients, contractors, and developers – expediting the approval process by all stakeholders.
- **Developers** can provide a complete showroom experience to local or remote clients that allows them to select their own finishes, furnishings and other amenities – before ground

breaking. Suppliers of materials are able to integrate their supply chain processes with the developers and effectively design, order and deliver materials for construction of the space.

- **Brokers** can show prospective tenants or investors the space without the client needing to physically visit the space. VR tools can also be used to materially shorten the time needed and cost of completing test fits of spaces for potential tenants. This can shorten the transaction process and lead to a more efficient market. Investors and tenants can view more spaces in a shorter timeframe with less travel.
- **Construction and Renovations** can be clearly visualized at various phases of the process, assuring that the client understands the impact of their design decisions. It also allows the contractors to have better visual references. In addition, if an issue arises, all of the stakeholders can instantly be in the space from remote locations to see and better understand the problem, which should allow for a more rapid decision in how to resolve it.
- **Relocations** can be simplified for employees by allowing them to get familiar with their new work environment before they move in. The cost of change management to companies can be greatly reduced.
- **College / University Housing** can ease the search process for both the students and their parents by providing a virtual experience of the various room selections, common areas, study halls, and other recreational amenities. It is also a great way for developers and property owners to let students know about their project before they visit campus given them a competitive edge.
- **Property Management** can be integrated into the virtual environment by combining your existing database listing each property's availability status, square footage, maintenance requests or records.

Figures 11 to 13 below show screenshots of a Realtime-3D interactive and dynamic virtual student housing project done for IPA at the University of Illinois. Students exploring housing options can take a virtual tour of the property including looking at the specific unit that they might rent and even see the view from outside their windows.

Figure 11: Student Study Area

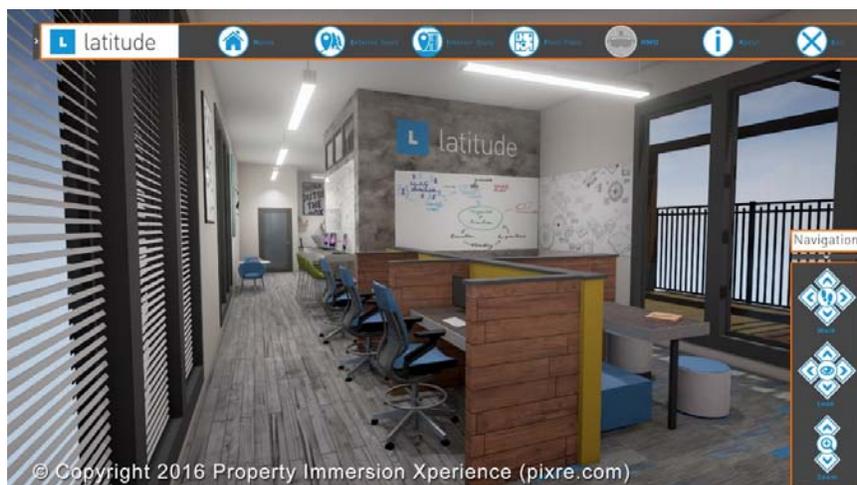
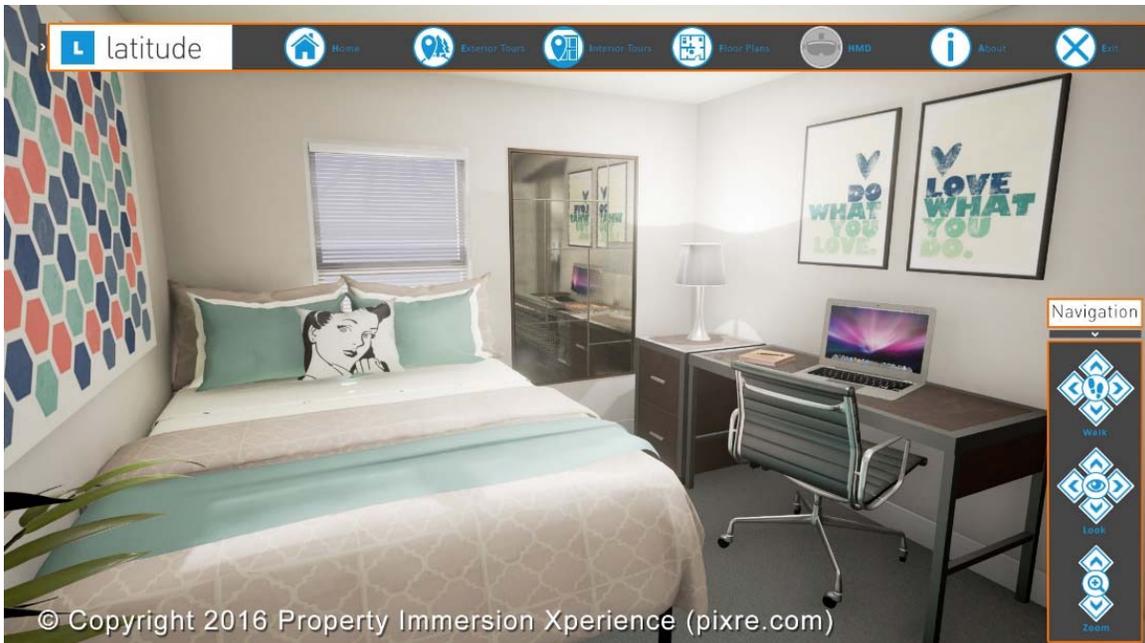


Figure 12: Poolside



Figure 13: 3 bedroom unit



To assist with relocation and change management, a virtual environment replicating the new ExxonMobil office building in Houston was created. Figures 14 and 15 below are from that user experience, and the illustrations are not photographs of the existing space but virtual scenes created from the plans, specifications and data base used in the design of the space before it was built.

Figure 14: ExxonMobil IT Support Area



Figure 15: ExxonMobil Courtyard



Virtual Environments can be created for a corporate campus to promote the company just as they can for a college campus to promote the university and help orient new students. Universities can also use Virtual Environments to assist with alumni engagement and recruiting.

Figure 16 (below) is the Old Bull Building Courtyard at the American Tobacco Campus in Durham, NC – it is the oldest building in Durham, which has been converted into Luxury Apartments. While on the Virtual Tour of the Old Bull building, the fire can be seen flickering as it would in real life. It's about as real as you can get without actually feeling the heat from the fire!

Figure 16: Old Bull

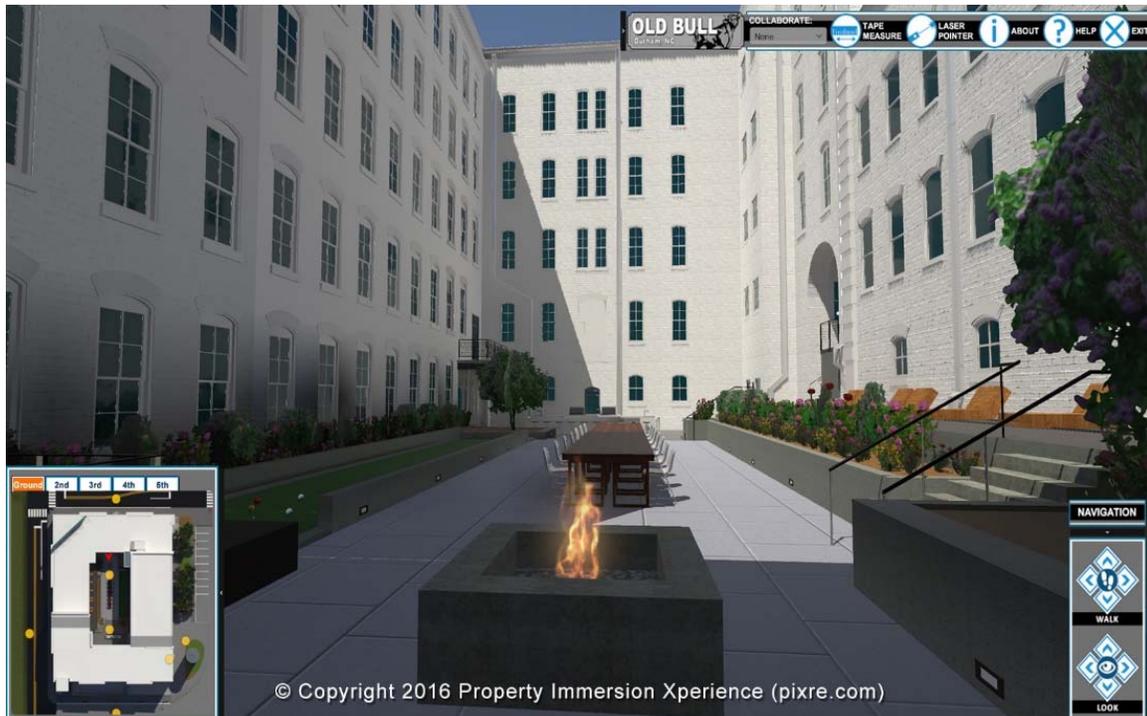


Figure 17: is just one of the virtual campuses created for Wake Tech Community College to help students get familiar with the campus layout and building locations.

Figure 17: Wake Tech Campus



Additional Benefits and Uses

One of the key benefits of creating a Realtime-3D VR Experience is the fact that any and all forms of communication, data and information can be integrated into the VR environment, and displayed from context sensitive menus, or by simply clicking on an object. This includes but is not limited to: specifications, pricing, BIM data, videos, PDF, PPT, etc. Furthermore, the visual nature of VR helps transcend all language barriers.

Another benefit is that after the VR environment is created for dynamic and interactive virtual tours, the same scenes can be used to create:

- Traditional Renderings and Videos
- Spherical Panoramic Images
- Exploring 'What-if' Design Scenarios
- Planning, and
- Security Assessment and Simulation

Virtual retail locations and college campuses can become interactive, 3D, web-based marketing tools to drive community involvement through collaborative games, online shopping, scavenger hunts and other events that increase web traffic and can provide rewards (e.g. a pre-paid gift card) for various levels of participation.

Buildouts of new space can utilize the 3D VR Experience to assist with reducing the costs and time for choosing the final configuration and getting agreement to start the construction of the space. The technology is directly able to provide an accurate and representative understanding of what the projected future development will be, which can be implemented within the marketing and sales process. This enables a reduced sales cycle, which in turn delivers a lower cost and quicker return for those developers, investors or owners utilizing the capability.

Certain early adopters have been able to identify the additional benefits of increased sales and more effective marketing for their projects that are utilizing the 3D VR Experience.

Content Creation

As discussed in “Emerging Technology is Reshaping CRE Practice” (Real Estate Review, Volume 44, Number 2, 2015) the evolution of 3D Computer Aided Design (CAD) to Building Information Modeling (BIM) is drastically reshaping the CRE design and documentation processes. For example Autodesk’s Revit²² is an excellent tool for such tasks.

However, when it comes to converting the resulting 3D files into a photo-realistic and Realtime-3D format, not all files are created equal. This does not refer to the file format, but how the objects in the file were created.

Often a 3D object may be created that looks and prints well from the source application, but when imported into an enhanced 3D visualization tool like Autodesk’s Max²³ or Maya²⁴, and then exported and published into a visualization or simulation-based application, many types of flaws can appear.

Despite these frequent discrepancies, starting with a 3D CAD file is much more cost effective than starting from a 2D set of construction documents. However, keep in mind that just because a building’s design exists in 3D, does not mean it is render ready; it may well require the finishing touches of those skilled in the use of game-based technologies to optimize the scene for distribution over the web, on mobile devices, or for viewing through an HMD for a truly immersive VR Experience.

In addition to the recent increased use of 3D CAD and / or BIM files, other data capture techniques have recently become more cost effective – helping lower the cost to create a virtual environment.

The following technologies are more geared to capture, re-create and possibly modify an existing building. These include but are not limited to:

1. LIDAR Scanning²⁵
2. Photogrammetry²⁶
3. Aerial / UAV Photography²⁷
4. Mobile Devices as Sensors

Although LIDAR technologies have been available for many years, the recent addition of full color spherical images overlapping the resulting point cloud data allows the resulting data to not only include the shape of the environment, but also the color and texture of it. Lately the ability to

process the lidar data using cloud processing to expedite the process has become available via Autodesk's Recap service^{32 33} (Video Links are available in the references)

Photogrammetry is the creation of 3D point clouds (like LIDAR) by analyzing the common pixels of overlapping images. When combined with aerial or Unmanned Aerial Vehicles (UAV) photography large areas can be scanned and the resulting 3D meshes can average an accuracy of 1 cm, and in certain circumstances the accuracy can be down to just 5 mm. Pix4D³⁴ for example can integrate aerial photos from a GoPro on a small drone, with high resolution images from digital single lens reflex (DSLR) cameras on tripods to create very detailed 3D models both inside and out with very little time on site. (Video Links are available in the references)

The UAV industry is "taking off" at an incredible pace... literally. Amazon is currently selling over 10,000 drones every month. The drone hardware market is expected to surpass \$12 Billion by 2025.³⁵ Some of the uses driving this growth include aerial photography, photogrammetry, mining, farming, surveying, and oil & gas exploration.

The "bleeding edge" technologies that are currently under development include Apple's acquisition of PrimeSense, a 3D sensing company^{28 29} from a few years ago. Many people don't realize it, but PrimeSense not only created the Kinect motion sensing input device for the xBox, it also created military versions of its sensors that provided a much higher level of detail at a faster data capture rate than the simplified consumer version. This technology has continued to evolve under much secrecy at Apple (whose acquisition of PrimeSense included the military grade hardware and software). See <https://vimeo.com/98649761> for a glimpse of this technology.

In addition, Google's Project Tango^{30 31}, computer vision systems are starting to gain publicity. Although they are not yet targeting the UAV market, it is high on their list after integrating their technology with mobile devices. See <https://youtu.be/MN46r-lzk8o>.

VR Display Technology

The variety of Virtual Reality consumer products is greatly accelerating, while their prices are dropping and their performance is increasing.

Some of the VR Head Mounted Displays (HMDs) that are attracting much of the media attention fit into three categories:

1. Foldable Smartphone Driven HMDs
 - Google Cardboard³⁶
 - Wearality Sky³⁷
2. Rigid Smartphone Driven HMDs
 - Samsung Gear VR³⁹
 - Apple VR⁴⁰
3. Computer Driven HMDs
 - Oculus Rift⁴¹
 - HTC Vive⁴²

Although there are many technical differences between these HMDs (some available now, some available this Spring, others are in the design phase), but the key two differences are:

1. Form Factor
2. Price Range (Smartphones not included)

The foldable Smartphone driven HMDs are the most portable (as they may fit in your pocket) and cost effective solutions, especially for use at tradeshow, in marketing campaigns and other demonstrations. These are also beneficial in that they are least likely to spread pink eye or other related viruses and bacteria between users by sharing the HMDs (if not cleaned with a sterile wet wipe before and after each use). (Video Link is available in the references)

The Rigid Smartphone Driven HMDs provide a similar experience to the more expensive units, but at a fraction of the cost (\$100 vs \$600 or \$800). But they aren't nearly as portable or disposable as the foldable HMD mounts.

The two top contenders in the VR media competition are the Oculus Rift (\$600) and the HTC Vive (\$800). These will provide a clearly high-end VR experience that requires a computer with a dedicated graphics processing unit (GPU). These computers that support a full gaming experience can cost an additional \$1,000 (or more) in addition to the VR HMDs. With the required cabling, power supplies, and external sensors, these are not as portable as any of the other HMDs, and require setup and calibration.

Realtime-3D Design Tools

Using Realtime-3D as a design tool ⁴³ (as opposed to a presentation or virtual tour) is a very powerful tool for preliminary design and analysis. Imagine having the ability to simply drag-and-drop walls, doors, windows, furniture, with your client's input (either face-face or over desktop screen sharing), while reclining on a couch or sitting at a conference table – without having ANY training in computer aided design and drafting or 3D modeling.

And once the client gives the preliminary approval, the resulting file can provide the foundation for the architects, engineer, and other designers. Further, this 3D file could be rapidly upgraded to a fully immersive VR experience since it would be created using the same technology. Use of this capability can be seen in the following video: <https://youtu.be/atC255E-wk4>.

Conclusion

If a property to be depicted in Virtual Reality already exists, is decorated and photo ready 'as-is' for publication, and the targeted use is short-term or only a 1-time event (like an initial sale), then using Cylindrical or Spherical Panoramic Images or Videos may be the best, most affordable option to provide a preliminary VR Experience.

However, if the building is still in the design, construction phase, or redevelopment stage then the use of Realtime-3D Virtual Reality is the best option. 3D Virtual Reality will provide prospective clients dynamic, interactive, and immersive experiences (locally or abroad) for individuals or

collaborative groups. Clients can freely experience the property, make changes to a particular unit's finishes / furnishings, get an itemized bill of materials (based on their selections) – all before ground breaking. Also, even for an existing building, being able to do a virtual walk through and “experience” the space as if one were actually in it gives the client a much better perspective than just seeing pictures, and could avoid making a costly mistake in a purchase or lease decision. This ability is now available to the market at a much more effective price point than ever before and with the added focus on VR from a consumer perspective it will be expected to be available within the business environment.

Although there truly is no one-size fits all approach to Virtual Reality experiences for the CRE industry, with the creation of development platforms, those who have specialized in creating VR experiences can quickly add, modify, or remove features on an as needed / per project basis.

When the decision is made to execute that first Virtual Reality project, it is strongly recommend to focus on a pilot project. Do something that is smaller in scale to provide a rapid turnaround, but has an immediate need to help the VR experience prove its value. It is also suggested that consideration be given to providing two types of experiences:

1. A broad but shallow user experience (like a site overview), and
2. A narrow but deep experience (like a fully furnished unit with the flexibility to select finishes and furnishings).

Once these limited virtual experiences are developed in a cohesive application, it's easy for all of the project's stakeholders to understand how the project could scale up in terms of breadth or depth (e.g. increasing the number of units to be included, or integrating new features and functions), and accurately calculate not only the budget but its return on investment.

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