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WHITE PAPER

The Value of Virtual Reality in Design and Construction

The next level of spatial understanding

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The construction sector continues to move ever closer to fully appreciating the critical role of collaboration in driving improved project outcomes and mitigating risk.

In communication and information sharing between architects and designers, contractors, subcontractors and customers, technology delivers capabilities to enable and promote mutual understanding among the many parties involved in a project. Virtual Reality (VR) is one such technology.

This white paper explores why and how VR is a game-changer for construction professionals.

Purpose of this paper

This paper discusses the value of VR as a visualisation tool which brings to the construction sector a deeper understanding both of the anticipated outcome of a project and the potential problems it may present along the way.

The discussion is timely, since VR is a rapidly emerging theme in construction. A GOV.UK announcement in November 2018[1], for example, attached transformational capabilities to the technology of VR: "Virtual Reality to revolutionise UK's construction sector".

Innovation, by definition, is about doing new things or doing old things differently and better. Further than that, it is how successful businesses differentiate themselves and strengthen their competitive advantage. It is about improving efficiencies and results, and challenging traditional routes to achieving them.

The paper provides a brief background on the gaming industry origins of VR technology, looks at common barriers to adoption, and outlines how a business can get started on a revolutionary, innovative, collaborative and, above all, efficiency-enriching journey. The paper also includes a 'Top 10' checklist of the major benefits: The value of VR in design and construction.

[1] www.gov.uk/government/news/virtual-reality-to-revolutionise-uks-construction-sector

A Note on the Author

The author of this paper is Geoff Alder, Application Specialist at Symetri, the UK leader in technology and services for the construction sector. Geoff has been training in, and developing training materials for, construction sector software solutions for over 30 years.

Geoff has trained on Autodesk products all over the world; from a nine-year stint in Southern Africa, to five years in China. He worked in South Africa, Lesotho and Botswana developing technical vocational curricula for vocational training colleges. Geoff has also been instrumental in designing technical training apprenticeships in computer-aided design (CAD) and computer-generated imagery (CGI) and development and training for 3ds Max and postproduction composition in media CGI and video game studios.

Focusing on 3D development within Autodesk software, Geoff's training initiatives have led him into an in-depth assessment of the role and value of visualisation as an aid and driver for clarity in communication. He believes that VR is often misunderstood and undervalued, with a tendency among construction professionals to view VR as a 'gimmick'.

Geoff brings to the VR discussion deep experience in 3ds Max and AutoCAD, with Rendering being a major area of training over the years. He has trained and developed rendering workflows for interior designers with V-Ray, the CGI rendering engine. He has researched and developed workflows towards Virtual Reality for Architectural, Engineering and Construction disciplines, with a focus on visualisation and spatial development: "We live in a three-dimensional world," he says, "Our spatial awareness and perceptions are developing and tested continually. This must be the best way to communicate space." In this white paper, he explains why.

Exploring Virtual Reality: Contents

Introduction and overview: How decisions are made

Digital first
The UK construction sector, and indeed the global construction industry, needs innovation in its endeavours to create a smarter and more sustainable built environment; a legacy for future generations, not simply in terms of how the built environment looks but also, in terms of enduring value and asset optimisation, in how it works.

The built environment of the future is smart; digital, self-monitoring, self-communicating and self-rectifying, through the machine-to-machine exchange of and response to data – the Internet of Things. Technology is propelling the evolution of this environment. Data is providing the fuel. Collaboration is driving the change.

The vision and the reality start not with the physical but with the digital, long before the foundations are ever poured; ensuring designs that pre-empt every eventuality, that at pre-construction the contractors can envisage their approach and ask informed questions about every detailed aspect of the project, that construction moves forward without hitch or delay and as close as possible to budget, if not bang on or under.

Whatever informs, improves
At every stage of construction there is an overriding need to keep clients informed of progress. Transparency and good practice dictate this need. The need is fulfilled by involving clients as much as possible in the project's evolution, in such a way that eventual users are given the opportunity to add their own real-life experience of, and requirements for, the facility being built; from a block of apartments to a campus, from hospitals to schools, from leisure facilities to transportation hubs and every aspect of the built environment in between.

Informed decisions reflect the experience of the decision maker, combined with the completeness and trustworthiness of the information provided to inform the decision. The more complete the information is, the more meaningful the decisions can be.

With VR, 'completeness' has a new meaning. Information is no longer exclusively about data, sometimes introducing its own barriers to comprehension and interpretation by people who are not overtly familiar with handling data; it is about visualising outcomes and foreseeing problems literally by seeing them as they emerge, as the design progresses. It is about seeing the likely outcomes of decisions and choices, rather than deciphering them.

Barriers to adoption: To see or not to see

Construction is going digital
It is easy to dismiss VR as superficial 'show business' in construction; just another way of presenting glossy marketing materials to clients.

The sector has a reputation among analysts and industry commentators, and one which many professionals working in the sector themselves acknowledge, for reluctance in its adoption of technology. The World Economic Forum (WEF) observes, in its report *'Shaping the Future of Construction: Inspiring innovators redefine the industry'*[2]:

"While most other industries have undergone tremendous changes over the past few decades, and have reaped the benefits of process, product and service innovations, the construction sector has been hesitant to fully embrace the latest innovation opportunities and its labour productivity has stagnated or even decreased over the past 50 years.

This mediocre track record can be attributed to various internal and external challenges: the persistent fragmentation of the industry; inadequate collaboration between the players; the sector's difficulty in adopting and adapting to new technologies; the difficulties in recruiting a talented and future-ready workforce; and insufficient knowledge transfer from project to project, to name a few."

Slowly, but surely, however, construction is going digital, and is addressing the challenges of the modern age identified by the WEF. Building Information Modelling (BIM) has played a catalytic role in this gradual transformation, emphasising the importance of sharing information and the immeasurable value of collaboration.

More can be done to build on the many initiatives and process improvements that the BIM framework has spawned. Construction professionals have a duty of care towards future generations to champion innovation whenever the opportunity presents itself and whenever the value is demonstrable and clear.

[2] www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_Inspiring_Innovators_redefine_the_industry_2017.pdf

Understanding spatial relationships

Collaboration depends on people, attitudes and commitment to transparency, alongside an acceptance of the time-honoured truism that many hands make light work.

To be able to collaborate, people depend on tools; once the function of spreadsheets, the sharing of which was accelerated through the advent of email, and now expanded into real-time tools for collaboration, from common data environments, to screen and model sharing, to video conferencing and mobility. This is where VR comes in, helping, alongside Augmented Reality (AR) to transform design, construction and the operation of the built environment.

"Technologies such as augmented and virtual reality will become widely used – transforming the sector and improving UK infrastructure"

said the YouGov announcement[3], which heralded a £72 million investment from the government into a 'Core Innovation Hub', designed to help "…make the UK a world leader in the latest construction techniques – creating new jobs across the UK."

Once you strip away the cynical 'showmanship perception' of VR, you find a rich source of insight which does far more than just improve the customer experience. You find a means of understanding spatial relationships in a building or a project that can enhance safety aspects, promote greater understanding of roles and directions, and support information sharing in a way that everybody involved in a project can understand and benefit from.

The origins of VR technology: Dispelling the myth

Warning: You may have already tried this at home

In exploring the value of VR in construction, a myth clouds the issue, just as if it were the slavering monster blocking your way forward in a gaming environment; a simulated environment where fantasy becomes real, the ludicrous becomes impossible, and everywhere you look, or direct your cursor, or turn your headset, you see a new threat you may not ever have imagined could lurk where it does.

The myth is that VR is for gamers. Great fun, say those who remain to be convinced, but is it a professional tool with a valid role to fulfil in improving project outcomes in the built environment?

What role can it possibly have other than just that – providing a bit of a thrill for customers, through a compelling view of what might be? More engaging than a brochure and more easily grasped by industry outsiders than a 2D drawing, or even a 3D model, VR is considered by the unconvinced to be not much more than a tool for sales.

The reality is far wider ranging, more ambitious, and of more relevant practical application than the belief of some in the industry. Digital construction is driving resounding change in collaboration, and the sharing of information, to the betterment of project outcomes and the greater sustainability of the built enforcement. The question that companies across the construction sector value chain should be asking at this point in time is not why they should adopt VR, but how soon can they do so. I'd like to explain why they should be asking that question.

Playing the game, for real

To appreciate the context, it's best to start by dispelling the game-playing/presentation tool myth. The entertainment industry has often initiated technologies and ideas that have passed into industry by being harnessed for broader ranging technology deployment. A good example is what's known as the 'gamification of IT'.

In broad terms, the gamification of IT is about picking out those nuggets of value from game playing that get round the complex aspects of using technology that can slow down or even prevent adoption.

When users are resistant, old ways persist, and the inefficiencies that the technology was designed to eliminate, continue to occur. The design of the 'intuitive' user interface using icons and simple signposting and reducing instructions to the minimum, is ultimately a descendant of game play.

[3] As above: www.gov.uk/government/news/virtual-reality-to-revolutionise-uks-construction-sector

Developing a vision

Turning again to the WEF report, it provides what could almost be considered a profile of the type of organisation most likely to be found in the vanguard of new technology adoption:

"To stimulate innovative ideas, successful companies develop a vision and instil an innovation culture into their workforce; they create talented, multidisciplinary teams that bring in experiences from non-construction industries and devise agile organisations; and they take a customer-centric approach, starting from the asset users' pain points". [4]

Keep it simple

VR provides visual understanding of an environment by immersing those who use it into the three-dimensional world. This is the world we live in, work in, and build in. Collaboration in understanding this world, via a tool that faithfully reproduces and represents 3D reality, has logic on its side.

The fundamental concept is flawless. Anything less than a view that is as close to reality as it's possible to get is, the converse logic dictates, inherently flawed; open to varying interpretations and one step removed, if not more, from the object it represents. Spatial awareness can never be a function of flat representation.

Prior to the advent of 3D models, traditional two-dimensional drawings had long been the means used to describe design. The more complex the elements within a project, the greater the proliferation of drawings; reams of them being a daunting prospect to any project participant let alone those not of a technical bent.

It was a prerequisite of viewing, and understanding, a 2D design that anybody looking at the design would have an intrinsic familiarity with visualisation such that they could convert 2D data to imagine and envisage the 3D project.

It was a complex and instantaneous cognitive process of imagining what something could look like by taking in visual cues composed entirely of elements that it didn't look like. Interpretation was all important. Misinterpretation was thus an ever-present danger.

As the old saying goes, *"There's many a slip 'twixt the cup and the lip"*. This observation is not to decry old ways. Assuredly, many Towers of London, Cathedrals, Palaces, Historic Places of Learning and Stately Homes have come to fruition enduringly enough. As they say, however, that was then, and this is now. We do things differently. Our duty as an industry and our responsibility to the future, is to do things better.

In a complex technological world, simplicity rules. The more that people understand something, they more warmly they respond to it, see its value, and start using it; comfortably and confidently.

[4] www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_Inspiring_Innovators_redefine_the_industry_2017.pdf

The top 10 benefits of VR in design and construction

The leading research and consulting firm, Ecorys, identifies in its study, "Virtual Reality and its potential for Europe" (April, 2019)[5], the benefits of VR for the construction sector as enabling:

… "architects, interior designers, property developers and their clients to immerse themselves in creations throughout different stages of the design process, and so allowing them to get a better feel of what the model could look like once finished. This can be done effectively by, for example, translating Building Information Modelling (BIM) into virtual experiences, providing everyone from designers to clients with beautiful and interactive walkthroughs…everyone involved has the opportunity to spot errors more easily and correct them more quickly. This drastically reduces the likelihood of an ill-designed finished product that does not fit well in its environment or does not suit the needs of those living in or using the space."

There can be no greater value than that; making a meaningful and fit-for-purpose contribution to the built environment and people's lives. I do not mean to suggest that VR is the answer to every problem in construction, but it is set to become an indispensable tool, when used in conjunction with others, that can bring stakeholders together, to view intentions and potential outcomes together, to improve the project as it evolves and to solve problems together as they can be seen to be emerging; seeing inconsistencies, clashes, and underused or squandered space…spatially.

An aid to focus, concentration, and appreciation

Design decisions are frequently made in meetings. There's nothing wrong with that; it's what collaboration is all about. Too often, however, the meetings can be in busy offices with distractions all around. If, to avoid distractions, reviews are taken into more peaceful and less-likely-to-be-interrupted meeting rooms, people still tend to bring their own distractions with them; checking phone messages, or texting when they feel a particular section of the meeting does not concern them, or simply not being able to give their full attention to the matter in hand because of whatever is going on in their own minds. This is all human nature.

How much better and informed, robust and accurate, decisions can be if everybody focussed to the maximum. Virtual Reality turns up the dial on focus and attention. It sends environmental sense stimulation to the brain from the eyes. The optical systems manufacturer, Zeiss, states the following: "By far the most important organs of sense are our eyes. We perceive up to 80% of all impressions by means of our sight"[6].

Therefore, if you harness that 80% in a VR environment you bring 100% attention to the project under review. This leads to saving time and therefore money. It precludes misunderstandings. It prevents any key points being missed. It relegates daily distractions to another dimension; one which, for the time of immersion in the VR world, viewers have simply left behind, much as if you had asked them to turn off their mobile phones before coming into the meeting, but with far greater effect.
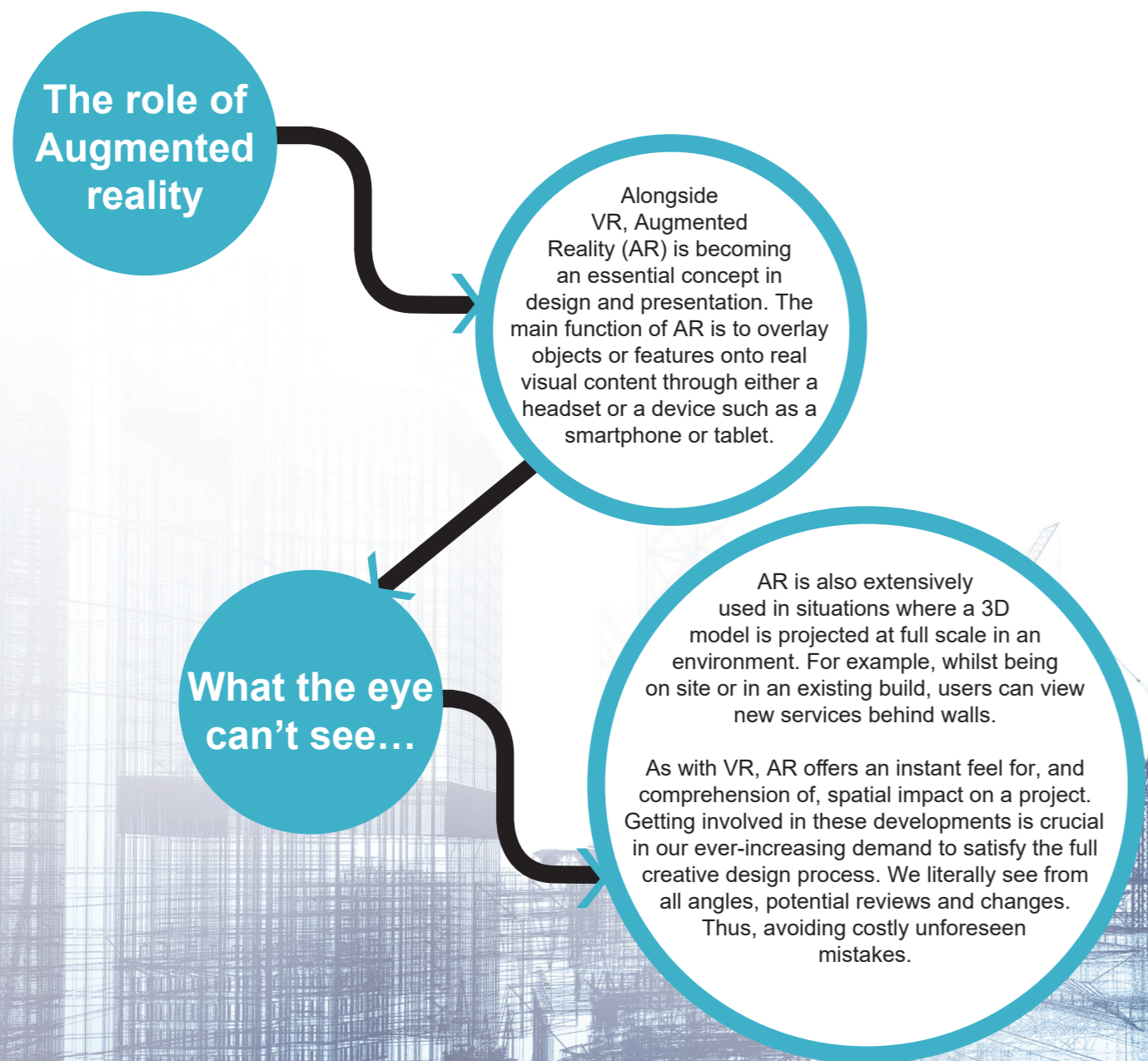
If you have your meeting in VR with clients and stakeholders, their attention is 100% within the boundary of the VR immersion. They are focussed, they concentrate and they appreciate what they are seeing more completely.

With this overview in mind, here are what I believe to be the top 10 benefits of VR and, in the true spirit of collaboration, I'm always happy to hear any thoughts you may have to add to them…

[5] https://ec.europa.eu/futurium/en/system/files/ged/vr_ecosystem_eu_report_0.pdf   [6] www.zeiss.com

1. **Better project planning:** Viewing and testing in a virtual environment reveals valuable information at every stage of development. This insight helps identify areas to review in the early design stages and the pre-planning stages of construction. Construction order and supply availability becomes smoother and more precise since all teams will be involved at the earliest time, gaining the opportunity to contribute further to their area of involvement in the earliest design stage.

2. **Clash detection in visual form:** Use VR to identify conflicts between design and engineering professionals and other subcontractors.

3. **Improving safety measures, advising actions in case of emergency, and clearly identifying evacuation/ escape routes:** Final stages of design allow fire and emergency routes and procedures, for final building occupants as well as site operatives during the build, to be rigorously identified. This process can be used to design and form a virtual orientation programme, enabling familiarity with the building. Adding to this, Augmented Reality can be used to help during practice drills in fire escape situations. Wearing the AR glasses and seeing the fire route overlaid in the real world.

4. **Build safer:** Provide phased safety on site, pre-empting difficult areas during construction.

5. **Improved project workflow:** Smoother transition between design and construction as everyone gains a clear picture of how it is intended that the finished project emerges. Eliminating demarcation between teams and phases.

6. **Try before you build:** Construction areas can be explored and practiced in VR, equipment placement, temporary works, potential dangers can be highlighted and factored into the phases

7. **Demonstrable compliance:** VR can demonstrate that the model is built to specification and building regulations

8. **Collaboration is quickly effective:** All interested parties can have important input. An example of more effective consultation with impacted stakeholders would be having doctors and nurses involved in spatial design in the design of a hospital. The public could also be offered the opportunity to view a development, smoothing the way towards more informed acceptability and greater understanding of the ultimate impact of a development on the community.

9. **Superior customer experience:** Customer experience is achieved to a depth and with clarity of understanding in a way not achievable in any other way: "Try before you buy".

10. **Line of sight:** A simple benefit I have seen many times in recent training sessions is that we have line of sight from any given point. Once again, a benefit unattainable with any other type of technology.

The role of Augmented reality

Alongside VR, Augmented Reality (AR) is becoming an essential concept in design and presentation. The main function of AR is to overlay objects or features onto real visual content through either a headset or a device such as a smartphone or tablet.

What the eye can't see…

AR is also extensively used in situations where a 3D model is projected at full scale in an environment. For example, whilst being on site or in an existing build, users can view new services behind walls.

As with VR, AR offers an instant feel for, and comprehension of, spatial impact on a project. Getting involved in these developments is crucial in our ever-increasing demand to satisfy the full creative design process. We literally see from all angles, potential reviews and changes. Thus, avoiding costly unforeseen mistakes.

The VR journey: You can see clearly now

Inclusive, immersive, persuasive

Virtual Reality is not a complex technology. It's a technology that strips out complexity and promotes faster understanding and easily comprehensible sharing of the proposed physical status of a construction and the constituent parts within it.

At its most basic it's about putting on a headset and seeing an all-round view of a building, a room, or any aspect of a construction project where clarity is required and understanding is important. That means every aspect of a project; every project.

I mentioned earlier in this paper that I would give a rationale as to why companies across the construction sector value chain should be asking themselves how soon they can adopt VR. The reasoning is simple; the answer is that VR improves collaboration, understanding, and outcomes.

User friendly technology

When 3D scaled models came into the mix in architecture and engineering, they significantly improved perceptions of space and volume. They also introduced another factor in making it possible to represent the aesthetic of the overall project.

As new talent comes into the design field, many individuals arrive with a certain level of familiarity with interactive 3D from video game play. Many of its users have faced down dauting adversaries in fantasy worlds; they are in their comfort zone when tasked with leveraging VR in the real world of construction. Having the key skills that are developed in video game play is greatly assisting the immersive visuals in VR.
On your journey into adopting Virtual Reality, you will find, indeed you will doubtless already have found, that people are confident about being immersed into a new world. (While there are instances of 'Virtual Reality sickness', similar to motion sickness, most professionals and customers tend to be more absorbed by the insights and value of the experience rather than deterred by adverse effects that there is no evidence to suggest touch a significant number of users. The possible ill effect is more a function of repeated and excessive use than of occasional and purposeful employment of VR as an aid to understanding).

Among construction professionals, initial apprehension and concerns are fading as it becomes increasingly evident that the visual immersive experience allows constructive design observations. For this reason, VR is increasingly becoming an essential tool in the design process.

While a 3D model on the desktop gives a visual understanding of the overall project, it is however, a 'bird's eye' view. Far more encompassing, VR allows the viewer to be in any position and scale within the design or outside the design. This flexibility offers significant design options to be considered. It introduces the ability to spot inaccuracies not fully apparent in the 2D drawing or the physical 3D model. Immersing in the VR world is the only way to fully absorb the spatial interpretation of a design.

Practical matters

It may appear that a technology that improves the way we see and interpret things – itself a bold and transformative claim – might imply complex adoption and implementation. This is not the case. The process of transposing a CAD design into a VR experience is simple.

A 3D view in Revit can quickly be converted into a VR visual through a number of solutions, allowing the geometry, together with textures, to be viewed through an interactive viewer either on screen (with navigation with a mouse and keyboard) or more impressively with a VR headset such as HTC Vive and Oculus Rift.

The particular solution you select depends on the uses you have identified for VR, from the creation of large-scale environments to make something like the campus experience come alive, through to specific uses, either for client sharing or for work-in-progress visibility.

The bigger picture

To create an inspiring overview there is a combination of three solutions which works in an integrated fashion; starting with the Revit model, then taking the model into 3ds MAX to create textures and finishes, and then taking the result into Unity for full VR visualisation. You can create rich scenarios to bring interactive experiences that engage viewers. In this case Autodesk are partnering with Unity.

There are some excellent applications that have been developed for the process of getting the 3D model into a VR and AR situation. The following solutions are all supported by Autodesk for use in association with Revit:

Four easy-to-work with solutions:

• IRISVR: The fastest way to start
There is a solution that enables you to get going with VR almost instantly but does not link into BIM 360. In this regard it is more about bringing the 'wow' factor into play to demonstrate to clients where the project is going and how it can look, giving them the chance to express meaningful input on finishes and other choices where choice is relevant. With IRISVR you simply load your 3D file and click launch, and you're in the VR world. This is a fast way to get going with VR, particularly where BIM is not of priority concern on a project.

• InsiteVR: Cloud-share the vision
The sharing of VR views between locations, even internationally, accelerates understanding and empowers decisions in a powerful way. InsiteVR enables remote collaboration meetings in the Revit model, in the cloud, linking with BIM 360. Participants can annotate the view in real-time and see each other's annotations as they are made.

• Enscape: Create a live link from BIM to a virtual walkthrough
For conceptual designs, Enscape enables operatives to move around the Revit model but is not appropriate for collaboration. This is more a work-in-progress tool. The user has the software installed on the system (not a cloud-based or Internet shareable solution) and simply opens it as required to do walkthroughs. It is a perfect tool for enabling designers to get the picture as the project develops. They can add textures and surface finishes, reflective if wanted, to gain a sense of visual impression, and a sense of volume. The views can be shown to clients, but not remotely; they have to be at the designer's screen.

• VisualLive: Overlay services details onto real world geometry
Augmented Reality (AR) is bringing a level of spatial understanding to the building services industry never before possible. With VisualLive you can overlay a model onto the natural (existing) view in a process known as 'mixed reality'. This provides a heads-up display (HUD) where, for example, you can look at real world walls via a HoloLens or even a tablet and then overlay the services pipes behind them to see exactly how they will lay out. Effectively, the overlay is a model and what it is overlaid onto is real world scenario.

VR gives a vast array of possibilities in the design and the final presentation of a project. Further interactivity can be achieved with features that allow the viewer to swap out or change materials on a surface, or change floor tiles or carpet tiles. Interior design options can be completely changed in line with client expectations; the viewer can set different scenarios. Entire room plans can be changed. Projects can evolve. Outcomes can be improved.

▎Final Thoughts

Build in sight before building on-site
It is no bad thing that VR is considered by some as a sales tool. Perhaps, however, its use can be qualified by referring to it as work-in-progress consultancy. If rooms can be changed, entire projects can be changed. Buildings can be inserted into a campus, access and egress can be repositioned; orientation can swivel in any direction practicable. Any option can be explored, before any commitment is made.

VR is immersive but, more than that, it is inclusive. VR invites and inspires collaboration. Its use demonstrates transparency. It serves as a customer-centric opportunity not just to achieve greater customer satisfaction through an inclusive customer experience, but also to garner thoughts and opinions, feedback and buy-in as a project develops.

VR also invests the creative zone, the place in which designers and architects work, with a deep level of focus that extends beyond the VR world and back into reality. In my experience I have met with many professionals in this field who say they come back from the VR experience with a greater sense of clarity about how a project is unfolding. They have a faster understanding of how things will look. They see things clearer. I believe this is because they have had a glimpse of the future; they then understand better how to get there.

Finally, in a sector that can sometimes be adversarial by nature, any tool capable of minimising misunderstandings has, I believe, immeasurable value.

The journey into a new vibrant, practical and relevant way of looking at the future you plan for the built environment can be faster than you may imagine. Once you arrive in the VR world you may then start to imagine faster than you ever have before.

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