Technical Information Note | 22/1

Digital Realities (2nd ed.)

Image courtesy of THINKlab: RHS Bridgewater Garden

Digital Practice Group

Landscape Institute
Inspiring great places

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1 Foreword

1.1 Acknowledgements

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1.2 Foreword

This document is provided for information only.

Its aim is to introduce and promote the use of digital realities by landscape practitioners. Given that this is a rapidly changing field, we welcome any updates from practitioners and third parties. Please email technical@landscapeinstitute.org with any suggestions.

The document has been developed by the Landscape Institute's Digital Practice Group.

2 Introduction

"We are beginning to expect the same things from public space that we expect from almost anything in our digitized connected worlds…buildings and infrastructure that we can click on, swipe, share, capture, and converse with"

Dave Colangelo, Media Architecture Compendium: Digital Placemaking.

2.1 Overview of digital realities

Digital Realities is the collective term for Augmented Reality (AR), Virtual Reality (VR) and Mixed Reality (MR). These are methods of visualising a digital object or environment in a more natural and intuitive way. They provide the opportunity to overlay data, making it easily accessible and relevant (see Figure 1).

Figure 1. Example to demonstrate the difference between Virtual (VR), Augmented (AR) and Mixed (MR) Reality

Images courtesy of the LI Digital Practice Group

Illustrated simply as an experience of seeing a football, VR is an enclosed environment experienced with a head mounted display (HMD). The environment and the football are completely artificial. The experience of AR differs, allowing you to display digital objects in the real world, most commonly with smartphones. MR is smarter, allowing you to display and anchor digital objects in the real world that respond to their real-world surroundings. Each of these methods are expanded on further throughout this document.

The term Extended Reality (XR) is also used to refer to all real and virtual combined environments and human-machine interactions generated by computer technology and wearable technology. This is illustrated on the following scale (see Figure 2).

Figure 2. Extended Reality Types

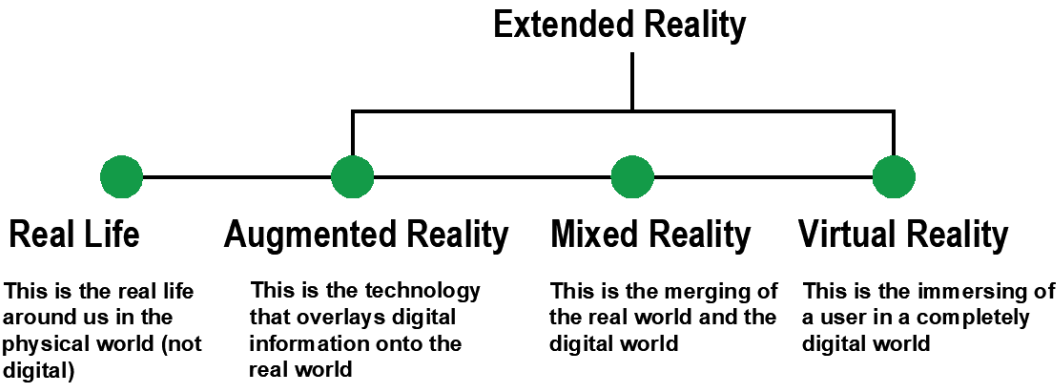


Image courtesy of the LI Digital Practice Group

AR, VR and MR offer different solutions, use different hardware and software combinations and are available at various price points. Within each, there are different levels of functionality, quality and accuracy. The best option will depend on the task for which it is required. For some tasks, an impression only will be enough, for others it will be important to have data and geometry at the highest quality and accuracy.

This document explains each solution and gives some examples of how they are currently being applied, or have the potential to be applied, to landscape architecture, landscape planning, landscape management, and digital placemaking.

This is a fast-moving field of technology and the examples given will rapidly become out of date. Please email technical@landscapeinstitute.org with any suggested updates.

2.2 Alignment with discipline and Landscape Institute's competencies framework

The significance of digital realities to landscape architecture is recognised through the LI competencies framework for its members. This includes professional competencies such as 'digital practice' (starred in Figure 3), and links to a range of core competencies, and additional competencies including 'digital technologies' (see Figure 3).

Figure 3. Chartered Member – Competency Requirements

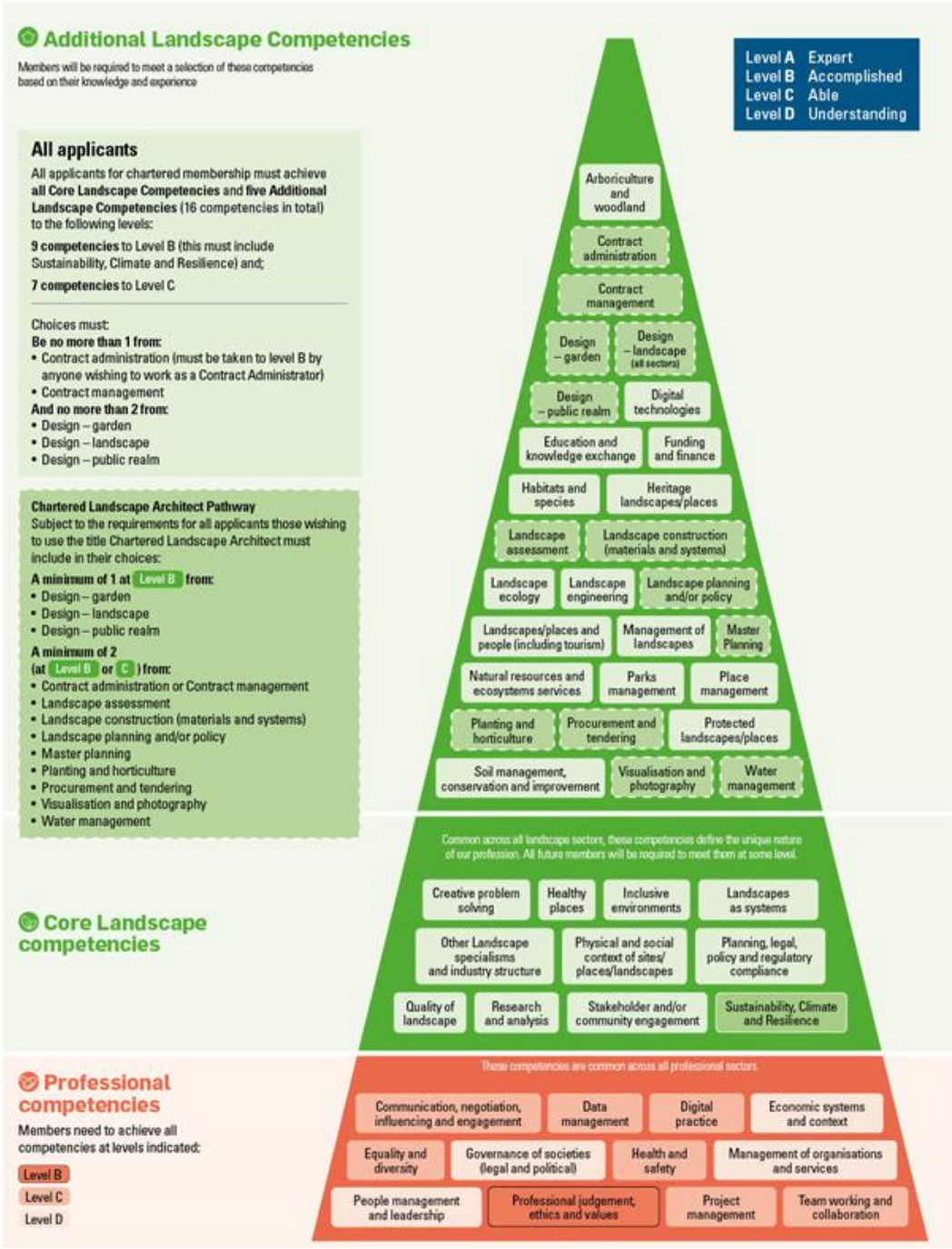


Image courtesy of the Landscape Institute

3 Virtual Reality

Virtual Reality (Noun); *"an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment*".

Merriam-Webster

3.1 Introduction to VR

Virtual Reality (VR) is an interactive experience which takes place in a simulated environment created using audio and visual stimulation, but which may also include scent, temperature, wind and other forms of sensory stimulation. The virtual world may be a realistic simulation of the real-world, or it can be out of this world, creating an experience that is not possible in ordinary physical reality. The experience can be constrained, for example a 360-degree photo or video where the user is entirely immersed in the content but can only look around, or it can offer freedom of movement, allowing the user to explore the virtual world they are experiencing.

The quality of VR experience is impacted by the field of view (FOV) (see Figure 4), latency (delay to respond to movement), and the screen door effect (see Figure 5). This varies from device to device, and optimising these factors enables a more immersive experience.

Figure 4. Field of View (FOV)

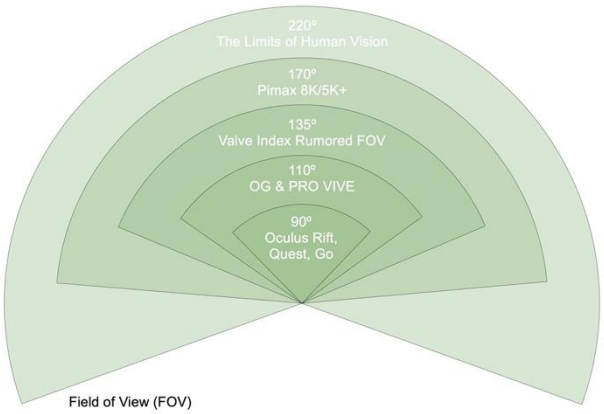


Figure 5. Screen door effect

Images courtesy of the LI Digital Practice Group

The maximum limits of the human FOV are around 220°. The closer devices can get to this, the mor realistic the experience will feel to the viewer.

Another important factor to consider is the latency of VR devices. This is measured in frames per second (FPS) and the recommended guidelines are for 90+ FPS.

The screen door effect is the visibility of individual pixels when having a screen close to your eyes, as though you were looking through a fly screen door. Screens with lower resolution will have a greater degree of visible pixels, but many devices have superb resolution, virtually eradicating this issue.

3.2 VR hardware

VR can be delivered through a range of hardware including:

- *VR for mobile*
- *VR for desktop and laptops*
- *VR standalone devices*

- *VR projection domes*

VR for mobile is the least capable as it relies on the processing power of an individual's mobile, which is typically inferior to desktops and laptops. The mobile creates two near identical images side by side, known as stereoscopic images, to align with each eye. To view VR on a mobile, it relies on physical add-ons in the form of either clip-on stereo-spectacles or, more commonly, a cardboard or plastic HMD that houses the mobile, viewed through the stereo-spectacles within.

Some companies have previously supported this market, with viewers such as the Google Daydream and Samsung Gear VR but, again, each requires a supporting mobile and that is what dictates the quality of the experience (see Figures 6, 7, 8 and 9).

Figure 6. Stereoscopic view (smartphone)

Figure 7. Clip-on stereo-spectacles

Figure 8. Cardboard viewer

Figure 9. Plastic viewer

Images courtesy of the LI Digital Practice Group

This budget approach to displaying VR still represents a step up in displaying virtual landscapes, versus static 2D and 3D images, as it adds depth perception and 360° viewing capacity.

It is worth noting that clip-ons and cardboard add-ons can be sent to clients and the community for individual use, making it more hygienic than single devices being used by multiple users.

Mobile VR HMDs

- *Clip-on spectacles (multiple suppliers)*
- *Cardboard (multiple suppliers)*
- *Google Daydream headset (technical support withdrawn)*
- *Samsung Gear VR by Oculus (technical support withdrawn)*

VR for desktop and laptops is typically delivered through a head mounted display (HMD) worn by the user. These are typically tethered to the desktop or laptop via a link cable which draw upon the processing power, most notably the graphics processing, to create a smooth user experience. These up-market devices are also accompanied by wands to track your hand movements and act as controllers.

Earlier generations of the VR HMD sometimes require tracking beacons, mounted on tripods or attached to the wall. This setup is known as outside-in tracking. The beacons link to sensors within the HMD to determine your movement in a room with a 4x4m space, or larger where recommended, and clear of obstructions. The range of movement within a VR environment is known as your degrees of freedom (DOF). Older HMD sometimes have 3DOF, but 6DOF is more common now which, in addition to sensing your movement left/right or forwards/backwards, can also determine your movements up/down, 'roll', 'yaw' and 'pitch', that is, rotation longitudinally, vertically and transversely, respectively (see Figure 10).

Figure 10. Degrees of movement

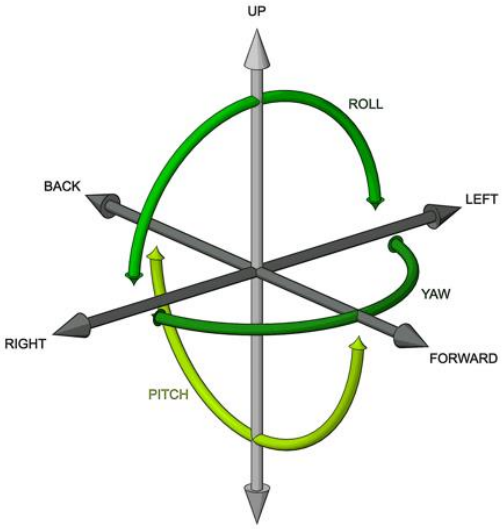


Image courtesy of the LI Digital Practice Group

The most recent HMDs are untethered. These can connect to the desktop or laptop via a link cable if required, but they are often standalone devices with their own on-board processing power (often inferior to their tethered counterparts). This brings the benefit of portability and demonstrates the benefit of inside-out tracking, where the HMD can sense your surroundings. It can take a while to sync to the immediate environment and indoors use is recommended (see Figures 11 and 12).

Figure 11. Forms of tracking: outside-in

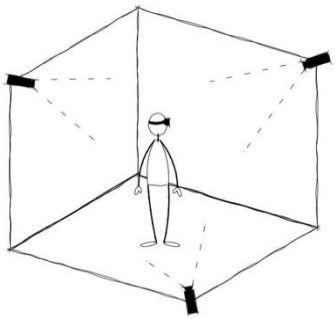
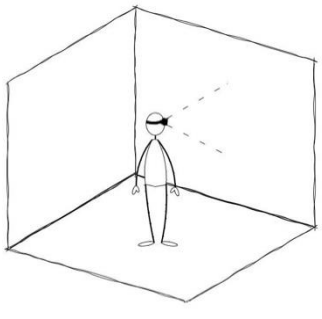


Figure 12. Forms of tracking: inside-out



Images courtesy of the LI Digital Practice Group

Dedicated HMD come with hand tracking devices as standard. These can take some time to mind map in the absence of a physical view of the wands when wearing the HMD. The benefit is that the controllers are often visualised within the VR environment so you can intuitively use the controller like an extension of your body. Some wands include haptic feedback (or simulated touch) and can even sense individual fingers. This can convey more lifelike gripping motions to interact with virtual objects (although this is more commonly achieved with a trigger on the wands). In a design and documentation sense, this might relate to drawing (in place of a mouse) but allows for opportunities to interact with other virtual objects in the virtual environment, such as a spade, or a light. How much more useful would it be for you and your clients to interact with your design rather than just view it?

Good practice using HMDs

First impressions are important. A poor introductory experience in VR can put people off. Some people are prone to nausea in VR, more so after extended use. The exact reason varies, but a contributing factor is the frames per second (FPS) possible on the VR device. A minimum of 90FPS is recommended, but some devices, such as smartphones, are only capable of 60FPS. By comparison, The PiMAX 5K Super HMD is capable of 180PFS, although this requires a more powerful PC to run.

The experience of HMDs means the users cannot see everything that is going on around them in the real word. It is therefore respectful to maintain your distance from them, not to touch them, or to take film or photographs of them without their prior consent.

Where HMD are to be used by groups, it is advisable for disposable masks to be provided for each user and for antiseptic wipes to be applied to the HMD contact surfaces between each use. This has never been more important or relevant than in the age we live in (see Figure 13).

Figure 13. Example of a disposable mask

Image courtesy of the LI Digital Practice Group

HMD

The head mounted displays listed below range from smart device-based systems to full professional headsets, requiring workstation class PCs with top of the range graphics cards.

Untethered VR HMD

- *HTC Vive™ Focus 3*
- *Oculus Go (technical support withdrawn)*
- *Oculus Quest*
- *Oculus Quest 2 (best-selling)*
- *Pico Neo 2*

Tethered VR HMD

- *HTC Vive™ Cosmos*
- *HTC Vive™ VR*
- *HTC Vive™ Pro*
- *HP Reverb G2*
- *Microsoft Mixed Reality Headsets*
- *Oculus Rift*
- *PiMax 5K Plus*
- *PiMax 5K Super*
- *PiMax 8K Plus*
- *Samsung Odyssey Pro*
- *Valve Index*

Note: console based VR, such as Sony Playstation VR, has not been included here as these platforms typically lack the software used by landscape practitioners. They can be used for virtual arts or the appreciation of virtual landscapes within videogames, which has its own merit in increasing expectations of real-world landscapes. For more information in this area, refer the talk by Dr Umran Ali 'The gamification of landscape architecture' at the Digital Skills Day, Manchester, 2018, on LI Campus.

VR Domes

- *Igloo Vision*
- *Virtual Domes*

VR Domes operate through light projection onto domes or curved walls. One of the benefits of this form of VR is the ability to create immersive experiences for multiple users at the same time. These can be expensive to hire but can be useful for high profile events or exhibits.

VR Cameras

- *Insta360 Evo*

- *Vuze XR*

Digital cameras that possess dual lenses can produce true stereoscopic photos and moving images. This creates a further opportunity to generate 360° monoscopic and 180° stereoscopic VR content to highlight the landscape as it is or how it will look at the end of a project. The quality of the images and footage is more effective with respect to the photographer's immediate surroundings and where there is enough illumination. It is also very effective when there are elevated features in the landscape to walk past, through and under.

3.3 VR software

For high quality simulations and visualisations of built or natural environments, the virtual world is modelled using 3D authoring software and optimised using a gaming engine, such as Unreal or Unity. The challenge for landscape architects is to get the 3D model from building information modelling (BIM) authoring software into the gaming engine. There are workflows for some applications, and some are easier than others, however the software is developing quickly with a view to having bidirectional links between authoring software and the gaming engine.

Where quality is not the driver but it is necessary to have real time virtual access to our developing model, software is beginning to appear that allows this bidirectional link, enabling us to place the viewer into the model on our desktop. In some instances, the model can be manipulated, changing colours, textures, time of day, lighting etc. This offers an exciting opportunity for clients and stakeholders to interact more openly in our design process and experience the spaces we are designing.

Software for developing and/or viewing VR content:

- *3D Studio*
- *ArchiCAD*
- *Arkio*
- *BIMx*
- *CS Artisan*
- *Enscape*
- *Fuzor*
- *IrisVR*
- *KeySCAPE*
- *Lands Design*
- *Lumion*
- *Revit/Revit Live*
- *SketchUp/SketchUp Viewer*
- *Twinmotion*
- *Unity 3D*
- *Unity Reflect*
- *Unreal Engine 4.2 or later with Datasmith*
- *Vectorworks/Vectorworks Web Viewer*
- *VeeR*
- *VR Sketch*

3.4 Application of VR for landscape professionals

- *Site survey and analysis*
- *Design visualisation*
- *Immersive collaboration*
- *Client and user sign off*
- *Design testing for inclusiveness*
- *Immersive modelling*

- *Storytelling related to place*
- *Digital experiences*
- *Immersive digital twins of protected or inaccessible landscapes*
- *Immersive digital twins for digital placemaking*
- *Communication of global issues to the public, making the issues real*
- *Training of owners, users and maintenance teams*

3.5 VR case studies

The following images represent four views of a VR case study by Tamae Isomura CMLI (see Figure 14). Other case studies include the RHS Bridgewater Garden presented by the University of Salford (Twinmotion and Unreal Engine), the Garden Bridge VR Experience by ARUP and Stonehenge VR by AECOM.

Figure 14. Four views of the Butterfly Garden for baby bereavement, NHS Hospital, Tamae Isomura CMLI (Vectorworks and Twinmotion), 2021

Images courtesy of Tamae Isomura CMLI

4 Augmented Reality

4.1 Introduction to AR

Augmented Reality (AR) is an interactive experience of a real-world environment, augmented by digital information overlaid in either a constructive manner (i.e. information added to the real-world environment), or in a destructive manner (i.e. used to mask the real-world environment). The digital information is seamlessly interwoven with the real-world environment so that it is perceived as an immersive aspect of that real environment.

Data

In a world where we have increasing access to both static and live data, AR is seen as a technology which can overlay that static or live data as we view the world around us, by either looking through a mobile device or a specialist headset. The data could be, for example, underground services in a street, policy areas on a landscape or the names of the hills in a view in front of us.

Triggering and occlusion

Data can be 'triggered' in several ways, from simple QR codes, to GPS, to image recognition, where smart device cameras recognise data points in the view and reveal the embedded images and sounds. Models can be dropped into a space, floating, or attached to flat planes by scanning the immediate area with smart devices and anchoring it. These models can then be rotated and scaled as required. This is beneficial for visually locating models in situ but highlights one issue. Where AR content is being displayed, it does not recognise physical objects in the foreground between the camera and the location of the AR content. This is known as 'occlusion', which is the natural progression required for extended reality in order to make for the technology truly immersive. Returning to the football image below, the digital model of the football on the MR slide is being occluded by the play equipment. With AR the football is merely anchored in the space, and it will always appear in front of the play equipment, even if it is intended to be behind it. This essentially breaks the sense of immersion (see Figure 1).

Figure 1. Example to demonstrate the difference between Virtual (VR), Augmented (AR) and Mixed (MR) Reality

Image courtesy of the LI Digital Practice Group

Despite this, AR technology provides an opportunity to overlay a digital layer in our professional work, everything from the digital labelling of plants in our designs, to enhancing wayfinding for site users, or even a method of telling the story of a place. AR encompasses both visual and audio elements. It is therefore possible to add spoken narrative, notation, music, or sound effects to visual AR models.

The opportunity for landscape professionals to benefit from and use this technology is vast, particularly with the advent of Web AR, allowing you to stream information rather than download it. Software

requirements for viewing are greatly reduced through web streaming, cloud data storage, and with the support of technologies such as local wi-fi (e.g. Info-Point), which enables data to be provided locally without consuming users' data allowances.

4.2 AR hardware

AR is typically experienced through smartphones and tablets, with manufacturers now including AR hardware support on their devices as well as 'kits' for software developers to exploit that hardware in their applications. The capability of these mobile devices offers portability for use in the field. This has led to an explosion in AR content, and it is fast becoming a mainstream technology with games such as Pokémon Go capturing the imagination of the public, and brands producing their own apps for use by their customers. As the technology and content is developing, dedicated headsets are now coming to the market for professional users. These are expensive and not yet orientated towards our profession, making mobile and tablet-based AR the focus at this stage.

Mobile devices

- *Android devices running Android 7.0 or later*
- *Apple iPhone SE/6s or later and iPad 5th generation or later and iPad Pro running iOS 12 or later supporting ARKit 2*

AR headsets

- *Magic Leap 1 & 2*
- *Microsoft HoloLens 1 & 2*
- *Mira Prism*

4.3 AR software

Software for developing and/or viewing AR content:

- *ARki*
- *ARize*
- *Augment*
- *AUGmentecture*
- *Echoes (audio)*
- *EnBW*
- *EyeJack*
- *Kubity Go*
- *Placenote*
- *REVisAR*
- *Revit/ArchiCAD via Umbra or Kubity*
- *Sketchfab*
- *SketchUp Viewer*
- *SketchUp with Augment Extension*
- *Spark AR*
- *Story City (audio)*
- *Umbra*
- *Vectorworks Nomad App*
- *Zappar*
- *Zapworks Studio*

4.4 Application of AR for landscape professionals

- *Cemetery management*
- *Data visualisation*
- *Design visualisation*
- *Landscape management and maintenance information*
- *Policy mapping*

- *Site survey and analysis*
- *Snagging (paperless)*
- *Storytelling related to place*
- *Wayfinding*

4.5 AR case studies

Key to the City: Using Augmented Reality in the Public Realm, Digital Skills Day, London 2018 – available on LI Campus

Augmenting Your Design, Digital Skills Day, Manchester 2018 – available on LI Campus

5 Mixed Reality

5.1 Introduction to MR

Mixed Reality (MR) is an interactive experience where a real-world environment is merged with a virtual environment. Physical objects and digital objects co-exist and interact in real time. This technology is often considered an amalgamation of AR and VR, however, it is more than that. It links the virtual and the physical world, where actions in the digital world influence the physical world and vice versa.

MR requires physical spaces to be mapped, using point cloud data, to capture associated dimensions and objects within that space. Digital models are then anchored to the space and, as users move around, physical objects that come between the model and device camera cause the model to become occluded, as though it was physically in that space. Returning to the image of the football, the football on the MR slide is being occluded by the play equipment. This greatly enhances the sense of immersion (see Figure 1).

Figure 1. Example to demonstrate the difference between Virtual (VR), Augmented (AR) and Mixed (MR) Reality

Image courtesy of the LI Digital Practice Group

MR content can be static or animated and can react to the environment in ways other than just being occluded. You could kick a MR ball around a room, for example, and it would bounce off scanned surfaces with the same physics you would expect from a real ball.

5.2 MR hardware

MR is typically experienced through specialist headsets that overlay the virtual world with the real-world. To date, this has been achieved in two ways. Microsoft's Mixed Reality Headsets appear to be more like VR headsets; however, they have cameras which can provide the user with real-world visual data combined with the digital world. The more advanced implementation of this technology comes in the form of a headset that mimics glasses, or a visor through which the user can see the world around them and onto which the digital world can be projected.

MR headsets:

- *Google Glass*
- *Magic Leap 1 & 2*
- *Microsoft HoloLens and HoloLens 2*

5.3 MR software

Software for developing mixed reality content:

- *3D Studio*
- *ArcGIS*
- *ArchiCAD*
- *CS Design*
- *KeySCAPE*
- *Revit*
- *SketchUp*
- *Unity with Mixed Reality Toolkit*
- *Vectorworks*

Software for viewing mixed reality content:

- *3D Viewer*
- *BIM Holoview (Revit viewer)*
- *Fuzor AR*
- *Holo360*
- *SketchUp Viewer for HoloLens*
- *vGIS Utilities*

5.4 Application of MR for landscape professionals

- *Real-time visual impact assessments*
- *Site survey and analysis*
- *Storytelling related to place*
- *Policy mapping*
- *Landscape management and maintenance information in the field*
- *Cemetery management*
- *Training of owners, users and maintenance teams*

6 FAQs

This document provides information to help overcome commonly perceived barriers to entry for practicing with digital realities. Here are some answers to frequently asked questions (FAQs).

What are the main benefits of using digital realities?

These are outlined in this document, but here is a short list:

- *Extended Realities (XR) are incredibly engaging, particularly if you have only ever viewed work on flat screens.*
- *Remote 3D & XR access to projects is possible. Positioning yourself in an environment at human scale means you can interrogate proposals and explore designs.*
- *You can exhibit work with a greater level of immersion than conventional 2D methods.*
- *Digital modelling in XR allows us to display projects in-situ and at scale.*
- *We can think about the design of spaces in new dimensions, not just as design proposals, but as continually programmed spaces that link the digital and physical aspects of spaces.*
- *XR is becoming more widely accessible to users than it has been in the past.*
- *Smartphone ownership means we can display work to the masses in XR very quickly.*
- *Digital realities have long been explored as a part of other industries, such as in videogame design. This provides a wealth of case studies and lessons learnt, demonstrating collaboration across industries, including the construction sector:*

"Given the increasing number of people who 'see' the built environment digitally, designing environments for the gaming industry can have an impact on the public's appreciation of good design and on their demand for better quality in their physical world".

Deanna Van Buren (Architect & The Witness contributor)

What is the cost and availability of hardware/software to purchase, update and maintain?

The current generation of extended reality devices and software have become more affordable for entry level, but newer releases require a greater outlay. Demand for devices and supporting hardware has been high, impacted by everything from lockdowns due to the COVID-19 pandemic (creating a surge for VR HMDs) to Crypto-currency mining (creating higher demand for processing units).

Like many products, new releases make older generations cheaper to buy, with opportunity in the second-hand marketplace. Software in this space is in a competitive market and often operates on subscription models. Free trials are sometimes available and are worth exploring to gauge their benefit, whilst some providers offer free use when earnings are below a certain threshold. Hardware and software are updated frequently, much like computer operating systems; if used enough, it is worthwhile keeping them up to date.

Why have my clients not requested XR related output?

Knowledge of XR is still not widespread, particularly for those who have not experienced it. However, it is already being used across the landscape profession in every sector, and within other associated professions. It is a forward-thinking aspect of professional practice, and it is an area worth building proficiency in rather than *on the job*. It is not a case of 'if' clients request this technology, but 'when'.

Is there a risk of XR technology becoming substandard/outdated within a few years?

XR is at a point in time where the technology is still evolving and there is an excellent chance that we will look back in 10 years' time in the same way that we do with early mobile phones. This is not the first generation of XR technology, but it has evidently progressed enough to improve what we do.

Are there technical obstacles to overcome before becoming proficient?

Like any new piece of hardware or software, there is a learning curve. Fortunately, the more tech-savvy in the profession have already been working in 3D for many years. Once you grasp the spatial advancements of XR, you can begin experimenting. It may be wise to integrate XR that communicates with your existing suite of hardware and software, and to trial its use first.

What are the sensory limitations of VR?

Whilst VR is predominantly an audio-visual experience, other elements are gradually being introduced. This includes smell and haptic feedback via controllers and wearables. The health sector is very proactive in the use of these in therapy and rehabilitation, for example with burn victims and stroke victims. Perhaps it is more relevant to ask about the sensory shortcomings of the user in order to tailor inclusive experiences of the landscape for them.

What are the spatial requirements to run the VR?

VR can be experienced in a stationary position, whilst lying down or sitting, but this is only recommended for VR experiences when the sole purpose is spectating. VR often encourages or requires movement in a standing position and, for these experiences, you might want to look at a clear space of at least 4x4m. Beware of loose objects and breakables in your environment.

How do I know if my existing laptop/desktop can run VR hardware/software?

Many providers of VR experiences offer online diagnostics to determine your system's capability of running VR. This is often more convenient and less confusing than researching it yourself. An overview of your system information is available on your machine. Typically, you need a computer with a powerful processor (CPU & GPU), dedicated graphics cards (e.g. Nvidia, AMD), and adequate memory (16+GB recommended, but you can run on 8GB RAM). This specification is similar to what you would expect from a 'gaming' PC or laptop.

Why not outsource rather than up-skill internally when it comes to technology?

If you can upskill internally, it offers a longer term saving, so long as you are committed to the training and application of the technology on the job and it adds value to the services you currently offer to your client. Outsourcing this work can be expensive and you are not necessarily learning much about the technology itself. There are businesses that focus on the use of extended reality and its application across a range of sectors rather than focusing on one. This includes Calvium, Arcade, Phoboz Interactice, Draw and Code, Pixel Mill, Love Exploring, and Peel Interactive.

7 Recommended reading

Champion, E. M., **The Phenomenology of Real and Virtual Places,** Routledge, 2021.

Cline, E., **Ready Player One**, Arrow, 2012.

Fink, C., **Charlie Fink's Metaverse - An AR Enabled Guide to AR & VR**, Cool Blue Media, 2018.

Harris, B. J., **The History of the Future: Oculus, Facebook, and the Revolution That Swept Virtual Reality**, DeyStrBks, 2020.

Hespanhol, L., Häusler, H. M., Tomitsch, M., Tscherteu, G. **Media Architecture Compendium: Digital Placemaking**, AV Edition, 2017.