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Fujitsu Virtual Reality

FOR PROFESSIONALS

Mixed Reality (MR) technologies, including Virtual Reality (VR) and Augmented Reality (AR), are changing the way designers, architects, engineers and manufacturers innovate, collaborate and communicate

MIXED REALITY FOR DESIGN AND BEYOND

With new Head Mounted Displays (HMDs), powerful 3D graphics and exciting developments in professional software, Mixed Reality is set to explode in all areas of design, manufacturing and construction.

Mixed Reality (MR) for design, engineering, architecture and manufacturing has been around for decades. But it is only now that this exciting technology is starting to explode.

MR has not only become more powerful, but also more affordable. It is no longer the preserve of large automotive and aerospace firms. Even small architectural practices can now get on board.

Head Mounted Displays (HMDs) like the HTC Vive and Microsoft HoloLens may be leading the charge, but there have also been huge advances in 3D graphics technology and professional software. With powerful desktop and mobile workstations and optimised workflows to move design and engineering data from CAD into mixed reality environments, MR no longer needs to be a consultancy-led technology.

THE REALITY SPECTRUM

Mixed Reality is an umbrella term that can be applied to a range of technologies along the 'virtuality continuum' that connects completely real environments to completely virtual ones.

At one end of the spectrum Augmented Reality (AR) broadens our perception of the real world by overlaying digital text, graphics or pictures on physical objects. This could be assembly instructions for a production line or maintenance information for a piece of machinery.

At the other end of the spectrum, Virtual Reality (VR) completely replaces the real world with a fully immersive, computer generated world. It allows the user to experience buildings prior to construction, or cars before they have been made, and to optimise the complete development process from design to manufacture.

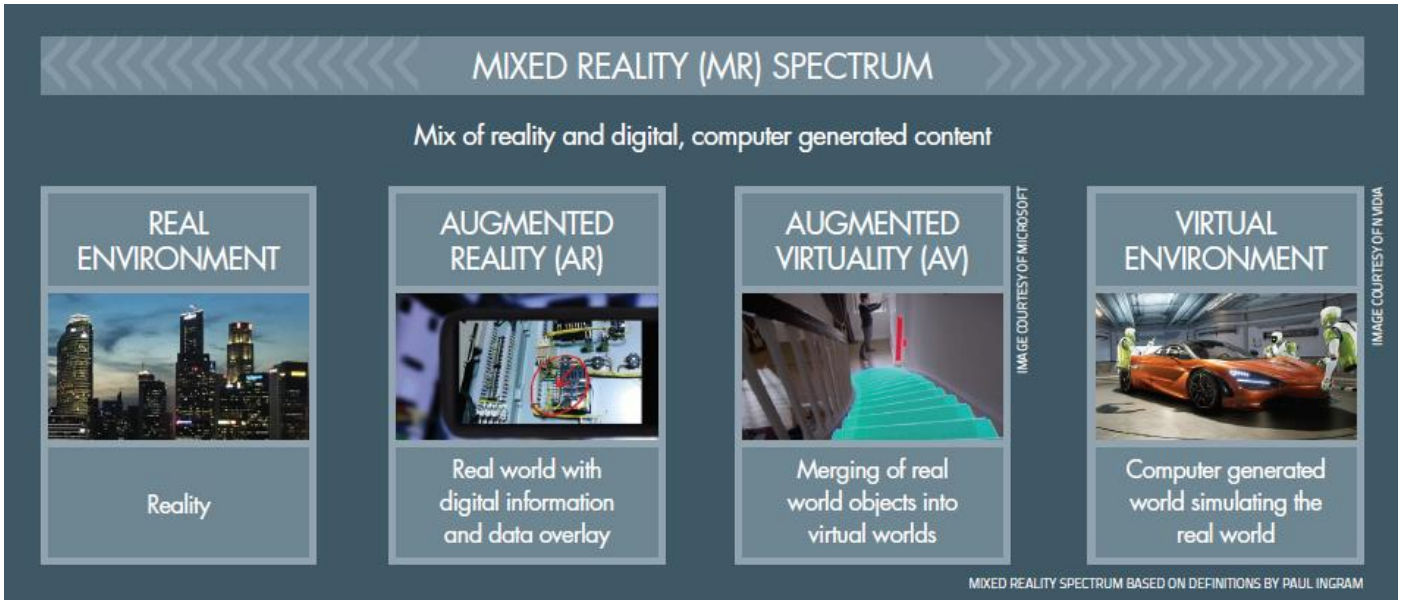
Augmented Virtuality (AV) sits in the middle, combining the best aspects of VR and AR, allowing users to see believable 3D virtual objects alongside physical objects. This could be a car in your driveway, or a new kitchen in your home.

VR - A PHYSICAL PRESENCE

To date, the architecture, engineering and construction, and product development and manufacturing sectors have felt the biggest impact from VR. This is down to both the maturity and availability of software and hardware and the power of the technology.

VR can give an incredible sense of being physically connected to a virtual product or building. It can evoke a visceral response that simply cannot be matched by viewing a 3D CAD model or photorealistic rendering or animation on a 2D screen.

But VR is not just a viewing experience. Users can interact with designs as they would in the physical world: car doors can be opened; light switches turned on; and engine parts grabbed and moved. This can be a powerful tool for design exploration, virtual prototyping, marketing or sales. VR can have a huge influence on collaborative design review, or act as an incredible communication tool for clients or customers. Engineers can be trained on virtual products before they have been built for servicing or operation.



THE FULL SPECTRUM OF MIXED REALITY SOLUTIONS

Fujitsu is perfectly placed to support the complete spectrum of Mixed Reality applications for product development, engineering, architecture, manufacturing and beyond.

The FUJITSU CELSIUS desktop and mobile workstations with NVIDIA® Quadro® GPUs can provide the 3D performance and reliability that professional Virtual Reality applications demand. And through close collaboration with companies like Autodesk at its VR Center of Excellence (page 3) Fujitsu can better understand the workflow requirements of designers and engineers, as well as the many challenges they face.

In the field of Augmented Reality Fujitsu is leading development, creating dynamic new workflows to support the maintenance, repair and operation of equipment.
Its AR solution centres on the lightweight, rugged FUJITSU Head Mounted Display IOT001 which can be fully integrated into the company's enterprise solutions.

VIRTUAL EDUCATION

When it comes to IT hardware, students at the London Design and Engineering University Technical College are some of the most demanding in the world. They need powerful workstations to create virtual worlds using advanced 3D software like Unreal Engine for gaming and VR, Autodesk 3ds Max and SolidWorks.

The UTC's dedicated VR lab provides its students with 25 FUJITSU CELSIUS M740 workstations. The powerful VR Ready machines were used on a recent project to design a virtual reality Ethiopian village environment inside Unreal, to be explored with the Oculus Rift.

The UTC supports other students with 50 FUJITSU CELSIUS J550 workstations, 88 FUJITSU Desktop ESPRIMO Q556 and 40 FUJITSU Notebook LIFEBOOK U745.

AUTODESK VR CENTER OF EXCELLENCE

In 2017 Autodesk opened its VR Center of Excellence at its European headquarters in Munich, Germany. The VR Showroom gives customers from the automotive, design and architectural communities the opportunity to get hands-on with the very latest VR / AR and MR technologies.

The state of the art facilities, which show off the latest Autodesk professional VR software tools including Autodesk VRED, are being powered by FUJITSU CELSIUS workstations. This includes three FUJITSU CELSIUS M740 'VR Ready' workstations with dual NVIDIA® Quadro® Pascal GPUs for HTC Vive.

For more information see

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ARCHITECTURE, ENGINEERING, AND CONSTRUCTION

Mixed Reality can have a huge impact on design. Life-sized buildings can be explored before they are built. The feeling of presence and scale from a fully immersive experience is already approaching reality.

The possibilities for MR in Architecture, Engineering and Construction (AEC) are countless – from bringing clarity to design review and solving construction and serviceability issues to revolutionising client communication and producing enthralling sales and marketing experiences.

The single most compelling reason for using MR in the AEC sector is the sense of presence, proportion and scale that you get from wearing a VR headset like the HTC Vive. It can make you feel that the virtual building is truly real. The physical connection can be so strong that some users experience vertigo in potentially perilous situations.

This connection can be a hugely powerful asset. VR for design review can reveal issues that simply would not have been spotted with 2D drawings or 3D models. Architects can be encouraged to try out new ideas and get timely feedback on what does and does not work. Clients are able to understand exactly how a proposed building might function.

Taking a 3D BIM model into a VR environment has traditionally been a highly skilled process. Specialist VR agencies earn their keep through their knowledge of VR game engines (such as Unity or Unreal Engine from Epic Games), geometry and lighting optimisation. Scenes can be customised so clients can explore different design options, materials and lighting without leaving the virtual world.

But for VR to go mainstream in the AEC sector, it has to be quick and easy for non-expert users to move between BIM and VR. The good news is, this is already a reality.

Autodesk Revit Live is a cloud service that is designed to take your BIM model from Revit to an interactive VR environment in two clicks. Desktop software tools Enscape and IrisVR Prospect offer a similar push button approach through Revit plug-ins. IrisVR Prospect also supports other 3D applications, including SketchUp and Rhino (through Grasshopper). Mindesk has a push button workflow from Rhino to VR.

Unreal Engine is renowned for its visual fidelity, but the pipeline for bringing in data from CAD and BIM software has historically been fragmented. Epic Games is working hard to change this with a new

MIXED REALITY: FOR DESIGN AND BEYOND

Mixed reality can deliver huge benefits throughout the entire construction process. Here we look at some of the ways various technologies are supporting new efficient workflows from concept design all the way through to operations and maintenance.

COMMUNICATION

VR is a hugely effective communication tool. It can be used for presentations to clients, planners and for public consultations. A fully immersive VR HMD like the HTC Vive will give best results, but smartphone VR headsets like Google Cardboard can be effective. They also allow many more people to view the content.

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MR can be used at the very early stages of design - using massing models to explore the relationships between spaces or freeform 3D sketching and modelling tools to develop ideas. This can be done in a fully immersive environment with a VR headset or in augmented virtuality where a 3D holographic model floats on a table in the middle of a design office.

CONCEPT DESIGN

Detailed design is currently done on the desktop in BIM and VR is used to give the architect a much better understanding of scale and space. With push-button workflows it's possible to move between BIM and VR very quickly. In the future it may become more common to model in VR or make simple changes such as moving walls, doors, etc.

DESIGN DEVELOPMENT

Commercial buildings, office space and high-end apartments can be marketed and sold 'off plan' long before they are built. VR gives the client a much better understanding and feel for a space than a traditional 2D render. The client can even change fixtures and fittings in real time. Some developers are now using VR instead of traditional show apartments.

SALES / MARKETING

workflow toolkit called Datasmith and tight integration with SketchUp.

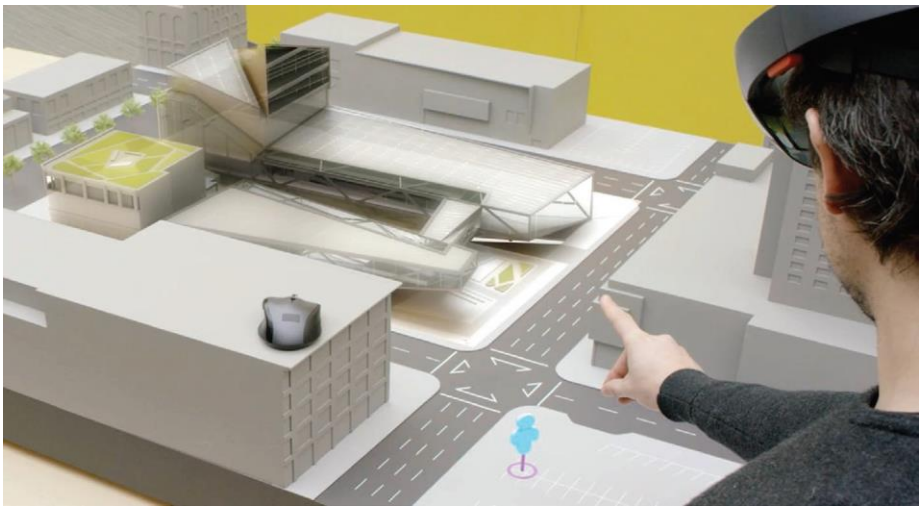
For extremely high-quality and accurate visualisations, VR can be paired with a physically-based renderer. This is ideal for polished presentations and simulations but does require a lot of processing time.

Navigating around a building in VR can be done in a number of ways. For a sitting experience use a game controller or keyboard. For a room scale experience walk around the building, then teleport larger distances with a VR controller.

Users don't have to keep their feet on the ground. During construction of NVIDIA's new Silicon Valley HQ, for example, site managers tracked construction progress by flying around point clouds that had been scanned periodically by automated drones.

VR interaction can go beyond a simple viewing experience. Users can access head-up display toolboxes to control layers, mark up models or explore daylighting with time and date sliders.

Software is also emerging that enables architects to design in a fully immersive environment. ArchiSpace, for example, includes a number of 3D modelling tools for use directly inside VR, as well as the ability to place and scale 3D objects.



VR is also having a huge impact on collaboration. Co-presence technology allows multiple users to exist in a single VR environment. Participants don't have to be in the same physical location. A New York-based architect, for example, could collaborate on the same virtual building with a London-based engineer and a Munich-based cladding contractor. For communication, collaborators can use VOIP and make gesticulations with their virtual mannequin. Virtual sight-guides and pointers can also be used to understand who is looking at what.

Even with these virtual communication tools, when inside a fully immersive VR environment, collaborators can miss out on all important eye-to-eye contact.

To help solve this challenge, the real and virtual worlds can be blended with Mixed Reality headsets like the Microsoft HoloLens. Trimble has been driving developments in this space with tools like SketchUp Viewer (see picture above).

COLLABORATION

Collaborative design review sessions can be held in a CAVE, a projection-based VR display or enabled with VR or MR headsets. With 'co-presence' participants do not have to be in the same room, or even in the same country. Architectural, structural and MEP models can be co-ordinated and clashes identified and resolved.

SITE SAFETY

Construction workers can be trained in VR, using life-size construction site models to help prevent accidents. By actually 'experiencing' potentially dangerous situations, knowledge is retained much better. When on site, AR headsets can be used to alert workers to potential hazards by overlaying pop up warnings.

DESIGN VERIFICATION

Digital fabrication and construction models can be overlaid on top of as-built conditions during construction and refurbishment. This can provide visibility into construction progress and allow construction accuracy to be verified in real time. When errors do occur on site, they can be resolved much earlier, saving time and money.

4D simulation allows firms to 'virtually' construct and rehearse a project before 'actual' construction work begins. Visualisation using VR or MR can bring greater clarity to complex construction sequences and help identify and resolve potential issues before construction begins, saving time and money.

4D SIMULATION

BIM models and data can be augmented over the real-world construction site to spatially orient workers and effectively convey design intent. Tasks can be displayed on voice controlled AR / MR headsets, giving easy access to data, drawings and in-context 3D models while leaving both hands free to complete manual tasks.

CONSTRUCTION

Systems operation and maintenance information can be overlaid over installed equipment on site. Maintenance workflows can be communicated through stills, videos or augmented models and hands kept free. By capturing as-built conditions during construction, workers can have 'x-ray vision' to see utilities behind walls or underground.

MAINTENANCE

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PRODUCT DEVELOPMENT AND MANUFACTURING

MR can promote a holistic development process, where design, engineering, manufacturing, operations and maintenance can all be optimised, long before committing to costly physical prototypes or production tooling.

While the automotive, aerospace and heavy machinery sectors continue to drive adoption of Mixed Reality in design and manufacturing, the combination of low cost HMDs and powerful GPUs means MR is now expanding into many different areas.

VR is driving this change and is being deployed at all stages of product development, from 3D conceptual design and virtual prototyping to factory planning and interactive marketing.

It allows products to be experienced at human scale before they are built, often in context of where they will be used. This can encourage designers to explore bold new ideas and give them the confidence to make the right decisions early on.

With a focus on render quality, VR can aid aesthetic decision making. Here, the use of physically-based materials, dynamic lighting and ambient occlusion can help make products look incredibly real. Shadows and reflections are convincing and react instantly as the user moves position. In addition, anti aliasing, which smoothes the jagged edges of diagonals, can aid perceived quality assessment.

Functional and ergonomic aspects of products can also be validated. Realistic mock-ups can include motion simulation so users get a physical behavioural experience as well as a fully immersive and realistic visual experience. Parts can be 'virtually' assembled and disassembled for serviceability checks or training.

Manufacturing processes can be simulated to make the production line safer and more efficient.

MR can promote a holistic development process, where design, engineering, manufacturing, production, maintenance, overhaul and repair can all be optimised, long before committing to costly physical prototypes or production facilities. This can significantly reduce change orders, time to market and in-the-field operations.

Smoothing the path between CAD and MR is essential for adoption to go mainstream. Powerful professional VR tools such as moreViz, TechViz XL, ESI Group IC.IDO, Virtalis Visionary Render and WorldViz Vizard offer CAD to VR workflows for traditional high-end CAD

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CONCEPT DESIGN

Conceptual models, created in desktop CAD, can be viewed in VR so the designer is truly immersed inside the design. In the automotive sector, for example, this method is much cheaper and quicker than producing a physical concept vehicle. New generation tools also allow designers to 3D sketch and model inside VR at 1:1 scale.

VIRTUAL PROTOTYPING

Designers and engineers can explore human machine interaction and validate the functional aspects of a product inside VR. This includes ergonomics, reach and accessibility studies and physics-based serviceability testing. Virtual prototyping is not limited to physical objects. Engineers can also visualise simulation results using MR.

An AR headset can be used to capture the requirements for a design / engineering project using its built-in camera, microphone or 3D scanner, or Bluetooth/USB colorimeter or digital callipers. This could be to review features of current / competitive products or for capturing context (e.g. adding virtual notes and annotations to a factory layout).

REQUIREMENTS CAPTURE

Designers can jump between desktop CAD and VR to properly understand the scale and proportion of products. Different iterations can be compared and contrasted. Designs can also be visualised in context, in both the virtual world and the real world - such as a car in a driveway or an electrical appliance in a kitchen.

DESIGN DEVELOPMENT

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tools such as Siemens NX and Dassault Systèmes CATIA.

Dassault Systèmes is collaborating with HTC to drive VR into the enterprise space. PTC has similar aspirations and is also heavily involved in the development of Mixed Reality applications for manufacturing with its ThingWorx Studio application which works with the Microsoft HoloLens.

Autodesk is delivering advanced VR capabilities through its product visualisation and virtual prototyping tool, Autodesk VRED, which can import many of the leading CAD file formats. The software places a big emphasis on visual quality and collaboration. Designers, engineers and other stakeholders are able to participate in interactive design review sessions, even from different geographic locations.

NVIDIA is developing Holodeck, a 'photorealistic' collaborative VR environment that features customisable avatars, sound and haptics.

Enterprise VR solution specialist WorldViz is also focusing on collaboration with a new tool called Visible.

Virtalis is bringing its high-end VR knowledge to the mainstream with VR4CAD, a tool designed to help firms

easily connect design data sets with VR.

Custom CAD to VR workflows also exist for mainstream CAD applications. Data from Autodesk Inventor and Dassault Systèmes SOLIDWORKS, for example, can be brought into the Unity or Unreal Engine game engines via neutral file formats such as OBJ.

To help optimise CAD to VR workflows, Epic Games recently introduced Datasmith for Unreal Engine which streamlines the translation of assets including geometry, textures, materials, lights and cameras.

While VR is not currently suitable for detailed 3D modelling, software like Dassault Systèmes Dream Sketcher is demonstrating how VR can be applied to 1:1 scale conceptual 3D sketching. At the other end of the product lifecycle, Zerolight develops virtual car showrooms for leading car manufacturers such as Audi and Pagani, where customers can interact with and configure cars instantly, in incredible detail.

MARKETING & SALES

Products can be marketed and sold even before they have been manufactured. Custom products can be designed and viewed in situ - e.g. a kitchen or a stair lift. Car configurators allow customers to sit inside bespoke vehicles and evaluate fabric and paint options. With VR smartphones, marketing content can reach a mass audience.

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TRAINING

With MR, operators can be trained on how to use products and engineers on how to service machinery. This can cut down on shipping and travel and help ensure products are used and maintained safely and correctly. Workers can also be trained on virtual production lines, guiding them through the assembly process step by step.

DESIGN REVIEW

Collaborative design review can be done in a CAVE or using various HMDs. With 'co-presence' participants do not have to be in the same room, or even in the same country. With NVIDIA Holodeck, for example, remote collaborators are represented in VR by humanoid avatars. Design review can focus on functional testing, aesthetic evaluation and more.

PRODUCTION SIMULATION

Virtual production lines can be designed, and simulated using MR. Multiple 'what if' scenarios can be assessed and the entire process optimised long before production starts, saving time and money and making the process safer. This can be done entirely in the virtual world or in the context of the physical factory where it will be installed.

MAINTENANCE

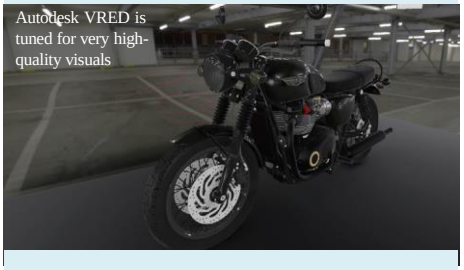
For maintenance, repairs and operation, AR headsets can be set to automatically recognise equipment. Engineers can be walked through repairs using annotations or in-context 3D models, leaving both hands free for manual tasks. For additional guidance, expert engineers in a remote control centre can give assistance.

VR FOR PRODUCT DEVELOPMENT

WORKFLOW

Software

VR needs dedicated VR-capable software. VR is not possible today inside CAD software. Software should be chosen according to intended use. e.g. Autodesk VRED for aesthetic evaluation (very high-quality real time rendering) or IC.IDO for physics-based digital mockup. Also the ease with which it is possible to move from CAD to VR.



Autodesk VRED is tuned for very high-quality visuals

Data pipeline

Some VR applications offer automated 'push

require manual preparation of data.

flexibility. Manual or semi-automated workflows

out of your workstation hardware, but it can be time consuming and requires specialist skills.

Geometry should be optimised to improve

Materials can be mapped from CAD appearances or applied inside the VR application.

Lighting can be automatically taken from CAD or set up in VR. In some applications, lights can be baked into the scene to improve performance.

Consider import and re-use of non-geometric information. e.g. CAD, PLM and IoT meta data

Build in interactivity. e.g. product animations

Workflow should be 'non-destructive', so a lot of

Consider where content might be used beyond its

cost 'mobile' VR headset

Consultanc

VR can be complicated, but

development workflows bet VR, configure hardware or cre and functional VR experien presentations and car co

HARDWARE

Workstations

Choose between a desktop or mobile workstation. Desktop workstations can offer higher-end performance and greater expandability. Mobile workstations allow you to easily take VR anywhere - to the boardroom or a client office.

To view VR content you need a high frequency CPU (3.0GHz or higher). To create VR content some applications can benefit from a CPU with lots of cores. e.g. for data import or light baking.

Workstation GPU

Many GPUs that are traditionally used for 3D CAD are not powerful enough for VR. Instead you need a GPU that is 'VR Ready'.

The NVIDIA Quadro P4000, P5000, P6000, GP100 and GV100 are 'VR Ready' and also optimised and certified for 3D CAD applications, so designers get the best of both worlds when using CAD and VR. Consumer GPUs are not certified for 3D CAD.

NVIDIA Quadro 'Pascal' GPUs have large amounts of high-bandwidth memory, which is important for loading up huge engineering datasets quickly. Consumer GPUs do not have as much.

GPUs should be matched to VR workflows. More powerful GPUs are required for larger datasets, enhanced realism (physically-based materials, dynamic lighting and ambient occlusion), and smoother lines with Anti-Aliasing, which is important for styling.

Some VR applications can harness the power of two GPUs (each GPU renders its own eye).

Head Mounted Displays (HMDs)

For a fully immersive VR experience there are currently three main options (HTC Vive, Oculus Rift and Windows Mixed Reality Headset). In general, the HTC Vive offers a more polished, room scale experience, while the Oculus Rift and Windows Mixed Reality Headset are known for their ease of setup and portability. The HTC Vive can also offer a cable free experience with the TPCast wireless adapter and forthcoming Vive Wireless Adaptor.

Oculus Rift headset

ENVIRONMENT / SETUP

Choose your experience

Choose between a seated experience or a roaming 'room scale' experience.

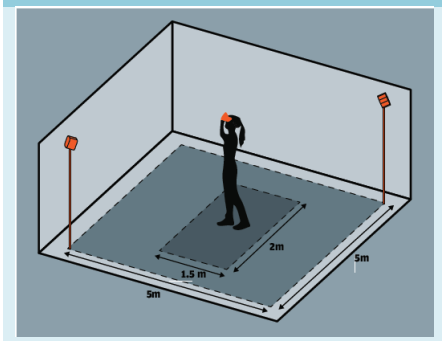
A seated experience is good for jumping quickly between CAD and VR for design validation or when creating a VR experience.

A 'room scale' experience is good for design review or for customer presentations. Explore a car from any angle or walk around a factory assembly line and teleport larger distances.

Seated experience

For setup, place Oculus Rift sensors on a desk and HTC Vive lighthouse emitters on camera tripods or wall mount brackets behind the desk. Interact with keyboard, mouse or VR controllers.

Multiple Vive lighthouse emitters in one office can cause interference, so there are some challenges to overcome for mass adoption. Interference can also be caused by mirrors or direct sunlight.



Room scale experience

Works best in a dedicated room with up to 5m x 5m of floor space (min 1.5m x 2m). No trip hazards.

HTC Vive lighthouse emitters should be mounted at opposite corners of the room, on the wall or on telescopic camera tripods. The Oculus Rift sometimes requires a third sensor.

Interact using VR controllers and additional devices (such as HTC's tracker).

Consider HMD cables. Trailing floor cables can be a trip hazard and contravene health and safety policies. Use metal frames or ceiling mounts to route cables above head height. The HTC Vive Business Edition includes a 5m extension. Eliminate cables altogether with new generation wireless HMDs.

Consider power for all devices and data cables. USB extension cables for movement sensors.