



Kognita

# MIXED REALITY : FROM THEORY TO PRACTICE

*Report about mixed reality sector in 2023*



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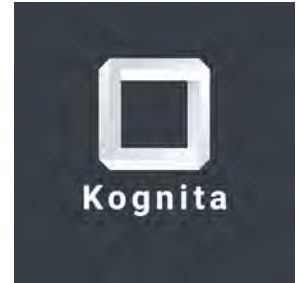
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# MIXED REALITY - WHERE WE ARE AND WHERE WE ARE GOING?



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The debate regarding the potential ubiquity of virtual/augmented reality technologies, or their remaining merely niche innovations, constitutes one of the most heated topics of recent years in the technological and business spheres.



For some time now, we have been hearing announcements that we will soon begin to exist in the era of virtual or augmented reality devices. Founders of startups, hardware manufacturers, CEOs of global corporations periodically assert that it is only a matter of time before these devices replace our televisions, laptops, or smartphones. On the other hand, despite the passage of years, these forecasts do not materialize. Increasingly, many journalists are proponents of the theory that VR technology will always be niche, never gaining mass popularity, and that AR technology is too complicated to

be developed into mass-market product in the near future. Recently, opinions have been appearing in the press more and more often that the era of widely used VR/AR glasses will never come, and companies that invest in it are wasting money and time. Which side is right in this dispute? Can we already definitively assess what fate awaits VR/AR technology?

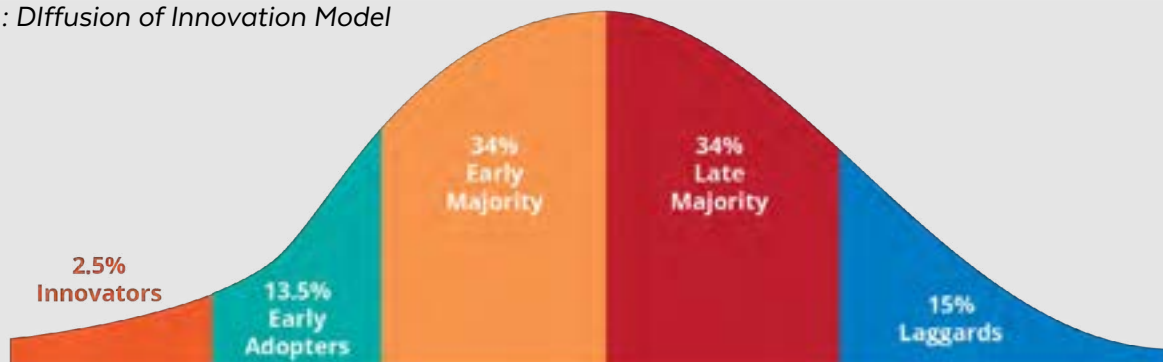


# SCIENTIFIC FOUNDATIONS OF MY ANALYSIS

To answer this question, let's turn to scientific sociological and business theories that explain how innovations are introduced and spread in society. The diffusion of innovations theory is seeking to explain how, why, and at what rate innovative ideas and technologies spread. The creator of this theory, Everett Rogers, is the most frequently cited author in the field of diffusion of innovations research in contemporary societies. The diffusion of innovations is considered the leading theory explaining the spread of innovations in society.

According to Rogers, we deal with five categories of social groups adopting an innovation that becomes mass: innovators, early adopters, early majority, late majority, laggards.

CHART 1 : Diffusion of Innovation Model

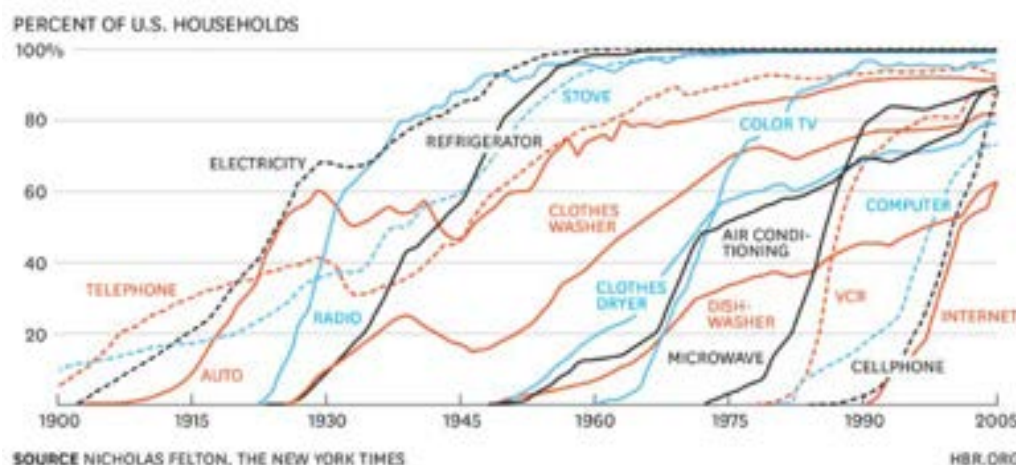


The difference between innovations that remain niche and those that become mass lies in how large a part of society decides to use a given innovation. Not every innovation is used by 100% of its potential users; those that become niche stop at the level of 5% or 10%. For an innovation to become mass, the number of its users must reach a critical mass. It is estimated that this is the point between early adopters and the early majority, or about 16% of the potential size of its users. This means that innovations that cross this threshold have a chance to become large-scale innovations.

## SO HOW LONG DOES IT TAKE FOR AN INNOVATION TO REACH A CRITICAL POINT AND BECOME MASS?

Let's analyse the pace of innovation adoption in the 20th and 21st centuries using the example of American society. As can be seen in the chart, the pace of innovation adoption has changed over the years, and with it also the time needed to reach the critical point and spread throughout society. In the first half of the 20th century, an innovation needed at least 50 years to become widely used. This was the case with the telephone, electricity, or cars.

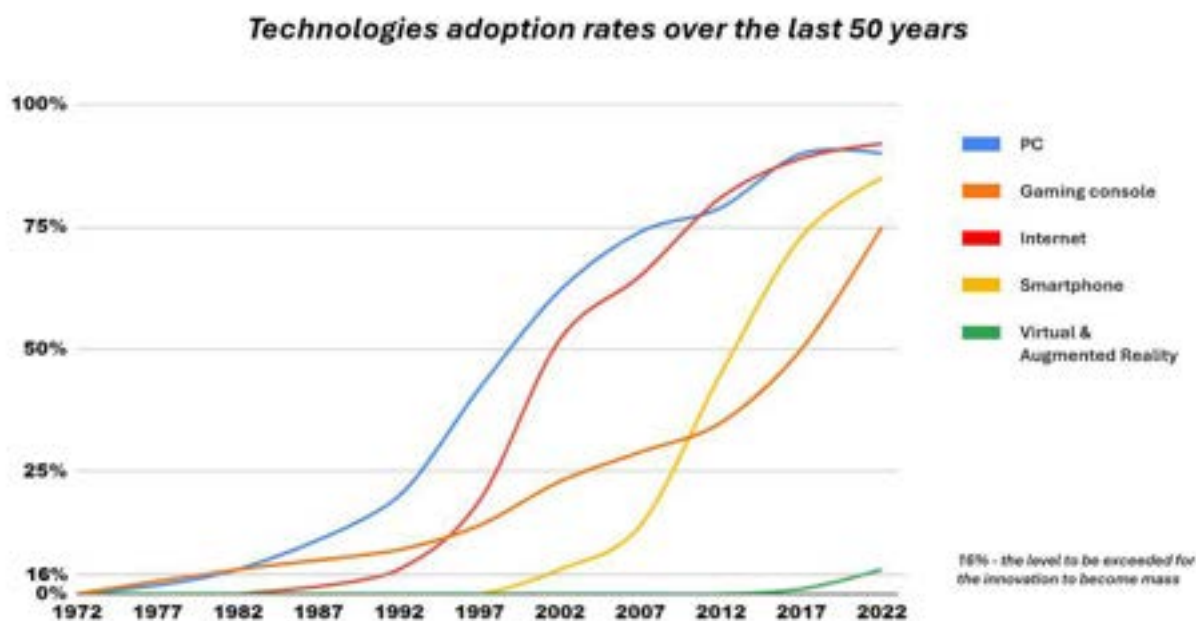
CHART 2 : Diffusion of Innovations in United States in XX Century.



However, in the second half of the 20th century, the pace of innovation adoption significantly accelerated, which we can associate with the dynamic pace of economic growth after World War II, but also with the more efficient flow and access to information and increasing globalization. Innovations such as colour television, computers, or the internet became widely used in society much faster than previous technologies. However, this did not happen overnight. It still took several decades from their invention for a large part of society to start using them in their daily lives. This is due to the basic limitations of these technologies, such as the need to build appropriate infrastructure, the emergence of companies with a business model that can earn money by implementing this technology, or refining it in such a way that it is better and cheaper than existing solutions.

Let's take a closer look at how the development of the direct predecessors of virtual and augmented reality, which we currently use, such as the personal computer, the internet, gaming consoles, or smartphones, looked like. We have been able to observe their adaptations with our own eyes over the past few decades. What conclusions can we draw from this?

CHART 3 : Pace of Innovation Adaptation



Based on data collected by: Horace Dediu, Comin and Hobijn, Our World in Data and Harvard Business Review

## WHAT WAS THE PACE OF ADAPTATION OF PERSONAL COMPUTERS, THE INTERNET, CONSOLES, OR SMARTPHONES?

The first personal computer, the Xerox PARC Alto model, appeared in 1972. The gradual emergence of IBM, Commodore, or Apple computers in the first half of the 1980s accelerated the adaptation of this technology. It was not until the late 1980s that the level of computer adaptation among the American society exceeded the critical threshold of 16%. This means that the pace of adoption gained significant acceleration only about 15-18 years after the appearance of the first personal computer. Personal computers took another 30 years to become a technology used by the entire society, and to reach the last, fifth group, the so-called laggards.

The first smartphone, produced by IBM, appeared in 1992. It took another 15 years until the first iPhone appeared in 2007, which, using the created infrastructure and developed components to that point, was able to significantly accelerate the pace of technology adoption. The level of 16% penetration in society, or our critical mass, smartphones exceeded two years later, in 2009, as a result of the sales success of iPhones 2G and 3G, as well as their imitators. It took another 10 years for the smartphone to become a device used by the vast majority of developed and developing countries' societies.



Analysing the development of the internet, we can also notice that the moment when there was a rapid acceleration of its adoption appeared about 15 years after the moment when we date its invention. Despite our feeling that the internet has developed incredibly quickly, it also took it over 20 years to be used by the majority of American society.

In the case of gaming consoles, the adoption cycle was even longer. In 1972, the Odyssey, the first home video game console, produced by Magnavox, premiered. After the sales successes of the first generations of consoles, there was a sharp drop in demand for the next models of this type of equipment. In 1983, the revenues of gaming console manufacturers in the USA fell from 3 billion to 100 million dollars. Within one year, the market shrank by over 95%! Only the success of Nintendo and its cult NES model in 1985 re-accelerated the pace of adoption. Sony's entry with PlayStation, its rivalry with Nintendo in the 90s, and then with Xbox, gradually attracted more and more players. In 2020,  $\frac{3}{4}$  of households in the US had at least one gaming console.

The above technologies developed during our lifetime, and most of us believe that their development was extremely fast. However, as the above data show, they still took at least 15 years from the moment of their first appearance for 15-16% of society to start using them. This critical threshold allows for a rapid acceleration of technology adoption in society. Often only then does the majority of society learn about this technology, start wanting to use it, and can afford it. Therefore, our perspective is distorted and it seems to us that the internet or smartphone became mass in a few years. The truth, however, is that they needed 20 years to become part of our daily life. The situation will be similar with mixed reality, represented by virtual and augmented reality devices.

## WHEN DID WORK BEGIN ON THE DEVELOPMENT OF VIRTUAL AND AUGMENTED REALITY DEVICES?

Efforts to construct augmented reality glasses began over a decade ago. In 2010, Microsoft initiated work on the HoloLens platform, and Magic Leap was also founded that same year. In 2011, the Google Glass concept was presented, which debuted just two years later as the first commercial product ready for purchase in this category under the name Google Explorer Edition.



Work on creating the first virtual reality headsets began around the same time. In 2011, Sony began a project related to the creation of PlayStation VR, Oculus was founded a year later, and in 2014, Google showed its Google Cardboard VR platform, the first relatively cheap and widely available VR solution. Meanwhile, in 2016, the first high-quality VR headset of the time, such as Sony PS VR, HTC Vive, or Oculus Rift, appeared on the market.

Since then, each of the mentioned manufacturers has already released the second, and sometimes even the third generation of equipment, gradually improving technical parameters such as display resolution, processor computing power, or battery capacity. At the same time, they also ensured increased comfort of using these devices, for example, by reducing their weight or eliminating the need to connect them to computers. The biggest players in the market are also trying to build competitive ecosystems of solutions around their devices, consisting of applications, stores, systems, or tools for developers. This has allowed for the creation of hundreds, sometimes thousands of dedicated VR/AR applications that VR headset or AR glasses owners can use.

## HOW MUCH HAVE THE LARGEST TECHNOLOGY COMPANIES INVESTED IN THE DEVELOPMENT OF MIXED REALITY TECHNOLOGY?

The major technology conglomerates have poured significant resources into the advancement of VR and AR technologies over the past 13 years. Let's start with the journalists' favourite example: Meta, the owner of Facebook, acquired Oculus in 2014 for about 2 billion dollars. Meta is an excellent case for analysing this type of expenditure for two reasons. Firstly, as a publicly traded company, it's obligated to report financial results. Secondly, for several years, it has openly disclosed investments in the VR/AR domain, categorizing this area in its results as Reality Labs. Unlike rivals like Apple or Google, Meta reveals some financial data about investments in this field.

An analysis of financial reports shows that from 2014 to mid-2023, Meta invested between 51.5 to 56 billion dollars in the development of VR/AR-related products. This encompasses expenses for hardware production, marketing, software, research and development, and acquisitions of other companies (e.g., Oculus). During this period, Meta generated revenues of 7 billion dollars from the sale of VR devices and applications. This translates to a loss of 44 to 49 billion dollars over 9 years.

Comparing this to the competition is difficult because neither Apple, Google, nor Microsoft share such information in their financial reports. Nonetheless, we can estimate Apple's investments in the mixed reality space based on R&D expenses. Matthew Ball, a renowned metaverse expert, conducted an analysis of Apple's spending post the launch of their first mixed reality device, the Vision Pro, in June. It suggests that since 2018, Apple might have invested around 40 billion dollars in XR technology development. This amount is comparable to what Meta invested in the same timeframe.

Google's and Microsoft's expenditures on XR technologies are likely smaller than those of the two aforementioned companies, but they have certainly been, and will continue to be, significant in the future. We're talking about investments in the billions of dollars. Both companies introduced their own devices before Meta and Apple entered the market, undoubtedly involving substantial research and development costs. Currently, both Microsoft and Google are focusing more on software development than on producing successive generations of mixed reality hardware. Their strategy involves collaborating with other manufacturers (Google with Samsung, Microsoft with Meta) to promote their operating systems and practical applications for the new generations of mixed reality headsets.



## **WHY, DESPITE THESE EFFORTS AND MASSIVE INVESTMENTS BY GLOBAL CORPORATIONS, ONLY A SMALL PORTION OF SOCIETY USING VR/AR TECHNOLOGY IN THEIR DAILY LIVES?**

It's because the current generations of devices are not yet the most convenient solution for users in most envisioned applications. For people and companies to want to use MR devices on a mass scale for work or everyday life, they need to be simply better – faster, easier, and more comfortable – than existing devices or solutions.

For example, if an MR device allows us to navigate an unfamiliar city more easily than a smartphone, it becomes a reason to use it. However, there must be a sufficient number of such reasons for an individual or a company to choose to use MR glasses on a daily basis instead of a smartphone. Since smartphones solve many problems for us and were an improvement over many previous solutions they replaced, and at the same time their price was reasonable enough to justify purchasing them, our expectations for MR devices will be equally high.

Currently, we can list individual cases where AR/VR/MR devices are better than existing solutions. This is evident in the field of video games, where VR games offer a different level of immersion and entertainment compared to traditional gaming consoles. Similarly, in the training sector, learning through VR yields faster results than traditional methods. AR glasses also serve as a better substitute for smartphones in industrial and technical inspections, as they allow users to utilize both hands while providing necessary information to the person conducting the inspection or someone assisting remotely.





# WHAT IS HOLDING BACK FURTHER RAPID DEVELOPMENT OF THE VR/AR MARKET AND WIDESPREAD ADOPTION OF MIXED REALITY TECHNOLOGY?

## *Weight and Battery Life*

Mixed reality headsets need to be comfortable for extended use, particularly if they are intended to replace laptops or smartphones for daily tasks. The minimum expected battery life without recharging is around 2 hours. However, to truly compete with smartphones and laptops, AR/VR glasses should ideally offer a battery life of about 6-8 hours.

Currently, most VR or MR devices operate for about 2 hours on a single battery charge. Some AR glasses, or even certain VR headsets, provide longer usage times, up to 8 or 12 hours, but often rely on external power sources such as external batteries (as seen with Vuzix M400) or smartphone connectivity (like Xreal Air or HTC Flow) to achieve this.

Why can't VR/AR/MR glasses currently achieve the same battery life as smartphones without relying on external power? This is primarily due to the significantly higher power consumption resulting from the greater number of cameras and sensors (thermal, light, etc.) compared to mobile phones. Additionally, the display and processor require more energy to maintain the desired image quality without latency.

However, what limits the extension of battery life in MR devices is their size and weight. MR devices are worn on the user's head and cannot be too large or heavy. The ideal weight for mixed and virtual reality devices is estimated to be between 300-700 grams. For AR glasses, the ideal weight should not exceed 150 grams, while for VR glasses, the limit is around 700 grams. This is based on the assumption that AR solutions are mainly intended for daily use or work (which requires longer usage), while VR is primarily for entertainment purposes, hence the shorter intended usage time. The principle is simple – the longer the device is intended to be used, the lighter it should be to avoid discomfort associated with wearing it.

Current MR solutions, like HTC Elite or Meta Quest Pro, hover around 600-700 grams. VR goggles, such as Sony PSVR or Quest 2, achieve around 500 grams, while AR glasses range from 200-300 grams. An exception is the Xreal Air, which weighs just 79 grams.



TABLE 1: Weight of VR/MR Headsets

1.	Meta Quest 2	503 grams
2.	Sony PSVR 2	560 grams
3.	Pico 4	586 grams
4.	HTC Elite XR	625 grams
5.	Meta Quest Pro	722 grams
6.	Valve Index	810 grams

TABLE 2 : Weight of AR Glasses

1.	Xreal Air	79 grams
2.	Rokid Air	250 grams
3.	Epson BT-40	280 grams
4.	Vuzix M400	370 grams
5.	Vuzix Blade 2	380 grams
6.	HoloLens 2	579 grams

Glasses or goggles must also be comfortable to wear, meaning that the weight is distributed in a balanced way, and the headset's design allows for rapid movements while securely staying on our head. As seen with the device weight, manufacturers have been able to achieve a level that already satisfies a significant group of users. Similar to battery life, this will, however, be a limiting factor in addressing other key elements that are holding MR devices back from entering the mainstream.

## Image Quality

One of the goals of AR/VR/MR devices is to display images of such high quality that they are indistinguishable from the real world. The quality of the image displayed on MR device screens is influenced by several factors, such as screen resolution, pixel density (expressed in pixels per degree and pixels per inch), field of view, screen proximity, and refresh rate.

Each of these elements impacts the quality of the displayed image. What parameters must MR glasses have to present an image in photorealistic quality? In this context, photorealistic quality is defined as the same quality of image that human eyes perceive in the surrounding physical world.

Let's start with the first parameter, which is the image resolution. Although most of us are accustomed to evaluating the quality of monitor or smartphone screens based on the number of pixels in the screen resolution (e.g., 4K or HD TVs), this is not the best measure for VR/AR. A much more accurate indicator here is pixel density, expressed in pixels per degree of field of view. This allows for a better assessment of whether we are approaching the goal of achieving the same screen resolution as provided by the human retina. Achieving this level means that we are unable to perceive any difference between the digital image on the device screen and the physical world.

It's worth noting that there are difficulties in comparing the human eye to devices that capture and display digital reality, such as cameras or VR goggles. The first challenge arises from the fact that screens display pixels that are evenly distributed and of uniform size. In contrast, our eyes do not perceive the world in pixels, making it difficult to compare the human eye to a digital display. Nonetheless, if we wish to make this comparison, it's important to remember that the human eye doesn't see equally sharply in all parts of the field of view. The part of the retina with the highest visual acuity is called the FOVEA. In other words, this is the part of the eye with the highest resolution, which according to our indicator of pixels per degree, means it has the „highest pixels per degree density” compared to a digital display. In the rest of the eye, visual acuity is lower, resulting in a lower pixels per degree density.

If the human eye were a digital camera, its technical specification might indicate it's capable of seeing up to 60 PPD (pixels per degree) in the FOVEA. In terms of visual quality, any display exceeding 60 PPD essentially wastes resolution because the eye can't perceive more detail. This is often referred to as retinal resolution or the resolution that the eye is limited to.

Currently, the best mixed reality glasses in terms of pixels per degree are the Varjo XR-3 and VR-3 models, achieving 70 PPD and exceeding retinal capabilities. Other models, like Pimax Crystal and Varjo Aero, achieve 42 and 35 PPD respectively. However, most of the dominant models on the market, such as Quest 2 and Valve Index, do not exceed 20 PPD.

As seen, achieving a screen resolution close to the resolution of the human lens is technically possible, and the first models that have achieved this have already emerged. However, they remain awfully expensive – the Varjo VR-3 costs over \$4,000. However, it's worth considering whether other key image quality parameters, such as refresh rate and brightness, also reach levels that allow for achieving photorealistic quality.

## Refresh Rate in VR



Pixel density and quantity are only part of the success. Another key aspect is achieving a high enough refresh rate so that the brain cannot perceive delays in rendering the image on the display of a mixed reality device. It is generally accepted that an MR headset must refresh the image at a rate of at least 120 frames per second (120 Hz), and ideally 240 frames per second (240 Hz), to avoid feelings of nausea when using mixed reality. And what are these feelings of nausea, also known as motion sickness or simulator sickness?

Motion sickness arises due to discrepancies between what the eyes observe and what the body feels. When using VR goggles, your eyes perceive a virtual world in motion, while your body isn't actually moving. This can lead to a disorientation of the brain and symptoms like nausea, vomiting, dizziness, and headaches. This happens because the interaction in the VR

environment comes from head movements, not the rest of the body, and any delays between movement and response are more noticeable when the screen is right in front of your face, unlike a monitor or TV at a distance.

Currently, there are VR and MR device models that can display images with a refresh rate of up to 144 Hz, as is the case with the Pimax Crystal. Popular models like Quest 2 and Valve Index utilize a refresh rate of 120 Hz. However, it's worth noting that models like Varjo VR-3 or XR-3, which boast the highest image resolution, offer only 90 Hz. This is due to the limitations of currently available generations of processors, which do not allow for such rapid rendering of a large number of pixels to achieve a photorealistic effect with minimal delays. As a result, MR device manufacturers are forced to compromise – either render the image at a lower resolution or refresh it slightly more slowly.

## Brightness of AR Display

There is yet another limitation related to achieving photorealistic image quality. While the previous two limitations were focused on virtual reality, this limitation pertains to augmented reality. AR glasses must have extremely high brightness to be usable in highly sunny or bright conditions. We've all experienced difficulties viewing a TV or using a smartphone when sunlight hits the screen directly. In the case of AR glasses, they would need at least the same level of brightness as current smartphones. Currently, models like Xreal Air or HoloLens 2 achieve brightness levels of around 400-500 nits, while the latest smartphones like the Samsung Galaxy S22 Ultra feature displays with brightness levels of 1750 nits.

Additionally, AR glasses must allow light to pass through their display to enable the augmentation of the real environment. This leads us to two options – the display must selectively emit even more light to compensate for the light that passes through it, or it must selectively dim areas that shouldn't be illuminated. Both of these options are challenging to implement at the pixel level, and currently, there are no AR glasses that have achieved this. However, implementing either of these options would certainly put a significant load on the headset's processor.

Xiaomi has announced that their latest AR glasses model will feature a display with a brightness of 1200 nits. The device has not yet been released to the market, but this is the current record in the category of AR glasses. When looking at the latest models of MR devices like Quest Pro or HTC XR Elite, we can see that their displays achieve slightly better results – 1800 nits. However, this is still insufficient for comfortable outdoor use on sunny days. A comparable situation applies to AR glasses – their outdoor usage is still heavily restricted.

To increase the brightness of displays in AR glasses, it's necessary to consume more energy, which in turn shortens the device's operating time. The solution to these problems could involve combining several elements, such as a more powerful processor, a more efficient battery, and improved display technology, along with the implementation of selective dimming or illumination of individual pixels.

## **Rendering Images and Processor Computational Power**

Higher pixel density, higher image frequency, and screen brightness - all these elements require increasingly powerful computational capabilities in processors integrated into AR glasses, VR goggles, or MR sets.

Currently, the most advanced processor model used in MR/VR devices is the Snapdragon XR2 Gen 1, present in all the most popular headsets like Meta Quest 2, Quest Pro, HTC Focus 3, Valve Index, Pico 4, and PSVR 2. It was released by Qualcomm in 2019 and has been powerful enough to render images within the specified parameters for the current generation of MR/VR devices.

Apple's Reality Pro is expected to feature the M2 processor, which compared to its competitor, the Snapdragon XR2, offers better performance, higher image quality, and lower latency. We still don't know the exact image parameters that Reality Pro will display. However, it's conceivable that it will enable approaching photorealistic image quality at a refresh rate of 120 MHz, with greater image brightness than previous MR setups.

Does this mean that Apple will dominate the high-quality MR headset category? Not entirely. Qualcomm is already announcing the readiness of the XR2 Gen 2 processor, which will be integrated into the upcoming Meta Quest 3 model, set to be released in October this year. XR2 Gen 2 is expected to be significantly more efficient and allow for a three-fold increase in image quality. This could translate to achieving 60 PPD at a frequency of 90 MHz or up to 120 MHz at the expense of slightly lower PPD. This should enable displaying photorealistic image quality with minimal delay, putting Meta in a competitive position against Apple.

Qualcomm also claims that XR3 and XR4 are ready for mass production and offers significantly greater computational power than previous processor generations. However, the challenge lies in providing sufficient energy for devices that have size and weight limitations, such as MR headsets. The weight and size constraints continue to limit the use of larger batteries, which in turn restricts the use of more powerful processors. Furthermore, it's important to consider the cost of the processor; both the M2 and the new Snapdragon generations are expected to be more expensive than current models. This will influence the price of MR headsets themselves, a crucial factor in the adoption of any technology.



## **Device Price**

Price plays a crucial role in accelerating or decelerating technological innovations, including VR/AR/MR technologies. When it comes to the mass adoption of mixed reality devices, affordability is a key aspect that needs to be accessible to a majority of the population. This price level must also account for differences between countries and regions due to variations in purchasing power.

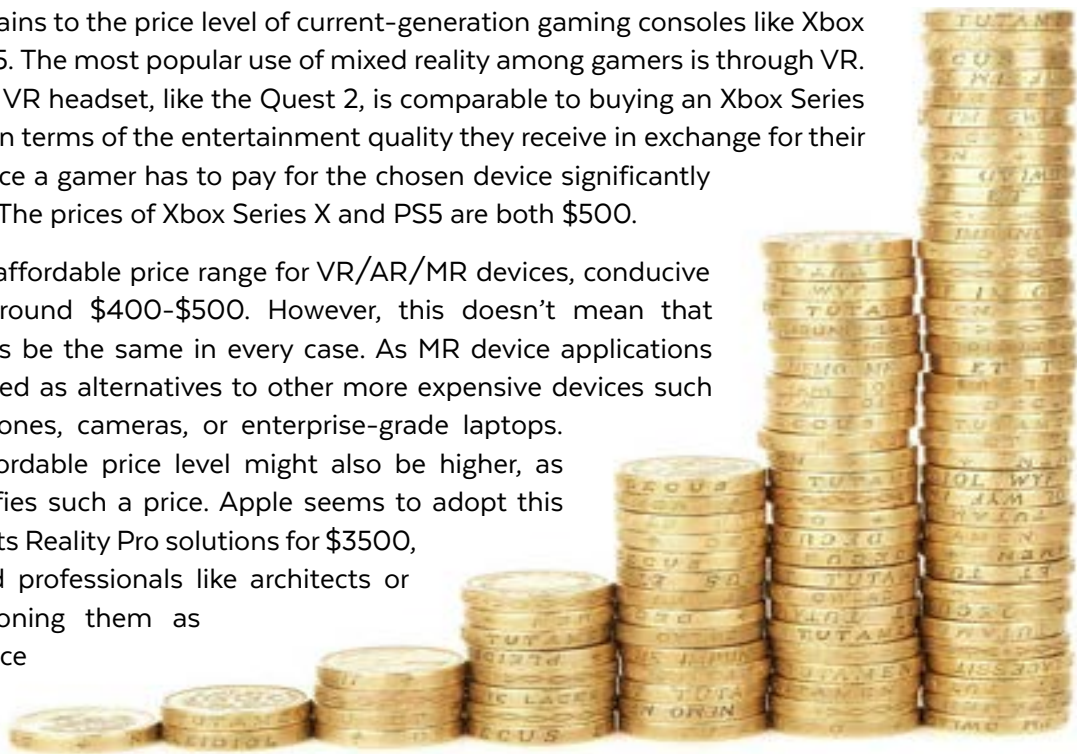
Analysing the American and Western European markets, one can conclude that the current affordable price range for AR/VR/MR devices is around \$400-\$500 USD (€350-€450), net, without accounting for sales tax or VAT. In Poland, this price level is around 1600-2000 Polish zlotys, net.

This price range stems from two observations: the success of Meta's Quest 1 and Quest 2 devices since 2020, and the price levels of gaming consoles like Xbox and PlayStation.

By launching the Quest series, Meta aimed to increase VR technology adoption. This goal was largely achieved by selling over 20 million units of Quest 1 and 2 combined in the past 3 years. This is four times more than the previous VR headset sales leader, Sony's PSVR 1, achieved between 2016 and 2021. However, Meta's success came with financial losses; it is estimated that Meta incurred losses of around \$100-\$200 per unit of Quest 2 due to the exceptionally low price in relation to manufacturing costs. Quest 1 and 2 were sold in 64 GB (Quest 1), 128 GB, and 256 GB (Quest 2) versions, priced from \$400 to \$500. It's worth noting that the previous sales leader in this category, PS VR 1, cost \$400, while its successor, PSVR 2, is sold for \$550. According to analysts' reports, its sales haven't reached similar levels. The reasons for this phenomenon could be diverse, but the higher price point might be one of the main factors.

Another observation pertains to the price level of current-generation gaming consoles like Xbox Series X and PlayStation 5. The most popular use of mixed reality among gamers is through VR. For gamers, purchasing a VR headset, like the Quest 2, is comparable to buying an Xbox Series X or PlayStation console in terms of the entertainment quality they receive in exchange for their money. Therefore, the price a gamer has to pay for the chosen device significantly influences their decision. The prices of Xbox Series X and PS5 are both \$500.

In summary, the current affordable price range for VR/AR/MR devices, conducive to mass adoption, is around \$400-\$500. However, this doesn't mean that this price level will always be the same in every case. As MR device applications increase, they may be used as alternatives to other more expensive devices such as high-quality smartphones, cameras, or enterprise-grade laptops. In that scenario, the affordable price level might also be higher, as the delivered utility justifies such a price. Apple seems to adopt this strategy, planning to sell its Reality Pro solutions for \$3500, targeting businesses and professionals like architects or content creators, positioning them as tools for work assistance or delivering exceptional entertainment quality.



## WHEN WILL WE REACH THE BREAKTHROUGH MOMENT AND ACCELERATE THE DEVELOPMENT OF MIXED REALITY?

Currently, mixed reality is on the verge of a rapid increase in popularity. Referring to the innovation diffusion cycle, virtual and augmented reality devices are used by pioneers, used by 2.5% to 15% of society. According to my calculations, this is currently rather about 5-10% of the entire potential number of users. We are still 2-3 years away from the moment when we reach the critical threshold of 15-16% of society using mixed reality in everyday life. As we already know, this is a breakthrough moment in which there is a rapid acceleration of technology adoption, as was the case with personal computers or smartphones. History will also repeat itself in this case, and we will be dealing with the mass use of VR and AR in our work or daily life activities. However, another generation of equipment is needed, which will solve problems with image quality, operating time, comfort and convenience of use while ensuring an affordable price for the mass user. This generation of equipment will sell in a sufficiently large number of copies for the IT industry to recognize that it is worth creating dedicated applications only for these devices. And this will result in an enormous number of applications serving a wide range of needs, from professional to those from our daily life, such as entertainment, health, communication, or learning. There will be a feedback loop, i.e., a larger number of applications will drive faster hardware development so that developers can deliver even better VR/AR experiences.

The premiere of new equipment from Apple - Vision Pro at the beginning of next year will probably not yet be a breakthrough moment driving the mass adoption of XR technology. Also, the third generation of Meta equipment - Quest 3 will probably not be good enough yet to meet the requirements of the mass user. However, these are the next small steps towards the widespread adoption of this technology. The second model from Apple at a lower price, with a built-in battery, released in 2-3 years, may be what the release of the iPhone 3G was for the smartphone market in 2009. Meta also has a good chance that the successor to Quest 3 (Quest 4?) or its improved Pro version (if that will be the name) will become a mass success, repaying this extraordinary investment that Mark Zuckerberg decided on against the opinion of financial markets and technology journalists. It is also not worth crossing out Samsung's chances, which, together with Google, plans to show its XR device soon. Maybe one of the smaller players, like Snap, Xreal, or an unknown startup to us at the moment, will surprise us with their breakthrough solution. According to the theory of innovation diffusion and observations of the adaptation of recent mass technological innovations, we can safely say that the time of mixed reality is still ahead of us. It is worth remembering the old rule - as people, we overestimate what we can do in a short period of time, we do not appreciate what we can achieve in the long term."

## Chapter 1B

# KOGNITA: LEADING MIXED REALITY INTEGRATOR - HARDWARE, SOFTWARE AND CONSULTING SERVICES

Kognita is providing mixed reality solutions for consumers and businesses. As an integrator of virtual and augmented reality technologies, we are delivering end-to-end solutions meeting customer needs. Our product portfolio includes software, content, hardware and consulting services.

We are analysing customer requirements and addressing them through tailored solutions consisting of selected hardware, ready-to-use or custom-built applications and mixed-reality content. By implementing them inside your organizations we are achieving expected results that can be measured by previously determined KPIs and SLAs.

Since 2020 we have been working with numerous organizations from large companies including Asseco, Play, DLA Piper, by fast-growing firms namely Baselinker or public organizations such as the City of Warsaw till universities like Wroclaw University of Technology.

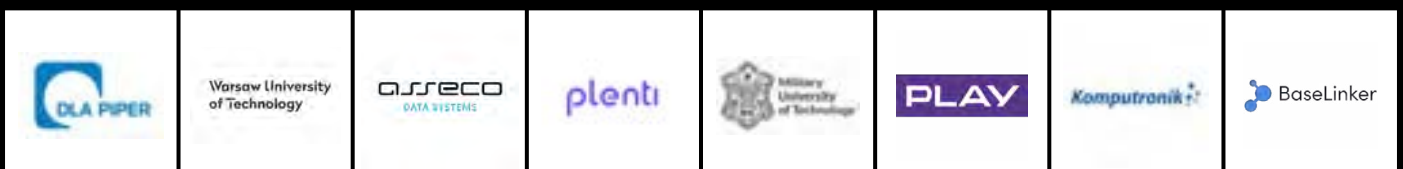
Our international team consists of highly skilled and experienced developers, project managers, 3D visual artists and consultants ready to tackle business challenges with innovative tools and technologies. Our scope of operations includes Europe and the GCC region.

European consumers and SMBs can get access to our product portfolio through Techvers.eu , an eCommerce store specializing in mixed reality. Our group is delivering extended reality hardware from leading technology brands such as HTC, HP, Lenovo, Microsoft or Vuzix. We are an official reseller of virtual and augmented reality software from a large network of verified partners. Kognita is also an owner of Oaza VR, a brand focused solely on the entertainment segment with location-based VR solutions and VR equipment.

### Our Partners



### Our Clients

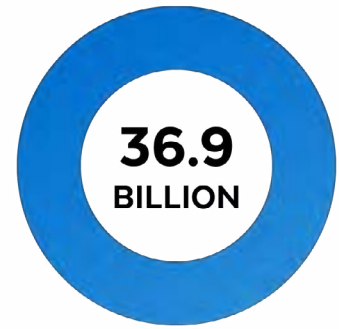


## Chapter 2A

# ANALYSIS OF MIXED REALITY SECTOR

The global mixed reality market that includes augmented reality and virtual reality reached 29.26 billion U.S. dollars in 2022. It is estimated to rise to over 100 billion U.S. dollars by 2026. Compound annual growth rate (CAGR) of mixed reality market has reached astonishing level of 44,5% in the last five years. According to various analysts CAGR rate will remain high at around 40% for the next 7 to 10 years. Extended reality technologies which is just another name for mixed reality, could potentially deliver a 1.5 trillion dollar boost to global economy by 2030 according to an economic impact assessment conducted by PwC economists. Currently the largest sales markets are the United States, European Union and China while Japan, South Korea and Canada are also driving significant growth demand.

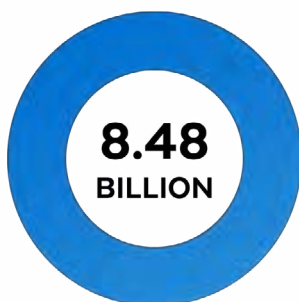
### GLOBAL MIXED REALITY



2023 (in USD)

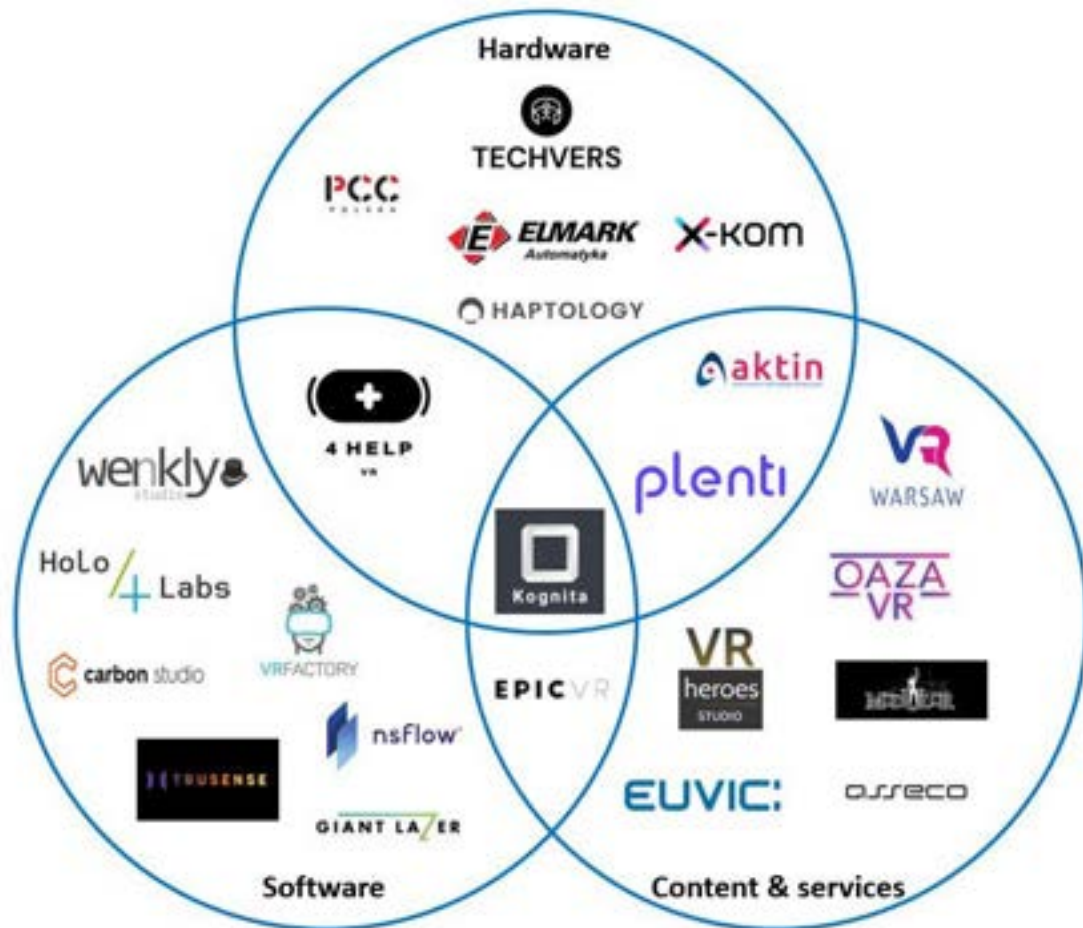


### EUROPE MIXED REALITY

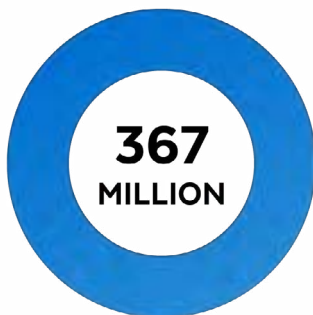


2023 (in USD)

In 2022 the value of European mixed reality market have been calculated at 6.72 billion USD. The European market CAGR was slightly lower than global market reaching 43,56% since 2017 till 2023. CAGR is expected to stay at this high rate over the next several years. Germany, United Kingdom and France are leading European MR market in terms of generated revenues while Italy, Spain, Benelux region, Switzerland and Poland are also significantly contributing to Europe's demand.



**POLAND MIXED REALITY**



2023 (in USD)

Mixed reality market value in Poland is estimated at around 292 million USD in 2022. The market is projected to grow at the same pace as the whole European market with estimated CAGR between 40-45% until 2033. One of the key drivers of growth in Poland market are research projects carried out by universities funded by European Union grants. Another substantial chunk of growth is fuelled by private and public sector R&D initiatives. There are also growing number of commercial projects involving MR technologies, few of them we are describing in another chapters of the report. Last but not least AR & VR gaming industries are also responsible for large portion of generated revenue in this sector.

## HARDWARE SEGMENT

Based on the components, the market is segmented into hardware, software and content & services. Hardware includes devices such as VR headsets, AR glasses, controllers, tracking and haptic devices as well as other accessories. Over the last few years, hardware has been the main revenue source for virtual reality vendors. The value of VR hardware market is estimated at 9.4 billion USD in 2023. However in augmented reality segment, hardware sales have not record such a rapid increase in comparison to VR. On a consumer level, the AR hardware market was valued at 2.4 billion USD in 2023.

The analysts believe that hardware is expected to dominate mixed reality overall market in terms of revenue in the next couple of years. The reason would be launch of new generation VR & AR headsets from Meta, Apple or HTC and growing demand for them due to their valuable applications in entertainment, games and many business areas. Hardware will stay key driver of revenue growth in VR and become more important in the next foreseeable future in AR space.



## SOFTWARE SEGMENT

On the other hand, software is the most critical component of mixed reality, as it provides the applications and tools necessary to create and experience mixed reality. The device is useless unless it provides us value through entertaining experience or productive use case. At the beginning of the development of each hardware platform - computers, laptops, smartphones or gaming consoles, the largest source of income was the sale of hardware. Once the users are in hold of new hardware their spendings are focus on acquiring software enabling them to use device in a most useful way. Software becomes then the most valuable revenue stream for the whole platform ecosystem.

The mixed reality software category consists of consumer, business or military applications, game engines, 3D modelling or animation tools, AR/VR development platforms. It is worth to mention that software is already the largest category of revenue in augmented reality segment. AR Software has a market volume of 11.58 billion USD in 2023. The answer to the question why it overcome AR hardware sale so fast in the initial phase of AR technology development lies in double direction of AR adaptation development. AR software vendors have been relying mostly

on smartphones capabilities to attract new users and monetize them. This let them address already massive userbase of smartphones owners with their solutions without waiting for the AR primary device to build up their userbase. Those AR software companies which focused on dedicated devices for augmented reality such as AR glasses have been left behind in terms of users or revenue. However, it will change in following years as new generation of AR capable devices will enter the market. We expect that AR hardware will catch up with AR software growth rate. In virtual reality segment where hardware was the fastest growing market the situation will change in favour of VR software. It will be the fastest growing segment in virtual reality market over the next 3 to 5 years but still remain lower in revenue nominal numbers.

## CONTENT & SERVICES

The last MR segment, content & services is the most diversified and broad category. It includes virtual avatars, items and experiences purchased inside games or virtual worlds accessible through VR or AR. It is worth to mention that games are classified as a part of software category while for instance in-app purchases for items are treated as a content category. VR movies are also fall into this category. Mixed reality services, second part of this market segment consists of variety range of mixed reality services such as location-based VR, system integration & implementations as well as consulting. Overall content & services currently do not account for a significant share of mixed reality sector revenue. Until the pandemic, the largest source of income in this category were location-based VR centers. During the pandemic with NFT and crypto hypes the fastest growth was noted in virtual avatars and items category. Nowadays system implementations & integration and consulting services gaining a momentum while enterprises are looking into mixed reality being a part of their strategies and everyday business operations.



# UNLOCKING THE POTENTIAL OF MIXED REALITY: HTC VIVE'S INTEGRATED ECOSYSTEM FOR SEAMLESS EXPERIENCES



### Aleksandra Grzybowska

*Head of Marketing  
Eastern Europe HTC Vive*

In recent times, discussions about mixed reality (MR) have largely focused on hardware—devices like the VIVE XR Elite that enable users to explore alternative realities. However, the true power of MR becomes apparent when hardware not only works in isolation but also harmonizes effortlessly with software and digital infrastructure. HTC VIVE's range of offerings embodies this unified approach, exemplified by the smooth integration between its leading hardware products and the VIVERSE for Business platform.

VIVE XR Elite is more than just a state-of-the-art MR headset; it serves as an entry point into a broader digital ecosystem. Instead of just offering immersive experiences, this device establishes a deep synergy between software and hardware, expanding the possibilities of what mixed reality can achieve.

Taking this vision to the next level is VIVERSE for Business, which extends far beyond the notion of simple virtual spaces. This robust platform offers a carefully crafted suite of tools designed for the future of enterprise. It merges elements like cloud infrastructure, cybersecurity, and compatibility with existing enterprise systems such as ERP and CRM to create a formidable digital environment. This comprehensive approach narrows the divide between the physical and digital worlds, enabling businesses to fully harness the transformative potential of MR technologies.

## BEYOND THE DEVICE: MAKING REAL-WORLD IMPACT

### Transformative Virtual Showrooms:

The VIVERSE platform offers businesses the capability to craft interactive, virtual showrooms that bring products to life for potential customers. This feature is particularly significant for industries like automotive and real estate, as it allows consumers to virtually explore and customize products before making a financial commitment.





### Advanced Training:

Leveraging the VIVE ecosystem in conjunction with VIVERSE for Business, companies can offer remote training sessions and collaborative projects within a unified digital space. These immersive simulations authentically replicate real-world environments, providing a controlled setting for learning critical tasks. Demonstrated outcomes include faster learning, improved concentration, and increased confidence and engagement. Such training methods are finding their place across various sectors, including military, healthcare, and broader enterprise applications, providing safe, scalable, and economical solutions.

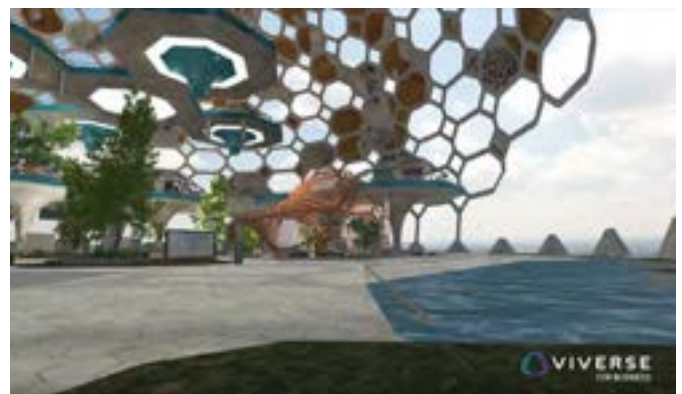
### Revolutionizing Design and Prototyping:

With the VIVE Pro 2, VIVE Focus 3 and VIVE XR Elite, professionals in architecture, engineering, and industrial design can completely immerse themselves in their 3D models and prototypes. This level of immersion allows for real-time design evaluations, early identification of potential issues, and fosters quicker innovation.



## Insightful Data Visualization:

Within the VIVERSE for Business platform, complex datasets transform into interactive, 3D visual experiences. Business analysts can interact with data in a more dynamic manner, potentially revealing insights that would be difficult to discern using traditional 2D methods.



## Enhanced Remote Assistance:

In sectors like manufacturing and healthcare, remote assistance benefits significantly from mixed reality technology. Using virtual annotations, technicians can receive expert instruction, improving the efficiency and effectiveness of maintenance and repair tasks.

## Redefining Business Through HTC VIVE's Integrated Approach

The transformative potential of Mixed Reality (MR) goes beyond just hardware; it lies at the intersection of software, hardware, and digital infrastructure. HTC VIVE's philosophy fully embraces this concept, offering solutions that merge these elements to create seamless work environments for today's evolving business landscape. As organizations adapt to hybrid work models, platforms like VIVERSE for Business offer not merely three-dimensional spaces but fully equipped digital workplaces equipped with a gamut of tools designed for enhanced collaboration, interaction, and innovation.

## Partnerships and Robust Cybersecurity: The Cornerstones of Flexibility and Trust

A unique aspect of HTC VIVE's approach lies in its strategic partnerships and integrations. Recognizing the interdependent nature of modern businesses, VIVERSE for Business is built with scalability and adaptability in mind. It is compatible with a broad range of VR applications and supports seamless integration into mobile and desktop environments. Furthermore, HTC VIVE's commitment to maintaining high standards of cybersecurity is evident from its alignment with numerous international security standards, including ISO27701, ISO27001, GDPR, CPRA, BSIMM, and ACPA SOC. This ensures that enterprises can operate in a secure digital landscape, bolstering trust and reliability.

## Mapping the Future: The Synergy of Hardware and Software

As businesses increasingly look beyond hardware, the focus is shifting towards integrated ecosystems that can offer a more holistic experience. HTC VIVE is leading this change by aligning cutting-edge devices like the VIVE XR Elite with robust platforms such as VIVERSE for Business. This cohesive strategy places the company at the vanguard of guiding the next wave of digital transformation for businesses. It offers enterprises a blueprint for moving beyond the constraints of traditional hardware, enabling them to tap into the full spectrum of opportunities that MR technologies present.



  
**VIVE XR**  
ELITE

# SURPASSING THE LIMITS OF HARDWARE: TANGIBLE BENEFITS ACROSS INDUSTRIES

## Accelerating Aerospace Innovation with Bell

Bell, a forefront innovator in the aerospace industry, leveraged the VIVE ecosystem to modernize their aircraft design processes radically. Through VIVE's immersive hardware and collaborative features, Bell's teams have transformed how they conduct design reviews. The real-time interactive discussions and swift issue identification have catalysed innovation, enabling Bell to reduce the time-to-market for cutting-edge aircraft by a factor of ten.



## The Power of VR: WSB University's Innovative Approach to Logistics Training

In a groundbreaking partnership with HTC VIVE, WSB University and Giant Lazer has redefined logistics training. The shared vision of WSB University and Giant Lazer was clear: to develop a comprehensive didactic system for Logistics education. This ambitious project aimed to cover a wide range of topics and activities, including prototyping a warehouse, loading a container at a seaport, and inspecting a truck in a logistics yard, among others. The outcome? Thirteen bespoke applications, featuring eleven VR applications and two designed specifically for AR smartglasses, were meticulously crafted to bring these educational experiences to life. The VIVE Focus 3 offers students an authentic experience within a simulated logistics environment. This fully immersive training outperforms traditional methods, imparting practical skills that better prepare students for the ever-changing logistics industry.

## Strengthening Cybersecurity Skills with Hackers in Disguise

Giant Lazer, in collaboration with IT company Sun Capital, has devised a cutting-edge solution to address the pressing issue of cybersecurity awareness among employees. By harnessing the power of VIVE Focus 3, they have developed a training simulation that puts trainees in the shoes of a hacker. This immersive experience allows them to gain insights into the methods hackers employ to breach sensitive data, equipping them with the knowledge and best practices to safeguard their companies and themselves from potential threats and showcasing the vast potential of VR in reshaping cybersecurity education.

## Redefining Dental Surgery Training at the Medical University of Warsaw

By employing the all-in-one VR headset VIVE Focus 3, the Medical University of Warsaw has revamped surgical training for aspiring dentists. Immersive experiences enable precise interaction that mirrors real-world procedures, preparing students with unparalleled expertise before they step into actual operating rooms.

Mistakes are a critical part of the learning experience; they help us to understand our errors and learn how to avoid them. But what if those same mistakes caused injury, pain or even death? This concern has plagued medicine and dentistry students for many years, where a slip of the scalpel or needle can result in a very displeased patient. The solution has long been to replace human beings with lifelike models or cadavers, meaning students can train without fear of causing injury. However, in doing so, the training strips away some of the real-world experiences trainees encounter with actual patients. The Medical University of Warsaw (MUW) in Poland wanted to find a new way to train its dental students –one that would marry the realism of working on an actual person with the safety of a model. The institution turned to VR/AR app developer Giant Lazer, a creative company whose immersive solutions aim to change thinking around workflows in education, industry, and business. From design through to 3D modelling and programming, Giant Lazer pushes the boundaries of VR in their projects.

## Elevating Learning Through Interactive Experiences with Human Partner Leroy Merlin

In a groundbreaking collaboration, Human Partner Leroy Merlin has harnessed the power of VIVE Focus 3 to reimagine the educational landscape, particularly in the realm of hands-on learning experiences. By integrating virtual reality, learners now have the unique opportunity to engage with lifelike tools and materials in an immersive environment. This innovative approach provides a safe and experiential platform for boosting confidence and honing practical skills essential for real-world projects.

## Pioneering Pilot Training with VRPilot and HTC VIVE

Becoming an aviator is no easy thing. However, with VR training, you can simplify the process and deliver more confident flight cadets when they get behind the controls of a real aircraft. Collaborating with HTC VIVE, VRPilot uses the VIVE Focus 3 to offer aspiring pilots highly realistic flight simulations. This revolutionary training modality speeds up the learning curve and provides a safe yet challenging environment for mastering crucial aviation procedures.

## Electrolux uses VR to Better Understand What Its Customers Find Important

Electrolux has capitalized on the VIVE Pro Eye's eye-tracking technology to gain deep insights into customer behaviours. This unique method of studying customer interactions in an immersive setting offers invaluable data for shaping product development and innovation.



## PAVING THE WAY FOR A NEW ERA OF DIGITAL TRANSFORMATION

As we stand at the precipice of a new digital age, HTC VIVE's mixed reality ecosystem offers a vision that goes beyond mere technological novelty. The hardware serves as more than just a point of entry; it's the cornerstone of a more expansive, integrated, and strategic approach to digital transformation. From radically altering traditional training methods to transforming customer experiences, the VIVE ecosystem demonstrates not just the potential, but the actualization of mixed reality in achieving tangible business outcomes.

In navigating the future of work, especially in an increasingly hybrid world, enterprises need more than isolated solutions; they require interconnected ecosystems that are secure, flexible, and adaptable. With HTC VIVE's commitment to robust cybersecurity standards, seamless software-hardware synergy, and a platform that encourages integration and customization, businesses are equipped to not only adapt but thrive in this evolving landscape.

In essence, HTC VIVE isn't just offering businesses a way to experiment with mixed reality; it's offering them a strategic roadmap for navigating the digital future, one that's as expansive and limitless as the virtual universes it creates. As industries continue to discover the power of MR, one thing becomes unequivocally clear: HTC VIVE is not merely keeping pace with the future; it's setting the pace, marking itself as an irreplaceable guide in this remarkable journey towards digital transformation.

# TECHVERS: LARGEST VR & AR OFFERING FOR BUSINESS



## TECHVERS

Techvers offers the largest selection of virtual and augmented reality solutions in Europe. As an independent provider, we have built the widest range of hardware and software for consumer and business customers based on partnerships with major manufacturers. We have been providing our customers with mixed reality solutions throughout Europe since 2016.\*.

Our offer includes virtual as well as augmented reality hardware such as VR goggles, AR glasses, simulators, holograms, projectors, tracking devices, haptics, gaming consoles and many other accessories. We also provide ready-made software in the form of applications from our licensed partners from all over the world, and build and deploy elaborate VR/AR systems to our clients' orders. If you are looking for a unique product that we do not have in our offer, please contact us so that we can help you find and purchase it.

### ***Advice on hardware and software selection***

Our experienced consultants will listen to the needs of your organization and tell you how you can apply virtual or augmented reality in your business. They will help you choose the right technology, hardware and software to meet your strategic, business and technical goals.

### ***Equipment rental and testing at your organization's premises***

If you do not know if the planned product will meet your expectations, we will help you conduct tests at your company. We have a wide range of equipment and applications for business rental. In the absence of a specific equipment or application, we will contact the manufacturer to allow your organization to conduct the test. We also offer rental of selected equipment with delivery to a designated location within the European Union as well as the United Kingdom, Norway and Switzerland.

### ***Installation, configuration and deployment of mixed reality products***

We offer assistance in installing, configuring and fully deploying products purchased from Techvers. You can order this service when you make a purchase in our store. Our consultants will prepare the equipment before shipment, and can also come to your location to perform on-site installation, as well as provide training in the use of the equipment and software. We take a comprehensive approach to the process of implementing mixed reality solutions in such a way that the business processes in your organization take maximum advantage of the potential of this technology!

### ***Who have we worked with so far? Who are our clients?***

Our clients include global corporations such as **Toyota**, major Polish companies in the form of **PGE** or **Asseco** as well as fast-growing startups **Baselinker** or **Plenti**. We also serve public and private universities, elementary and high schools, research institutions and local government units – provinces, cities, counties and municipalities.

### ***Who are our partners?***

We proudly serve as the authorized distributor for leading and cutting-edge names within the mixed reality sector, including **HTC Vive**, **Vuzix**, **Pimax**, **Third-eye**, **Cyberith**, **SenseGlove**, and **4Help**. Our collaborative partnerships extend to the forefront of technological advancement, encompassing industry giants such as **Microsoft**, **Meta**, **HP**, **Pico**, and **DPVR**. These affiliations reflect our commitment to offering the finest products and solutions in the mixed reality landscape.

\*Techvers previously operated on the Polish market under the [sklepozavr.pl](http://sklepozavr.pl) and [dronehero.pl](http://dronehero.pl) brands.



# MIXED REALITY APPLICATIONS IN ENTERTAINMENT



## VIRTUAL REALITY GAMING MARKET

VR gaming market has experienced significant growth over the past decade, transforming from a niche technological interest into a widely accepted entertainment medium. Increasing tech sophistication, decreasing hardware costs, and a rising demand for immersive gaming experiences have significantly bolstered the market's growth.

As of 2023, the VR gaming market continues to surge forward, reflecting a robust growth trajectory driven by improving hardware, higher-quality VR game offerings, and a growing base of consumers. Many industry analysts agree that we're only just scratching the surface of VR's full potential in gaming.

A broad range of players, from independent developers to established gaming giants like Meta, Sony, Valve, Bytedance (owner of TikTok and Pico) as well as HTC and Ubisoft continue to invest heavily in VR technologies. This is not only limited to hardware but also includes content development, creating high-quality, immersive experiences that range from puzzle games to full-fledged VR RPGs.

Some VR games have left an indelible mark on the market. The biggest hit so far was Beat Saber, a rhythm game developed by Beat Games. It is a global sensation, blending music, rhythm, and exercise into a compelling VR experience. Meta bought studio Beat Games behind Beat Saber in 2019. Beat Saber earned a total of approximately 255 million dollars, of which nearly 100 million dollars were earned in the year 2021 alone. Beat Saber's success can be attributed to its simple yet engaging gameplay, immersive VR implementation, and the physical activity involved, aligning well with current fitness trends. Challenges include maintaining user interest over time, expanding song libraries due to licensing issues, and dealing with potential competition from similar games such as Supernatural, SynthRiders or PistolWhip. Beat Saber and their competitors are part of the major emerging category called fitness-focused VR games. It emerged as a major trend, offering a unique and fun way to exercise at home. The success of VR fitness games indicate the sector's versatility, blurring the line between entertainment and exercise.

Valve's Half-Life: Alyx, has also set a high bar for narrative-driven, AAA VR experiences. Half-Life: Alyx's success comes from its immersive narrative, high production values, and leveraging the popular Half-Life franchise. However, its high system requirements and full-length gameplay could be barriers for more casual gamers or those with lower-end hardware.

The proliferation of social VR platforms such as VRChat and Rec Room demonstrates the growing demand for social interaction within VR environments. The success of social VR platforms is due to their focus on social interaction and user-generated content. The challenge lies in moderating user content to prevent inappropriate behaviour, managing server loads, and ensuring consistent user experience across different hardware.

Roblox launched on Quest platform in the end of July 2023. Its official launch on VR platform presents an exciting opportunity for growth for VR gaming space. Roblox had 202 million monthly active users and 66 million daily active users in Q1 2023. By entering the VR space, it opens up a new market for VR developers to tap into, potentially bringing VR gaming to a mainstream audience. It not only opens up new creative and monetization possibilities but also has the potential to drive mainstream adoption of VR gaming, creating a thriving ecosystem for developers, players, and the broader VR industry.



The Polish VR gaming scene is gaining prominence on the international stage, and games like “Superhot” and “Elven Assassin” are prime examples of this. “Superhot,” created by the Polish studio SUPERHOT Team, is a revolutionary shooter where time moves only when you move. The game has won numerous awards and critical acclaim, selling over 2 million copies across various platforms. “Elven Assassin,” on the other hand, is a spear-throwing and archery game that offers both single-player and multiplayer modes. Developed by Wenkly Studio, this game has also received positive reviews and has a strong player community. The success of these games speaks to the growing strength and creativity of Polish developers in the VR field, as well as their ability to create innovative and engaging experiences that attract players worldwide.



In the pipeline, several promising titles could be future hits. Ubisoft announced two new VR games based on their popular franchises, Assassin's Creed and Splinter Cell. Assassin's Creed Nexus VR, the first VR game in the franchise, planned for release on Quest 2 and Quest Pro (and likely Quest 3) this November or December. These announcements were made in collaboration with Facebook, and the games are expected to bring the rich storytelling and action-packed gameplay of these series to the VR platform. There is also increasing interest in VR adaptations of popular non-VR games, as seen in popular Resident Evil 4 VR. There are also rumours that the same way will follow Rockstar, by releasing their incredibly popular title GTA 5 in VR in 2024.



Several trends are shaping the VR gaming landscape, reflecting the evolving needs and interests of gamers. Standalone VR headsets like the Meta Quest or Pico series are gaining popularity due to their affordability and ease of setup, offering a more comfortable and less tethered experience, although PC-tethered and console-tethered devices continue to cater to premium users seeking higher performance. The rise of Social VR platforms, accelerated by the pandemic, has created a new way for people to connect in a socially distanced world, a trend likely to persist as these platforms develop further. Cross-platform play is enhancing inclusivity within the gaming community by allowing players using different hardware to interact in the same VR space. Additionally, VR esports are experiencing steady growth, paving the way for a professional platform for competitive VR gaming. Together, these trends highlight the dynamic and multifaceted nature of the VR gaming industry, pointing to a future with more accessible, social, and competitive virtual experiences.

The development and adoption of VR gaming has faced few roadblocks that present challenges to its widespread success. High development costs are a significant barrier, as creating quality VR games often requires substantial investment, potentially deterring some developers from entering the space. Physical discomfort is another concern, with VR motion sickness affecting a subset of users, and the wearing of headsets for extended periods leading to discomfort for some. Despite notable growth, the VR market's limited audience size compared to the traditional gaming market poses challenges in attracting both developers and consumers. Furthermore, the scarcity of AAA VR game titles, although improving, could act as a deterrent for potential users, limiting the appeal of VR gaming. These roadblocks collectively highlight the complex nature of the VR gaming landscape, indicating areas where further innovation, investment, and development are needed to fully realize the potential of virtual reality in the gaming industry.

The future of the VR gaming market looks promising. With the advent of 5G and cloud technologies, VR gaming could reach new heights. These advancements may help resolve issues associated with high bandwidth needs and storage limitations for VR games, enabling seamless, high-quality experiences. Additionally, the introduction of next-gen VR headsets with improved resolution, field of view, and comfort will further boost the market. The development of faster processors, high-resolution displays, improved sensors, and AI could lead to more immersive VR experiences. It could also eliminate completely physical discomfort and VR motion sickness. The decline in the prices of VR headsets and the rise of standalone devices make VR more accessible to a broader audience. Coming AAA VR game titles from Ubisoft and other large gaming studios can attract more users which will pull more developers into this space.

# AUGMENTED REALITY GAMING MARKET

The AR gaming market has experienced a significant transformation over the past decade. With the integration of AR technology into mobile devices and the development of specialized AR glasses, the gaming industry has seen a new era of immersive experiences. Integration of AR into smartphones was one of the key growth driver of this market in the last decade.

There is no better example of AR game success is Pokemon Go game phenomenon which set the stage for the other AR games. Pokémon GO was launched on July 6, 2016, by Niantic, in collaboration with Nintendo and The Pokémon Company. The game quickly became a cultural phenomenon, leveraging the beloved Pokémon franchise that had already captured the hearts of millions around the world 20 years ago. The game's launch was met with unprecedented success, reaching over 28 million daily active users in the United States alone by August 2016.

The game's integration of AR technology with location-based gameplay created a unique and immersive experience. It allows players with their smartphones to explore their real-world surroundings to find and capture virtual Pokémon. Players were encouraged to interact with other players, and participate in special events. Niantic's previous experience with location-based gaming through Ingress provided a solid foundation for Pokémon GO's mechanics.



As of 2023, Pokémon GO has surpassed an astonishing 1.7 billion downloads globally, maintaining a strong user base with approximately 150 million daily active users. The game's sustained popularity can be attributed to Niantic's continuous efforts to keep the experience fresh and engaging. Regular updates, introduction of new Pokémon, unique events, and collaborations with other brands have kept players invested in the game.

The amazing success of Pokemon Go has attracted crowds of other companies ready to copy Niantic's idea and release their own AR games for smartphones utilizing location-based feature. Since 2016, there have been many AR games that have been financially successful. Most of them leverage popular franchise for instance basing on popular movies or TV series such as Jurassic World Alive which lets players find and collect dinosaurs in the real world. Another examples

were The Walking Dead: Our World or Star Wars: Jedi Challenges. There were also successful AR experiences leveraging gaming legacy titles such as Angry Birds or Minecraft. Niantic also did some new AR games, this time using widely popular Harry Potter brand by launching Harry Potter: Wizards Unite which allowing players to explore the magical world of J.K.K Rowling through augmented reality.

While other AR games have been popular, none have reached the same level of success as Pokemon Go. Why did this happen? One of the key elements was the novelty factor. Pokémon GO was the first major AR games to hit the market. Its launch in 2016 came at a time when smartphones were becoming ubiquitous, and AR was a novel and exciting technology for the general public. Another factor is social engagement, as the game design is encouraging social interaction, both in-game and in the real world. Combining them with brand strength, accessibility, continuous updates, and media coverage created a perfect storm for Pokémon GO's success. While other AR games have been successful in their own right, the unique convergence of these factors for Pokémon GO has made it challenging for other games to achieve the same level of success.

Nevertheless we believe that AR Games utilizing real-world locations and smartphones will continue to grow in popularity in the nearest future. However in order for AR games to attract substantial more users and keep up with growing VR gaming segment there have to be a major shift in the hardware space.

Traditional AR gaming which we get familiar in the last decade, primarily reliant on smartphone and that has certain limitations in terms of immersion and user experience. The development of lightweight and user-friendly AR glasses by providing a more intuitive and hands-free interface, can overcome these barriers. Lightweight designs ensure comfort during extended use, while user-friendly interfaces make the technology accessible to a broader audience. This can lead to a more immersive and engaging gaming experience, where the virtual and real worlds blend seamlessly.

The surge in AR gaming due to these advancements isn't merely speculative; it's grounded in the evolving needs and expectations of gamers. As technology progresses, so does the demand for more interactive and lifelike experiences. AR glasses can provide a level of immersion that smartphones cannot match, allowing players to interact with virtual objects and characters in their actual surroundings without the need to look through a handheld device. This not only enhances gameplay but also opens up new possibilities for game design and interaction. The integration of AR glasses with other wearable technologies, like haptic feedback devices, could further enrich the gaming experience, making the prospect of AR gaming through glasses a promising frontier for the industry.

Over the last 2 years we have been seeing the release of first generation consumer AR glasses sometimes called smart glasses. There are various Chinese manufacturer such as Xreal, Rokid, Huawei, RayNeo or TCL launching their first or second model of smart glasses. What is the difference between them and fully-capable AR glasses described in the paragraph above?

First smart glasses are providing mostly basic overlays without interactive or immersive AR experience. What's even more important is that they don't track user's movements and the surrounding environment, which prevents from enabling accurate placement of virtual objects in the physical location. Smart glasses such as Xreal Air are projecting massive virtual screens before our eyes where we can watch movie or browse internet. They are just an extension of our smartphones, gaming consoles or laptops and very often they need to be connected to them in order to work. Smart glasses are useful for watching movies or to use with very simple AR experiences but they lack of certain tracking and sensing capabilities prevents them from being next-level device for AR games.

On a contrary Apple Vision Pro, new mixed reality headset from Apple possess full AR capabilities allowing spatial mapping in other words sensing environment around us, track our moves and position virtual object in the precise physical locations. This is an augmented reality capabilities we are expecting from a device to be a new game-changing device to propel AR gaming industry. Unfortunately high cost of Vision Pro and Apple strategy focusing on enterprise and lifestyle use cases will definitely restrict number of potential users. It will not be a mass-market device and so AR gaming developers cannot count on that glasses to be their new platform. If they want their new AR game to be as successful as Pokemon go, they should arm themselves with patience and wait for new cheaper device from Apple or someone else. It could be a fully capable AR glasses from Meta, Xreal or mixed-reality headset from HTC or other hardware manufacturer.



The AR gaming market is poised for significant growth in the coming years. With technological advancements, the introduction of new gaming concepts, and the backing of major industry players, the future looks promising. However, challenges such as hardware limitations and privacy concern must be addressed to realize the full potential of this exciting sector. The trends towards wearable AR devices, integration with VR, and location-based gaming are likely to shape the future landscape. Games like Pokémon GO have set a precedent, and the industry is ripe for further innovation. The combination of entertainment, education, and real-world interaction presents a unique opportunity for developers and investors alike.

It is worth to mention that mixed reality games could be a new emerging sector combining AR and VR games into one seamless experience, unique experience. It is hard to know if one hardware such as mixed reality headset will be preferred by gamers instead of few various devices such as VR headset, smartphone or AR glasses providing different type of experience. What we learnt from smartphone revolution is that one fits all approach could be that best strategy for hardware manufacturers so we will be very curious if that strategy will be beneficiary also here. There could be also a scenario where different devices such as VR headset or AR glasses have their own independent growing userbases as it happens in gaming industry. After all, the rivalry between PCs and gaming consoles has never ended with one of the devices winning but with two of them growing their market shares.



Technological innovation will continue to push the boundaries of immersive gaming. AI-powered NPCs, enhanced haptic feedback, and eye-tracking technologies are some of the advancements expected to enhance player immersion. We might also witness a rise in mixed reality (MR) gaming, blending real and virtual worlds for a unique gaming experience. Growing investment in VR by tech giants like Facebook, Google, and Apple is an encouraging sign for the industry's future growth.

## MOVIES IN VR AND MIXED REALITY

Virtual reality and broadly speaking mixed reality movies industry represents a transformative evolution in the way audiences experience cinematic storytelling. In VR movies, viewers are immersed within the narrative, gaining a sense of presence and interactivity that traditional films cannot offer. By wearing VR or MR headsets, audiences can explore scenes from multiple angles, engage with characters, and even influence the storyline's progression. This technology has garnered significant interest from both filmmakers and audiences alike, promising to redefine the future of entertainment.

It is worth noting that there are two distinct way of making VR movie, one can use volumetric and 360-degree videos as tool to present immersive experiences. Volumetric video involves capturing a three-dimensional representation of a scene or subject, allowing viewers to move around and explore the content from different angles. This technology uses an array of cameras or sensors to capture the depth and texture of objects, creating a lifelike experience that can be viewed in virtual reality or mixed reality environments. On the other hand, 360-degree videos capture a panoramic view in all directions, immersing viewers in a spherical environment.

The benefits of volumetric video lie in its ability to offer a more interactive and immersive experience. Filmmakers can use volumetric technology to bring characters and objects to life in three dimensions, allowing viewers to not only watch but also engage with the content from various angles. This can be particularly impactful in storytelling, as it enables the audience to forge a deeper connection with the narrative. 360-degree videos, on the other hand, provide filmmakers with a powerful tool for creating immersive environments without the complexities of full 3D capture. This format's accessibility and ease of production make it an attractive choice for filmmakers looking to experiment with immersive content. It is more limited as it do not allow audiences to be fully immersed in the experience the way volumetric video do. However it is much more easier, faster and cheaper to do a 360-degree videos than creating a volumetric movie.

The development of the VR movies industry is slowly accelerating, driven by advancements in VR technology, greater accessibility of VR headsets, and the creativity of content creators. In 2021, the number of all movies produced in VR by professional studios was about 400 films. This number is now doubled every year since that! Independent filmmakers are experimenting with this new medium to create immersive and captivating experiences. The rise of VR film festivals and dedicated platforms for distributing VR content further illustrate the industry's growth.

However, the industry also faces challenges that must be addressed for sustained growth. The biggest is the limited number of VR users compared to the number of people using traditional ways of watching movies through TV, cinemas or computers. It prevents major movie studios to create blockbusters movies in the new VR format, and lack of the greatest and newest movie hits limit the increase in the number of viewers. Another issue is that creating compelling VR narratives demands a different set of skills than traditional filmmaking, requiring directors to consider how viewers will engage with the story in a 360-degree environment. Additionally, monetization strategies and content distribution channels for VR movies are still evolving. It would take time to build exciting VR movies which can attract the attention of large audiences. Nonetheless, the opportunities for growth are substantial. As VR technology continues to improve and become more affordable and provide better quality, a wider audience could embrace VR movies as a novel form of entertainment. In conclusion, the virtual reality movies industry holds immense potential, poised to redefine entertainment while surmounting the challenges through time, innovation and creative exploration.



## LOCATION-BASED VR ENTERTAINMENT

VR location-based offers immersive and shared VR experiences in physical venues. Participants wear VR headsets and often other peripherals to engage with interactive and visually captivating content, all within a designated location. It merges traditional entertainment spaces with cutting-edge technology to provide users with a highly immersive and engaging experience that goes beyond what can be achieved at home. These VR arcades or centers offer a wide range of experiences, from thrilling games and simulations to educational and artistic content.

The growth of the VR location-based entertainment industry has been notable due to several factors. One key driver is the desire for more immersive experiences that go beyond what is achievable on personal VR setups. Location-based venues provide a space where people can gather to enjoy high-quality VR content without the need for expensive equipment. The audience for these type of entertainment are mostly teenagers, gamers, families, tourists and corporate groups seeking team-building activities.



The covid pandemic has hit this industry hard and caused the collapse of one of the largest VR location-based center chains - American company The Void. Other companies such as Sandbox, Zero Latency or Oaza VR in Poland survived and revived after the pandemic. Despite its promising growth, the industry faces certain challenges. One primary hurdle is maintaining a consistent quality of experience across all locations. Ensuring that VR hardware and software are up to date and properly maintained can be resource-intensive. Additionally, creating compelling and diverse content that justifies the cost of visiting a location-based venue is crucial. Balancing the need for high-quality content with accessibility and affordability is a continuous challenge. Furthermore, as the technology landscape evolves, staying ahead of the curve with the latest VR advancements is essential to retain the interest of tech-savvy consumers.

Opportunities for growth in the VR location-based industry are still significant. Collaborations with popular intellectual properties, franchises, and film studios could attract fans seeking unique and immersive experiences. For instance, Sandbox has developed VR experience around The Squid Game IP and they will be presenting it inside their location from November this year. As the industry matures, addressing challenges through strategic partnerships, content

innovation, and technological advancements will be vital to sustaining its upward trajectory. If you are interested in this sector, reach out to our team in Oaza VR (a brand from Kognita portfolio) specializing in VR location-based offering.

Finally, there is also a trend among amusement parks operators to implement VR attractions such as thrilling roller coaster simulations, multiplayer competitive games, immersive storytelling adventures, and interactive challenges. The largest amusement parks such as Disneyworld or Universal Studios are already using VR to attract guests and provide them unforgettable experiences. There is even a VR amusement park in China strictly focus on virtual reality attractions and experiences. It utilizes advanced VR technology, incorporating high-quality headsets, motion platforms, and interactive peripherals to transport visitors into captivating virtual worlds. We should see more and more such parks being built in other parts of the world in the near future.



## Chapter 3A2

# OAZA VR: ENTERTAINMENT IN VIRTUAL REALITY



Oaza VR is providing entertainment services involving virtual reality and simulations in Poland. Since 2020 we have been building and operating largest location-based VR centers in Poland. Our team of professionals VR enthusiasts will help you choose the best VR attractions for your corporate or public events.

We are renting and operating VR equipment, games and experiences during business or casual events, creating dedicated VR attractions for businesses as well as delivering consulting services for VR entertainment sector.

Our virtual reality and simulator product portfolio includes:

VR headsets such as Meta Quest 2 or many others

- Flight simulators
- Haptic vests
- VR treadmills
- Driving simulators
- Cayak simulators
- Biking simulators
- Hang glider simulator
- VR fitness simulators such as Icaros

Oaza VR have been working with countless organizations from large companies such as DLA Piper, Millenium, Decathlon, General Electric, Michael Page or public entities like Teatr Studio, Warsaw University or City of Warsaw.

If you are planning an event, contact us to learn more about how to use VR to attract more visitors and make their stay more entertaining. We can make help you create amazing immersive experiences for you and your guests that can be remembered long after your event is over!

## Our Clients



## Chapter 3B

# MIXED REALITY APPLICATIONS IN RETAIL SECTOR

The integration of Virtual Reality and Augmented Reality into the retail landscape will revolutionize the way consumers interact with products and services. These technologies bridge the gap between the physical and digital world, offering immersive experiences that enrich the customer journey.



## VIRTUAL STORES AND AUGMENTED SHOWROOMS

Utilizing VR, retailers can create virtual stores that allow customers to browse and purchase products as if they were in a physical store. Let's start with furniture retailers offering virtual showrooms to visualize how items fit within a home setting. It is increasing purchase confidence and reducing returns rate. American home improvement company Lowe created Holoroom enabling customers to design a room using VR, by selecting products from Lowe's inventory. They combine it with Space Visualization and Design Tools giving customers the freedom to create customized equipment's using various materials, colours, shapes, and other details. Another example is famous IKEA through its AR app enables customers to visualize how furniture fits within their home environment before purchasing. Since its launch in 2017 Ikea Place have been downloaded over 10 million times and have over 1 million monthly active users. American retailer giant Macy also created VR furniture experience that allows customers to see a 2D floorplan in 3D in real-time. Customers can pick from a vast selection of furniture and accessories to design a space they will enjoy. These applications and experiences have revolutionized the way customers shop for furniture, providing immersive and interactive ways to visualize products in real-world environments. They have helped in reducing the uncertainty associated with online shopping for big-ticket items like furniture, leading to increased customer satisfaction and sales. From retailers perspective it also decrease number of returns which results in significant shipping costs' reduction.

There are other retailer sectors trying VR/AR implementations and benefitting from being first-to-the-market with their cutting edge solutions. The great examples can be automotive industry. The first one utilize mixed reality technologies to present their products to attract new potential customers to their car dealers physical locations or convert them there into buyers. For instance, Audi VR Experience enables customers to configure their car in a virtual space, with lifelike details. Another German car manufacturer BMW created augmented reality experiences allowing car shoppers to go into showrooms and customize cars with unusual colours or styles using their tablets or phones. They can also use VR goggles to experience what it's like to drive the cars without the need to leave their homes.

## **TRY-ON AND CUSTOMIZATION FEATURES**

Augmented reality enables customers to virtually try on clothing, accessories, and even makeup. It can also allow customization of products, such as adding monograms or changing colours. There is a countless examples how AR solutions are already delivering values for the brands through try-on use case. One of the most interesting AR products are virtual mirrors allows users to virtually try on products, such as clothing, eyewear, or accessories, through a digital interface. Utilizing augmented reality (AR) and real-time image processing, virtual mirrors create a live reflection of the user, overlaying virtual items on their image to simulate how the products would look on them. This technology is commonly found in retail stores, online shopping platforms, and beauty salons, enhancing the customer experience. For customers, virtual mirrors offer the convenience of trying on various products without the need for physical fitting. This not only saves time but also provides a personalized and engaging shopping experience. The virtual mirrors are used by such brands as H&M, Wella, Adidas, Ralph Lauren, Lacoste, Zara, and Burberry.

Augmented reality doesn't always require virtual mirrors to help retailers utilize its enormous potential through try-on and customization use cases. They can use smartphones or AR glasses abilities to present their products on them without need to visit physical retailer locations. Customers can use the Warby Parker iOS app's virtual try-on feature to see how frames will look on them. They select a pair of eyeglass frames, open the camera, and see the frames fitted to their face. The Sephora Virtual Artist tool uses AR to allow customers to try on various makeup products virtually as well as L'Oreal allowing you to experiment with leading beauty brands like Maybelline, L'Oréal Paris, Lancôme, Giorgio Armani, Yves Saint Laurent, and Urban Decay. Another example could be luxury watch retailer WatchBox using AR to let customers try on varied sizes of watches to pick out the perfect one. There are also various AR experiences created by Kate Spade, Asos, Zalando, PacSun and many others helping you better understand the product and fit them before you make a purchase online.

## **ENHANCED PRODUCT INFORMATION**

Augmented reality provides also additional opportunity to deliver product information to customers in a new more engaging ways. With their smartphones featured in AR capability or in the future AR glasses, customers can scan products to access additional information, tutorials, or reviews instantly. It is worth to mention that using only this application seems to be of little interest to customers and in itself is not enough to attract their attention and interest them in your offer. However when we mixed it with other use cases such as virtual stores or try-on its is substantially enriching VR/AR users experience inside the app as well as let us increase conversion rates. Notable example of that approach is Nike's strategy regarding their AR and VR applications. Nike AR app not only allow customers to use their phones just to scan items like shoes or clothing to view information but also provide view how different shoe styles would look on their feet, let them customize it and offers personalized recommendations. It is a powerful combination of augmented try-on, customization and enhanced product information delivered to their customers. Nike is also leading company in implementing mixed reality approach inside their sales processes. They use both AR and VR applications which will in the future become one fully immersed mixed reality application. Right now we can enter VR world through headsets such as Quest 2 to experience the different steps in Nike's supply chain. We can easily imagine Nike integrating that experience inside mixed reality app where the last step of this journey will be Nike virtual store where we can try on new sneakers, customize it and purchase it without visiting physical location.

However inside physical store there is also other interesting application of AR besides virtual mirrors. Augmented reality possesses the potential to significantly revolutionize the way we navigate through stores. It's no secret that locating particular items within a physical store can be a tedious and exasperating process. By incorporating AR, customers can now be directed through the store in a more effective and enjoyable manner.

## VIRTUAL ASSISTANCE AND CUSTOMER SERVICE

Retailers can create personalized immersive shopping experiences for customers by utilizing artificial intelligence capabilities inside mixed reality experiences. Retailers use this technology to provide virtual assistants that can guide customers through their shopping journey, whether online or in physical stores equipped with VR/AR interfaces. These virtual assistants can understand customer preferences, answer queries, and offer tailored recommendations, much like a human salesperson. The benefits for customers are manifold such as providing immediate, 24/7 support, eliminating waiting times and enhancing convenience. Personalized recommendations based on individual preferences and shopping history lead to a more targeted and satisfying shopping experience.

Italian e-commerce platform, which deals with luxury fashion goods, launched a unique product called Yoox Mirror. This was one of the first companies to introduce a digital avatar called Daisy inside virtual mirrors. This particular AI avatar could be fully customized to resemble the buyer and they could edit and view different looks.

Another famous Italian brand Gucci followed their footsteps with its own virtual avatars based on Genies, third-party provider of virtual assistance technology. Gucci let customers create their own Genie avatars by personalizing it to make it look like them. It has also announced plans to develop a “digital closet” which gives all their customers the opportunity to personalize their avatars further. They are few other companies providing technologies enabling creation of its own virtual assistants, one of them is polish company Virbe. Virbe is a Polish company specializing in the creation of virtual beings, offering a framework that transforms brands into virtual personas and enables the deployment of interactive 3D avatars across various platforms.

The implementation of virtual and augmented technologies inside retail processes will be driven by two major trends in the following years. As we

discussed earlier personalized shopping experiences are the current force driving the need to innovate and search for new ways to provide it to the customers. Customization and personalization are becoming central to retail, with VR and AR tailoring experiences according to user preferences. Secondly, integration VR and AR applications into one Mixed Reality experience will be a burgeoning trend due to offering a seamless and immersive customer experience. For customers, this means higher quality experience which is at the same easier than ever to interact with. For brands this means they can attract longer potential buyers attention to their products and let them easier convert into paying one's.

The intersection of AR/VR with the retail sector signifies a transformative shift in the way customers interact with products and services. From virtual try-ons to immersive showrooms, these technologies enhance the shopping experience by adding convenience, personalization, and entertainment. The continued growth of AR/VR in retail will likely be fuelled by technological advancements, consumer readiness, and investment in innovation. However, challenges such as high development costs, security concerns, and technological limitations must be carefully navigated. As the retail industry continues to evolve, the integration of AR/VR will become increasingly central to maintaining competitiveness and relevance. By leveraging these technologies, retailers can create engaging, meaningful experiences that meet the changing needs and expectations of modern consumers.



# ALLEGRO: COSMIC EXPERIENCE CREATED BY EPIC VR

Innovation and technology often go hand in hand, creating new solutions that help organizations achieve their goals. In the context of improving customer service skills, EpicVR teamed up with Allegro, one of the largest e-commerce players in Central and Eastern Europe. The shared goal of both companies was to create a tool that would provide Allegro employees with the opportunity to enhance their customer service skills in an engaging and interactive manner.



## INTRODUCTION AND PROJECT BACKGROUND

The aim of this initiative was to design the VR application “Allegro: Cosmic Experience,” which would serve as an unprecedented training tool. This application was intended to transform how Allegro employees acquire and develop their skills, focusing particularly on those related to customer service.

This project was a response to the growing market demand for innovative training methods. In the digital age, where customers are becoming increasingly demanding and aware of their rights, customer service is a key element of any company’s success. By leveraging VR, it was possible to create simulations of realistic customer service scenarios, allowing employees to acquire skills in a safe and controlled environment.

“Allegro: Cosmic Experience” aimed not only to provide practical training for Allegro employees but also to increase engagement and motivation for learning through gamifying the training process. By harnessing the appeal of VR technology, the application aimed to create an experience that is not only educational but also enjoyable and engaging.

This project reflects EpicVR’s commitment to creating solutions that leverage the potential of cutting-edge technologies to solve specific business problems and enhance employee skills. It also showcases how Allegro, as a dynamically growing company, actively seeks and implements innovative training methods to meet the expectations of its customers.



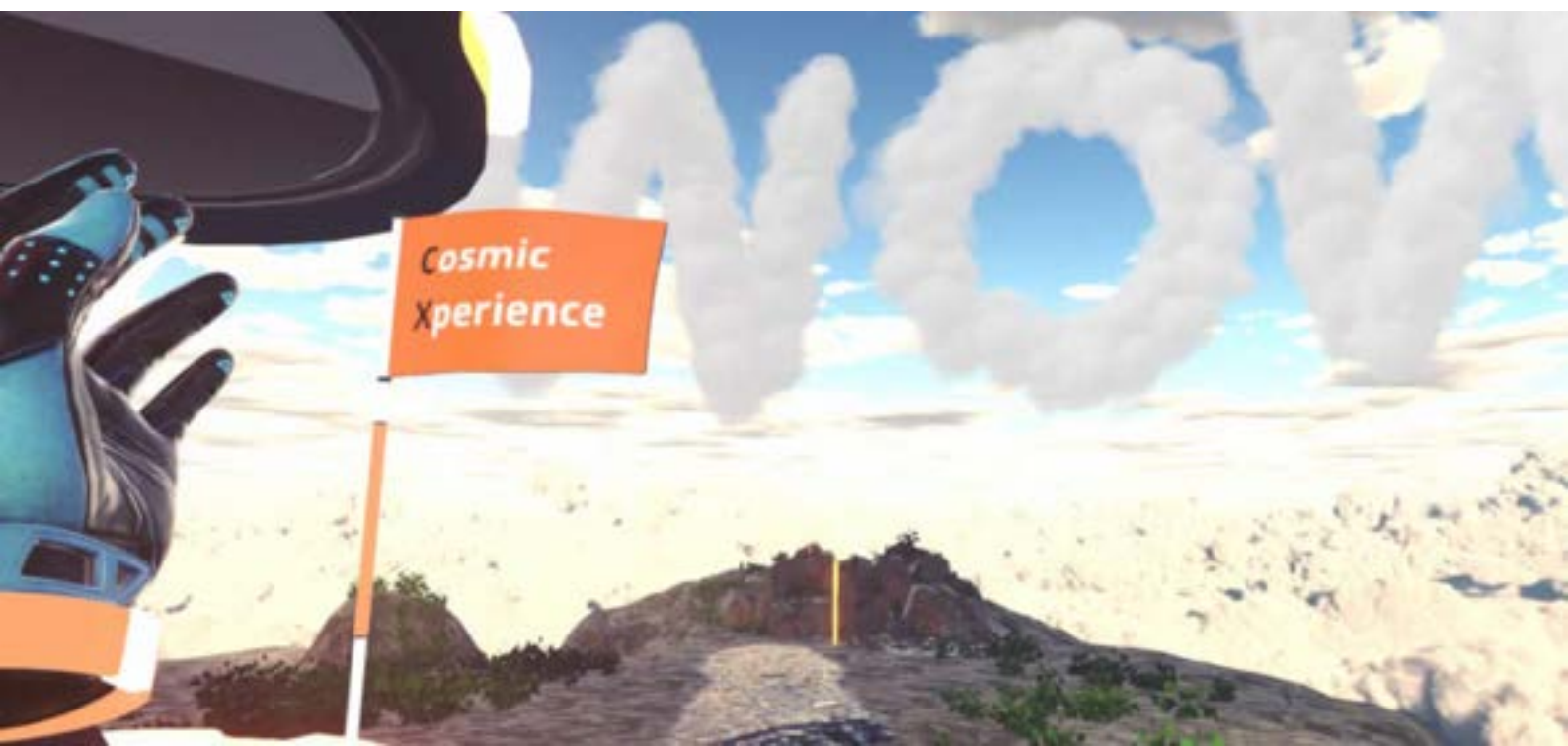
## CREATIVE PROCESS AND IMPLEMENTATION

The creative process is a crucial element in developing any application, and in the case of “Allegro: Cosmic Experience,” it required an understanding of business, technical, and human aspects.

The first stage was requirements analysis. During this process, the EpicVR and Allegro teams precisely identified the project’s business and technological needs. This involved understanding Allegro’s unique requirements, business goals, and end-user expectations.

After defining the requirements, the next step was conceptual design. Here, the team of designers and developers at EpicVR focused on creating the application’s concept. They translated the project’s requirements and goals into a detailed action plan that encompassed all the functions and capabilities the application would offer.

Next, the team focused on scenario creation. At this stage, Allegro presented specific scenarios that were later consulted and simulated in the VR application. Each scenario was meticulously designed to reflect realistic situations that employees might encounter in their work.





# ALLEGRO COSMIC EXPERIENCE

After preparing the scenarios, it was time for programming and implementation. During this phase, programmers concentrated on turning ideas and concepts into reality. Utilizing cutting-edge technologies and tools, they developed a VR application that was not only functional but also user-friendly.

Subsequent steps involved testing and optimization. The application underwent testing for performance, stability, and ease of use. Any issues were resolved, and functions were optimized to provide users with a seamless and satisfying experience.

Application deployment followed as the next step. In this process, training was provided to Allegro staff to ensure that each user would effectively use the application.

The final stages involved monitoring and support during the training phase conducted by Allegro. The EpicVR team provided technical support and monitoring of the training process to ensure the application's stability and performance, as well as to assist users with any issues or questions that arose between training sessions.

## **VISUAL LAYER AND APPLICATION THEME**

The application was designed using attractive 3D graphics that guarantee engaging and interactive training experiences. The overarching theme is the Star Wars universe, adding an element of fun to the learning process and enhancing participants' engagement.

## **RESULTS AND IMPACT ON THE COMPANY**

The "Allegro: Cosmic Experience" application enabled Allegro employees to practically enhance their customer service skills in a virtual environment. This improved the quality of customer service, employee efficiency, and the overall experience for customers using Allegro's services.

Through interactive training scenarios and gamification elements, „Cosmic Experience" effectively elevated customer service skills among employees, contributing to the improved quality of services provided by Allegro.

**EPI**CVR

**Adrian Łapczyński**  
CEO Epic VR

## Chapter 3C

# MIXED REALITY APPLICATIONS IN REAL ESTATE AND CONSTRUCTION

The real estate sector has not usually been at the forefront of implementing modern IT solutions. As a mature, enormous sector of the economy it has typically a more conservative approach to the innovations over the last decades. Nevertheless it was not a case with virtual and augmented technologies. Real estate companies was one of the first to embrace virtual tour in the form of 360 degree virtual reality videos as well as augmented reality models utilized inside property visualization use cases.

## VIRTUAL TOURS & PROPERTY VISUALIZATIONS

Let's start with virtual tours which many of us saw over the years already becoming standard way of presenting the property to the buyers. If you bought, sold or rent high value real estate in the last few years there is a high chance you viewed first by watching virtual tour around the property. Virtual tours enable users to explore a property remotely through a 360-degree virtual environment. These tours can be experienced through VR headsets or web browsers, providing an immersive walkthrough of a property. Virtual tours allow potential buyers or renters to explore properties from the comfort of their homes, saving time and travel expenses. At the same time they enable real estate agents to showcase properties to a broader audience, increasing the chances of a sale or lease.

Second mostly common mixed reality use case in real estate are property visualizations. Developers, architects and real estate agents can show how the property will look like after the construction by utilizing both VR staging and AR modelling. VR staging is the process of creating a virtual, three-dimensional representation of a property based solely on architecture designs. It allows potential buyers to see how they new property would look like before its built or renovated it. They can take a virtual tour of a property from anywhere in the world, using VR headsets or other devices like smartphones and tablets. Unlike traditional staging, where physical furniture and decor are used, VR staging involves creating digital furnishings and decorations that can be customized according to the buyer's preferences.

There is also AR modelling which in real estate involves overlaying virtual furniture, decor, or even entire buildings onto a real-world view. This can be done through smartphones, tablets, or AR glasses. Potential buyers or renters can see how a space might look with different furnishings or how a new development will fit into its surroundings. AR modelling is recommended to use in already built properties where we are planning to switch furniture or do more selected point-based refits. If we are planning huge renovations it is mostly better to do VR staging.

Property visualization tools helps buyers and renters to envision how a space can be customized to their preferences, aiding in decision-making with time-consuming travels. It allows also developers, architects and real estate agents to present properties clients all over the world in various styles, appealing to different tastes at the same time facilitating client understanding and approval.







## ON-SITE CONSTRUCTION ASSISTANCE

The use of Augmented Reality (AR) for on-site construction assistance is a groundbreaking application that's transforming the way construction projects are executed. This technology involves workers wearing AR glasses or using tablets to see virtual blueprints overlaid directly onto the construction site. These digital overlays can include detailed information about the placement of structural elements, electrical wiring, plumbing, and more. By aligning the virtual blueprints with the physical space, workers can see exactly where each component should be placed, ensuring that the construction follows the design specifications precisely. It significantly reduces the likelihood of errors, as workers have a clear, real-time guide to follow. This not only saves time but also minimizes costly rework. Secondly, it enhances collaboration among different teams, as everyone has access to the same accurate and up-to-date information. Thirdly, it allows for quicker decision-making, as any discrepancies between the plan and the actual construction can be identified and addressed immediately. AR on-site assistance can also provide real-time safety information and warnings to workers, helping them recognize potential hazards and take appropriate precautions. This leads to fewer safety incidents and significantly reduce risk of fatal accidents.

Notable example of AR on-site assistance solutions being used in large complex construction is development of Los Angeles International Airport. AECOM global construction service company used there AR while designing and constructing different parts of the airport. There are also various large construction companies already utilizing AR on-site assistance such as Swedish Skanska, Bechtel, Volkert, Mortenson Construction or Highways England.

## Chapter 3D1

# MIXED REALITY APPLICATION IN EDUCATION

Immersive Learning Environments (ILE) are educational spaces that utilize technology to create a simulated or artificial environment where learners can be fully engaged in an educational experience. These environments use Virtual, Augmented and Mixed Reality to create a sense of presence and immersion. ILE represent a significant advancement in education, offering a rich and engaging way to teach and learn. By leveraging VR, AR, and MR technologies, these environments provide a hands-on, interactive experience that can enhance understanding, engagement, and collaboration. While the implementation of ILEs requires investment in technology and training, the potential benefits for both students and teachers are substantial. As technology continues to evolve, immersive learning is likely to become an increasingly integral part of modern education. We can divide ILEs into three categories: virtual labs happening inside school classrooms, mixed & augmented reality tools enhancing school lessons and virtual classrooms accessible outside physical location of the schools.

## VIRTUAL LABS INSIDE SCHOOL CLASSROOM

Virtual labs accessible through VR headsets are innovative educational tools that allow students to engage in laboratory experiments within a simulated environment. These labs are utilized inside school classrooms to provide hands-on experience without the need for physical equipment or materials. By wearing a VR headset, students can manipulate virtual chemicals, apparatus, and conduct experiments just as they would in a real lab. This technology is not only limited to chemistry lessons but also are especially useful in performing physics



experiments, biology anatomy classes or history lessons by transporting the whole class to historical sites or virtual experiences build around it. Virtual labs provide several benefits both for the students and for the teachers. The first group are more engaged in learning due to performing lifelike trainings inside more immersed environment. The virtual environment and tasks inside them are also more connected to the discussed topics than regular classroom activities. **A study by PwC found that VR learners were 4 times more focused than their e-learning peers and 1.5 times more focused than traditional learners.** In addition it is worth to mention that complex concepts most of the time are more understandable and easier to remember

if they are visualized and explored in 3D. **Research by the University of Maryland showed a 8.8% improvement in recall accuracy using VR.** For students, virtual labs provides a safe space to practice and learn, making complex scientific concepts more accessible and engaging. Mistakes can be made without real-world consequences, fostering creativity and exploration. **A study by the University of Copenhagen found that VR increased students' laboratory skills by 76%!**

For teachers, virtual labs offer a cost-effective and manageable way to provide laboratory experiences, especially in schools where resources may be limited. They can also tailor the virtual environment to suit specific learning objectives, ensuring that the virtual labs align with the curriculum. It also provides opportunity to increase efficiency of their classrooms teaching by allowing them to learn in VR how better they can manage students during the lessons. **According to a study by the University of California, VR training improved teachers' classroom management skills by 27.5%.**

# AUGMENTED & MIXED REALITY TOOLS INSIDE SCHOOL CLASSROOM

AR and MR provide interactive and engaging learning experiences, transforming static content into dynamic visualizations. They are quite useful if we don't want to introduce virtual labs yet in our school due to low age of students, limited budget, lack of teachers training or just these particular lessons or subject doesn't require fully immersive experience in VR. Then we can utilize such tools as augmented reality textbooks or worksheets. They both provide interactive 3D models, videos, and animations that enhance understanding and instant feedback to the students. They do not require the same level of training for teachers and students as VR headsets and applications and most of the time are less expensive and easier to implement inside daily classes without the need to reorganize the whole lesson plan.

With the use of Mixed Reality, classroom education can be interactive as MR can enable teachers to show virtual examples of concepts and add gaming elements to support textbooks. This will allow students to learn faster and memorize more information. **Microsoft stated that there is a 22% improvement in test scores among students using immersive technology and a 35% increase in student engagement and retention when learning with immersive and 3D technologies through mixed reality**



The number of students experiencing difficulties concentrating and staying focused while learning is constantly rising. Admission shows that at universities and colleges, students face difficulties while focusing. Moreover, they face other mental health issues, like depression and anxiety. Even at a much younger age, statistics show students experiencing difficulties in staying focused, with the Center for Disease Control and Prevention reporting that the diagnoses of ADHD among K-12 schoolers are continuing to rise, with over 5.7 million children currently diagnosed. In such scenarios, using MR technology during classes enables students to concentrate on literally what is in front of their eyes. In a way, they are forced to interact with their study mates and exclude any potential side stimuli. More research is needed to assess how effective mixed reality could be in the long term to help students with mental health issues as well as other group of students.

## **VIRTUAL CLASSROOMS ACCESSIBLE ALL AROUND THE WORLD**

VR classrooms are innovative educational platforms that leverage virtual reality technology to create immersive 3D learning environments. In these environments, students can attend classes, interact with instructors and peers, and engage with course materials as if they were physically present, regardless of their geographical location. This technology has gained significant traction in recent years, revolutionizing traditional education methods and offering a plethora of benefits. Firstly, they break down geographical barriers, enabling students from around the world to access high-quality education without the need for relocation. Secondly, the immersive nature of VR stimulates engagement and active participation. Students can explore virtual artifacts, environments, and experiments that would be otherwise inaccessible in traditional classrooms. It is also perfect tool to enhance students with many disabilities and let them participate in the same learning environment as the rest students from the same age cohort. Virtual reality technology allow to create much safer environment where your appearance or clothes do not affect how you are perceived by other people.

Moreover, VR classrooms cater to various learning styles, offering a dynamic range of teaching techniques that suit visual, auditory, and kinesthetics learners. For educators, VR classrooms provide insights into student interactions and engagement patterns at the same time facilitating personalized instruction and assessment much better than regular 2D video online calls through Zoom or Google Meet.

Numerous universities and schools have adopted VR classrooms to enhance their teaching methodologies. Institutions such as Stanford University, Harvard University, and the University of London have integrated VR technology into their curricula. VR classroom platforms often provide customizable avatars for students, collaborative virtual spaces for group projects, and already created interactive simulations from several topics to facilitate hands-on learning experiences. Professors can use VR tools to present complex concepts visually, making it easier for students to grasp and retain information.

## **HOW SCHOOL CAN IMPLEMENT VR/AR IN TO LEARNING PROCESS?**

First, we create framework for the curriculum immersive content creation. These are guidelines regarding curriculum from each selected school subjects like chemistry, physics, biology, etc. We ask questions like: What parts of the existing subject should we teach using VR or AR technologies? How do we plan to use mixed reality to teach these topics to students? How much time should they spend on these new tools? How will we track how fast they are learning?

Next, we focus on creating content and integrating technologies. We decide whether to make something customized for our needs or to find existing solutions and use them. We then pick a VR/AR technology provider to work with. They help us build or buy and put VR/AR solutions into the learning process. The provider might also advises us on the right hardware and software to use with the selected VR/AR solution. It worth to mention that both teachers and students would need training to use the technology properly. Ongoing support makes sure that tech problems don't get in the way of learning. Lastly, once VR/AR tools are implemented , we should evaluate how students and teachers using them, gather their feedback and improve the whole process. Nothing is perfect so the only answer it constant improvement and it is up to education institution to continuously advance their learning capabilities.

# TRUSENSE: HOW AI AND MIXED REALITY TECHNOLOGIES CAN UNLOCK VALUE FOR YOUR BUSINESS?



**Jan Boberek**  
*Founder & CEO*

**Damian Lewandowski**  
*Founder & CFO*

The accelerating development of artificial intelligence (AI), which was manifested last year by the rapid increase in the popularity of large language models (LLMs) such as OpenAI GPT-3 brought a lot of excitement in virtually every environment - business or academic and even in the conversations of ordinary people. One of the many valuable applications of these LLMs is combining it with virtual or augmented reality to provide unique innovative solutions for business, schools, governments and regular consumers. What are these solutions?

Let's begin with discussing how business can leverage AI and mixed reality technologies to transform various aspects of operations, communication, and customer experiences through virtual AI assistants. These assistants also called virtual avatars fuelled by AI are digital representations of individuals that utilize advanced AI algorithms to simulate human-like interactions, behaviours, and responses. Virtual AI assistants are capable of understanding natural language, adapting to context, and mimicking emotions, making them sophisticated tools for communication and engagement. They can take form of 3D avatars inside virtual or augmented reality applications or become part of mobile and web applications as a 2D representations of humans.

In business, virtual avatars find application in a wide range of scenarios. They can serve as customer service representatives, guiding users through product information, troubleshooting, and inquiries. Virtual avatars also excel in delivering personalized marketing messages, conducting market research, and facilitating interactive virtual events or training sessions.

There are numerous benefits of employing virtual AI assistants in business. Firstly, they provide round-the-clock availability, enabling consistent and immediate customer support without time zone limitations. This fosters customer satisfaction and loyalty. Secondly, virtual avatars reduce the need for human intervention in routine tasks, freeing up human resources to focus on complex and value-added activities. This can lead to increased efficiency and reduced operational costs. Additionally, these assistants can collect and analyse data from user interactions, offering valuable insights into customer preferences and behaviours. This data-driven approach facilitates informed decision-making and targeted marketing strategies. Overall, virtual avatars powered by AI present an innovative and efficient way for businesses to elevate their customer engagement, optimize processes, and gain a competitive edge in today's technology-driven landscape.

Virtual avatars fuelled by AI can solve a wide range of business problems across various industries. Here are a few examples:

### **Customer service:**

AI assistants can be used to provide 24/7 customer service support to customers. The virtual avatar can guide the customer through the purchasing process, answer frequently asked questions, and provide assistance with any issues. In travel and hospitality industry virtual avatars can serve as virtual travel agents or concierge, offering information about destinations, tourist attractions, flight options, hotel bookings, and travel itineraries. They can also assist with travel-related inquiries, such as visa requirements and local attractions, providing a comprehensive travel planning experience. Moreover in telecommunications companies virtual assistants can troubleshoot common technical issues with internet services, mobile plans, and devices. They can guide customers through setting up new devices, troubleshooting connectivity problems, and explaining billing details, reducing the need for lengthy support calls.

### **Employee training:**

Virtual avatars can be used to provide employees with training and development programs. The avatars can simulate real-life scenarios, allowing employees to practice and develop their skills in a safe environment. In the finance industry, virtual avatars and AI-driven simulations offer a dynamic approach to employee training. These technologies enable professionals to practice risk assessment, trading strategies, compliance protocols, customer interactions, and financial product knowledge in a controlled and safe environment. Virtual avatars aid in refining decision-making skills, understanding market trends, and ensuring compliance with regulations. This immersive training enhances employee proficiency, boosts ethical conduct, and equips financial professionals with the practical expertise needed to navigate complex scenarios and deliver value to clients. Virtual avatars might also simulate equipment operation, safety protocols, and maintenance procedures. Employees can practice handling machinery and responding to emergency situations without the risk of actual physical harm. It could be especially beneficial use case in energy, manufacturing or energy & utilities industries.



## Sales and marketing:

Virtual avatars and AI can be used to personalize marketing and sales messages for customers. The avatar can gather data on the customer's preferences and make recommendations based on their interests and previous purchases. For instance, in e-commerce virtual assistants can help customers navigate through the e-commerce platform, suggest products based on their preferences and purchase history, and provide assistance during the checkout process. Fine-tuned LLMs can be used to provide personalized recommendations, answer customer questions, and even create customized product descriptions. Virtual avatars can be also used to assist customers in brick-and-mortar stores, providing information about products, suggesting alternatives, processing payments and even anticipate customer needs.



## Healthcare:

Virtual AI assistants have substantial applications in the healthcare sector, revolutionizing patient care, administrative tasks, and medical research. These AI-powered assistants can aid in patient interactions, scheduling appointments, and providing medical information. They enhance patient engagement by offering personalized health advice, reminding patients about medication schedules, and answering medical queries. Virtual AI assistants streamline administrative workflows by handling billing, insurance claims, and appointment coordination, allowing healthcare professionals to focus more on patient care. In medical research, these assistants can process and analyze vast amounts of patient data, helping researchers identify patterns, develop treatment plans, and make data-driven decisions to advance medical knowledge.



## EDUCATION WITH VIRTUAL ASSISTANTS

There are also various potential useful applications of virtual AI assistants outside of business world. For instance, in education these assistants can provide real-time support to students, answering questions, explaining concepts, and offering clarifications on assignments. They facilitate personalized learning pathways, adapting to individual student needs and pacing. AI assistants also assist educators by automating administrative tasks like grading, data analysis, and content organization, allowing them to focus on teaching and instructional design. Furthermore, AI assistants enable collaborative learning through group discussions and project coordination. They can monitor student progress and provide insights to educators, helping them tailor their teaching strategies.

The benefits of virtual AI assistants in education are substantial. They foster self-directed learning, encouraging students to take ownership of their education and explore topics beyond the curriculum. AI assistants create an inclusive environment by catering to diverse learning styles and offering support to students who may require extra help. They enhance efficiency by automating routine tasks, freeing up educators' time for more meaningful interactions with students. Additionally, AI assistants contribute to data-driven insights, enabling educators to identify areas where students may be struggling and adjust teaching methods accordingly. As technology evolves, virtual AI assistants hold the promise of revolutionizing education, making learning more dynamic, personalized, and interactive while creating a symbiotic relationship between human educators and intelligent technologies.

Overall, virtual avatars and ChatGPT-4 have the potential to revolutionize the way businesses and public organizations interact with customers, employees, and stakeholders, providing personalized and efficient solutions to various social and business problems.

At Trusense, we combine artificial intelligence with the areas of virtual and augmented reality by creating dedicated virtual AI assistants. Our company experience in developing mixed reality applications bundle together with team of highly skilled AI developers and vast network of industry experts let us build and implement virtual avatars inside your organization. If you would like to know more about AI assistants and how can they be used by your company reach out to us or our partner Kognita.

# MIXED REALITY APPLICATIONS IN HEALTHCARE

Healthcare industry is experimenting with various potential mixed reality applications from VR simulations for medical training, AR-assisted surgeries to patient treatment and therapies. Many of them are still in the early stage of testing while other are already proven tools bringing benefits to patients along with medical personnel.

## MEDICAL TRAINING AND EDUCATION

The applications of VR and AR in Medical Training and Education are revolutionizing the way medical professionals are trained. VR Simulations allow medical professionals to practice surgeries and procedures in a controlled, virtual environment. These simulations replicate real-life scenarios, providing an immersive experience without the risk associated with actual surgeries. VR Simulations are being used by renowned medical institutions for surgical training, resulting in improved performance and skills development. One of the most prestigious medical university - Stanford University School of Medicine has already implemented VR surgical simulations inside their learning courses for future surgeons. Similarly hospitals like Cleveland Clinic also using VR for surgical training for students undergoing medical internships. There are variety of high-growing startups such as Osso VR and more established companies offering platform for VR training in medical industry. The most important benefits of VR simulations are obviously risk reduction as it allows practice without endangering patients. In addition it enhances surgical skills and decision-making. **A study by the University of California found that VR-trained surgeons had a 230% boost in their overall performance compared to traditional training.** That significant improvement could be also connected with more cost-effective approach as it reduces the need for expensive physical models and cadavers in the long-term. However it could be a still a substantial investment upfront which could prevent some hospitals and university to move forward with VR simulations for now.



If that is the case it is worth to test more accessible solution such as AR anatomy models. They are providing medical students with an innovative way to study human anatomy, making learning more engaging and accessible at the same way easier to understand and remember. AR models can be manipulated and explored from various angles, providing a comprehensive understanding of the human body. There are few examples of organizations such as University of Twente or Case Western Reserve University using AR to teach anatomy to their students. It offers interactive and engaging learning and can be done by using inexpensive devices such as smartphones or other AR-enabled devices such as tablets. It won't be the same high quality as some high-end VR simulation programs but it is definitely a more accessible choice. If you are searching for higher quality you can try AR anatomy tools created for high-end AR/MR devices such as HoloLens 2 or Varjo XR-3.



## AR ASSISTED SURGERIES

AR Assisted Surgeries allows surgeons to overlay digital information, such as 3D models of organs, real-time data, or guidance paths, onto the physical world. This information is typically displayed through AR glasses or screens, allowing surgeons to see both the patient and the augmented information simultaneously. Leading hospitals and medical institutions are adopting this technology, recognizing its potential to revolutionize surgical procedures. Johns Hopkins Hospital and Imperial College London utilizes AR for spine surgeries and complex procedures. Previously mentioned Cleveland Clinic being at the forefront of mixed reality adoption is also employs AR to assist in cardiac surgeries.

AR provides real-time guidance, improving the accuracy of incisions and placements. Likewise by providing immediate visual information, AR can reduce the time required for surgeries. **A study at Imperial College London showed a 15% reduction in surgery time using AR.** Shorter operation time translates into less burden on the patient's body and better chances for quick recovery.



## PATIENT TREATMENT AND THERAPY

VR Therapy is a form of psychotherapy that utilizes immersive virtual environments to treat various mental health conditions, including phobias, anxiety disorders, and Post-Traumatic Stress Disorder (PTSD). Through controlled exposure to virtual scenarios that trigger anxiety or fear, patients can gradually confront and overcome their conditions under the guidance of a mental health professional. There are numerous hospitals such as Duke University Medical Center using VR for treating phobias and anxiety disorders or Cedars-Sinai Medical Center implements VR therapy for pain and anxiety management. The most promising application of VR therapy is to cure PTSD among combat veterans and people who have experienced or witnessed a physical or sexual assault. **A study by the University of Louisville showed a 60% reduction in PTSD symptoms using VR therapy!**

Another interesting application can be VR Rehabilitation, a therapeutic approach that uses immersive virtual environments to help patients with physical disabilities regain body functions. Through engaging virtual exercises and simulations, patients can practice movements and tasks that may be challenging in the real world. This approach is often used in conjunction with traditional physical therapy to enhance recovery. In Spaulding Rehabilitation Hospital, VR is utilized for stroke rehabilitation and mobility training while in Shirley Ryan Ability Lab it is applied for spinal cord injury rehabilitation. Studies have shown significant improvements in mobility and function. **For example, a study at Harvard Medical School found a 20% improvement in walking speed among stroke survivors using VR rehabilitation.**

Similarly augmented reality could be used into physical therapy. By overlaying digital information such as guidance paths, movement tracking, or real-time feedback onto the physical world, therapists can enhance traditional physical therapy exercises. Patients can see both the real environment and the augmented information, allowing for a more interactive and guided therapy experience. Boston Children's Hospital and Cleveland Clinic are one of the first hospitals employing AR in various rehabilitation programs. Though specific quantitative data may vary, the use of AR in physical therapy has been associated with improved outcomes and faster recovery. **A study at Stanford University found that AR-guided exercises led to a 30% improvement in movement accuracy.**

Last but not least virtual reality can educate patients about their medical conditions, treatment plans, procedures, and overall health. By placing patients in a controlled and interactive virtual setting, they can gain a deeper understanding of their health through visualizations, simulations, and guided experiences. Stanford Health Care, Cedars-Sinai Medical Center, Children's Hospital Los Angeles all of them are already using VR to educate patients about upcoming medical procedures and surgeries. It lets complex information more accessible, enhance engagement and comprehension and reduce patients anxiety and fear.

Leading hospitals and medical institutions are adopting this technology, recognizing its potential to revolutionize surgical procedures. While the technology is promising, it is still relatively new, and ongoing research and development are essential to fully realize its potential. Collaboration between technology providers, medical professionals, and regulatory bodies will be key to ensuring that VR/AR medical applications continue to evolve and become a standard practice in healthcare.



# EFFECTIVENESS OF TEACHING FIRST AID USING VIRTUAL REALITY TECHNOLOGY BY 4HELP VR



Virtual Reality technology is an advanced computer system that enables users to experience and interact with a virtual world. The main goal of VR technology is to immerse the user in an environment that can be entirely fictional or inspired by the real world. Through advanced visual, auditory, and interactive systems, individuals using this technology have the opportunity to participate in various simulated situations. This is a technology that has also found its application in the field of first aid training, allowing for realistic simulations of dangerous situations.

First aid is a crucial aspect of taking actions to save the life of a person exposed to a situation that threatens their health or life.

It includes a series of actions that must be

taken to provide immediate assistance to the injured person until the arrival of a professional medical team. Quick response is crucial in cases of sudden cardiac arrest. Performing appropriate rescue actions within 3-5 minutes from the onset of cardiac arrest significantly increases the chances of effectively saving the injured person. An essential element of this process is educating the public about providing first aid. Bystanders often become the first individuals who can provide support to the injured in those critical initial minutes after cardiac arrest occurs.

Traditional methods of teaching first aid are based on theory and practical exercises, during which a considerable amount of knowledge is imparted to participants. The challenge of dealing with a large amount of content results in difficulties related to its absorption and retention. Despite completing first aid courses, many individuals still experience a certain level of anxiety and lack of confidence in situations requiring effective emergency intervention (in cases of health or life-threatening situations). That's why alternative, modern teaching methods are being sought to enhance the effectiveness of knowledge acquisition in training, raising the question: can virtual reality technology be utilized in training processes related to acquiring first aid skills?



As the company 4 HELP VR, our focus lies especially on the application of virtual reality technology in teaching first aid. Our goal is to showcase the potential of using VR in training processes and strive to improve the way essential first aid skills are conveyed. Virtual reality allows for the creation of realistic scenarios that replicate everyday situations and real conditions. Through virtual reality technology, we have developed an innovative training solution: the „First Aid VR” program, which focuses on teaching:

- Cardiopulmonary resuscitation (CPR) with the use of an automated external defibrillator (AED),
- Dealing with an unconscious person who is breathing,
- Providing assistance to an injured person in an unfortunate accident.

This training has been designed to enhance the quality of first aid education, creating more realistic and engaging courses. With carefully crafted scenarios developed by an experienced team of specialists, course participants have the opportunity to practice first aid techniques in realistic situations that can happen to anyone.

It is worth emphasizing that virtual reality training is intended for both adults and children. Knowledge of first aid is essential for everyone, regardless of age. Children should also possess basic knowledge about responding to situations that threaten health or life. Thanks to virtual reality, they have the opportunity to learn in an interesting and interactive manner, which translates to more effective knowledge acquisition.

Our company, primarily relying on widely available VR equipment in the form of „headsets” such as the HTC VIVE Focus 3, offers first aid training using advanced virtual reality technology. Within these training sessions, essential equipment includes a set of virtual reality goggles, controllers allowing interaction with the virtual environment, and a mannequin - an anatomical model of the human body used for cardiopulmonary resuscitation. The learning process begins by putting on the VR goggles, which transports participants into a virtual environment. VR devices enable practicing specific actions such as operating an AED or dressing wounds. Our system responds to actions performed by participants, providing precise feedback on their actions, for instance, correcting the technique of chest compressions.

A key element that distinguishes VR is muscular memory. As participants engage in specific actions within the virtual environment, their bodies remember the movements made. This phenomenon is known as „learning by doing,” and it holds significant importance in learning first aid in VR. A notable advantage of VR is the ability to make mistakes in a safe environment. Participants can experiment and learn from their own mistakes without fearing real-world consequences. This leads to a better understanding of the outcomes of various actions and more informed decisions during real situations of health or life-threatening emergencies. This process aligns well with the idea of learning through action, as emphasized by the Kolb cycle. In practice, by utilizing VR for learning first aid, participants can:

- Experience realistic scenarios
- Learn from their own mistakes
- Increase engagement and motivation
- Improve decision-making skills.

First aid training in virtual reality is becoming increasingly popular. The skills of providing first aid are becoming essential for a growing number of companies across various industries. By tailoring virtual scenarios to different situations, we assist groups of people in learning practical life-saving skills easily, engagingly, and effectively.

To avoid relying solely on subjective assessments and opinions regarding the effectiveness of first aid training in VR, we decided to gather numerical data that could confirm statements about the role of virtual reality in effective learning. We conducted a survey in several companies, posing questions to participants before and after experiencing VR training. The survey included both men and women aged 20 to 60 years. We asked questions such as:

- Are you familiar with the principles of providing first aid?
- Can you perform first aid?
- How do you assess your first aid skills?

Based on these responses, we gained insights into the effects of virtual reality training. The data presented in the following report showcases the results of the conducted survey aimed at evaluating the effectiveness of first aid training in virtual reality (VR). Chart No. 1 illustrates the changes that occurred after participating in training utilizing virtual reality, specifically focusing on improvements in first aid skills.

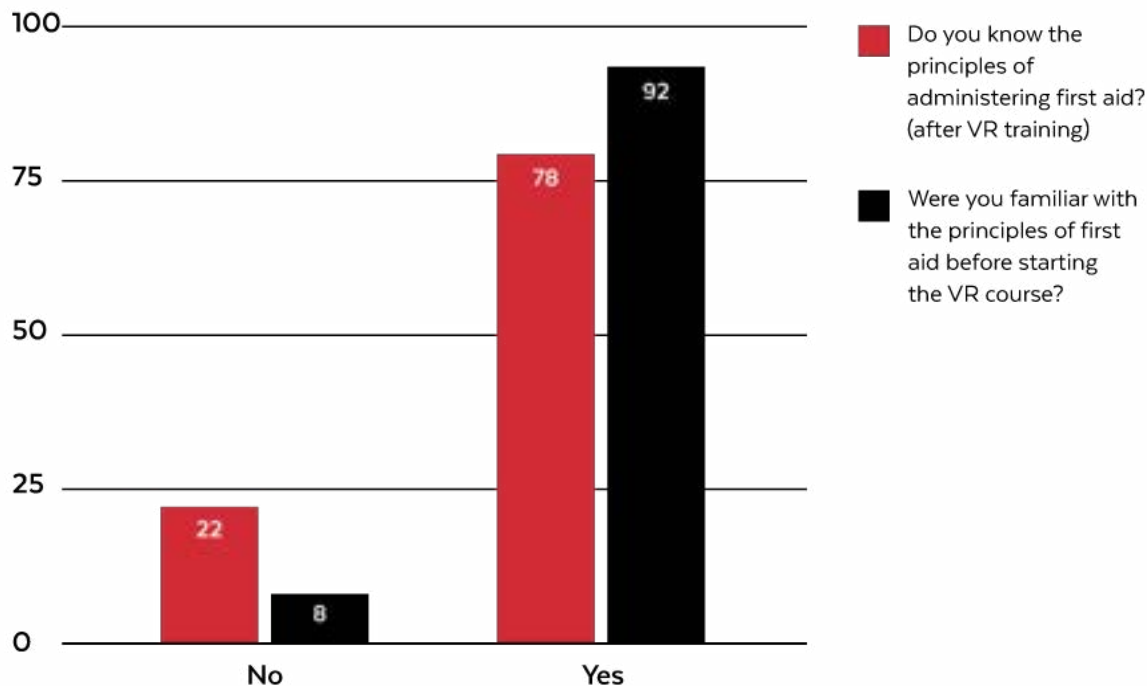


CHART 1: COMPARISON OF KNOWLEDGE OF FIRST AID PRINCIPLES BEFORE AND AFTER TRAINING USING VIRTUAL REALITY

The results from the survey show that before participating in virtual reality training, 78% of the participants claimed to know the principles of first aid, while 22% admitted to lacking such knowledge. After undergoing virtual reality training, the number of individuals who knew these principles increased to 92%, with only 8% still lacking this knowledge. This indicates that taking part in our VR training had an impact on improving first aid skills among the participants. This knowledge increase of 14% serves as clear evidence of the effectiveness of the training in building practical life-saving competencies.

The survey included a question focused on participants' readiness to administer first aid both before and after participating in our virtual reality training. The gathered results are presented again on the chart (Chart 2).

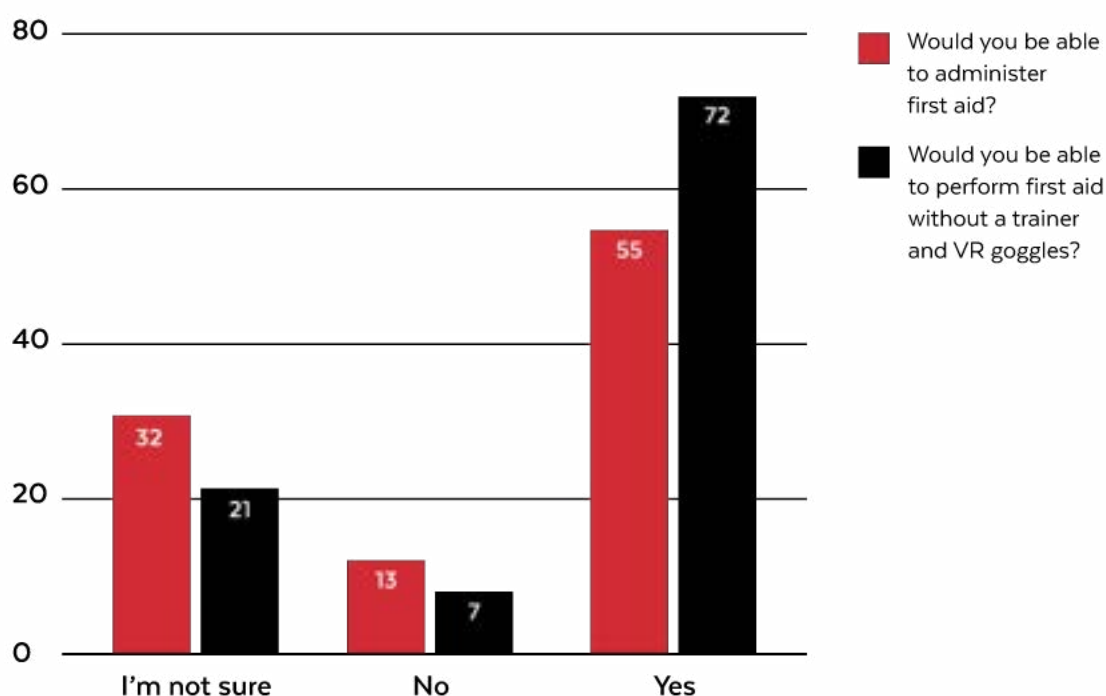


CHART 2: COMPARISON OF SELF-REPORTED CAPABILITY TO ADMINISTER FIRST AID BEFORE AND AFTER TRAINING USING VIRTUAL REALITY.

From the collected responses, it is evident that participants in first aid training using virtual reality exhibit a significant increase in confidence when performing rescue actions. Prior to the training, 55% of the respondents felt ready to provide assistance, while after the VR sessions, this number rose to 72%. Simultaneously, the decrease in the number of individuals who were unsure of their skills, from 32% to 21%, demonstrates an improvement in participants' self-assurance following VR training. This illustrates that the educational sessions effectively enhance skills and confidence in acting during situations requiring first aid.

In the third chart (Chart 3), we have chosen to compare the ratings of first aid skills provided by the participants. Company employees had the opportunity to rate their skills on a scale from 1 to 5, where 1 represented very poor and 5 represented very good. In this case as well, the survey was conducted both before and after the utilization of virtual reality (VR) technology.

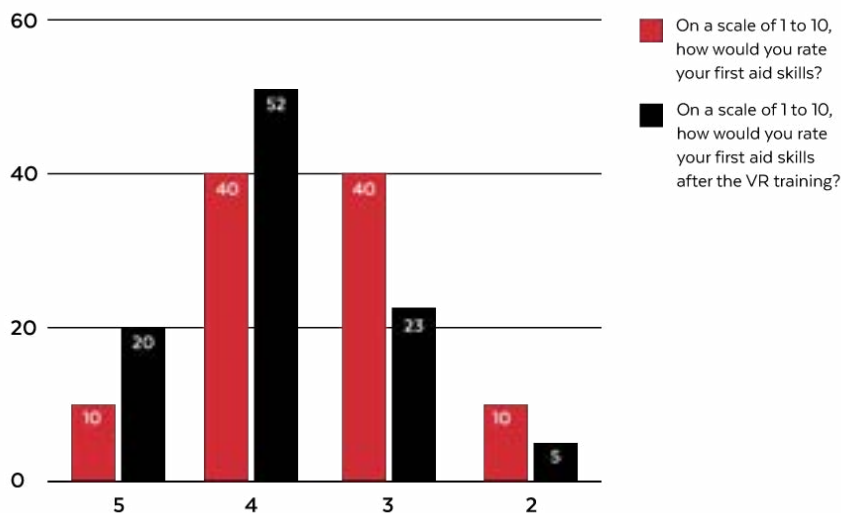


CHART 3: COMPARISON OF RATINGS OF FIRST AID SKILL PROFICIENCY ON A 5-POINT SCALE BEFORE AND AFTER TRAINING USING VIRTUAL REALITY.

The results indicate that participants had a more positive assessment of their skills after undergoing virtual reality training. Prior to the training, 50% of the respondents rated their skills as average (score of 3), yet after the VR sessions, this percentage decreased to 23%. At the same time, the number of participants rating their skills as good (score of 4) increased from 40% to 52%. This demonstrates that VR training contributed to an improvement in participants' perception of their first aid skills, potentially positively impacting their readiness to respond in crisis situations.

Our study unequivocally confirms that first aid training based on virtual reality technology is effective. Participants experienced an increase in knowledge, skills, and confidence in crisis situations. VR technology provides an interactive and engaging educational platform, enhancing the preparedness of communities to provide first aid and respond to emergencies. This modern approach contributes to building safer and more competent communities in life-saving efforts.



**4 HELP**  
VR

## 4 HELP VR

We've transported first aid, occupational health and safety (BHP), and fire safety training to the virtual world. This provides invaluable experience in saving the life of an injured person, boosts self-confidence in real life-threatening situations, and allows for education in workplace safety and fire protection. Our mission is to increase the number of potential Superheroes.

# MIXED REALITY APPLICATION IN INSURANCE

Insurance companies grapple with numerous challenges, including the intricate task of assessing damages accurately, the need for effective customer engagement in an increasingly digital age, and the demand for streamlined training for their personnel. Mixed reality emerges as a potential solution to these issues. By overlaying digital information onto the real world, MR can enable adjusters to assess claims with greater accuracy, referencing historical data or model predictions in real-time, minimizing discrepancies. Additionally, MR provides an immersive platform for training, allowing new agents to step into real-life scenarios virtually, ensuring consistent knowledge transfer and preparation. In essence, mixed reality properly implemented offers tools to enhance accuracy, engagement, and training, addressing some of the core challenges faced by insurance firms.

## TRAINING AND DEVELOPMENT

Insurance professionals can be trained in virtual environments that simulate real-world scenarios. These environments are designed to mimic situations that insurance professionals may encounter in their daily work, such as assessing property damage, interacting with clients, or navigating complex insurance policies. Virtual simulations can replicate various scenarios, such as car accidents, natural disasters, or customer interactions, allowing trainees to practice in a controlled yet realistic setting. Trainees can explore 3D environments through VR headsets, inspecting details and gaining a spatial understanding of the situations they might face.

**There are a couple major benefits from virtual training such as cost reduction, increased safety and enhanced skill development.** Virtual training reduce costs by eliminating the need for travel to centralized training location. The

virtual scenarios can also be reused, which is another cost-reducing factor. It is worth to mention that trainees can practice in complex or hazardous situations without any real-world risk, ensuring safety of company's employees. What's more important is that trainees can apply theoretical knowledge in practical scenarios without any risk, enhancing their understanding and skills.

As an example let's see how American insurance companies - Allstate Insurance and Farmers Insurance apply VR into their training & development process. The first one has implemented VR to train claims adjusters, providing them with realistic scenarios to enhance their skills. The latter has developed a VR training program that simulates home damage assessments, allowing adjusters to practice their skills in a virtual environment.

There are also companies operating on European markets such as **PZU Group** which

**is already relying on virtual training to prepare claim adjusters.** If you want to know in more detail how it works or what are the results look into PZU case study presented in the next chapter.



# CLAIMS PROCESSING

Insurance companies are testing how applying VR & AR could enhance claims processing both on the part of the claims adjuster and the client. Adjusters are using VR to conduct virtual inspections of damaged properties or vehicles. Instead of physically visiting the site, insurance adjusters can utilize VR headsets or compatible devices to virtually „walk through” the damaged area, assessing the extent of the damage and determining the necessary repairs or compensation.

It could help insurers reduce time required for claims processing and handle a larger volume of claims, especially after widespread events like storms or earthquakes. However it requires from clients or insurance subcontractors delivering data such as videos or aerial images in order to create virtual walkthrough. Insurance company have to create virtual assessment based on the real 3D data from the damaged area and it is not possible to get it without previously send a machine or human to collect it from there.

That’s why the more interesting use case could be to equipped adjusters with AR glasses, smartphones or tablets with dedicated AR software. During the physical inspection, the AR application overlays relevant information, such as previous inspection reports, damage guidelines, or repair estimates, onto the adjuster’s view of the damaged property or vehicle. Adjusters can interact with the AR interface, accessing additional information, making annotations, or capturing images with embedded data. The information collected through AR can be directly integrated into the claims processing system, streamlining documentation and assessment.

The quantitative benefits, includes increased efficiency by providing immediate access to relevant information and fast collection of images and videos from inspection that reduce the time required for assessments and subsequent documentation. In addition AR can enhance the accuracy of assessments, minimizing errors and inconsistencies by providing guidelines, historical data, and real-time support.

Global insurers Zurich Insurance, GEICO and Chinese Ping An are experimenting with AR to assist adjusters in on-site inspection regarding property or vehicle damage assessment. It is still far away from being an industry standard and the companies needs to carefully balance the idea of implementing new tech with benefits coming from it. But it looks much more promising business application than virtual assessment done through VR headset.

Similarly AR can also guide customers through the claims process, providing real-time assistance and information. By overlaying digital information onto the real world through smartphones, tablets, or AR glasses, customers can receive step-by-step instructions, visual aids, and immediate answers to their questions. Insurance companies can provide real-time, interactive support that not only streamlines the claims process but also enhances the overall customer experience. If the insurance company is also planning to use AR to assist adjuster it can develop one solution for both clients and adjuster. The core structure and features of the solution will be the same for the both groups and there only be a minor differences in a front-end part of the application. They could also add dedicated features for one or the other group if they need to. But the return on investment would be much faster and greater thanks to larger group of users benefiting from the same AR core solution. If insurance company is thinking about implementing AR into claims processing they should seriously consider using it in a way that benefit both customers and adjusters as it will be usually more efficient way to do it.

Virtual and Augmented Reality are transforming the insurance industry by enhancing customer engagement, streamlining claims processing, providing innovative training solutions, and improving risk assessment and management. Current examples from leading insurance companies demonstrate the practical applications of these technologies. The ongoing trends highlight the growing integration of VR and AR with other technologies and the focus on personalization and compliance.

The insurance sector must continue to explore and invest in these technologies to stay competitive and provide innovative solutions to both customers and employees. Collaboration with technology providers, adherence to regulatory guidelines, and a focus on customer-centric approaches will be key to leveraging the full potential of VR and AR in the insurance industry.



# VIRTUAL REALITY AT PZU: NEW HORIZONS IN TRAINING



For many years, I have worked as a specialist in the field of digital training at PZU, and I want to share with you our experience of using virtual reality (VR) in educating our employees. This advanced educational tool has allowed us to introduce modern and engaging forms of training that have contributed to improving the effectiveness of our development programs.

**Damian Prokopowicz**  
*Coordinator for digital learning  
development PZU*



## FIRST AID - LIFESAVING SIMULATIONS

The application of realistic rescue simulations enables our employees to practice skills in conditions similar to real-life situations. This enables them to repeatedly practice various scenarios, which enhances their readiness to act in emergency situations. Virtual reality provides practical and realistic experiences that are invaluable in learning first aid. Our employees highly appreciate this form of training, considering it effective for knowledge acquisition and skill practice. Below is a sample comment from one of the training participants.

“Such training takes less time and is more effective. After this short training, I remembered some aspects probably for a lifetime. And I’ve participated in ‘traditional’ training sessions more than once. However, most of the time, the knowledge would ,fade’ after some time. In the case of VR training, knowledge acquisition is also based on our experiences, guaranteeing knowledge retention. Great idea, great training, more of it, more often :)”

## CYBERSECURITY - RESPONDING TO GROWING THREATS

The fight against cybercriminals is an ongoing challenge for many organizations, including ours. Therefore, we decided to incorporate VR into our cybersecurity training. This allows our employees to take on the role of hackers and understand their methods. As a result, employees gain awareness of threats and effective skills to deal with them. Our cybersecurity training, enriched with virtual reality, has contributed to raising awareness in the field of network security. This has better equipped our employees to identify and avoid threats.



## MANAGEMENT TRAINING - SIMULATIONS FOR EXCELLENCE

As someone who frequents training rooms, I have encountered certain challenges, especially related to role-playing during training sessions. Not all employees are comfortable participating in role-playing in front of others, and limited time during training prevented everyone from participating. To address these issues, we introduced



virtual reality into our training program. The application, based on 360-degree videos with professional actors, allows new managers to practice various types of conversations with employees without the fear of making mistakes in real-life scenarios. Through surveys and conversations with managers participating in the new training, we know that they are more willing to engage in scenarios (using VR) than if they had to perform them in a group setting. They also believe that this form of exercise more effectively allows them to translate practiced skills into their daily teamwork.

## CLAIMS HANDLING - PRACTICAL TRAINING FOR MOBILE EXPERTS

Our industry requires well-prepared mobile experts (employees who assess damages during incidents) who need to act quickly and precisely during claims handling. Virtual reality has enabled us to create simulations of various situations that mobile experts need to resolve. As a result, we have practical training available on demand, and our employees gain greater self-assurance.

From conversations with mobile experts, we know that for incidents such as crop damages, they also face difficulties in practical training outside the growing season (which lasts only a few months). VR provides them with such opportunities, enabling them to gain practical experience and enhance their skills at any time.

Virtual reality has proven to be an invaluable educational tool at PZU. From first aid to management training and claims handling, VR brings new possibilities to our training programs. This technologically advanced solution contributes to increased safety, efficiency, and quality of our work. We are convinced that this is just the beginning of our adventure with virtual reality, which continues to surprise and inspire us to create new innovative training. At PZU, we not only adapt to new trends in education, but we also create them, fully utilizing the potential of virtual reality.



# MIXED REALITY APPLICATIONS IN ENERGY

The energy industry currently grapples with multifaceted challenges including aging infrastructure, increasing operational costs, regulatory complexities, and the pressing need for transitioning to renewable sources. Simultaneously, there's an imperative for enhanced safety and efficiency during exploration, maintenance, and training. Mixed reality offers potent solution to these challenges through virtual training, design & prototyping or AR-guided maintenance support.

## VIRTUAL TRAININGS

Virtual environments created using VR technology provide realistic training scenarios for employees, especially in high-risk areas like nuclear power plants or offshore oil rigs. These environments replicate real-world scenarios that employees in the energy sector might encounter, especially in high-risk areas. They create lifelike situations that mimic actual working conditions in nuclear power plants or offshore oil rigs. It provides hands-on experience as trainees can interact with virtual equipment, tools, and systems, practicing procedures without real-world risks. Different training parts can be designed to cater to various skill levels, job roles, and specific training needs while progress and performance can be monitored and assessed autonomously without using time of other employees.



The implementation of VR Training in high-risk areas of the energy sector has led to several tangible benefits:

**Reduction in Training Costs:** By replacing physical training setups with virtual environments, companies can save on equipment, space, and travel expenses. For example, **BP reported a 40% reduction in training costs** after implementing VR training for offshore oil rig workers, covering aspects like equipment handling and safety procedures.

**Enhanced Safety:** Training in virtual environments eliminates the risk of accidents during training, contributing to overall workplace safety. EDF Energy noted a significant decrease in training-related incidents after utilized VR to train nuclear power plant operators, focusing on safety protocols and emergency response.

**Improved Training Efficiency:** Customized training paths and real-time feedback lead to faster skill acquisition. **Shell reported a 50% reduction in training time for certain modules** once it developed VR training programs for offshore drilling operations, providing realistic simulations of emergency scenarios.

## AUGMENTED REALITY TRAININGS AND MAINTENANCE SUPPORT

Augmented reality trainings can provide real-time guidance and instructions to technicians, especially those new to complex procedures. AR glasses or devices display step-by-step instructions, diagrams, or videos directly onto the equipment, guiding technicians through procedures. Technicians can interact with virtual elements, enhancing understanding and engagement while AR can be integrated with existing systems, documentation and training materials, providing a seamless learning experience. If a technician encounters a complex issue, experts from remote locations can see what the technician sees through the AR glasses and help them in real-time. AR could also be connected to Internet of Things (IoT) sensors to provide real-time data on equipment performance, aiding in diagnostics and repair.

The adoption of AR guided training and maintenance in the energy sector has already proved to generate significant value for early adopters such as Shell, Schlumberger, Siemens or GE by:

**Reducing Errors:** By providing clear, real-time guidance, AR reduces the likelihood of mistakes. **Siemens reported a 30% decrease in errors** during turbine maintenance with AR guidance.

**Reduction in Downtime:** By providing real-time guidance and information, AR significantly reduces the time required for maintenance and repair. **Siemens reported a 15% reduction in downtime** using AR.

**Increasing Efficiency:** AR speeds up training and on-the-job support, leading to faster completion of tasks. **GE Renewable Energy noted a 20% reduction in wind turbine maintenance time** using AR.

**Cost Savings:** Reduced downtime and increased efficiency translate into substantial cost savings. Shell reported saving millions of dollars annually through AR-assisted maintenance implemented for offshore oil rigs.

## DESIGN AND VISUALIZATION

Virtual Prototyping is the process of using Virtual Reality to create a digital replica of a physical energy system. It is a transformative tool in the energy sector, allowing engineers to create, visualize, test, and optimize virtual prototypes of energy systems. Engineers can visualize and interact with a 3D model of the energy system, exploring its design from various angles. Virtual Prototyping allows engineers to simulate different scenarios, such as varying weather conditions or mechanical stresses, to test the system's performance. Moreover engineers from different locations can collaborate in the virtual environment, working together on design and testing. Virtual Prototyping can be integrated with Computer-Aided Design (CAD) tools, providing a seamless transition from design to virtual testing. In addition it let engineers to make changes to the virtual prototype and instantly see the effects, allowing for rapid iteration and optimization.

Companies like GE, Siemens, and ExxonMobil are leveraging this technology to reduce development time, save costs, enhance accuracy, improve collaboration, and contribute to sustainability. The main quantitative benefits are:

**Reduction in Development Time:** By allowing for rapid iteration and testing, Virtual Prototyping can significantly reduce the time required to develop energy systems. GE Renewable Energy reported a 30% reduction in development time for certain wind turbine designs.

**Enhanced Accuracy:** Virtual testing allows for more precise analysis and optimization, leading to more accurate designs. ExxonMobil reported increased accuracy in drilling equipment design.

**Cost Savings:** Virtual Prototyping eliminates the need for physical prototypes, saving on materials and labour costs. Siemens noted substantial cost savings in power plant component development.



# AUGMENTED REALITY INSIDE MAINTENANCE PROCESSES IN EUROPEAN ENERGY COMPANY BY KOGNITA



Kognita together with one of the largest operators of photovoltaic farms in Poland have conducted pilot project using augmented reality technology inside maintenance process. A photovoltaic farm is a sophisticated installation that converts solar energy into electricity. This complex consists of many photovoltaic panels distributed over a vast area of land. Equipment



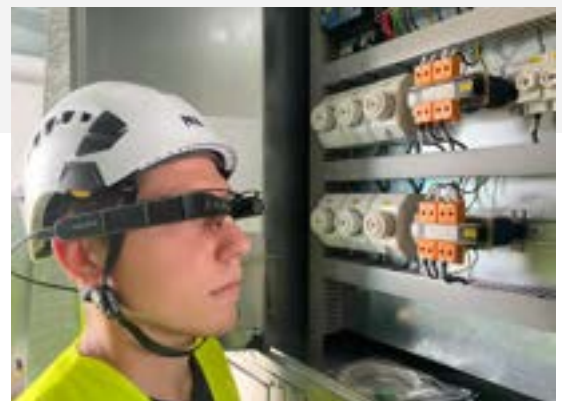
located at the photovoltaic farm must undergo regular inspections to ensure its outstanding quality and reliability. The inspection process is time-consuming and requires a high degree of precision. Traditional methods of control, involving manual measurement and visual inspection, may prove inefficient and are prone to errors. This process requires technicians on site to engage in audiovisual communication with engineers and specialists at company's headquarters.

Using smartphones for this purpose proves inefficient, as it prevents the technician from carrying out further repairs or tasks while communicating with the central office. The technician must use both hands when conducting inspections and repairs; however, if they wish to contact the headquarters, they must stop their work, thereby slowing

down the process and increasing the risk of errors. To address this problem, the company is seeking a solution that could enhance the technician's abilities on site and streamline the inspection process.

To increase the efficiency of its inspection process, the company decided to purchase augmented reality glasses Vuzix M400. This head-worn device transmits view from the camera directly to the headquarters through the Microsoft Teams application. Voice-controlled, it eliminates the need to use hands while communicating with the central office. Features such as image capture or video recording allow the cessation of using other devices during inspections, such as tablets or smartphones.

Currently Kognita and photovoltaic operator are together testing the effectiveness of the purchased AR equipment in field conditions. If the tests prove successful, the operator will equip its technicians with this solution and will also begin implementing additional functionalities offered by AR solutions. Functionalities offered by AR software enable, for example, the virtualization of the inspection process in the form of a task list to be performed at specific locations and equipment, enriched with photos and training videos displayed next to the controlled object. Another feature is the addition of a detailed view of the equipment components or the ability to see what is inside without having to dismantle its casing, allowing faster identification of any defects and their subsequent repair. It is also possible to create a virtual assistant based on artificial intelligence, guiding technicians' work by indicating on the AR glasses' screens precisely where and how things should be done.



# VIRTUAL REALITY TECHNOLOGY AS AN INNOVATIVE TRAINING METHOD AT ENEA OPERATOR



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The possibilities offered by virtual reality technology allow for the replication of the IT environment in a virtual dimension. This enables the simulation of authentic workstations and realistic procedures, as well



as seamless interaction with users. Such capabilities contribute to effective knowledge assimilation and the enhancement of practical skills in learners. Virtual training scenarios, which find practical applications, are designed to guide users through a series of tasks. This also includes tasks that would be difficult or even impossible to perform in reality (for instance, under extreme conditions such as severe weather). This allows for repetitive training without concerns about real-world consequences of failures, leading to continuous skill improvement. Furthermore, the motivation for training is bolstered by the ability to monitor progress through the collection

of learning process statistics. Users also receive direct and precise feedback on their current achievements, which further motivates them to put in ongoing efforts.

Virtual Reality technologies enable the creation of diverse simulation environments that prove highly effective for educational purposes. Through the use of virtual reality, users become part of practically isolated worlds, enabling them to fully immerse themselves in training material. Building virtual environments relies on available programming platforms that facilitate the creation of interactive, three-dimensional worlds using specialized terrain editors. This process involves simulating physics, implementing objects, animations, interactions, and advanced lighting. To achieve the intended effect, it's necessary to transform software code into realistic three-dimensional images and sounds, presenting implemented training scenarios effectively to users. Dedicated VR hardware solutions, such as virtual reality headsets, controllers, and motion tracking systems, are used for this purpose. With these tools, users can fully immerse themselves in the virtual environment, leading to more efficient knowledge and skill acquisition.

For the Distribution System Operator (DSO), the use of virtual reality technology offers an excellent opportunity for conducting professional training in a modern, innovative, advanced, and efficient manner. The utilization of digital models of energy infrastructure in three dimensions, along with reliable interaction methods like controllers, gestures, precise human body positioning, and tracking of physical elements, enables full engagement in virtual training scenarios. The comprehensive nature of this solution allows for achieving deep immersion, providing a sense of physical presence in the virtual world during participation in training. The level of engagement of participants in virtual training increases with the intensity of immersion, resulting in effective absorption of conveyed knowledge.

The preparation, adaptation, and implementation of an advanced virtual reality (VR) system enable the system to meet the technical training requirements for highly skilled engineers, technicians, and electricians. An essential feature of the system is the flexible customization and expansion of content for future scenarios and elements of the power infrastructure. This functionality is possible due to the open structure of the computing platform, encompassing a database of objects, scenes, components, dependencies, and training scenarios.

Presently, the training process in the energy sector, particularly for Distribution System Operators (DSOs), largely relies on traditional methods. Typically, this involves theoretical lectures followed by, if possible, practical sessions. Such conventional training methods demand a significant amount of time and direct physical interaction between instructors and participants. To achieve more effective results in the training process, the implementation of advanced technical equipment, such as sophisticated measurement instruments, becomes essential. This is especially crucial for complex infrastructure objects like HV/MV and MV/LV transformer stations. It's worth emphasizing that the traditional training approach has its limitations since training often cannot take place directly at the worksite. This is due to the fact that certain segments of the network cannot be disconnected for training purposes. Additionally, adjusting or deactivating operational devices is restricted or even prohibited. Consequently, the practical application of previously acquired theoretical knowledge is significantly constrained.

Conventional forms of training also entail additional indirect costs due to the inevitable necessity of travel, leading to employees being absent from their daily duties for a substantial period. This applies to both the training participants and the company itself. Furthermore, this training format requires a special location, referred to as a "training ground," which involves the need for travel for trainees and instructors from various, often distant, workplaces. It's important to highlight that while this training ground is equipped with several stations utilizing specific technologies, it does not encompass the full range of solutions present in actual HV/MV/LV networks, which are constantly serviced by authorized personnel.

Another challenge lies in the difficulty of training procedures and human behaviour in highly specific and demanding conditions, such as mass disasters, fires, floods, hurricanes, and other natural disasters. Recreating such circumstances realistically is nearly impossible, which can significantly influence the decisions made by training participants. A significant limitation of real-world training is the inability to witness the potential consequences of making mistakes, both minor and those directly endangering health and life. An additional challenge is the lack of opportunities to face the consequences of errors in practice. The energy infrastructure undergoes continuous modernization, resulting in the integration of new technologies, configurations, and solutions. Consequently, a significant challenge is the ongoing adaptation of training programs to the current technical state of the network (while also considering safety and occupational protection aspects during practical training).

## UTILIZING VR TECHNOLOGY FOR SPECIALIZED PRACTICAL TRAINING OF DSO EMPLOYEES

The techniques and methods employed by employees in the electrical power network necessitate comprehensive training, which calls for the implementation of dedicated procedures, tools, and effective management. This leads to demanding requirements for the practical skills of technical staff. Daily tasks related to operation, investment, maintenance, and problem-solving demand advanced technical knowledge and procedural skills. It's important to underline that these activities come with a direct risk to the health and lives of employees.

Due to this, training solutions must exhibit the highest level of expertise, focusing on practical skills, adapting to the specific requirements of the Distribution System Operator (DSO), incorporating „what if“ scenarios, and consistently updating the contained information. In light of challenges posed by traditional training methods, the question arises whether there are more efficient, innovative ways to conduct training. The concept of utilizing virtual reality seems to align perfectly with this notion. Additionally, it's worth considering the potential of conducting selected training procedures entirely in a virtual environment or introducing them partially as a complement and expansion of traditional practical training.

The application of VR technology paves the way to acquire and practice correct behaviours, including emergency situations, in controlled and safe conditions within specially designated training areas. Thanks to visual stimuli in the virtual environment, participants can engage in realistic and interactive simulations, maintaining not only their interest but also aiding the retention of information and reinforcement of acquired skills. A meticulously planned and implemented VR system has the capability to simulate conditions characteristic of a station during risky operations. Moreover, employing VR techniques allows for monitoring participant behaviour in stressful situations. By integrating this type of training system into the structure of the Distribution System Operator (DSO), engineers, technicians, and electricians can partake in on-site workplace training within a precisely replicated virtual environment. This form of training brings benefits in the form of cost reduction and enables repeated sessions without the need to disrupt the normal operation of facilities.

The central concept of employing virtual reality in response to the key needs of the Distribution System Operator (DSO) is the delivery of high-quality electrical energy and the minimization of costs associated with fault repairs and the maintenance of a robust power grid. The concept of a training system based on virtual reality contributes to raising the qualification level of electricians and enhancing their efficiency. Utilizing an advanced immersive environment allows both future and current employees to learn task execution, including practical scenarios like interactions within a specific transformer line or at a substation, employing realistic 3D projections, natural movements, and gestures. All of this occurs in a risk-free environment, simultaneously minimizing costs (in most cases, training is self-conducted or in teams without direct instructor involvement).

The experiential learning method brings forth numerous benefits in the learning process:

- Enhancing Learning Process Efficiency – by fully reflecting real procedures, routine actions, and needs related to solving contextual problems and making dynamic decisions according to the training scenario.
- Providing a Secure Learning Environment – participants observe the consequences of incorrect actions, as simulations are based on actual procedure scenarios and additional challenges that users must overcome, enabling experimentation in a safe and controlled setting.
- Linking Theory with Practice – users gain experience first and then have the opportunity for practical application of resulting skills.
- Increasing Engagement Level – through direct individual feedback regarding training outcomes and the opportunity to learn from other participants.
- Enabling Personalized Learning Approaches – the learning process pace is adjusted to each participant's individual needs.
- Offering Company-Tailored Learning Opportunities – virtual reality training can be conducted anywhere and anytime, on various devices, thereby enhancing the flexibility and accessibility of the training program.

## IMPLEMENTATION OF A VR TRAINING SYSTEM IN ENEA OPERATOR

Introducing a VR Training System into the training process of employees working on the power grid at ENEA Operator requires a comprehensive and tailored project. Within the project process, a key step involves gathering functional requirements identified by various stakeholder groups. The next step is decomposing these requirements, defining specific outcomes, and potential anticipated changes in the company's processes. Gradual software implementation is another crucial phase. Given the innovative nature of this solution, it's important to select an appropriate project methodology for the development and implementation of the system within the company's structures (whether it's the Waterfall concept or Agile approach). Such a choice is contingent on individual factors like organizational culture and the preferred project methodology of the company.

The concept of defining, creating, and implementing a VR Training System revolves around using virtual reality techniques to train employees on virtual models representing the power infrastructure. This virtual approach enables realistic interaction with animated, three-dimensional objects that reflect various elements of the infrastructure. Over the long term, there's potential to transform the entire infrastructure into virtual models, allowing for training of other employee groups, such as dispatchers.

The implementation project titled ***“Flexible Competence Enhancement System for Technical Services Employees Using Virtual Reality Techniques,”*** co-financed by EU funds under the Research Program „Fast Track for Large Enterprises and Consortia” implemented by the National Centre for Research and Development, was launched by ENEA Operator in 2019. The total project budget amounted to PLN 6.4 million, including PLN 3 million in grants, covering costs of industrial research and development work. The project implementation was divided into 4 stages. The primary goal of the first stage was to establish technical requirements for the comprehensive virtualization process of training for technical services employees. The unique nature of the planned VR system was considered, taking into account its adaptability, scope of operation, and potential range of applications at Enea Operator. This stage encompassed research related to collecting data about the power infrastructure, necessary for creating virtual training scenarios. Furthermore, flexible 3D content tailored to the training needs of technical services employees was developed during this stage, with appropriate interactions added to create training scenarios. Research activities of this stage also focused on methods for managing virtual training scenarios after their creation. Stage 1 involved the realization of five logically related research tasks:



- Development and Definition of Technical Requirements for a New Training System for Electric Operator Training using Knowledge Engineering Techniques and Design Thinking Methodology.
- Investigation of Content Creation Processes in Electric Operator Training within Laboratory Conditions.
- Study of Interaction Methods in Electric Operator Training within Laboratory Conditions.
- Exploration of Contactless Digitalization Methods for Large Objects in the Construction of Virtual Training Scenarios for VR Electric Operator Training System.
- Development of a Methodology for Knowledge Transfer from Real Electric Operator Training to the Virtual Environment.



FIG. 1. TRAINING SCENARIOS - INTERACTION STUDY

Stage 2 involved conducting industrial research aimed at developing a methodology for constructing a flexible training solution for technical services employees using virtual reality technology. Within this stage, it was necessary to devise a methodology for building the training system, starting from the digitization stage, data collection, information and metadata gathering, three-dimensional modelling in design support systems, visualization, programming logic and object behaviours, all the way to composing complete training scenarios and intuitive interaction with virtual tools and objects. When creating the methodology and knowledge base, the requirements, scenarios, and results from the industrial research in the first stage needed to be applied. Throughout the implementation of this stage, concepts from Knowledge Based Engineering (KBE) were employed, which is an effective method for supporting the construction of engineering systems containing organized knowledge about products and processes. Stage 2 of the project was carried out through five logically interconnected tasks.



FIG. 2. TRAINING SCENARIOS - INTERACTION STUDY AMONG EMPLOYEES

- Development of a methodology for digitizing energy infrastructure with the aim of constructing a library of assets for virtual training scenarios.
- Experimental measurements, digitization, and creation of conceptual digital models for selected energy infrastructure objects, intended for the development of a methodology and knowledge base within a flexible virtual training system in a virtual reality setting.
- Formulation of a methodology for creating adaptable virtual training scenarios using knowledge engineering techniques.
- Creation of a knowledge base for interacting with objects in virtual training scenes, considering a three-dimensional user interface.
- Establishment of a knowledge management methodology within a flexible virtual reality training application.



FIG. 3. POINT CLOUD OBTAINED FROM PNIĘWY SUBSTATION MEASUREMENTS



FIG. 4. FLEXIBLE TRAINING SCENE

As part of this phase, five logically interconnected tasks were executed:

- Development of guidelines and implementation of the plan for digitizing energy infrastructure according to the devised methodology and training scenarios.
- Measurement and digitization of selected energy infrastructure objects using 3D scanning techniques to develop virtual training scenes for electricians and distributors.
- Creation of a library of 3D objects representing energy infrastructure based on data from the digitization process (sorting, grouping, optimization, texturing, lighting, animation).
- Construction of virtual training scenes corresponding to the infrastructure (Virtual Power Plant), utilizing the 3D object library and the developed methodology.
- Implementation of selected interaction methods within virtual training scenes.

The tangible outcome of the third phase was a functional prototype of the training system, operating under conditions approximating reality (TRLVII). This prototype allowed for the execution of planned training scenarios. It comprised a complete software layer and a trial hardware layer based on ENEA Operator's resources.



FIG. 5. EXAMPLE TRAINING SCENE DEPICTING PNIĘWY SUBSTATION

In Phase 3, a prototype of the software layer for the flexible training system was built and tested, taking into account the results obtained in the earlier stages of the project, i.e. :

- Methodology for knowledge transfer and guides prepared in Phase 1,
- Results of experimental measurements of the infrastructure
- Methodologies: building flexible training scenes and managing knowledge within a flexible training application
- Knowledge base for methods of interacting with objects in virtual training scenes



FIG. 6. EXAMPLE TRAINING SCENE DEPICTING PNIĘWY SUBSTATION



FIG. 7. EXAMPLE TRAINING SCENE DEPICTING LIVE-LINE WORK TECHNIQUES



FIG. 8 TRAINING SCENE INTERFACE - INTERACTIVE TABLET



FIG. 9 EXAMPLE TRAINING SCENE DEPICTING MANUAL TASKS

In the final Stage 4, a new dedicated and complex flexible training system for technical service employees was designed and constructed. The software layer of the system, developed in Stage 3, was enhanced at this point with a meticulously designed hardware layer, considering the specifics of training technical service personnel, the technical capabilities of VR systems, and workplace safety aspects. Developmental efforts in Stage 4 focused on designing the infrastructure of the prototype system - both mobile and stationary VR training stations - and giving the prototype physical form through the construction of a trial setup for both mobile and stationary training stations. Subsequent work aimed to investigate the new training process, using various methods to combine real-world training with training taking place in a virtual environment.

In this stage, four logically related tasks were accomplished:

- Development of the project for the infrastructure of prototype mobile and stationary VR training stations.
- Construction of prototype VR training stations.
- Research on the new training process implemented on the prototype virtual reality system, targeting specific points within the energy infrastructure.
- Enhancement of the prototype VR training system based on research results.

One of the objectives in Stage 4 was to create two mobile and three stationary training stations, along with a server installation. This involved selecting computer components and equipment for displaying and interacting within the virtual reality environment. Engineering designs for the construction of mobile training station structures were prepared, including the selection of the most effective manufacturing techniques, analysis, and research related to station usage, as well as its rapid assembly and disassembly. The interior space of the vehicle was divided into three zones – two for users to work with the VR system and one designated for a technician to manage the training system.



FIG. 10 VR BUS WITH TWO STATIONS FOR TRAINING IN VIRTUAL REALITY



FIG. 11 MOBILE TRAINING STATION



FIG. 12 MOBILE TRAINING STATION

As part of the task, the software architecture of the VR training system was developed, as presented in Fig. 13.

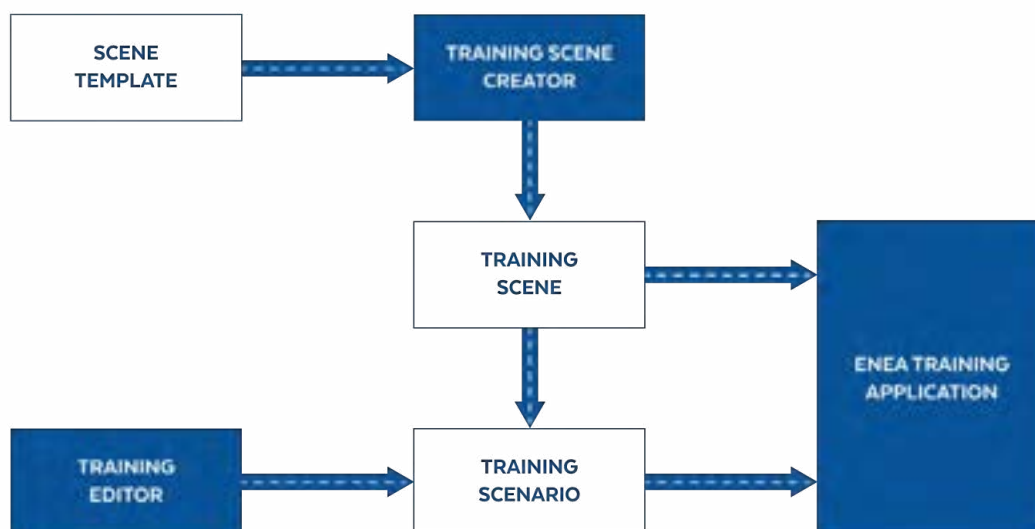


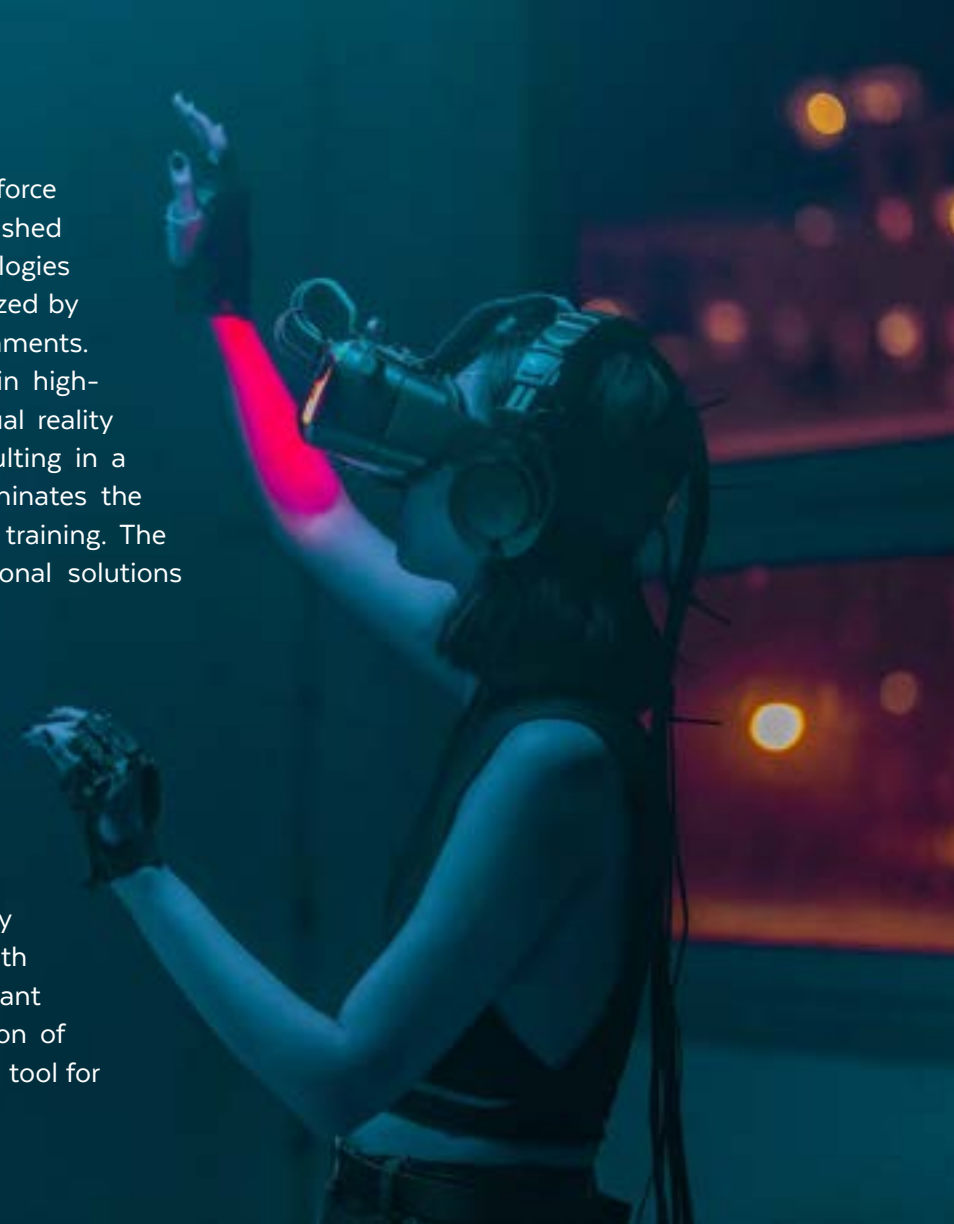
FIG. 13

The developed system includes 30 implemented interactive virtual training scenarios, based on 3D-scanned data from 15 main power supply points, 9 medium-voltage stations, and live-line training facilities. The system promotes active participation and responsibility at every stage of the training scenarios, resulting in increased engagement and expanded knowledge concerning safety practices.

The created system enhances training accessibility for both new and upskilling employees. It also provides an opportunity to familiarize individuals without professional qualifications for working as electrical assemblers. This solution can also be presented to students interested in future careers in the energy sector.

## SUMMARY

According to the HR report titled “Workforce Development and Training Trends” (published by Gamma in 2020), virtual reality technologies excel in skill development areas characterized by high risk or cost in traditional training environments. Such challenges are especially prevalent in high-risk or high-cost sectors. The use of virtual reality experience enables instant feedback, resulting in a more balanced learning process that eliminates the randomness often found in conventional training. The introduction of VR or AR-based educational solutions gradually transforms the role of traditional instructors, contributing to the efficiency of training. In the context of the energy industry, particularly within the realm of Distribution System Operators, these aspects carry paramount significance. Technical demands and the complexity of training scenarios in this industry are exceptionally sophisticated. Direct threats to the health and safety of employees present significant challenges. In such a context, the adoption of virtual reality technology becomes a crucial tool for more effective and safe employee training.



The innovative implementation of virtual reality technology in training within Enea Operator represents a revolutionary step in the training process, providing participants with more immersive and effective practical experiences. As the project concludes, several key findings and outcomes have been achieved:

- **Enhanced Training Effectiveness:** The project confirmed that the use of VR technology significantly enhances the efficiency of the learning process. Participants were able to practice a variety of scenarios in a controlled virtual environment, resulting in better skill acquisition.
- **Improved Safety:** VR application eliminated potential hazards associated with practicing skills on actual devices. Participants can refine their abilities without the risk of damage or malfunction, contributing to increased safety.
- **Tailored Training:** The project demonstrated that VR technology allows for individualized training. The system monitors participants' progress and adjusts the level of difficulty, contributing to more effective knowledge and skill acquisition.
- **Modern Company Image:** Embracing VR in training strengthens Enea Operator's image as an innovation leader in the industry. The company showcases its readiness to invest in modern solutions to provide its employees with the highest quality training.
- **Continued Development:** Even though the project has concluded, Enea Operator continues to develop the VR-based training system. Leveraging the experience gained, the company can further refine its approach to employee education.

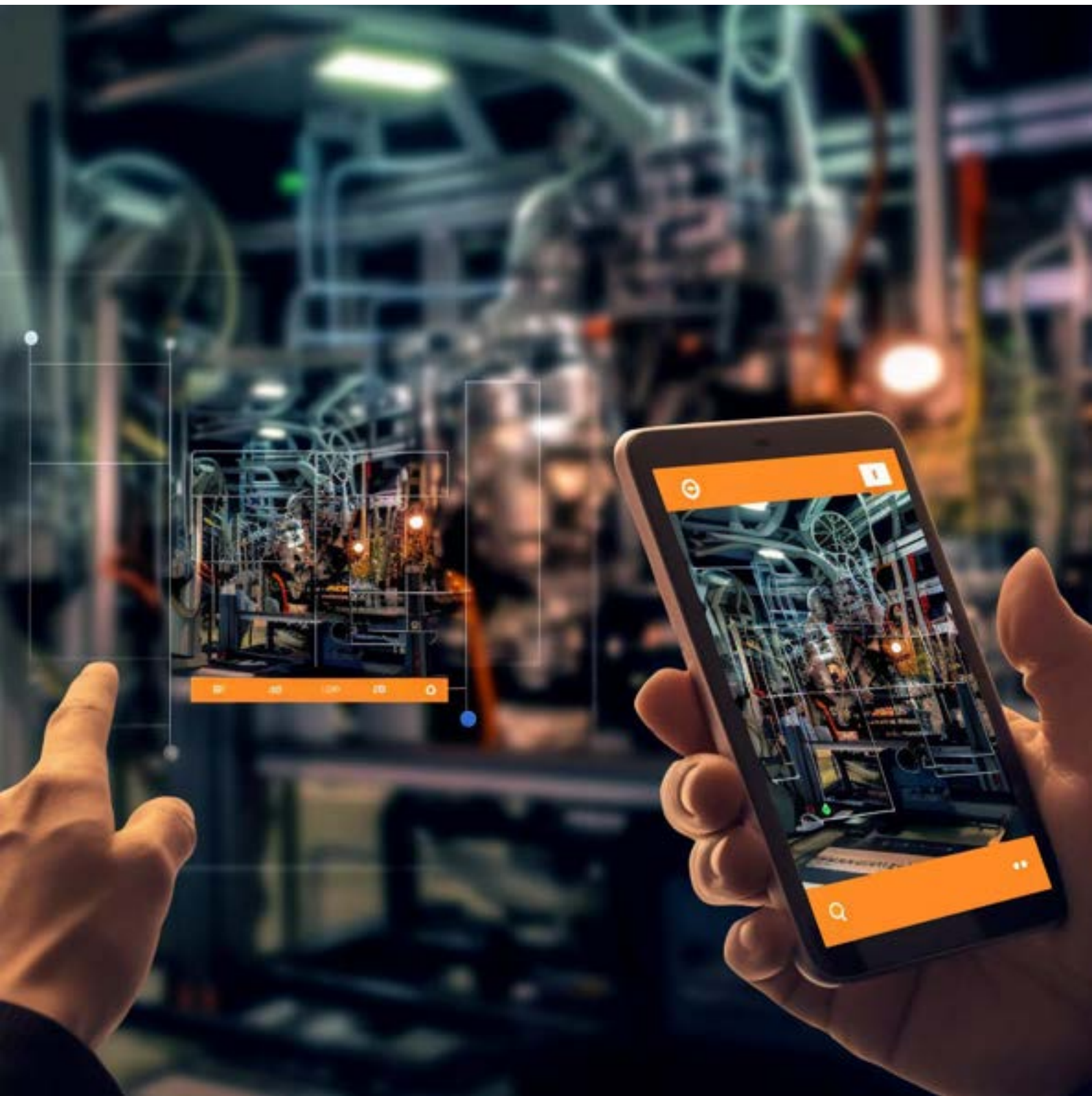
In summary, the execution of the R&D project concerning the utilization of virtual reality in training at Enea Operator has brought numerous benefits, including enhanced training effectiveness, improved safety, personalized learning, and financial savings. The company has confirmed its innovativeness and commitment to developing modern training methods, which could serve as an inspiration for other enterprises in the industry.



## Chapter 3H1

# MIXED REALITY APPLICATION IN MANUFACTURING

The manufacturing sector is experiencing a transformative shift with Industry 4.0 concept becoming a new blueprint for every major factories all around the world. Integration of artificial intelligence, IoT and mixed reality application will streamline operations from design to production. MR superimposes digital information onto the physical environment, enabling engineers and designers to visualize, modify, and test prototypes in real-time without the need for multiple physical iterations. The most interesting use cases are built around virtual trainings, AR assembly and maintenance as well as product design and prototyping.



## VIRTUAL TRAINING & EQUIPMENT SIMULATION

Virtual Training involves creating realistic and interactive virtual environments that replicate real-world manufacturing scenarios. These scenarios could range from operating intricate machinery to handling complex assembly processes. Employees can wear VR headsets to immerse themselves in these simulated environments and practice tasks just as they would in real life.

This approach provides a safe and controlled space for learning without the risks associated with working on actual machinery. Well-trained employees are also less likely to make mistakes that could lead to machine downtime. This reduction in downtime can translate to increased operational efficiency and productivity. In addition better-trained employees are likely to produce higher-quality products, reducing the costs associated with defects, rework, and customer complaints.

A wide variety of industries and companies within manufacturing have recognized the potential of VR training. In Aerospace sector, Boeing and Airbus have been exploring VR to train their workers on assembly procedures without having to be near an actual aircraft. Automotive companies such as Ford and Volkswagen use VR to improve to train their employees on new assembly techniques. Other companies producing heavy machinery such as Caterpillar and John Deere utilize VR for service training, allowing technicians to familiarize themselves with machinery in a virtual environment before they encounter it in the real world.



## AUGMENTED REALITY ASSEMBLY & MAINTENANCE

Augmented reality can be used for various purpose inside manufacturing operations of various industries. One of the most interesting is **Augmented Assembly** which means applying AR to assist workers in assembling complex products or components. In this use case, digital instructions, visual cues, and relevant information are overlaid onto the real-world view of assembly workers.

This aids them in following assembly steps accurately, positioning components correctly, and ensuring that the assembly process is completed efficiently and without errors. By minimizing human errors AR-guided assembly enable reduction in defective products and the need for rework, which can save significant costs associated with scrap and reprocessing. New assembly line workers can also learn complex assembly processes more quickly using AR-based training. This reduces the time required for training and allows new workers to become productive sooner.

Manufacturing companies across various industries have recognized the value of Augmented Assembly and have implemented it to improve their assembly processes. Some notable examples of companies using Augmented Assembly include:

**Boeing:** Boeing reported a **30% reduction in assembly time and 90% improvement in first-time quality** when using AR for training and guidance in complex assembly tasks

**BMW:** Its logistics division uses AR to assist with quality checks and part identification, reducing errors and speeding up processes.

**JCB:** JCB, a construction equipment manufacturer, has integrated AR into its assembly processes. Workers can use AR glasses to visualize assembly instructions, ensuring precise alignment and reducing the time required to assemble intricate components.

Second promising use case is applying **AR into maintenance support processes**. AR overlays digital information, such as instructions, diagrams, or data, onto the real-world view of a technician wearing AR glasses or using a mobile device. This enables technicians to access critical information in real-time, hands-free, and in context, thus improving their ability to diagnose issues, perform repairs, and conduct maintenance procedures accurately.

There are two major benefits of implementing AR-based Maintenance Support:

**Reduced Downtime:** AR-equipped technicians can access step-by-step instructions and real-time data during maintenance tasks, reducing the time required to diagnose and address issues. This leads to shorter downtime for equipment and machinery, resulting in increased production efficiency.

**Improved First-Time Fix Rate:** AR provides technicians with accurate visual guidance, which can lead to a higher first-time fix rate. This minimizes the need for repeated visits or multiple attempts to resolve a problem, saving both time and resources.

Manufacturing companies across different sectors have been adopting AR-based maintenance support to streamline their operations and achieve numerous benefits. Some well-known manufacturing companies that have utilized AR for maintenance support include:

**General Electric:** GE has used AR to guide technicians through the repair and maintenance of complex machinery, improving the accuracy of their work and minimizing the need for specialized training.

**Siemens:** Siemens employs AR for maintenance support in its industrial manufacturing processes. Technicians can use AR glasses to access manuals, schematics, and real-time data, enhancing troubleshooting and reducing downtime.

It is worth to mention that Siemens is betting heavily into AR-enabled products. Siemens and TeamViewer are collaborating on augmented and mixed reality (AR/MR) solutions for product lifecycle management. The companies have established a „strategic relationship” to combine the advantages of Siemens Teamcenter product lifecycle management with TeamViewer’s enterprise augmented reality platform, Frontline.

## PRODUCT DESIGN AND PROTOTYPING

Product Design and Prototyping using Virtual Reality and Augmented Reality is a technology-driven approach that revolutionizes the design and development process. It involves creating digital prototypes of products and visualizing them in immersive VR environments or overlaid onto the real world through AR. This enables designers, engineers, and stakeholders to interact with and evaluate the product before it’s physically built, reducing the reliance on traditional physical prototypes and potentially accelerating the design iteration cycle.

Implementing VR and AR for product design and prototyping can yield several quantitative and financial benefits:

**Reduced Prototyping Costs:** Traditional physical prototypes can be expensive and time-consuming to produce. VR and AR allow companies to iterate on digital prototypes at a fraction of the cost of creating physical models.

**Faster Time-to-Market:** With quicker design iterations, products can be developed and brought to market faster, giving companies a competitive edge.

**Design Validation:** Designers and stakeholders can evaluate the ergonomics, aesthetics, and functionality of a product before manufacturing, reducing the likelihood of design flaws and costly post-production changes.

**Improved Decision-Making:** Design decisions can be based on immersive experiences rather than abstract 2D drawings, leading to more informed choices and better end results.

Many major manufacturers across various industries have adopted or experimented with AR and VR for design and prototyping. Some notable examples include:



**Automotive:** Companies like Ford, Volkswagen, and Jaguar Land Rover have used VR to refine designs and detect issues before the costly physical prototyping phase. Designers and engineers can explore virtual prototypes and make design decisions without the need for physical models.

**Aerospace:** Airbus and Boeing have explored VR and AR for designing new aircraft models and enhancing the manufacturing process. Stakeholders can evaluate layouts, aesthetics, and functionality before physical components are manufactured.

**Consumer Electronics:** Companies like Apple, Samsung, and Sony have likely used AR and VR (though they might not publicize it) in the prototyping phase of their hardware products.

**Furniture:** IKEA has been known to use VR and AR for product design.

**Footwear & Apparel:** Nike and Adidas have dabbled in the AR and VR space, not just for marketing and customer experience but also potentially in the design phase.

**Cosmetics:** L’Oreal employs AR to prototype and visualize cosmetic product packaging. This helps in assessing how packaging designs look on retail shelves and in the hands of consumers.

# VIRTUAL PRODUCTION LINE CHANGEOVER FOR VELVET CREATED BY EPIC VR

Virtual reality (VR) technology brings revolutionary changes to employee training in various industrial sectors. This article presents project carried out by EpicVR - "Virtual Production Line Changeover" for Velvet. The project utilize innovative VR application for training purposes, focusing on the visual layer, application theme, customer needs, and methods of meeting those needs. It analyses the creative process associated with implementing the application, the positive value for companies embracing new solutions, and the overall outcomes of the completed training.



**Adrian Łapczyński**  
CEO Epic VR

## PROJECT INTRODUCTION AND BACKGROUND

In today's globalized world, companies must constantly seek ways to enhance the efficiency of their operations. Velvet, a manufacturing company, faced such a challenge - regular production line changeovers, which are essential yet time-consuming and costly processes. The need for continuous adaptation of the production line to changing market requirements, as well as evolving product portfolios, drove the search for modern and efficient solutions.

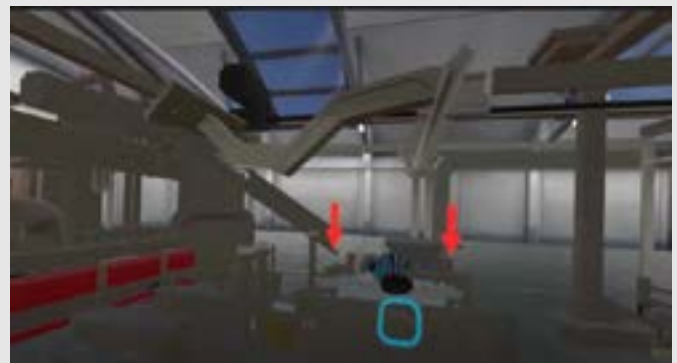
The solution to these challenges came in the form of the VR application "Virtual Production Line Changeover," created by EpicVR. Virtual reality, increasingly employed in training and production sectors, offers unique capabilities to simulate real processes and situations, enabling users to perform tasks and training in a controlled, safe environment.



In this case, the application of VR enabled Velvet employees to virtually conduct the changeover process without halting the actual production line. This allowed them to practice, test, and refine various changeover strategies and procedures without disrupting ongoing production. The ability to practice in a virtual environment translates to real-time savings in time and costs, and it enhances employee safety by eliminating potential errors before they occur in the real production process.

Moreover, the “Virtual Production Line Changeover” application allows for precise modelling and analysis of the changeover process. This empowers Velvet to identify potential areas for improvement, resulting in continuous process enhancement and increased production efficiency.

In response to Velvet’s challenges, EpicVR delivered an application that not only addresses the company’s immediate needs but also opens new avenues for future innovations and process improvement. This application serves as a prime example of how VR technology can be effectively harnessed in the manufacturing sector, benefiting businesses, their employees, and ultimately, customers.



## CREATIVE PROCESS AND IMPLEMENTATION

The process of creating a VR application is intricate, involving considerations ranging from client needs analysis and virtual reality design to interactive scenario creation, testing, and optimization. For the “Virtual Production Line Changeover” application, the completion of these stages was essential to create a realistic simulation of the changeover process, enabling effective learning and practice.

Analyzing Velvet’s needs constituted the initial and pivotal step. Understanding the specifics of the changeover process, as well as the challenges and difficulties associated with it, was crucial for designing an effective application. The EpicVR team conducted multiple meetings and consultations with Velvet to grasp not only the technical aspects of the process but also the intricacies of the teams responsible for changeover.

Designing the virtual reality came next, involving the creation of a 3D representation of Velvet’s production line. The application of VR allowed the development of a realistic, interactive simulation that accurately replicates the actual changeover process. Attention to detail was paramount, encompassing both the general production line configuration and specific machine elements.

Creating interactive scenarios followed, aiming to generate various situations that could occur during changeover. These scenarios encompassed both typical operations and potential issues, enabling users to practice and enhance their skills in a safe, controlled environment.

Ultimately, testing and optimization were pivotal stages concluding the application’s creation process. During these stages, the EpicVR team, in collaboration with Velvet, assessed the application’s functionality, interactivity, and realism of the simulation. All identified issues were addressed and resolved, while the entire process was continually optimized to ensure the highest quality of user experience.

Through this comprehensive approach to creating a VR application, EpicVR was able to provide Velvet with a tool that not only met their immediate needs but also offered unique opportunities for practical learning and process improvement.

## VISUAL LAYER AND APPLICATION THEME

Visually, the application was designed to closely replicate real working conditions on the production line. Realistic 3D graphics were employed, aiding employees in easily grasping knowledge and skills in a safe virtual environment. The application's theme centered on faithfully replicating the production line changeover process, encompassing all its stages.

## RESULTS AND IMPACT ON THE COMPANY

The “Virtual Production Line Changeover” application yielded significant benefits for Velvet. Production downtime was reduced, costs were lowered, production efficiency increased, and employee safety improved. Employees became better trained and more competent in the changeover process, translating to continued successes and company growth.

By simulating the real work environment and the changeover process, the application enabled employees to practically internalize the knowledge and skills necessary for efficient and safe changeovers on the production line.

## SUMMARY

The projects “Virtual Production Line Changeover” and “Allegro: Cosmic Experience” serve as clear examples of the effective use of VR technology for training purposes. The work on these projects illustrates how innovative technologies can contribute to streamlining business processes and developing employee skills. The benefits stemming from these initiatives are invaluable, benefiting not only Velvet and Allegro as the beneficiaries of these solutions but also EpicVR, the creator and provider of these innovations.

Both projects demonstrate how VR can transform traditional training and education approaches. Instead of relying on conventional teaching methods such as presentations or seminars, VR technology allows for immersive, hands-on experiences. Training participants can interactively engage in the learning process, enhancing their understanding and retention of newly acquired skills.

“Virtual Production Line Changeover” showcases how VR can enhance complex technical processes.

By simulating real conditions on the production line, the application enables employees to improve their skills without the risk of errors that might occur in the real world. This results in reduced downtime, increased efficiency, and overall process improvement.

On the other hand, “Allegro: Cosmic Experience” highlights the potential of VR in developing soft skills. By assuming different roles in customer service scenarios, employees have the opportunity to practice and develop skills that are essential for effective communication and building customer relationships.

The benefits for Velvet and Allegro are significant. On one hand, they gain access to advanced training tools that can help them achieve their business goals. On the other hand, through VR, their employees have the opportunity to develop skills in a safe, controlled environment, translating to higher work quality.

For EpicVR, the realization of these projects signifies the opportunity to showcase their technical knowledge and creativity. The company not only delivers innovative solutions but also contributes to the business development of its clients, solidifying its position as a market leader in VR technology.

In summary, the projects “Virtual Production Line Changeover” and “Allegro: Cosmic Experience” illustrate how VR can be effectively utilized for training purposes. These examples underscore the potential of VR as a tool for improving business process efficiency and developing employee skills.



## Chapter 3I

# MIXED REALITY APPLICATION IN LOGISTICS

Virtual Reality and Augmented Reality are emerging technologies that have found applications in logistics industry. These technologies offer innovative solutions to enhance efficiency, reduce costs, and improve customer experiences.

Let's explore the various applications of VR and AR in the areas of logistics sector such as training & simulation, warehouse management, transportation and route optimization by providing current examples of companies utilizing these technologies and identifying trends.

## TRAINING AND SIMULATION

Training and simulation using VR and AR technologies involve creating virtual environments and augmented overlays to replicate real-world scenarios. These virtual environments provide immersive and interactive experiences that enable logistics personnel to practice handling equipment, managing inventory, and dealing with emergencies without risk. Augmented reality can provide real-time guidance and feedback during training, overlaying instructions and information on physical objects. DHL has experimented with AR glasses to provide real-time guidance for warehouse operations, including training for picking and packing. It resulted in a 25% efficiency increase in the picking process, reducing labour costs. DHL also found out that AR-guided picking employees reduced errors by 40%. Another example could be Walmart logistic department implementing VR training, which allow to reduce training time by 30-40%, leading to significant cost savings. The reduced time in training translates to more productive hours on the job. The reduction in errors leads to fewer returns and corrections, saving both time and money. It is also worth to mention that UPS's VR training for drivers has contributed to a decrease in accidents. While specific numbers are proprietary, UPS has noted a measurable improvement in safety metrics which results in continuing using VR training for drivers in the following years.

## WAREHOUSE MANAGEMENT



The implementation of mixed reality into warehouse management can be divided into two categories: AR-Powered picking and VR warehouse design. AR-powered picking involves using AR glasses or devices to guide warehouse workers to the correct locations and provide information about the items to be picked. It overlays digital information onto the real world, enhancing efficiency and accuracy in the picking process. We already discussed how DHL used AR

to train picking employees and how it increase 25% their efficiency and reduced errors by 40%. They not only use AR for training but also continue to use it during their normal workday, that's how they get to such great results! Geodis, leading distribution company from France, is also using AR-powered picking solution inside their logistic department. They experienced a 30% reduction in error rates and a 20% increase in productivity when they compare regular workers with employees empowered by AR.



Another use case example - VR warehouse design involves using VR technology to create virtual models of warehouse layouts. It allows for the visualization and optimization of space, workflow, and equipment placement before physical implementation. By enabling better planning and utilization of warehouse space, companies benefit from reduced design time and improved space optimization. Logistic operator Tompkins International, achieved a 15% reduction in design time and a 10% improvement in space utilization through VR warehouse design. Let's also noted that a study conducted by Deloitte found that using VR for spatial planning and design can reduce planning errors by up to 40%, leading to cost savings. This not only applies to logistic sector but broader spectrum of companies already applying VR for planning & design. The data from early adopters demonstrates the potential of VR and AR to revolutionize warehouse management in the logistics industry. As the technology matures and becomes more accessible, it is likely that more companies will explore and benefit from these innovative solutions.

## TRANSPORTATION AND ROUTE OPTIMIZATION

There are few interesting application of extended reality inside area of transportation and Route optimization. One of them is called AR navigation which involves overlaying digital information onto the real world through AR devices, such as smartphones or AR glasses but it can also provide data directly onto a car's windshield. This is called AR head-up display (HUD) and its projecting augmented reality interface and creating a smart windshield for valuable information. It provides drivers with real-time information about traffic, weather, and route alternatives, enhancing traditional GPS navigation. There are luxury brands such Mercedes and Cadillac already are incorporating navigation screens with AR to provide drivers with an enhanced view of the road ahead. Also Daimler and Volvo are testing AR navigation inside their newest car models. In the nearest future we should see other car manufacturers such as Tesla, Toyota moving forward with implementing it into trucks. As some reports suggest AR navigation can reduce navigation errors by up to 10%, leading to fuel savings and reduced delivery times. It's becoming clear that it should enhance both safety and driving experience if it would be implemented correctly. There have to be more research into that technology in order to not distract the drivers but the potential benefits are pretty straightforward.

The last application is VR traffic simulation enabling creation of virtual environments to simulate traffic scenarios. It helps logistics companies analyse and optimize routes by understanding traffic patterns, congestion, and alternative routes. Siemens is utilizing VR traffic simulation for urban planning and transportation optimization. There is a specialized IT & consulting company PTV Group which offers VR traffic simulation tools used by logistics and transportation companies. Based



on their clients testimonials, logistic companies reported up to a 15% reduction in fuel consumption and a 5% reduction in delivery times using VR traffic simulation. This could indicate another room of improvement possible to achieve if a company is willing to utilize VR simulation to perfect their logistics planning & routes.

The integration of AR and VR with the Internet of Things (IoT) is a growing trend, allowing for real-time data collection and analysis. This convergence allows devices to interact and share information, enhancing user experience by providing immersive and context-aware insights. For example, a warehouse manager can use AR glasses to see real-time data about inventory levels, shipment status, and equipment performance. This integration enhances decision-making, improves efficiency, and reduces errors, making it an attractive investment for logistics companies. Second major trend pushing the adoption of mixed reality technologies is sustainability. The logistics sector is under increasing pressure to reduce its environmental impact. VR/AR technologies contribute to sustainability by enabling more efficient planning and execution. For instance, VR can be used to simulate different transportation scenarios to find the most fuel-efficient routes. AR can assist in loading optimization, ensuring that space is used efficiently, reducing the number of trips needed, and consequently lowering fuel consumption and emissions. By aligning with the global push towards sustainability, the adoption of VR/AR in logistics becomes not only a means to enhance efficiency but also a way to meet environmental responsibilities.

# ELMARK: FROM THEORY TO PRACTICE: HOW MIXED REALITY IS UTILIZED BY POLISH AND INTERNATIONAL COMPANIES?



### Mariusz Rozbicki

*Product Development and Sales Manager in ELMARK*

Reality technology began, allowing users to experience a virtual world. Simultaneously, the initial concepts of Augmented Reality emerged, enabling the overlaying of digital objects onto the real environment. The concept of Mixed Reality emerged in the 1990s, combining AR and VR environments. This integration aimed to merge digital content with the physical world more effectively than either AR or VR could achieve alone. However, the technology was limited at the time, and its practical application was minimal. As MR solutions evolved, devices like Head Mounted Displays (HMDs), smart glasses, helmets, and motion tracking sensors were developed. This equipment facilitated practical applications of Mixed Reality in various fields.

Mixed Reality aims to provide users with a more realistic perception of external information and stimuli, allowing interaction with virtual objects in the real environment. As a result, MR finds applications in various sectors, including industry, manufacturing, IT, telecommunications, energy, as well as medicine, education, and entertainment. This versatility makes it a multifaceted tool with numerous possibilities.

Mixed Reality is continuously evolving and holds the potential to revolutionize our way of functioning. It prompts reflections and changes in priorities within business, technological, and economic approaches, and particularly in the way we think, especially in the area of enterprise digitization and entire industries. Growing demands from the environment, both economic and organizational, have made the digitization of processes not just desirable but necessary.

The question is: where does this innovative solution find practical application? For many, it's not surprising that Mixed Reality is already proving itself in many industries. It has become an essential element of operation both in Poland and worldwide. MR streamlines processes, influences effective workforce management, reduces operational costs, and guarantees greater employee safety.

The genesis of Mixed Reality is directly linked to the development of Virtual Reality and Augmented Reality. Mixed Reality represents an interaction between the digital and real world, combining the characteristics of both technologies. Its primary aim is to create more advanced, realistic, and interactive experiences for users.

The roots of AR and VR date back to the 1960s and 1970s. During this time, experimentation with Virtual



Importantly, MR supports the growing need for environmental protection. It's a significant factor shaping consumer awareness and public opinion, directly affecting a company's image and brand reputation.

In industries and manufacturing, MR solutions excel in supporting assembly and service processes. Less experienced employees can receive real-time guidance from more seasoned colleagues, aided by digital documents and visual instructions. This leads to fewer errors and a shorter task completion time, or the faster integration of new employees.

Training and education are another sector where Mixed Reality transforms our accustomed ways. Learning becomes interactive and realistic. Employees, trainees, and students can practice tasks, acquiring practical knowledge in a virtual environment without the risk of damaging equipment or jeopardizing lives.

Mixed Reality has broad applications in medicine, aiding in planning, simulation, and performing surgical procedures. Future doctors and experienced medical professionals can enhance their skills by practicing complex procedures in a digital environment, improving the quality of medical care and patient safety.

The academic environment also benefits from MR technology. Remote mentoring opens doors for data analysis, virtual prototyping, testing, and simulations.

These are just a few examples of how Mixed Reality is being utilized. The evolution of Mixed Reality is ongoing. One thing that's certain today is that with the advancement and accessibility of technology, Mixed Reality will have an increasingly significant impact on our daily and business lives.



## Chapter 4

# WALKING IN VR: SOLVING VR'S LOCOMOTION PROBLEM WITH THE CYBERITH VIRTUALIZER ELITE 2



**Tuncay Cakmak**  
CTO Cyberith

After years of continuous technical improvements, VR technologies are increasingly becoming established as tools for a variety of applications, including professional training, education, and research.



However, the problem of VR locomotion - how to walk in virtual environments that are larger than the physical space available - typically limits VR to applications where walking is not required over long distances, or where walking can be replaced by artificial concepts such as teleportation.

As you can imagine, a variety of applications require walking over long distances, and concepts like teleportation don't work for all of them because it doesn't involve physical activity (and the exhaustion that comes with it), doesn't take the same amount of time as walking

somewhere, and in many cases doesn't work conceptually.

Applications that suffer from these problems include

- Industrial safety training;
- Training for firefighters, police, military personnel, etc;
- Medical rehabilitation (requiring the user to physically walk for gait rehabilitation, motor function training, combination of physical and cognitive tasks for neurodegenerative disease rehabilitation);
- and a wide variety of research applications, whether for pedestrian simulation in urban planning or road safety, architecture, biomechanics, or psychological or neurological experiments.

In short, any application that requires physical walking in a large virtual reality environment requires a solution to the VR locomotion problem.

That's why both researchers and private companies have been working on different types of VR walking simulators for decades. However, the results have long been unsatisfactory, either because of technical challenges that are difficult to solve, or simply because of poorly designed and cheaply manufactured products that have become available on the consumer market in recent years.

According to our customers (some of whom own many different VR locomotion systems), our second generation product for walking in VR, the Virtualizer ELITE 2, is the best product available to solve the VR locomotion problem in areas such as the ones mentioned above.

This is because of its system for actively supporting the user's walking motion: A 2 DOF motion platform inclines a flat, low-friction surface on which the user walks. The actively powered motion platform tilts the walking surface to allow the feet to glide easily backward without the user having to push forward strongly with their hips against a harness. The inclination allows the feet to glide easily backwards, rather than requiring a constant hard push.



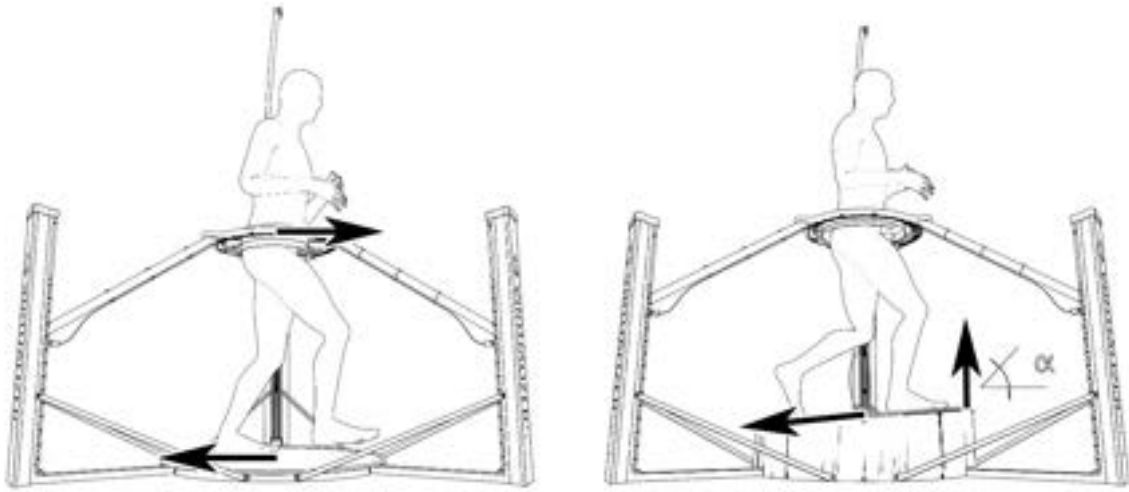
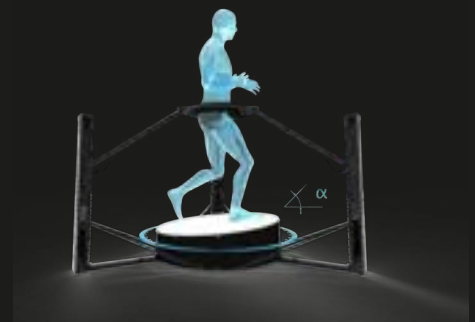


FIGURE 1: THE VIRTUALIZER ELITE 2 (RIGHT) INCLINES THE BASEPLATE BY 2°-8° TO ALLOW THE FEET TO GLIDE EASILY BACKWARDS WITHOUT HAVING TO PUSH AGAINST A HARNESS OR OTHER STRUCTURE.

Correctly setting the tilt angle eliminates the need to push against a harness, vest or other structure and helps the feet slide in the correct direction: backwards, which is the downward direction. When the user turns on the platform, the 2 DOF motion platform causes the inclination to rotate with the user without rotating the platform itself. This allows the user to easily turn and walk in all directions in 360°. The Virtualizer ELITE 2's system continuously adapts the inclination to the user's orientation, walking direction, and walking speed to optimally support the user's gait. The maximum tilt can be easily adjusted by the user to adapt the system to personal preferences and body characteristics such as weight.

By using this system, the Virtualizer ELITE 2 provides active support to the user's gait without the need to move the floor horizontally under the user, as moving the floor in the style of a belt-based omnidirectional treadmill leads to several serious technical problems that have not yet been sufficiently resolved. Aside from challenges related to technical complexity, size, weight, noise, cost & longevity, the biggest problem with such belt-based systems is the fact that they need to accelerate the belts rapidly to keep up with the user's movements. These quick accelerations of the floor on which the user is standing destabilizes the user and eventually causes the person to fall. Simply put, such systems quickly pull on the ground the user is standing on, making it challenging to create a comfortable and safe experience, especially when considering that the user is blindfolded by wearing a VR headset.

While the Virtualizer ELITE 2 is the first and only system of its kind, it is simple compared to such belt-based omnidirectional treadmill systems. It is based on the proven technology of a 2 DOF motion platform, which has allowed us to create an easily deployable, relatively small, quiet and cost-effective VR treadmill that actively supports the user's gait. This active support provided by the system makes a huge difference in the user experience, comfort and realism of the walking movement. While physically walking on the Virtualizer is not identical to walking on the regular floor, it is intuitive enough that the vast majority of users can get started immediately without the need for explanation.



The Virtualizer ELITE 2 system comes with an implemented low latency tracking system that works optically. The data collected by the tracking system is used to precisely control the movement of the avatar within the VR as well as to continuously control the movement/tilt of the Virtualizer base as described above.

This makes our system flexibly compatible with a wide range of VR headsets and alternative display solutions, making the Virtualizer ELITE 2 a very suitable tool for anyone who wants to realize longer distance walking in their VR applications. The product can be shipped worldwide from our production facility in Austria and requires little maintenance and effort to implement, making it an ideal purchase for labs, companies and other professional users of VR.

## Chapter 5

# SENSEGLOVE: TRANSFORMING INDUSTRIES THROUGH TOUCH



**Sense Glove**

**Sophie Smith**

*Marketing Manager in SenseGlove*

SenseGlove develops wearable haptic gloves that enable professionals to feel virtual objects and interact with them more efficiently in VR. The SenseGlove Nova uses a combination of force feedback, vibrotactile feedback and hand tracking to provide the user with a truly immersive experience and natural interactions. Unlike controllers, the gloves allow you to hold, push, touch,

connect and squeeze the virtual like it's real. Since its release in 2021, the SenseGlove Nova is already in the hands of over 500 companies worldwide, with the most popular industries being: manufacturing, automotive, aerospace, construction, energy and defense sectors.

## A BRIEF OVERVIEW OF SENSEGLOVE'S BEGINNINGS

SenseGlove was founded in 2017 by Gijs den Butter and Johannes Luijten with a bold vision: to create haptic gloves that would enable users to feel virtual objects. The company's journey began with a deep understanding of the potential of haptic technology to revolutionize various sectors. Their dedication to bridging the gap between the physical and digital worlds led to the development of sophisticated haptic gloves that offer tactile feedback, revolutionizing industries and setting new standards for human-computer interactions.

## SENSEGLOVE'S IMPACTFUL COLLABORATIONS

The impact of SenseGlove's haptic gloves is best understood through a series of innovative collaborations that highlight their transformative capabilities. These partnerships have not only demonstrated the power of the technology but also paved the way for new applications in diverse fields:

### **Procter & Gamble Health:**

SenseGlove's collaboration with Procter & Gamble involved creating a simulation that was used in a worldwide campaign for Procter & Gamble Health to raise awareness about nerve damage and to build empathy for those that suffer from it. The haptic gloves enabled the user to experience sensations and difficulties patients with nerve damage suffer on a daily basis. The SenseGlove technology was used to create an immersive, thought-provoking experience.

### **Dutch Ministry of Defence – Royal Netherlands Army:**

The Ministry of Defence Simulation Centre has been experimenting with VR and haptics for several years. In this case, the SenseGlove Nova has been implemented in the military VR training for assembling a satellite receiver in order to avoid damaging expensive training equipment. While VR allowed for keeping the equipment and trainees safe, haptics enabled the development of muscle memory, which is crucial for complex assembly tasks.

### **Volkswagen Commercial Vehicles:**

Volkswagen Commercial Vehicles implemented and tested SenseGlove Nova for automotive VR training in assembling a Volkswagen T6 and T7 door. The goal was to improve the realism of VR simulation and to protect the expensive vehicles from damage that could potentially occur during on-hand training.

Volkswagen's decision to implement the SenseGlove Nova stemmed from 2 main factors; to save training time and to offer an alternative to training with expensive pre-series vehicles. "One hundred percent of the trainees who completed the T6 vehicle assembly training found it more realistic to work with SenseGlove Nova versus the controller, simply because they could do more, like grabbing things. It just feels more realistic" said Marcos Antelo Barrio, trainer at Volkswagen.

## Staffordshire University:

Staffordshire University used the SenseGlove DK1 to research new ways to communicate history. The goal of the research was to explore how haptic technologies combined with VR can better engage viewers in the museum and heritage sectors. Using SenseGlove DK 1, participants were able to explore the museum in VR and handle the fragile ceramics, physically feeling their size and stiffness, and experiencing the unique features of each artefact.

“The haptics spark the potential to revive how we interact, communicate and preserve ceramic artefacts long term. This innovative way of interaction reinvents the way we communicate history, aids interpretation and increases visitor engagement”, says Emma Fallows.

## TNO (Netherlands Organisation for Applied Scientific Research):

SenseGlove’s partnership with TNO demonstrates the far-reaching implications of its technology. By integrating haptic gloves into research projects, TNO is pushing the boundaries of what is possible in scientific exploration. SenseGlove’s haptic gloves are used by workers to control robotic arms from a safe location, executing tasks in environments with extreme temperatures, radiation, or toxic substances.

## LEADING THE WAY WITH SENSEGLOVE NOVA 2

As SenseGlove continues to push the boundaries of haptic technology, the recent release of the SenseGlove Nova 2 stands as a testament to their dedication to innovation. The SenseGlove Nova 2 is the first and only glove equipped with Active Contact Feedback. This pioneering feature allows users to experience tactile sensations directly on their palms, opening up new dimensions of interaction. With the Nova 2, SenseGlove is setting a new standard for haptic gloves, redefining the possibilities for industries and individuals alike.



## EMBRACING A TOUCH-ENABLED FUTURE

SenseGlove’s pioneering journey in haptic technology is a testament to its vision, dedication, and innovation. Their collaborations with partners such as Procter & Gamble Health, the Royal Netherlands Army, Volkswagen Commercial Vehicles, Staffordshire University, and TNO illustrate the versatility and potential of their haptic gloves. As SenseGlove continues to innovate and redefine human-machine interactions, they are shaping a future where touch plays an integral role in digital experiences. The company’s mission is to one day become the mouse and keyboard of the future.