INTRO 4.0

Modelado, Virtualización y simulación

EuroProfis

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apoio à gestão

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INTRODUCTION TO THE INDUSTRIAL REVOLUTION 4.0

These didactical materials, which have been developed in the framework of the European project 'Industry 4.0 - INTRO 4.0', funded by the European Commission aims to come up with an overview of what has been done in the European Industry in terms of Industry 4.0.

The content of these didactical materials provides the most relevant and useful information on Industry 4.0 to a target group that includes: adults, educators (VET & Higher Education), teachers, trainers, coaches, employers, employees, the general public, and suppliers of innovative solutions.

This information is rooted within the report 'Current Status Of The Industry 4.0' and the report 'Summary Report of the expert interviews/questionnaires and the specific research on the field of manufacturing companies", both developed by the partners of this project.

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THIS CONTENT MAY BE OF GREATER INTEREST TO THE COMPANIES

THIS CONTENT MAY BE OF GREATER INTEREST TO THE GENERAL PUBLIC

LEARNING OBJECTIVES

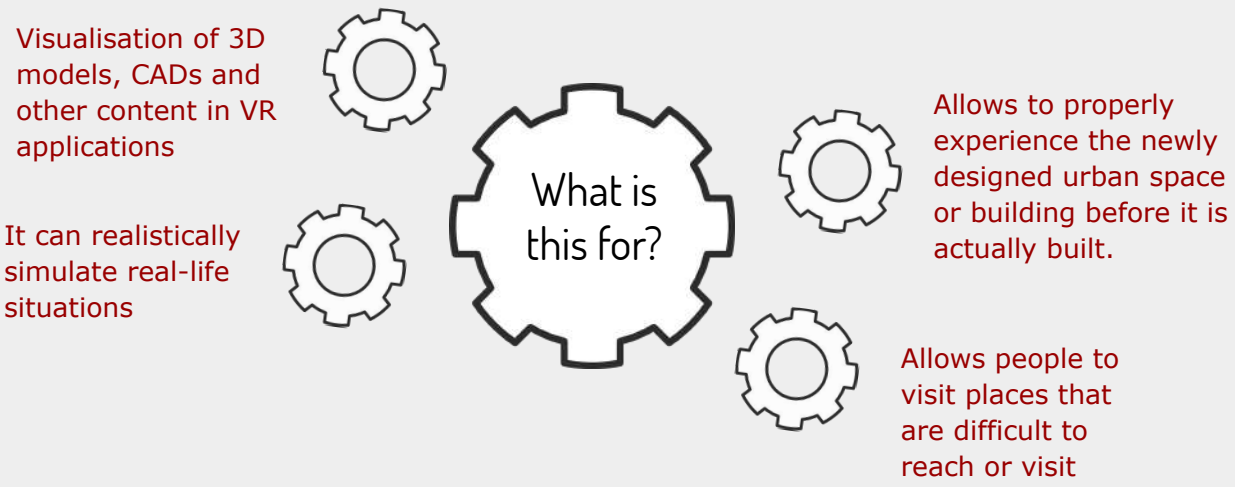
- Increase general knowledge Modelling, Virtualization and Simulation.
- Identify Virtualization benefits.
- Know the uses of simulation and Virtual Reality in society.
- Know the impact and trends of Virtual Reality

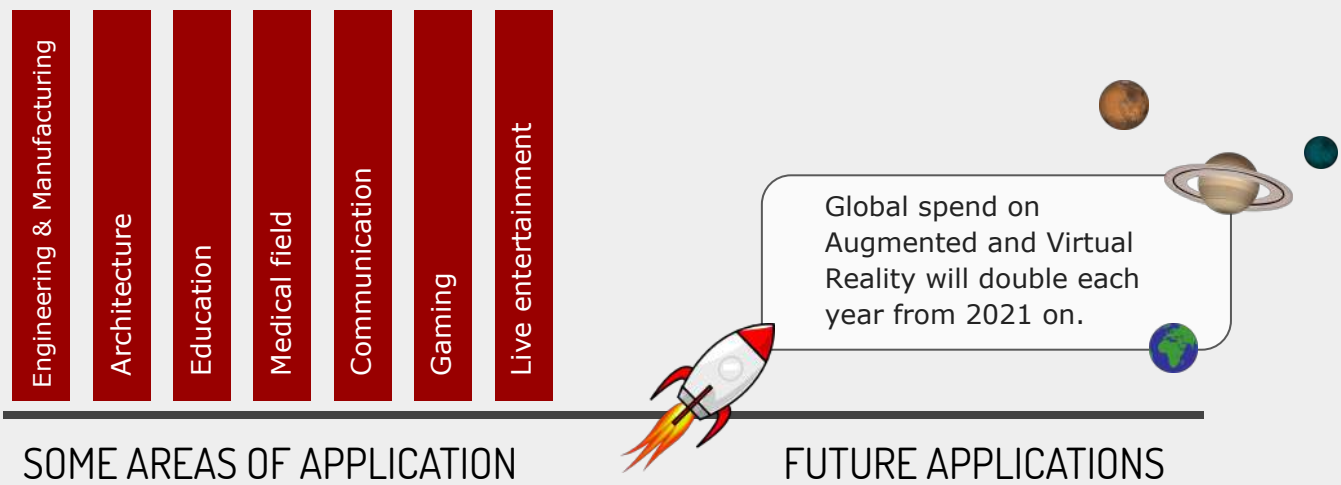
INTRODUCTION

Simulation modeling solves real-world problems safely and efficiently. It provides an important method of representation which is easily verified, communicated, and understood. Across industries and disciplines, simulation and virtualization provides valuable solutions by offering a clear view of different scenarios.

Learning Objectives

- Increase general knowledge Modelling, Virtualization and Simulation.
- Identify Virtualization benefits.
- Know the uses of simulation and Virtual Reality in society.
- Know the impact and trends of Virtual Reality





WHAT IS IT?

Modeling is anything that represents something else, usually on a smaller scale. Modeling is helpful because it allows you to take a good look at something that is too big or impractical to see otherwise.

Virtualization or **Virtual Reality (VR)** refers to computer-generated environments that simulate the physical presence of people and/or objects and realistic sensory experiences. VR has also spurred the evolution of 3D video technology, which uses dual imagery so that objects on the screen appear three dimensional and replicate real-world objects and places.

Simulation still has a clear the edge on the term Virtual Reality. Many aspects of the natural world can be transformed into mathematical models, and using simulation allows IT systems to mimic the outcomes that happen in the natural world.

Figure 1. 3D Simulation in Architecture.

WHAT IS IT?

Product development today is increasingly based on simulation and optimization of virtual products and processes. Mathematical models serve as digital twins of the real products and processes and are the basis for optimization and control of design and functionality. The models have to meet very different requirements: Deeply refined mathematical models are required to understand and simulate the true physical processes, while less refined models are the prerequisites to handle the complexity of control and optimization. To achieve best performance of mathematical modeling, simulation and optimization techniques (MSO), in particular in the industrial environment, it would be ideal to create a complete model hierarchy.

The current most favoured way in industrial applications to achieve such a model of hierarchy is to use a sufficiently fine parameterized model and then apply model order reduction (MOR) techniques to tune this fine level to the accuracy, complexity and computational speed needed in simulation and parameter optimization.

Although the mathematical models differ strongly in different applications and industrial sectors, there is a common framework via an appropriate representation of the physical model.

What is the difference between VR and AR?

Virtual Reality (VR) is described as a 3D environment in which a person can become immersed, using a dedicated headset, powered by a computer, game console or smartphone. The VR experience can be enhanced thanks to 3D audio sounds and by using haptic devices that use sensors to transfer body movement into the virtual space. **Augmented Reality (AR)** refers to a real-world environment enhanced with computer-generated information such as sound, video or graphics.

WHAT IS THIS FOR?

One of the great promises and at the same time one of the main focus areas in Industry 4.0 is the bridging of digital/cyber/virtual and physical worlds, hence the focus on cyber-physical systems.

Apart from the fact that this isn't just a technology issue *(nor is the Industry 4.0 vision as such)*, from the technological perspective one immediately thinks about the Internet of Things. However, Virtual Reality (VR) and augmented reality (AR) are certainly as important.

Virtual reality (VR) and augmented reality (AR) are used in several sectors and contexts, from consumer applications to manufacturers. Yet, it's in manufacturing that augmented reality offers great value in myriad applications, in combination with several other technologies as per usual.

The use of VR and AR in manufacturing and other industries for which the term Industry 4.0 gets used is not fiction. It happens as we speak and is poised to accelerate as the benefits become increasingly clear, offerings, hardware and applications mature and move to the next level and manufacturers increase their digital transformation efforts on the strategic and staged path towards the realization of Industry 4.0 and the digital transformation of manufacturing.

WHAT IS THIS FOR?

Although they are different, VR and AR share common processes and technologies, such as audio software and data processing. They also tend to concentrate in the same business and research worlds hence creating overlapping ecosystems.

- **VR** is used within a wide array of areas, ranging from the gaming industry and entertainment, to training and simulation, including training in the medical field. Other areas of application include education and culture, sports, live broadcasting, real estate, advertising, architecture, and arts. More areas of application are still to come.

- **AR** has an almost limitless range of uses in a wide variety of areas, be it commerce, technical applications, work processes or education. VR & AR serve both consumers and professional users that can be private and public.

Virtual Reality and augmented reality can play a role in the typical earlier stages where optimization and enhanced productivity (quantity, quality, speed, flexibility) are more important than later stages of innovation and genuine business transformation (which can of course be set out as Industry 4.0 goals at the start, more about that in 'Finding the value in Industry 4.0').

Just think about how simulation models and the use of augmented reality can speed up the entire production chain, in combination with the right data, starting from the use of AR and VR in virtual design. Or about the use of augmented reality in maintenance. And then there is of course the possibility to put a virtual layer, based on the right data and information, on top of the 'reality' in all sorts of factory and industry environments, using devices such as AR/VR glasses/viewers. The latter is probably the best known illustration of how de facto virtual or cyber and physical meet.

WHAT IS THIS FOR?

Application of AR/VR:

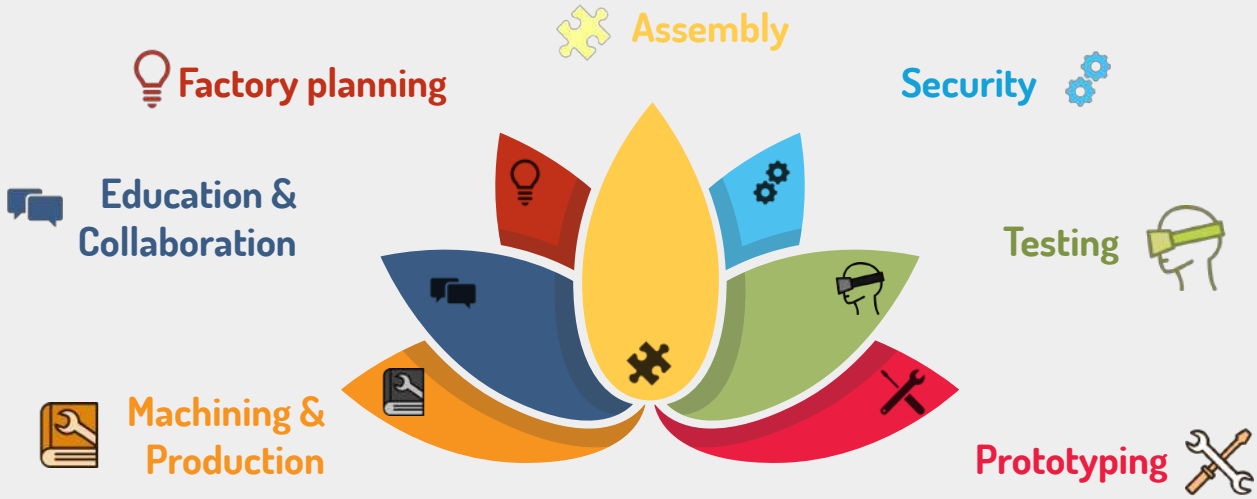


Figure 2. Use cases of AR and VR. Source: Self made

Tha application of AR/VR includes machining and production, education and collaboration, factory planning, assembly, security, testing and digital prototyping, to name a few. As we'll see showcasing and immersive *(key in AR/VR)* experiences on the customer side are important as well. So, marketers should also pay attention, certainly in the manufacturing of products where showcasing technological manufacturing expertise strengthens the perception of the technological wealth of both company and product. So, no, it is not a coincidence if many applications of AR/VR in manufacturing which get a lot of attention are in, for example, the automotive industry *(and certainly the luxury car brands)*.

In operations, you can certainly also imagine how, with the proper equipment and solutions *(from the worker's perspective as well of course, have you seen those first headsets?)* service people, factory staff and logistics staff can better perform their tasks if they have the information they need in front of their eyes and two of their main work instruments, on top of their brain, free: the left hand and the right hand. The result: smoother processes and flows.

WHAT IS THIS FOR?

Application of AR/VR:

ENGINEERING AND MANUFACTURING INDUSTRY

VR applications can be used for industrial purposes to improve product development processes, train staff and enhance communication. Driven by the needs of major European industries, VR applications are either developed in-house or are outsourced to VR/AR dedicated companies.

The visualisation of 3D models, CADs and other content in VR applications give the possibility for different people to access to them from any location, to analyse and interact with them in a virtual environment. This can improve the manufacturing process, firstly during the conception phase for the design and development of components or the final product, and secondly for the creation of prototypes and experimentation once the final product has been developed.

ARCHITECTURE, REAL ESTATE AND CONSTRUCTION

From streamlining the design process to facilitating property sales, Virtual Reality is revolutionising the construction, architecture, and real estate industries.

Not only does this eradicate the need for building physical mock-ups at each step of the process, but it also allows to properly experience the newly designed urban space or building before it is actually built. That way everyone involved has the opportunity to spot errors more easily and correct them more quickly. This drastically reduces the likelihood of an ill-designed finished product that does not fit well in its environment or does not suit the needs of those living in or using the space.

EDUCATION AND CULTURE

VR allows people to visit places that are difficult to reach or visit more spots virtually in a short period of time at lower cost. This can be for example used in education: pupils and students, or anyone interested in learning, can visit for example Jerusalem or a festival in ancient Rome in a 360-degree video. VR is capable of bringing knowledge closer to a student who wouldn’t be able to access it otherwise – for example due to disability or unavailability of quality education in her or his country.

MEDICAL FIELD

VR has great potential for health professionals and hospitals, ranging from trainings to better collaboration and mutual understanding.

In this way students and professionals in the medical sector have the opportunity to perform a realistic surgery on a virtual patient, test their knowledge and learn new methods and tips, without any risk for the patient. Another special element in VR trainings is that they can realistically simulate real-life situations by bringing together professionals or students from different disciplines and promoting cooperation.

WHAT IS THIS FOR?

AWARENESS-RAISING AND REPORTING

Many broadcasters and companies active in news and journalism, as well as organisations engaged in and/or furthering humanitarian efforts, are tapping into the unique potential of VR/AR technologies, in particular the empathy-inducing capabilities of VR. These can effectively educate and raise awareness about certain issues, and even elicit response and action among viewers. VR/AR can act as powerful tools for increasing compassion and influencing behaviour, tackling serious issues ranging from racism to climate change.

COMMUNICATION AND SOCIAL INTERACTION

VR has the potential to change the way we communicate and interact with each other. The added value of VR in comparison to other distance-based communication tools, is the interactivity and visualisation possibilities (data, documents, 3D models). In this respect, VR can offer new opportunities for efficient distant business meetings as well as fun social interactions.

ART AND STORYTELLING

VR does not only bring art to users' doorsteps, it is also a new form of expression and storytelling. VR film production possibilities are being explored in order to take full advantage of its potential to tell the stories in fresh and creative ways. Europe has a rich heritage and cultural diversity that have always been a great source of inspiration for film production and artistic expression, and this competitive advantage is also true for VR cinematic filmmaking.

COMMERCE AND BRANDED EXPERIENCES

The 'wow' factor of VR/AR technologies enables companies to engage with their customers in new and innovative ways, as the immersive nature of VR/AR tends to leave a lasting impression on existing and new audiences. At the same time, customers are able to undertake more interactive and enjoyable shopping experiences. Thus, not only can VR/AR help put brands on the map in customers' minds, but these technologies can also significantly increase and enhance e-commerce activity.

GAMING

The gaming industry has been one of the key drivers of consumer adoption of VR headsets and advancement in software development and content production. Creation of VR games is a field for highly skilled developers and requires skills in 3D design, animation and software programming, but also needs creativity and innovative ideas.

WHAT IS THIS FOR?

LIVE ENTERTAINMENT AND EXPERIENCES

VR/AR technologies are creating new experiences and ways of entertainment that are immersive and in real time. This means being able to experience sport matches, concerts and theatrical performances as if you are there, despite actuality being miles away.

With VR, however, fans may be ensured the best seats at every game. However, live streaming sports has certain requirements that VR has yet to fully meet. High definition TV already provides very good sports coverage, with an experienced director, a sharp picture, zoom as well as pause, rewind and replay - none of this is currently available with VR. Secondly, VR also creates mounds of data, making live-streaming with current broadband capacities difficult - 5G will therefore be very important.

OTHER AREAS OF VR & AR APPLICATION

Not all possible applications of VR technology have been further detailed above. This is mainly because they are either less visible or not yet fully developed even when they have a high future potential.

Potential also lies in big and complex data visualisation where extra dimension and virtual space can help capture flows in time and relations.

Figure 3. Virtual Reality examples.

WHAT IS THIS FOR?

Advantages and Disadvantages of using VR:

Positive implications	Negative implications
VR can be used to **save time and resources**. This technology is an asset because users in any industry can test its products without actually using raw material and increases the success rate of achieving their end goal.	Without the proper hardware it is **difficult to fully create the immersion and interactivity** necessary for a successful Virtual Reality system.
Trial time and resource waste can be greatly diminished, **vastly reducing the costs of development**.	Some people may experience cyber-sickness, or **feel nauseous because of the motion of the environment**.
Virtual reality can be used to test and practice delicate or important procedures.	**Psychological effects** the users may experience; one issue could be desensitization to aggressive actions. In terms of virtual reality gaming, being so fully immersed in a violent world, without any real world consequences, may lead people to behave more aggressively or callously towards real people.
Virtual Reality can enhance the daily lives of individuals. Not only can it improve gaming experiences, but it can also be used to encourage exercise by creating virtual worlds that demand movement while allowing people to forget that they are actually exercising.	**Cyber-addiction** may result from Virtual Reality technology since a tool that allows individuals to easily detach themselves from the real world may result in some people neglecting real life.
• *Gaming experiences* • *Virtual prototypes (ex: cars)* • *Training programs for military* • *Medical training (ex: surgical procedures and diagnosing)* • *Psychological therapy* • *Training astronauts, and many more*	• *Better tracking systems* • *Lag time* • *Overlooking basic laws of physics* • *Lack of acuity*

GOOD PRACTICES

VR companies are involved in three main core activities – R&D, manufacturing and content creation. European VR companies produce three main types of products: hardware, software and content. Many companies provide more than one of these product types at the same time. Companies are taking advantage of the VR research infrastructure and the skilled workers it produces.

Hardware manufacturing in Europe is mostly precision and niche technology. In the European context, companies involved in manufacturing also perform their own R&D activities, often in cooperation with European universities and research centres. When it comes to hardware for mass production, R&D is often done in Europe while the actual products are manufactured elsewhere. Interesting example of that is a joint initiative of **Starbreeze Studios (SE)** and **Acer (TW, Asia)** that resulted in the high-end headset StarVR.

Europe is a centre of R&D for both software and hardware and specialised applications. Interestingly, even non-European companies such as **Jaunt (USA)**, **Oculus (USA)** or **EON (USA)** often locate their R&D departments in Europe to benefit from the presence of high-skilled workforce. Some successful software and hi-tech companies such as **Unity (USA–DK)** or **Metaio (USA–DE)** kept their R&D in Europe but either relocated their business development and official headquarters to the USA or were acquired by big global brands such as Apple.

Content that can be either 360-degree videos or computer-generated images (CGI) is mostly associated with the creative processes of making video games, VR experiences and movies. Europe is strong in creative processes, with studios such as **Okio (FR)** providing independent movies and VR experiences. European broadcasters including the **BBC (UK)** and **ARTE (DE/FR)** are also involved in the VR content creation process. Some content studios would also build their own cameras to fit their needs.

GOOD PRACTICES

CycleSpex: Cycle and Spatial Context Experience Simulator (VR)

This research tool is being developed to answer knowledge and design questions about cycling. The advantage for planners and policy makers is to test possible design solutions ex-ante in a safe and controlled setting before the definite investment. The innovative experimental design facilitates the possibility of asking questions within the VR environment to large groups of respondents. This allowing us to collect valuable data about cycling behaviour, experience and performance.

Currently CycleSpex lines up multiple VR experiments to answer research questions on cycling experience related to road design, urban green, lighting, way-finding and underpasses/barriers in cities. Analyzing relationships between cyclists on the move and (designed) urban environment will lead to insights into which spatial factors contribute to a better cycling experience. Different urban environments might need a different set of spatial measures to ensure a cycling experience which will lead to a higher bicycle usage. The output from these VR experiments will be used to optimize the EU recommendations for Cycle Highways through the CHIPS project.

Training through simulation in the Lorraine Virtual Hospital

The Lorraine Virtual Hospital (HVL) provides students with health and sports simulation equipment and tools. Responding to the challenge of "never for the first time on a patient", the HVL is run by the Collegium-Santé of the University of Lorraine, which brings together the faculties of medicine, dentistry, pharmacy and sports sciences.

Figure 4. Lorraine Virtual Hospital. Source: https://ec.europa.eu/

GOOD PRACTICES

Some leading companies:

acer
JAUNT
OZO STUDIO
oculus
e·on
unity
metaio
BBC
arte
Google VR
NOKIA
UBISOFT
Capitola
VERTIGOGAMES
SOLIRAX
ZeroLight
THE FOUNDRY.

BENEFITS FOR THE COMPANY

AR and VR is far from omnipresent in all the mentioned and other use cases applications, even in high-tech industrial manufacturing.

In this stage virtual and augmented reality certainly aren't mainstream and you most likely will find them in (product) design, in virtual training programs and in the simulation of important scenarios and tests regarding key assets in factories and beyond. In other words: where the stakes are high and the value/risks are equally high.

Process manufacturing training, assembly and safety are by the way among the main use cases of VR and AR. However, across all industry use cases it's retail that takes the lead from a spending perspective with the 'retail showcasing' use case, as we'll cover next.

Showcasing also plays a role in manufacturing, among others in design and development and in customer-facing circumstances. In the end, someone needs to convince and sell. But this of course doesn't mean that VR and AR are just sales tools or gizmos, not in the consumer industry and most certainly not in Industry 4.0. A token of the increasing role of augmented reality in Industrial IoT is the growing support for it in several Industrial IoT platforms.

Time to look at some facts and findings about the usage of Virtual Reality and augmented reality in manufacturing and beyond with research data, predictions and trends, before looking at benefits, solutions and a few practical applications and cases.

KEY VR/AR applications in Industry 4.0:

- Product design
- Virtual training
- Simulations/tests with a focus on important assets, scenarios and security aspects.

BENEFITS FOR THE COMPANY

IDC's Tom Mainelli rightfully stated that "AR and VR headsets get most of the media attention right now, but the hardware is only as good as the software and services running on it".

In an Industry 4.0 context we can add that the use cases which will thrive are those generating the highest value, enabling to avoid risks, issues and downtime the most, optimizing the end-to-end manufacturing process and workflows in the best possible way, making productivity, satisfaction and making experiences of field engineers, factory workers, customers and stakeholders the most satisfactory – and immersive in ways that make sense. And that goes beyond just the technological dimensions and requires an individual business case – as always.

The infographic from the announcement of that semi-annual update below shows the predictions of IDC per AR/VR industry from a spending perspective for 2017, showing the 'place' of process manufacturing and discrete manufacturing in the bigger picture and isn't related to the forecasts mentioned for the next years.

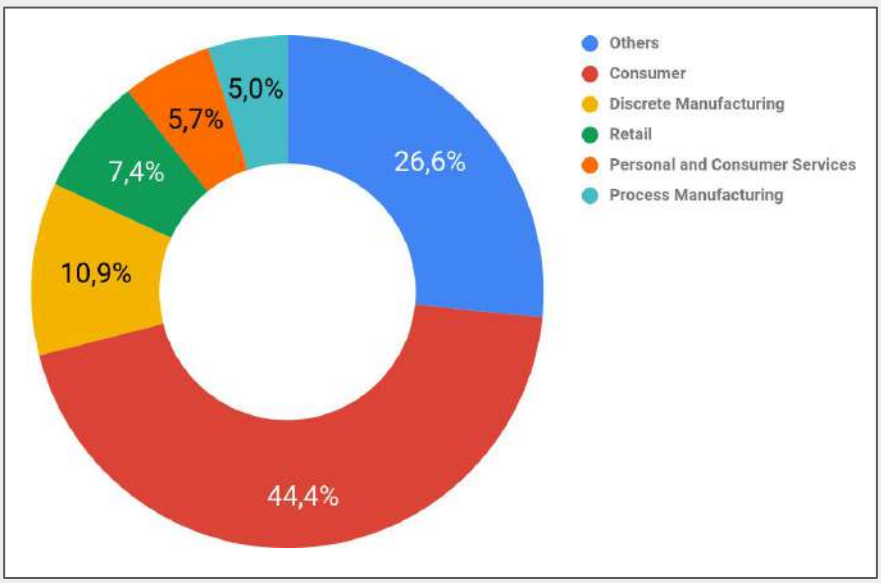


Figure 5. Source: IDC Worldwide Semiannual Augmented and Virtual Reality Spending Guide

BENEFITS FOR THE COMPANY

Companies that apply VR solutions and thus create the ecosystem demand are driving the adoption of VR technology. Sometimes they are an intermediate platform to the use of applications by consumers. In general demand can either come from:

Consumers that currently use VR mostly for entertainment (e.g. gaming) and shopping, but increasingly adopt VR apps for healthcare, commerce or education.

Professional users from the public sector such as ministries and governments who are particularly interested in VR trainings, the potential of VR rehab and psychological treatment, and the immersive value added for promotion of countries and regions.

Professional users from the private sector who demand VR to improve the internal production process, off er new value to their customers or implement a new media in building relations with customers.

Universities that advance (basic) research.

Some entities that demand VR & AR either **for internal processes** (e.g. Airbus (FR) or Jaguar Land Rover (UK)) **or to provide content for the public** (the BBC (UK) and ARTE (DE/FR)) develop VR internally but also hire external suppliers. Demand for VR is generated in a large number of domains, ranging from the manufacturing industry to consumer applications.

FUTURE APPLICATIONS

European companies in the European VR & AR ecosystem are mostly small and medium-sized enterprises. Together they employ over half of the total number of employees. The large companies are often established firms that come from manufacturing industries and deploy VR solutions for engineering. About half of these companies are at initial phases of product development, meaning that they are either in an R&D phase or at the very early stage of product launch, and they are not making any profits yet. The rest of the companies are already generating profits and/or have already launched their products.

Despite the many strengths of the VR and AR industry in Europe, there are certain issues that will need to be addressed in order for Europe to become a powerful player in the global VR and AR industry. Based on an extensive consultation with VR players in Europe, various challenges have been identified that have an impact on the growth of the European VR landscape. These include:

- A lack of risk funding as well as a pro-risk and experimentation mentality in general
- Weak links between research and the market
- A lack of cooperation across the different countries in Europe
- Current and expected needs for adequate infrastructure and resources

Figure 6. Four changes that have an impact on the growth of the European landscape.

FUTURE APPLICATIONS

AR and VR trends in Industry 4.0 and beyond:

The above mentioned main industry use cases of VR/AR for 2017 are part of some takeaways of IDC's August 2017 forecasts on the worldwide spending on augmented and Virtual Reality.

In that forecast IDC predicts that global spend on AR and VR will double each year through 2021, which is pretty impressive. However, given the broad scope of VR and AR use cases across several industries this obviously doesn't only fit in a context of manufacturing and Industry 4.0.

In each of the regions IDC looked at, the consumer segment is poised to be the largest in 2017. However, in the US and Western Europe, discrete manufacturing and process manufacturing already rank second in third.

In the US, process manufacturing and discrete manufacturing are predicted to take over the consumer segment in the forecast period, along with government, retail, construction, transportation and professional services. In Western Europe, discrete manufacturing, retail and process manufacturing are predicted to start growing fast by the end of the forecast *(until then the consumer segment remains largest)*.

By 2021, the majority of AR/VR spending will be for industrial maintenance

FUTURE APPLICATIONS

If we look at the key use cases for VR/AR we also see evolutions with a strong role for industrial use cases. In 2017 the three major VR/AR use cases from an investment perspective are respectively:

- **Retail showcasing**, accounting for a total investment of $442 million.
- **On-site assembly and safety**, worth a total spend of $362 million.
- **Process manufacturing training** as the number three with $309 million.

By the end of the forecast, however, the majority of spending will go to industrial maintenance with $5.2 billion and public infrastructure maintenance with $3.6 billion. And that, of course, brings us close to one of the key aspects of the Industrial Internet of Things, Industry 4.0 and so forth: maintenance, preventive and predictive. Industry 4.0 trends, drivers and spending evolutions, preventive and predictive maintenance are main priorities.

Again, the number of applications for VR/AR is very broad and manufacturing, transportation, logistics (Logistics 4.0) and other markets in today's current 4.0 scope are far from the only ones. Moreover, in some regions AR and VR predominantly will keep seeing investments in, among others, the consumer segment and retail. Education is often mentioned as well. In the APeJ region it's already the third most important 'sector' in 2017 according to the mentioned IDC research. The link with training in any given manufacturing context is quickly made.

Yet, it's clear that the usage and types of applications with VR/AR in manufacturing and related industries increase with a current focus on training and safety, to name just two, and an increasing focus on discrete manufacturing, process manufacturing and maintenance in the US and Western Europe.

FUTURE APPLICATIONS

While still too cumbersome and bulky, current VR interactive systems (think how they will be considered as funny in 50 years from now) will start delivering soon into single-user experiences. However, once the technology moves to a further step in the direction of usability, there are enormous unexploited opportunities in multi-user social interactions, for example in virtual collaboration and co-creation. The team experience is the next breakthrough with far-reaching market opportunities but also social implications. And this requires a combination of competences and technologies that can be referred to the Next Generation Internet:

- Hardware and software to provide more realistic and natural experiences, including a larger field of view, light field, panoptic capture, focus free, photo-realistic rendering, increased resolutions or frame rates.
- Research on social interactions to develop theories and technologies allowing an augmented human experience through technologies such as augmented reality, Virtual Reality or brain interface, to interact, work or entertain in groups, thus developing new ways of social interactions.
- Support the transfer of these technologies across different sectors (industrial manufacturing, automotive, data life cycle, consumer goods, healthcare, public services, design, entertainment, media, culture…).

Google Earth VR 'the next step to help the world to see the world.':

https://youtu.be/SCrkZOx5Q1M

Plunge into a Caribbean gem with National Geographic:

https://youtu.be/v64KOxKVLVg

ADVANCED CONTENT

Interestingly, VR & AR ecosystems are also closely related to the industry of artificial intelligence (AI). This advanced technology helps to create more realistic simulations in the virtual space, as well as independently acting avatars. AI is not a subject of this study, however it is important to be aware of the synergies amongst these three high-tech industries and their closely related ecosystems with a great importance of R&D and creativity.

As with many new technologies today, VR and AR are industries characterised by global value chains where activities, ranging from research and development (R&D) to hardware production and content creation, are spread out across the globe. A number of regions are of clear importance, including Europe, Asia and the USA.

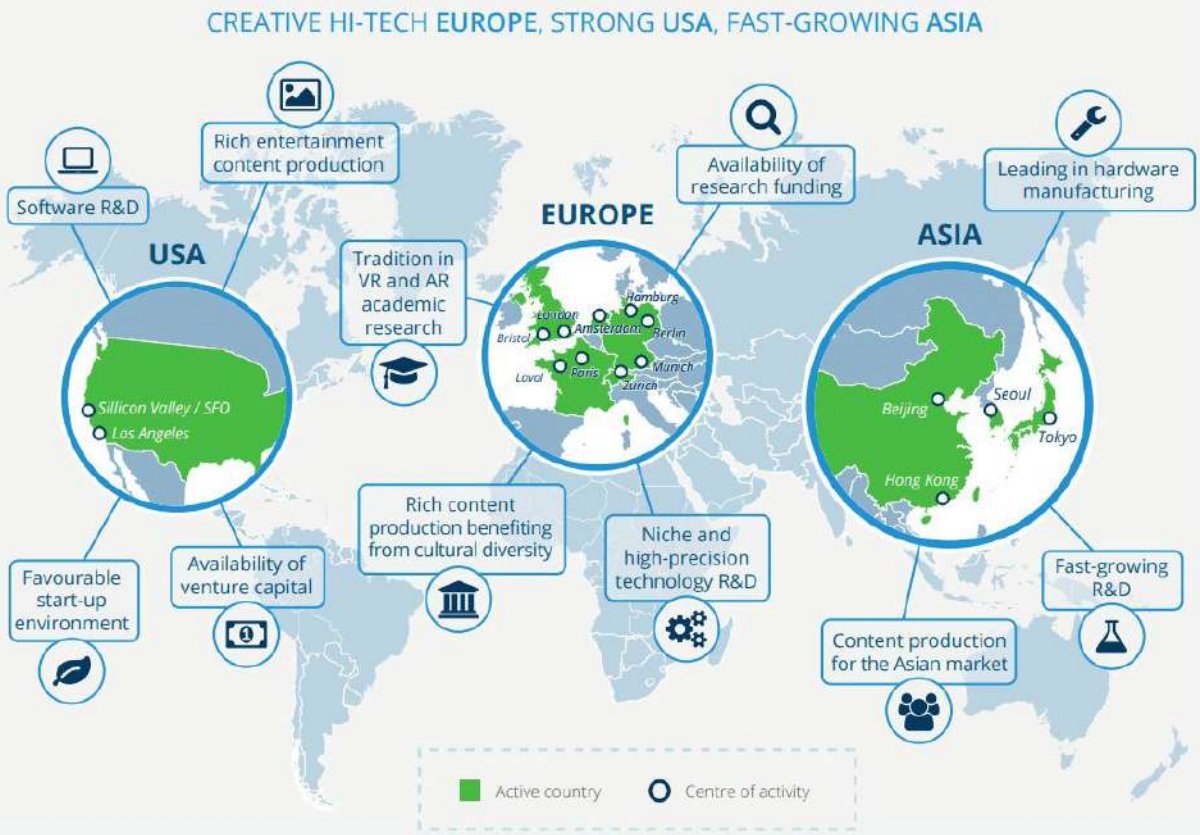


Figure 7. Source: Virtual Reality and its potential for Europe. Ecorys

ADVANCED CONTENT

What about Mixed Reality (MR)?

At the intersection of virtual and physical realities is an emerging environment known as mixed reality (MR), where digital and physical objects co-exist. This hybrid space integrates virtual technologies into the real world so that viewers cannot distinguish where one world begins and the other ends.

The virtual aspect of MR comes from the use of devices equipped with 3D viewing technology that seamlessly layers digital objects onto the real world.

Another major component of MR is the integration of augmented reality (AR), which is the layering of information over 3D space.

A key characteristic of AR is its ability to respond to user input, which confers significant potential for learning and assessment; learners can construct new understanding based on interactions with virtual objects that bring underlying data to life.

Holographic devices are also being used to create mixed reality environments, as their video displays project 3D images into a physical space. While lagging behind other virtual worlds, mixed reality is gradually making its way into the consumer market. In 2014, Michael Jackson was re-embodied in holographic form and debuted at the Billboard Music Awards, where his holograph performed on stage with live, choreographed dancers.

Tangible User Interfaces (TUI)
A TUI uses real physical objects to both represent and interact with computer-generated information
(Ishii & Ullmer, 2001)

Augmented Reality (AR)
AR 'adds' computer-generated information to the real world
(Azuma, et. al. 2001)

Augmented Virtuality (AV)
AV 'adds' real information to a computer-generated environment
(Regenbreach, et. al. 2004)

Virtual Reality (VR)
VR refers to completely computer-generated environments
(Ni, Schmidt, Staadt, Livingston, Ball & May, 2006; Burdea & Coffet, 2003)

ADVANCED CONTENT

VR technology in Education

As the technology improves, the ability to bring students into a single environment, even if they are from different schools, states, or countries, can help connect students to their larger world. This gives them the opportunity to learn from people they may otherwise never have met. A broader virtual world could expand their horizons and may promote more diverse collaboration in the future.While we are still only scratching the surface of what Virtual Reality can do in an educational environment, the potential exists for it to change education as we know it.

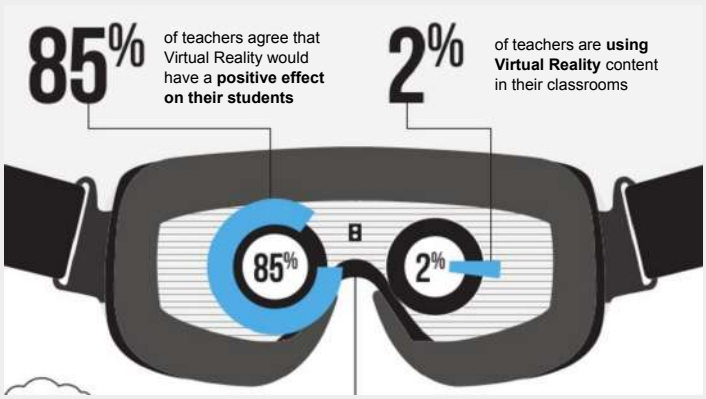


Figure 8. VR in the classrooms.
Source: https://www.vrmaster.co/teachers-ready-for-virtual-reality-education-infographic/

Researchers in science and medical fields are already making great use of immersive technology. Although augmented simulations and views inside the body are obviously great tools for learning, something as simple as experiencing the world from the perspective of an elderly patient with dementia can have an enormous lasting impact on a medical student's approach.

360 videos in Virtual Reality

https://bluehealth2020.eu/projects/360-virtual-reality/

Teacher ed programs turn to Virtual Reality

https://www.educationdive.com/news/teacher-ed-programs-turn-to-virtual-reality/511608/

ADVANCED CONTENT

SOME VIRTUAL REALITY TOOLS:

DESKTOP TOOLS

Unity 3D	Unity is by far one of the most ubiquitous of tools being used today for VR development.
Unreal Engine (UE4)	One of the main competitors of Unity 3D, Unreal Engine is also a gaming engine with VR integrations, an asset store, and great documentation.
3DS Max & Maya	These are Autodesk products for modeling, animation, lighting, and VFX. They don't have VR support by default but through pricey plugins instead.
Blender	It's free and open source software written in Python and is available for Windows, Mac, and Linux. There's a huge community of people devoted to this software and its use. Many websites provide tutorial videos, forums, and documentation.
SketchUp	Google's SketchUp is a basic modeling application with a very low learning curve that can get anyone up and running in a short amount of time. The tutorials on the website are excellent, not only teaching the basics of the software but also as introductory lessons to basic 3D modeling concepts.

WEB VR TOOLS

Three.js	This is a JavaScript library which works as a layer on top of WebGL. It has many helpers and abstractions that make working with WebGL much easier than the WebGL API alone.
A-Frame	This is a web framework built on top of Three.js and WebGL to build Virtual Reality experiences with HTML using an Entity-Component ecosystem. Works on Vive, Rift, desktop, and mobile platforms.
React VR	Promising to be the next big thing in WebVR, React VR promises rapid iteration and a syntax that is similar to A-Frame's but hinges on the benefits that React brings.
Vizor.io	Vizor is an interesting take on a WebVR editor in your browser built with NodeJS and Three.js. It's a visual programming environment for WebGL, WebVR and other HTML5 APIs.
JanusVR	Janus is more akin to a web browser for VR than a development tool. It's a platform and while the client is closed source and built in QT5, the server side component is open source and written in NodeJS.

EDUCATION

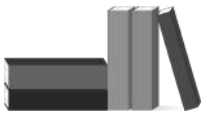
The use of Virtual Reality and cloud-based simulation engines promises to train automatons in real-world scenarios through simulated trial and error without endangering real people and real things. Developers will create VR simulations in the cloud rather than on a PC, able to run many simultaneous instances speeding the training of machine learning agents.

MOOCS:

- Introduction to Virtual Reality (Coursera)
- 3D Models for Virtual Reality (Coursera)
- 3D Interaction Design in Virtual Reality (Coursera)
- Making Your First Virtual Reality Game (Coursera)
- Using Virtual Scenarios to Create Effective Learning (FutureLearn)

EXTERNAL MANUALS FOR MORE INFORMATION:

- Virtual reality and its potential for Europe
- The VR Book: Human-Centered Design for Virtual Reality



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SELF APPRAISAL

- ★ Could Virtual Reality have any application in my company?
- ★ What simulation could be useful in relation to the activity of my company?

- ★ Could I say four applications of simulation and Virtual Reality?
- ★ Could I now distinguish Virtual Reality (VR) and Augmented Reality (AR)?