VIRTUAL REALITY
AND ITS POTENTIAL FOR EUROPE

Edita Bezegová
Marta Anna Ledgard
Roelof-Jan Molemaker
Barbara Pia Oberč
Alexandros Vigkos
## Europe within the global VR & AR landscape

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**Credits**

Project manager : Edita Bezegová  
VR industry expert : Marta Anna Ledgard  
Senior expert : Roelof-Jan Molemaker  
Researcher : Barbara Pia Oberč  
Researcher : Alexandros Vigkos  

Ecorys is an economic and strategy consulting firm with a global reach, serving clients in over 100 countries. The company has a history which dates back to 1929. Ecorys Brussels serves as a focal point for the company in delivering services to our clients at European Institutions and tech companies.

Opinions or conclusions expressed in this report represent a consensus of the authors based upon extensive qualitative and quantitative research and do not necessarily represent the official position of the actors of the VR industry.
This report maps the VR industry in Europe and analyses the dynamic VR and AR ecosystem.

This is done through a combination of various methods and data collection techniques, including:

- creation of a unique database of around 1000 VR and AR entities in Europe by pooling data from multiple sources, including the EU VR.org association. The entities included in the database range from policy makers, accelerators and innovation hubs to researchers and VR & AR companies
- extensive desk research of existing market reports and mappings, as well as wider literature on both VR and technology adoption
- a survey with participants from more than 100 VR and AR entities across Europe
- participation in major European events on VR and AR
- over 80 interviews with companies, policy makers, support institutions, researchers and other experts on VR and AR in Europe
- consultation with the relevant VR & AR expert of the European Commission
- econometric analysis and quantitative approximation based on observed developments in similar high-tech industries.

Our efforts resulted in a report that provides a snapshot of the state of play of the fast-changing VR and AR industry in Europe in 2016/2017. It describes the potential of this industry to sustain and grow its position as one of the key players on the global VR and AR scene. The key findings of the study include:

- Europe is a strong and promising player on the global VR scene its competitive advantage formed by a long-standing tradition in VR research and manufacturing industry applications, as well as creativity and cultural diversity
- Stable growth of the VR & AR markets is expected both in Europe and around the world. The total production value of the European VR & AR industry is expected to increase to between €15 billion and €34 billion by 2020 and account directly or indirectly for 225,000 to 480,000 jobs
- European companies and researchers can benefit from accelerators and start-up hubs, as well as national and EU public funding
- The European VR frontrunner countries include France, the UK, Germany, the Netherlands, Sweden, Spain and Switzerland. A lot potential for future growth can be found in Finland, Denmark, Italy, Greece as well as Eastern and Central Europe including Poland, Estonia and the Czech Republic
- VR is capable of transforming and innovating traditional sectors such as manufacturing industries, construction and healthcare. It can also revolutionize education, culture, travelling and entertainment. Europe will play an important part in this “VR revolution”
- Policies of the future enabling good access to finance for innovation and the development of the digital economy will play an important role in developing the VR industry.

We would like to thank all the people who actively supported us with valuable insights on this industry. We hope that our findings will make the potential of VR and AR well understood and will be beneficial to the development of the European VR and AR industry.
1.1 What is VR & AR and why they matter

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.

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. This study is primarily focused on VR, however we sometimes talk about VR & AR ecosystems or industries – this is because the VR & AR communities and their development are so interlinked, that in some instances it is also impossible to separate them.

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.

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.
1.2 The global VR & AR landscape

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.

The United States of America (USA) have a leading position in the global VR & AR market. R&D for hardware and software is centred around Silicon Valley with IT giants such as Google, Apple and Facebook. The content production is concentrated around big gaming studios and production studios in Los Angeles. The USA offers favourable conditions for VR & AR start-ups. The country has the most active VR & AR venture capital (VC) funds and is willing to invest in early technology start-ups, which is why commercial VR and AR companies started in the US earlier than elsewhere in the world.

In the Asian market many VR and AR companies are popping up especially in China, Japan and South Korea. Major Asian technology firms such as HTC, Sony and Samsung are active in the mass manufacturing of VR and AR hardware and they benefit from the competitively priced workforce. The Asian VR and AR market has been growing at a high rate also driven by the support of local governments. Asian VC funds, such as the Japanese company Gumi, support the Asian development but are also interested in VR talent globally, including Europe. Asia is also active in content creation, however, for cultural and language reasons, it is mainly focused on the Asian market.

1.3 Europe’s strengths in the global VR & AR industry

Europe has a number of particular strengths that enable it to be an important player in the global VR & AR industry:

**VR research and development**

in Europe has a long-standing history, for example in the industrial design, medical sector and psychology. Since the early 1990s, EU research funds have supported more than 450 projects dedicated to VR and AR, with a total of over €1 billion. Due to the availability of public research funding (European Union and national public funds), European universities and research centres have been experimenting with VR and AR since the 1970s and are well advanced in coming up with successful applications. For example, MindMaze, a hugely successful Swiss VR med tech company, is a spin-off of neuroscience research at EPFL Lausanne and ETH Zurich.

The cultural diversity in Europe enables rich storytelling that provides an excellent basis and inspiration for VR films and games production. This makes European content stand out on the global VR scene. European creativity in VR has been described as rivalling Hollywood and is promoted by public broadcasters such as the BBC (UK) and ARTE (FR/DE) who are already actively exploring the artistic and educational potential of VR. Public funds such as CNC (FR) are further supporting the diversity and quality of the content.

**A skilled workforce**

makes it relatively easy for companies to find employees and grow. Europe has many highly skilled and qualified workers capable of 3D modelling and creating computer-generated (CG) content for the gaming industry and VR animation. European universities teach developers to approach VR from different perspectives, including art, design, industrial production, film, game design etc.
European cities are historically diversified attracting people and experts from different backgrounds and cultures. They offer excellent breeding grounds for VR and AR technologies that will be used for different aspects of work, living and creation. The multidisciplinary nature of cities in Europe is an important asset. VR and AR applications arise when creative people meet with engineers, programmers and editors, who in turn meet with people from application domains in industry who work closely with marketing and business experts.

There is a tradition of collaboration within VR communities in Europe, as well as between different industrial sectors. This is largely thanks to the funding of collaborative research in Europe, the increasing number of national and European associations (e.g. EuroVR, KTN (UK)), incubators and accelerators (e.g. Realities Centre (UK), VRBase (NL), Invest Stockholm (SE)), think tanks (e.g. UNI-VR (FR)), and many spontaneous VR meet-ups and events where networking takes place (e.g. World VR Forum (CH)). For the time being, the spirit of collaboration seems to outweigh that of competition.

High-precision and niche manufacturing as well as hardware development are well established in Europe. They now feed into state-of-the-art audio and optical technologies and VR & AR for the medical sector. Europe is strong particularly in middleware and software, both of which are soon expected to emerge as the areas of true value for VR. On the user side, the European automotive industry, aviation and machinery are early adopters of VR and AR technologies.
2.1 State of play of VR technology – an emerging industry

VR and AR technology has gone beyond its early exploratory stage and is increasingly accepted and demanded. VR has reached a tipping point for large scale adoption, in particular thanks to the development of more comfortable and affordable hardware. Even though VR has been around for a while, initially it was not available for the wider audience. Headsets were either too clumsy and not allowing for smooth virtual experience, or they were too expensive and powered by large-scale computers. As a result, VR was mostly used by large companies in industrial design or by specialised research centres.

Today headsets have become affordable and powerful and even smartphones are capable of VR data processing. They create opportunities for consumers, researchers and businesses, including SMEs, to work and enjoy life in a virtual space.

The fact that VR is likely to enter a period of accelerated growth can be illustrated with a well-known typology of the acceptance of new technology – the Gartner hype cycle. According to this typology, both VR and AR have already passed the peak of inflated expectations or a “hype” and adoption of new technologies is first applied by early adopters, which can be observed at present, eventually followed by a fast increase in demand and production.

To put this in perspective, VR is now entering the “Slope of enlightenment” that smartphones entered around 2007. For smartphones it took 9 years to reach a 50% adoption rate by consumers in Europe. Today, smartphones are used by a third of the world population and the global sales of smartphones reached more than €375 billion in 2016. This took less than 10 years. In addition, a growing industry for the development of mobile apps is connected to the rise of smartphones. This has brought a revenue of €16.5 billion to the EU economy.

VR is currently ahead of AR when it comes to realistic expectations and real potential of use in various consumer and business areas. And its adoption can happen very quickly as the timespan needed for adoption of new technologies has been systematically decreasing.

These developments are confirmed by our research among actors in the European VR landscape. Most actors indicate that the current state of play of VR technology has induced growth of the VR industry which will further accelerate in the years to come:

European VR & AR companies are growing – over 50% of existing companies indicate that they have expanded their VR teams and for 35% this growth was substantial. Towards the future, one third of existing companies will double their VR activities in 2017 and another third expects to increase their activity even more substantially.

An increasing number of new start-ups is observed. About a quarter of current VR & AR businesses started in the last two years (VR company database).

Customers are increasingly accepting VR & AR technology, whether for professional or private use or as consumers. This acceptance rate is significantly higher compared to two years ago. An increasing number of customers are actively requesting VR solutions, whereas others are curious about VR and demand information and trials.

1. According to Survey of 100+ VR & AR entities in Europe.
2.2 Current size and growth of the European VR & AR industry

To determine the impact of the growing demand for VR & AR on European economy we have made an assessment of the current and future size of the European VR & AR industry. This is based on an analysis of a range of different market studies, taking into account the specific characteristics of the European industry. Our assessment is supplemented with a detailed mapping of VR-related companies in Europe.

According to our estimation, based upon an analysis of multiple market studies, the production value of the global VR & AR industry is estimated at €3 billion in 2015. The European VR and AR production value accounted for almost €700 million in 2015, or one quarter of the global value. The total production value of the European VR & AR industry is expected to increase to between €15 billion and €34 billion by 2020.

The estimation of the 2020 production value is based on two scenarios that consider different parameters and potential future developments, such as investments by major technology firms leading to innovation, and the creation of new hardware, software and content.

The baseline scenario counts on the steady growth of professional applications of VR, for example in industry and medical training, and on the moderate growth of the mass market of consumer applications.

In the optimistic scenario, optimal conditions exist for the growth of VR/AR that will spur the purchase of headsets by a large number of consumers. This includes more user-friendly and comfortable hardware in combination with further price decreases, software optimisation to allow minimal motion sickness and breakthrough consumer applications (like social VR), and new content.

For each scenario, the development of the VR & AR market has been estimated using a set of growth rates for hardware, software and content. These growth rates were developed individually for each year on the basis of the analysis of market studies and econometric predictions, interviews with industry experts, approximation to past development of similar industries, and the results of the VR & AR industry survey. For details on the methodology please consult Annex B.

In these scenarios, by 2020 the European production value is expected to increase to between €15 billion and €34 billion, representing a gross value added of between €9 billion and €21 billion and directly creating employment for some 140,000-300,000 people. Also, wider supply chain impacts are expected to indirectly increase the production value with between €5.5 billion and €12.5 billion and generate an additional 85,000-180,000 jobs. This will bring the overall economic impact of the VR and AR industry for Europe at a total production value of between €24 billion and €54.5 billion, a gross value added of between €14.4 billion and €33.6 billion and 225,000-480,000 jobs. Due to the strong growth of content-related VR activities the share of Europe in the global market is expected to increase.
The VR & AR ecosystem consists of various actors who are all interrelated. In the centre of VR and AR ecosystem are naturally companies creating technical solutions, software and applications. Nevertheless, the ecosystem is reliant also on other players. The following map provides typology of all actors and illustrates them with non-exhaustive examples that were selected from our database of 900 VR and AR European entities.
3.1 VR research

VR research is represented by universities, schools and research centres around Europe and their activity closely relates to that of VR/AR companies (supply of technology solutions). Their key importance for the ecosystem is twofold. On the one hand they run VR research projects in technical and creative fields and help advance VR technology and applications; on the other hand they also supply qualified workers to companies and other entities.

The most popular research subjects among European academics are industrial design, healthcare and training, and simulation.

VR research, especially in the areas of industrial design and mechanical engineering, has a long standing tradition within universities such as ParisTech (FR) or Technical University of Munich (DE). Technical universities often cooperate well with manufacturing industries – for example Paris Tech has a long standing partnership with SNCF (FR) or French car manufacturers. In the engineering sector, the cooperation between academia and the private sector seems to work well even though not all inventions are applied in the end. For example, more than a year ago CLARTE (FR), a top French VR research centre, invented a high-tech VR conferencing system that allows collaborating on the industrial design process in virtual space with fully realistic avatars and without the use of headsets. However, the company has not yet been able to commercialise its invention.

Another area where European universities are active and successful is neuroscience, psychology and psychiatry. Among them King's College (UK) has been researching for years on VR possibilities in treatment of phobias and deformed body image. The university is currently discovering opportunities to use their methods in the wider psychology practice. Other universities active in the field of psychology are the University of Barcelona (ES), University College of London (UCL), University of Oxford (UK) and Groningen University (NL). École Polytechnique Fédérale de Lausanne (CH) has been active in neurology technology and its research successfully resulted into the creation of the global leader in medical VR MindMaze (CH). Psychology VR applications in the past have sometimes struggled to find public research funding, however this is currently changing.

Another category is creative schools and art degrees. They are active in content creation in VR and teach how to capture images or create 360-degree movies. For example, University of Paris 8 (FR) in cooperation with a Athens School of Fine Arts (GR), teaches a degree connecting art and VR technology. This results in an art project involving a haptic device where the visitor moves around in a virtual space. Practical schools of gaming such as Futuregames (SE) help to advance computer graphics and software development, while movie making centres such as Bayerisches Filmzentrum (DE) help to advance cinematic production and also actively cooperate with local universities to find new technical solutions for a truly immersive VR experience.

In general, European universities’ prime focus is on fundamental research. Their main goal is to improve scientific theories and to better understand phenomena in a scientific domain with findings published by credible academic articles. Next to fundamental research, applied research projects, attempting to solve issues brought by a private sector partner, are relevant to many universities (two-thirds of universities are actively in touch with businesses). Also, universities across Europe are well connected and they actively work together – in fact, some EU research funding requires such international collaboration. Funding comes mostly from national public funds, however more than half of the universities and research bodies are using European research funds and one-third also receive private funding.

3.2 VR companies

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. The map below shows the relationships and overlaps between the three main product categories and illustrates them with selected non-exhaustive examples from our European VR & AR database.
Hardware manufacturing in Europe is mostly precision and niche technology. As an illustration, the company Tobii (SE) is involved in advanced eye tracking and manufactures all its products in its home country. The same applies to Zeiss (DE) that specialises in optics, or Fraunhofer (DE) that has been running its VR Solutions Centre since 2001 and in addition to other VR products provides globally renowned audio solutions. MindMaze (CH) is making its own neuro-treatment devices backed by hi-tech research. 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.

Some specialised applications are R&D intensive and require content creation, but also need software expertise to coordinate virtual images with real-time movement. These are for example healthcare companies such as Medical Realities (UK), Psious (ES), or industry companies like Jungle VR (FR) and Light & Shadows (FR).

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.

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.

Results from our survey indicate that the European ecosystem is to a great extent part of a global value chain. VR & AR companies are split between those that choose their suppliers from around the world and target customers globally and those that choose their suppliers from Europe and focus mainly on the European market.

Access to finance is a major challenge for European companies as many of them had to be creative to make it to the market. Most companies are either self-funded, or are financed as part of the larger company to which they belong(ed). Less than a quarter of European companies found access to venture capital to start their business.

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, offer 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.
3.4 Other actors in the European VR & AR ecosystem

An important part in the European VR ecosystem is played by actors beyond the demand and supply. These actors hold the ecosystem together, enable exchange of information and know-how, and facilitate business and research activities. These actors are:

**Policy makers at the European and local level** help to form favourable business and research environment. The European Commission (EC) provides a European policy framework for Internet networks, research investment or business rules. EU institutions have the power to ensure coordinated action at the European level and set up rules for the internal market. Policy makers at the national level, as well as those at the regional and city level can provide more targeted support to industries and can create VR communities. A great example is the administration of the city of **Laval (FR)** that started providing incentives for the growth of the VR community already 20 years ago.

**Associations, think tanks and other support institutions** that gather VR and VR-related companies and represent their interests. Some of these actors work on the European level (**EuroVR** connects researchers from universities and research-oriented companies from around Europe, **EUVR.org** is more business-focused and targets start-ups, the **European Broadcasting Union (EBU)** gathers broadcasters), and others work on the local level (**Finnish Virtual Reality Association (FIVR)**, **UniVR (FR)** – a VR think tank that connects actors across industries and specialisations).

“Support institutions” are often (semi-)public bodies and their goal is to provide support for innovation in general or VR in particular. Examples include **Realities Centre (UK)** or **Invest Stockholm (SE)** which have their activities aimed specifically at the local VR communities. **VRBase (NL/DE)** is a venture capital-funded initiative which is an example of a multi-country VR-specialised institution. It works as a city hub for VR companies and is currently placed in Amsterdam and Berlin, but expanding to Paris and Barcelona. Startup campuses such as **Station F (FR)** enable the sharing of knowledge and experiences between innovative entrepreneurs from different sectors.

**Funding from both private and public sources** enables development of VR technologies and paves the way from research to VR products. It also supports content creation. Venture capital funds that provide finance to new innovative businesses are less typical for Europe. However, some of the largest global VCs, such as **Gumi (JP)** or **Venture Realities (USA)** are active in Europe as well. National funds provide research grants to support development of technology and relatively large amounts are provided via EU schemes, such as **Horizon 2020. Centre national du cinéma et de l'image animée – CNC (FR)** or **German Federal Film Fund – DFFF (DE)** provide grants for independent VR content creation.

**Gradually there is a growing need for VR and AR services** that support the demand side in particular. Specialised training and consulting services help companies to understand what VR and AR are and how to benefit from them. Rental services allow companies to borrow high-end VR & AR equipment either to create VR content or to use them for example for VR trainings or promotional activities.

**Awareness and community building actors** include events and VR blogs. Events help the VR and AR community to periodically meet up and exchange the latest information across the border. Europe hosts some events of global importance such as **Laval Virtual (FR)**, currently the biggest VR & AR fair in Europe dedicated mostly to professional uses of VR. Other important events include **World VR Forum (CH)** and **Dutch VR Days (NL)** focused on content production or the EuroVR annual conference dedicated to VR & AR researchers. Local meet-ups and smaller informal events happen almost daily at VR hub cities such as London or Berlin. Blogs run by VR enthusiasts, such as **vrsverige.se (SE)**, or operated by companies further support flow of information and knowledge sharing.
4.1 VR & AR research and companies – European centre of activity

The analysis of the location of VR & AR research centres, universities and companies reveals that there are specific clusters of activity in Europe.

The European research scene is concentrated in France (especially in Paris and Laval), the UK (London and Manchester universities), and Germany (Berlin and Munich). Spain (Barcelona), Sweden (Stockholm), Austria, Italy and Greece are also engaged in virtual research. R&D is focused on health care, industrial use of VR or general advancement of VR and AR technology. European universities are used to working together and also cooperate on large-scale international projects funded by European research funds.
In terms of European VR and AR businesses, France, Germany, the United Kingdom and the Netherlands are clear frontrunners, with growing VR and AR activity to be observed in the Nordic Countries (Sweden and Finland), Switzerland, Spain, Italy and to a more limited extent Eastern Europe (Poland and the Czech Republic). Specific “hot spots” of VR activity can be found in Paris, Laval, London, Amsterdam, Berlin, Munich, Stockholm, Zurich and Madrid.

In terms of business environment, London and Amsterdam in particular create a favourable atmosphere for new VR and AR start-ups thanks to their vibrant business environment and innovative culture. Meanwhile, Paris and Laval are likely to go through a rapid growth in the upcoming years as they record the highest annual increase in investment.

The top application areas in Europe are entertainment and gaming, simulation and training for professional and industrial use, healthcare, real estate and architecture.

**VR & AR COMPANIES**

**EUROPE’S VR AND AR FRONTRUNNERS**

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>TOP APPLICATION AREAS</th>
<th>TOP TYPE OF PRODUCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>Cinematic entertainment, Gaming</td>
<td>Content - video, 3D modeling</td>
</tr>
<tr>
<td>FR</td>
<td>Manufacture &amp; engineering, Cinematic entertainment</td>
<td>Software and content</td>
</tr>
<tr>
<td>NL</td>
<td>Entertainment, Advertising</td>
<td>Content - video, 3D modeling</td>
</tr>
<tr>
<td>DE</td>
<td>Manufacture &amp; engineering, Entertainment</td>
<td>Software and content</td>
</tr>
</tbody>
</table>

**VR AND AR RUNNER-UP COUNTRIES**

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>TOP APPLICATION AREAS</th>
<th>TOP TYPE OF PRODUCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>Entertainment, Gaming</td>
<td>Software and content</td>
</tr>
<tr>
<td>ES</td>
<td>Gaming, Entertainment</td>
<td>Software and content</td>
</tr>
<tr>
<td>CH</td>
<td>Healthcare, Gaming</td>
<td>Software and content</td>
</tr>
<tr>
<td>PL</td>
<td>Entertainment, Gaming</td>
<td>Content - video, 3D modeling</td>
</tr>
</tbody>
</table>

Counting already a couple of decades of VR activity, Paris and Laval are the pioneer hubs that stand out as centres of excellence in the French and European VR landscape. Industrial VR applications dominate the French landscape, varying from 3D modelling and industrial design to highly specialised training applications. Many companies with a strong focus on VR film, art and new media content production are located in Paris, as well as companies working in social VR and VR teleconferencing. The second largest VR cluster in France is located in Laval – a city of less than half a million inhabitants which since 1993 has hosted one of the most important VR events in Europe - Laval Virtual. A lot of VR activity also occurs in Lille, as an outcome of the established high-tech cluster in 3D imaging, and Bordeaux, as a well-established regional industrial ecosystem.

France benefits significantly from the early adopting industries (e.g. automotive, fashion) and public broadcasters (e.g. TF1, ARTE) that created an early demand for VR. Collaboration with innovative start-ups and bigger players brings mutual benefits and takes place throughout the country. In this respect, Laval Virtual has significantly helped stimulate the exchange of best practices. A new facility called Laval Virtual Center is expected to open its doors in September 2017. It will be hosting a VR and AR technological accelerator for start-ups and more developed businesses, Laval Virtual University, which is offering trainings for VR and AR professionals, and the annual Laval Virtual exhibition. This multi-function venue focusing on VR is expected to boost further France’s VR performance and support multilateral collaboration between different VR actors.

The strong research tradition and the high quality of educational programs of French universities contribute to the VR industry by being a source of highly qualified developers and VR professionals, and by partnering up with companies that provide solutions to real problems. MINES ParisTech University has 25 years of research on using VR in industry and strong links with companies such as SNCF (France’s national state-owned railway company). It also runs a programme for the creation of research spin-off start-ups. Similarly Arts et Metiers ParisTech University and CLARTE research institute cooperate closely with most of Laval’s VR ecosystem as well as other French and international companies and universities.

Policies promoting high tech innovation and funding opportunities are well established in France and VR & AR also benefit from them. Bipfrance, Les pôles de Compétitivité and the French National Research Agency (ANR) are the main public bodies that fund VR companies and...
With the VRAR industry in the UK are able to develop and grow into companies of considerable size and stature, as exemplified by VR companies like Holovis, The Foundry, Virtualis, and Happy Finish, that have established a strong global presence.

There is an established collaboration within the creative industry as well as among various industrial sectors that are well supported by multiple VR and AR-dedicated events, such as VR & AR World or VRUK. The sheer number of events on VR and AR in the city of London is immense. These connect industry and academia and they seem to work better for VR/AR than for other industries in the French VR industry. Similarly, Laval Virtual is developing a tech mark for high-quality VR hardware and software. These initiatives show the focus of France on high-quality output in VR.

4.2.2 UNITED KINGDOM

**A BUSINESS MINDSET AND INNOVATION MENTALITY**

**KEY CHARACTERISTICS**

- Healthy start-up environment
- Good access to finance
- Lots of investment into tech and innovation

**KEY INSTITUTIONS**

- Innovate UK
- Immersive UK
- Knowledge Transfer Network (KTN)
- Digital Catapult
- Realities Centre
- SeedCamp
- Vertigo

**SUPPORT MEASURES**

- Good access to finance for tech & innovation through Innovate UK.

**KEY PLAYERS**

- BBC McLaren
- ILM Jaguar Land Rover
- The Guardian
- Hammerhead
- Holovis
- The Foundry
- Rolls Royce
- Virtual Reality System
- Arivion
- Rewind
- Cross Rail

**START-UPS**

- Medical Realities
- Zerolight
- Gardner Creative
- DevVR
- VRcity Future
- Visual Brandwidth
- Cityscape VR
- TrickVisio VR
- Savvy
- Neutral Digital
- ChronosVR
- VMB
- Hammerhead

**UNIVERSITIES**

- King's College
- UCL
- MMU
- University of Portsmouth
- University of Bath
- Bournemouth University

**ESTABLISHED COMPANIES**

- BBC
- McLaren
- ILM
- Jaguar Land Rover
- The Guardian
- Holovis
- The Foundry
- Rolls Royce
- Virtual Reality System
- Arivion
- Rewind
- Cross Rail

**INDUSTRIAL MEETS HP**

- Berlin VR meet-up
- VR Base Berlin
- Berlin-Brandenburg VR
- VR business club
- Bayerisches Filmzentrum
- G-Tech
- Start-up Berlin

**KEY PLAYERS**

- CryTek
- Metall Fahrenhuter
- Zeiss Imaginon Schenker
- Bosch Siemens

**START-UPS**

- AV VR
- Spice VR
- Wonderland
- Vragments
- Gestion Demodern
- Ignyt
- Splathoff

**UNIVERSITIES**

- Technical University Munich
- Max Planck Institute
- Deutsche Welle Akademie
- Medienhochschule
- Hochschule

**KEY CHARACTERISTICS**

- Decentralized character of the VR scene
- Large industrial base using VR for industrial design
- vibrant start-up and meet-up scene

**SUPPORT MEASURES**

- German Federal Film Fund (DFFF)

**GERMANY**

Germany has its VR and AR centres spread out across the country. Its most vibrant centre of VR is definitely Berlin with its animated informal meet-up scene and creative industries giving rise to creative start-ups. VR in the south of Germany is rather focused on the manufacturing industry base with large car makers, but also large film making and animation studios. VR in Germany is benefiting from the presence of Europe's biggest industrial manufacturers and thus business opportunities in design, training or production. It also offers numerous creative centres for start-ups and freelancers. An issue for striving start-ups in Germany is a relative gap between the start-up environment and the big companies, due to the formalised and hierarchical structures of traditional German industries.

As one of the world's largest financial centres, the opportunities for venture capital in London are more numerous, hence attracting VR/AR entrepreneurs and developers from all over the continent. London is a global media and post-production hub, as well as the home to many large businesses with departments active in VR & AR. Many of the main players within the UK’s creative and media industries have their own dedicated R&D departments for VR/AR (e.g. the BBC). Meanwhile, companies like Uniliver ensure that, not least in terms of marketing and advertising, there is plenty of opportunity for start-ups active in immersive content creation to get a foot in the door. For example the home to many large businesses with departments active in VR & AR. Many of the main players within the UK's creative and media industries have their own dedicated R&D departments for VR/AR (e.g. the BBC). Meanwhile, companies like Uniliver ensure that, not least in terms of marketing and advertising, there is plenty of opportunity for start-ups active in immersive content creation to get a foot in the door. For example home to many large businesses with departments active in VR & AR. Many of the main players within the UK's creative and media industries have their own dedicated R&D departments for VR/AR (e.g. the BBC). Meanwhile, companies like Uniliver ensure that, not least in terms of marketing and advertising, there is plenty of opportunity for start-ups active in immersive content creation to get a foot in the door. For example home to many large businesses with departments active in VR & AR. Many of the main players within the UK's creative and media industries have their own dedicated R&D departments for VR/AR (e.g. the BBC). Meanwhile, companies like Uniliver ensure that, not least in terms of marketing and advertising, there is plenty of opportunity for start-ups active in immersive content creation to get a foot in the door.
Berlin is often mentioned as the German VR hub and also the upcoming VR Centre in Europe. Its cultural scene has a blooming start-up environment and attracts creative minds and developers. Young entrepreneurs from around Europe are attracted by the multi-disciplinary character of the city, good access to start-up incubators and co-working spaces, as well as relatively low costs of living compared to other European metropoles. The Berlin VR meet-up scene is one of the largest in Europe and this well-working informal networking structure fosters collaboration in Berlin’s VR start-ups. Besides the main VR meet-up that has around 200,000 participants, there have been other specialised VR meet-ups, such as for psychology, “room-scale” VR developers, filmmaking, creative, science and mixed reality – these themes nicely illustrate the current focus of Berlin start-ups. The Munich VR scene also gathers VR filmmakers. The animation and special effects scene benefits from the presence of the German film industry and the Bayerisches Filzementrum. At the same time VR in Munich is also driven by a strong industrial presence. Hamburg is mostly focused on VR content creation for advertising. VR activity is flourishing also in Frankfurt and Cologne.

The growth of the VR community motivated several German cities and regions to research the potential of VR or support directly its development. The City of Berlin launched its own research on the Berlin VR scene while the Berlin-Brandenburg region started the initiative Berlin-Brandenburg VR with a goal of promoting VR in the area and eventually across Germany. Centres such as the German Technology Entrepreneurship Center (G-Tech) in Berlin and Frankfurt help to bring the tech community together with academia and businesses, as well as to promote new tech entrepreneurship, including VR in Germany and globally. Start-up Berlin works as a network and helps to connect start-ups with investors while VR Business Club connects VR companies with the business and the marketing community to help them commercialise their ideas. VRBase Berlin helps the industry by providing co-working space for VR and AR companies, building the community, providing advice and organising training and events. VR movie making and content can benefit from the support and funding of the German Federal Film Fund (DFFF) that supports VR as a media for film making.

The film and gaming industries dominate the VR field in the Netherlands, and the indie scene, being rife with creative minds, is big in both of them. Although it may be that filmmakers and gamers are not yet on the same page in terms of what is the best way to tell a story using VR/AR, within the Netherlands Amsterdam in particular is a place with a strong entrepreneurial spirit, a knack for experimentation, and a dedication to deliver quality content. The city and its surrounding areas are vibrant and international and they attract people from all over the world. With its quality of life and affordability, the Netherlands is also an inviting place to stay. A friendly place for English-speakers, Dutch entrepreneurs and developers may likewise find their place abroad, however rather than due to their language skills such transitions are mainly due to a lack of funding opportunities at home.

The level of venture capital opportunities for start-ups in the Netherlands lags behind that in the UK, Germany and Scandinavia. As a direct consequence start-up growth and development in the Netherlands tends to be rather cautious and slow. This is also due to having access to few available projects as the size of the national market is quite small. The VR start-up scene in the Netherlands is nevertheless very dynamic and the third most prominent in Europe, after London and Berlin. There is a number of prominent accelerators and incubators that make Amsterdam an ideal launching pad for start-ups. These are B. Amsterdam and Rockstart, as well as StartupDelta, promoting the Netherlands as a destination for start-ups. Much like elsewhere in Europe, Dutch VR start-ups often find funding in big brands, who are looking to up their advertising game. Once they consider their business model to be a viable one, they generally do well focusing on steady growth. Some successful examples of VR start-ups that have made it big within their field include Force Field and Vertigo Games. Once established within the Netherlands, however, having reached the confines of the Dutch market, some companies then choose to move to the US in order to be part of a wider VR and AR ecosystem and to grow further. Although from the interviews it seems that expanding within Europe would be preferred, it does not always seem to be that simple to do.

There are therefore a number of ongoing efforts to connect the players within the VR/AR industry across Europe. An important one is championed by VRBase, an accelerator (with “bases” popping up in other key European cities) which seeks to connect actors in the field and encourage knowledge sharing and mutual learning as a means of strengthening the Dutch and European VR scene. Purple Pill VR, for example, runs a blog where they share the latest tips and knowledge with others in the field. There are also many meet-ups across the Netherlands, bringing together actors from all over Europe, such as VRDays, an annual event since 2015. Across the country, networks of collaboration are already well in place, including between companies and universities (or simply students). They produce an abundance of highly skilled people. For example, among the VR/AR crowd Unity has been embraced early on, and a number of US-based companies have opened up their European HQs in Amsterdam due to the access to qualified labour.
Much like in the UK, the Netherlands have made tech and innovation a funding priority, although the focus rests somewhat more heavily on research. There is a favourable tax code, and innovation credits and grants are made available for developing innovative products. These tend to be quite result-oriented and risk-averse – not quite what a sector as nascent as VR/AR needs, as the nature of start-ups is to succeed after learning from previous failures. What is more, not all technologies that fall under VR/AR are considered to be ‘innovative’ and therefore eligible for funding. They are sometimes described as problematic by companies that focus on building cameras and filming 360-degree videos.

VR research is centred around engineering schools in Madrid such as the Technical University of Madrid and around the University of Barcelona and its Event Lab with experimental virtual environments for neuroscience. The research here is focused on body perception and ownership. Both Spanish universities and research-oriented companies are well used to European funding and take advantage of it.

In terms of support measures, in Spain support of new technologies hasn’t seemed to be a priority of the public sector. However, some private initiatives exist. Landzadera incubator in Valencia helps start-ups to create business plans and find funding. Wayra is an incubator from the telecom giant Telefonica. It functions as a global accelerator and also creates connections with Latin America. In Barcelona, a VR Awareness Centre is soon to be opened, financed privately by ThoughtWorks. Its mission will be to educate about VR and offer possibility to aspiring VR creators to borrow or rent VR hardware.

Following the economic crisis in 2008, Spain has been putting a lot of effort into attracting foreign investors to support the growth of its businesses. Despite a struggle to win investment over countries such as France or Sweden, the Spanish VR scene has been developing, building upon the creativity and skills of the local professionals as well as on the competitively priced workforce. The creative scene is characterised by small companies keen on experimenting and centred around Barcelona, while VR and AR for industrial purposes grow around Madrid. Spain is active in creative VR production and experiences, industrial applications, and post production software. VR companies in Spain may benefit from loyal, creative and skilled workers and a good “southern vibe”, but may experience issues with finding both private and public investment.

In terms of the business scene, Barcelona is leading in attracting small creative VR start-ups focused on content creation. Its VR scene is often described as similar to the one in Berlin, with creatives and designers, hip environment and vibrant VR community. The living costs are relatively low and many young VR entrepreneurs are also attracted by the lifestyle offered by this coastal city with a range of cultural activities and social life. Barcelona hosts three annual thematic meet-ups, besides the biggest general VR meet-up. Smaller specialised events focus on 360-degree videos and creative content production. Barcelona also hosts several companies active in VR adult industry.

Spain to be closer to big businesses and potential business presence to be located outside of Madrid. VR start-ups experience issues while trying to scale up and often opt for a formal headquarters and business presence to be located outside of Spain to be closer to big businesses and potential investors. This is the case of the successful content-production studio Future Lighthouse that combines 360-degree camera shots with computer animations to create high-level VR content. Despite being founded in Spain and having its developers located in Madrid, its initial headquarters was chosen to be in the UK and currently its official base is in the US. Madrid’s VR industrial scene, on the other hand, is more formalised and concentrated around branches of big European companies such as Airbus. The industry-focused companies are small to medium-sized with a focus on software and training applications. Unfortunately, in Spain, VR start-ups experience issues while trying to scale up and often opt for a formal headquarters and business presence to be located outside of Spain to be closer to big businesses and potential investors. This is the case of the successful content-production studio Future Lighthouse that combines 360-degree camera shots with computer animations to create high-level VR content. Despite being founded in Spain and having its developers located in Madrid, its initial headquarters was chosen to be in the UK and currently its official base is in the US.

Sweden is one of the most tech-savvy countries in Europe. There is no surprise that in a place where the population owns 1.5 smart devices per person, and foreign investment in tech companies has one of the highest growth rates in Europe, the VR community is flourishing. Stockholm is a hub of gamers and game-production companies have been present for years. Established game companies and start-ups are now actively working to become the leaders of the world gaming industry. Younger generations have access to the educational programmes specialised in game development. The Stockholm VR community is also characterised by its sense of collaboration and camaraderie. Company owners know each other, cooperate and share experiences, and are focused on gender equality issues, for example by creating strong female characters in VR video games. Sweden is also characterised by high-speed broadband network that is important for the smooth running of VR applications. The slight disadvantages of doing VR in Sweden can be the higher workforce and living costs and the taxation rate. Another area typical for Sweden is high-precision technologies, represented by the eye tracking solutions provider Tobii.

Nordics love games and global top gaming companies have had their home in Stockholm for years with practically oriented schools like Futuregames or Hyper Island. Established gaming studies such as Dice have naturally embraced the new technology, producing games for VR. The VR wave gave rise also to numerous new companies either by experienced game producers, such as Resolution Games (currently the most successful producer of mobile VR games, founded by the creator of the popular game Candy Crush), or by new, young, often female talents in VR, such as Neat Corporations and SVR Vive. Gaming drives the VR scene in Stockholm, but Sweden’s business scene also includes successful hardware companies producing high-end headsets and eye tracking technology, as well as medical VR start-ups. The VR business in Stockholm is driven by
Swedish research tends to be mostly applied and in close collaboration with companies and the business scene. Joint projects between universities and businesses are very common. University of Stockholm and Stockholm School of Entrepreneurship encourage cooperation amongst different fields and start-up projects.

The public organisation Invest Stockholm periodically monitors the needs of the local tech industries and helps to build the communities from the bottom up by providing financial support or resources, for example by creating dedicated co-working spaces. The public support in Sweden is thus focused mostly on growing the community from its roots, rather than applying a top-down approach. As for other tech communities, Invest Stockholm makes sure that the VR community has its co-working space and can provide small financial incentives if necessary. Stockholm also tries to attract investors from outside Sweden to grow financial resources for the local tech companies. The community character of the Swedish VR sector is supported by numerous networking events such as Women in Tech, where female tech entrepreneurs regularly meet and share their experience, or Stockholm VR Meetup that plays important role in informal networking. Co-working spaces such as Stena Center, that popped up recently, have since become characteristic for Stockholm. Last but not least, blogs and journalist servers, such as vrsvr.se do a great job keeping the community informed.

4.2.7 SWITZERLAND

**TURNING INNOVATION POTENTIAL INTO VALUE FOR THE ECONOMY**

**SUPPORT MEASURES**

Swissnex • ProKleve • Kommission fur Technologie und Innovation (CTI)

**KEY INSTITUTIONS**

Virtual Switzerland • Technopark Zurich • Artanim foundation • World VR Forum

**KEY PLAYERS**

Artanim Interactive • Dacuda • Kenzan Studios • WEAVR • Creologic

**KEY CHARACTERISTICS**

Top class research centres • Successful cooperation between research and business • Good access to funding

**ESTABLISHED COMPANIES**

Mindmaze • Dacuda • ZOE • Artanim Interactive • Sammics

**START-UPS**

Kompan Studios • WEAVR

**UNIVERSITIES**

Ecole Polytechnique Federale de Lausanne (EPFL) • Swiss Federal Institute of Technology Zurich (ETH)

Apart from the described front-runner countries a number of other cities spread all over Europe stand out for their research activities, start-up environments or strong focus on specific VR application areas.

In **Finland**, Helsinki and the nearby city of Espoo, a very technologically advanced region, are becoming a boiling hub of VR activity with new start-ups entering the game. The existence of a colossal tech company like Nokia which shifts towards VR by producing OZO (a 360-degree camera), as well as successful scale-ups in the mobile gaming industry, such as Rovio (Espoo) and Supercell (Helsinki) show that the ecosystem is ideal for the expansion of VR activities, especially gaming. The acquisition of Applifier (Helsinki), the cross-promotion network for social games, by Unity in 2014 and the successful crowdfunding of Arilyn (Helsinki) show the investment opportunities and interest in the region’s activity. There are various events that are especially important to start-ups like Futureplay (Helsinki) and Mindfield Games (Helsinki). These events include Slush in Helsinki, which brings together 2,300 start-ups and venture capitalists, journalists and 17,500 attendees, and other video game-focused happenings and meet-ups. They provide more opportunities to the region’s already privileged ecosystem.

4.2.8 REST OF EUROPE

**WHERE**

Finland • Denmark • Italy • Greece • Belgium • Poland • The Czech Republic • Estonia

**KEY PLAYERS**

**ESTABLISHED COMPANIES**

Nokia (FI) • Unity (DK/US) • The Farm 51 (PL) • BARCO (BE) • Rovio (FI) • IABM (FR) • Armadillo (FI) • VR Viva (PL)

**START-UPS**

The Yondr (BB) • Mimeoys (BB) • VR Inception (IT) • Vuforia VR (DE) • Anshar (PL)

**UNIVERSITIES**

ICTS (GR) • Athens School of Arts (GR) • ITA (IT) • Aalto University (FI) • University of Tallinn (EE)

**UTILITIES**

University of Lausanne (UNIL) • ETH Zurich (CH) • EPFL (CH)

Thanks to a well-developed support structure, technology-focused VR/AR companies in Switzerland are state of the art. **Zurich** is a dynamic tech hub that is becoming a VR/AR centre especially thanks to the proximity to ETH University. Major technological companies have their Swiss representation based in Zurich, Apple, Sony, Ricoh, Panasonic, Samsung, Autodesk etc.) which promotes the growth of the very technologically advanced region, are becoming a boiling hub of VR activity with new start-ups entering the game. The existence of a colossal tech company like Nokia which shifts towards VR by producing OZO (a 360-degree camera), as well as successful scale-ups in the mobile gaming industry, such as Rovio (Espoo) and Supercell (Helsinki) show that the ecosystem is ideal for the expansion of VR activities, especially gaming. The acquisition of Applifier (Helsinki), the cross-promotion network for social games, by Unity in 2014 and the successful crowdfunding of Arilyn (Helsinki) show the investment opportunities and interest in the region’s activity. There are various events that are especially important to start-ups like Futureplay (Helsinki) and Mindfield Games (Helsinki). These events include Slush in Helsinki, which brings together 2,300 start-ups and venture capitalists, journalists and 17,500 attendees, and other video game-focused happenings and meet-ups. They provide more opportunities to the region’s already privileged ecosystem.

**THE SWISS COMMISSION FOR TECHNOLOGIES AND INNOVATION (CTI)** closely collaborates with universities and helps research to move into the commercialisation phase by fostering collaborative projects and knowledge transfers. Research is very well funded as Switzerland is among the countries with the highest spending on R&D in relation to their GDP (currently 3% of GDP, or around 16 billion CHF). Together with a well-structured access to early finance, expertise and other support provided by the state, the Swiss have a successful model for generating viable research spinoffs. The cantons (regions) have a considerable freedom and negotiating power to attract new companies by offering them regional tax cuts and other benefits.
Estonia is also a tech-savvy country, where e-residence, e-voting, e-signing and other digital public services are established showing not only Estonia’s interest in digital technologies but also the high ease of doing business in the country. Estonia’s government has also recognised the potential of VR as they are preparing a massive VR campaign for promotion purposes. This ecosystem potential of VR as they are preparing a massive VR

Estonia’s government has also recognised the high ease of doing business in the country. Estonia’s interest in digital technologies but also public services are established showing not only

Another Reality (Milan) offers business VR

elements, and the start-up Absolute Zero

Italy is a receiver of a large portion of EU funds related to VR research. VR activity seems to be spread all over the country but many companies are located in Milan to benefit from the raised demand thanks to the industrial and business activity in the region. For instance Another Reality (Milan) offers business VR and AR solutions and trainings and inVRsion (Milan) creates realistic VR applications for industries. Italy is in the second place in received funds for VR and AR projects under the H2020 scheme. The significant research activity is done by well-known universities such as the University of Milan and research centres like ITIA-CNR, which also supports companies and promotes the VR and AR application for industries.

Poland has many VR companies that are spread in different regions all over the country a large portion of which focus on VR gaming. Farm51 (Glilwice) is a great example, as apart from gaming they also develop VR solutions for the army; Anshar (Katowice) and Setapp (Poznan) also develop VR games; apart from games, VR Visio (Gdynia) provides business VR solutions and produces 360-degree videos; and EPICVR (Krakow) works on VR content production for big companies in Poland and other European countries. Polish Immersion tries to integrate VR into business and guides their clients, stemming from the automotive or medical industries, through the whole VR app creation process.

Lastly, similar to Poland in a number of other European countries start-ups or more established companies perform their VR activities but are not in organised clusters. For instance in Austria there are a few VR companies and start-ups but they do not focus on a particular area of activities. Also, in many countries and regions there are ideal conditions for hub development and unexploited potential – for instance in the Czech Republic. Facilities such as the South Moravian Innovation Centre (Brno) are supporting the activities of entrepreneurs and businesses at any stage of development. Prague is also a regional hub for big software companies such as DELL, CISCO and Amazon and has a sophisticated software development scene and film industry that is starting to engage in VR and AR. Automotive industry Volkswagen Škoda Auto as well as some innovative start-ups like Sorilax (Prague) which develops a user-friendly VR engine where the user can create their own VR environment or Lifeliqe, focused on education, have managed to attract investment from big players in the VR industry. The existence of highly qualified workforce, passionate entrepreneurs and lower costs compared to other European countries create ideal conditions for a hub creation in the Czech Republic. Bulgaria’s VR scene is also slowly coming up with companies such as Escape Reality, with the first local VR escape room, or VRCity production studio, with its first Bulgarian VR film festival taking place in late 2016.

Portugal and Lisbon in particular has a high start-up activity that is built around one of the major tech events – the Web Summit. Another potential future hub of VR activity could also be Ireland. Hosting the European headquarters of many innovative global businesses, including IT giants such as Google and Facebook, and thereby attracting investment from abroad. The cities of Dublin and Cork tick the boxes for the development of a dynamic VR community. Companies such as Immersive VR Education exemplify this potential.
VR and AR are powerful technologies that can impact our everyday working and personal lives. So far, VR has proved that it is creating changes in various application areas from industry to healthcare, from training and education to gaming and entertainment. Continuously new application areas are arising making use of the advantages and strengths of VR and AR technologies.

Technological advancement by technology providers, both private companies and universities, enable and inspire practical applications of VR. In turn the need for applications of VR drive further technology advancement, by expressing their needs for a better customer experience and for concrete practical solutions. Comfortable and advanced hardware, from headsets to haptic devices are needed, as well as powerful software to allow for fast image processing for a realistic immersive experience.

This section further elaborates on the major current application domains. It is preceded by a description of the technology providers driving these applications.

The entities presented in this scheme are randomly selected examples only.
VR can be used in various application domains. Some of the most relevant domains in Europe are further elaborated below.

5.2.1 ENGINEERING AND MANUFACTURING INDUSTRY

MEANS OF USAGE
Industrial design + Prototyping
Interdisciplinary dialogue
Trainings

ADVANTAGES OF USING VR
- Eco-friendly
- Cost saving
- Reducing risk of injuries
- Enhancing communication and efficiency

WHO DEMANDS
All industries with a production or design process

KEY PLAYERS
ESTABLISHED COMPANIES
Fraunhofer (DE)
Lumiscaphe (FR)
Techno (FR)
Immersion (FR)
Light and Shadows (FR)
Barco (BE)
Jungle VR (FR)

START-UPS
Passer VR (NL)
Apizee (FR)

UNIVERSITIES / INSTITUTES
Arts et Metiers – Paris tech (FR)
Mines – Paris tech (FR)
Clarte (FR)

Many European innovative start-ups, companies and also universities, are working on the development of general VR technologies and software that enable the use of VR in different application areas.

Software is often developed for a particular area of use and is taken over by other sectors. This is for example the case of Unity (DK/US). The Foundry (UK) or CryEngine (DE), that were principally developed as processing engines for gaming and entertainment, but currently generate VR content in the medical field, industrial design and training.

Basic research also benefits from the progress on hardware and software. For example neuroscience basic research, taking place for example at Max Plank Institute (DE) or Humboldt University of Berlin (DE) uses powerful game engines and technology solutions for VR headsets to advance their exploration of the brain. New VR solutions, enabled by general technology advancement allow to perform complicated brain exploration on mice instead of monkeys, and activate specific parts of the brain. Basic research spin-off companies such as Winterlab (DE) work on a further advancement of the technology to perform safe brain exploration on humans.

The visualisation of 3D models, CADs and other content in VR applications give the possibility for different people to access 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. Both applications are radically reducing meeting costs and possible errors, as distant communication can be just as efficient as meetings in person. VR prototypes help improve the understanding of the final product between colleagues from different disciplines, enables clients to have more realistic expectations and investigate alternative options (different colours, sizes or material). According to OPTIS (FR) one of their clients in the automotive industry reduced the physical prototypes from 30 to 7 real prototypes complemented by VR 3D models, thus having a significant effect on cost reduction. A number of established companies are active in 3D visualisation with VR, offering solutions with different methods (photography, virtual imaging), functions (level of interactivity with the content), quality and costs. Some big companies actively offer such solutions for engineering and manufacturing, such as Fraunhofer (DE), Lumiscaphe (FR), ZeroLight (UK), TechViz (FR), Immersion (FR), PS-Tech (NL) and Light & Shadows (FR).
companies either offer their services on demand or by providing their software to the client. Also, there are hardware producing companies that also focus on the sector: Barco (BE) constructs VR showrooms, from simple screens and projectors to virtual “cubes” for industrial uses, ZEISS (DE) also focuses on VR hardware for manufacturing and produces VR lenses, Dassault Systèmes (FR) enhances the VR experience by allowing users to see and interact with their surroundings with a normal VR headset.

Trainings are yet another area where VR applications can support the engineering and manufacturing sectors by immersing staff in a simulation of a real-life situation. VR trainings are eco-friendly and cost saving, as no real resources are used, there are no safety hazards and they can be easily repeated. The benefits of VR trainings are bigger where expensive or specialised machinery is used in real-life or where there is an unnecessary exposure to danger. For example, according to EON Reality's department in France, the maintenance time of an energy plant’s facilities which requires the interruption of production can be reduced by 50% with the help of VR trainings. Jungle VR (FR), CLARTE (FR), Saint-Gobain (FR) and Antycip Simulation (UK) create such trainings and simulations. EON Reality’s departments in Europe (France, the UK and Sweden) also work on creating trainings. Specialised trainings often require specific complementary to the headset hardware. Light & Shadows (FR) produces on-demand, specialised hardware for industrial trainings, such as shoes with sensors.

From streamlining the design process to facilitating property sales, virtual reality is revolutionising the construction, architecture, and real estate industries. Cityscape VR (UK), opusVR (DE), Neutral Digital (UK), TruVision VR (UK), VMI Studio (UK), and Kaouenn Studio (FR) are just some of the companies enabling architects, interior designers, property developers and their clients to immerse themselves in creations throughout different stages of the design process, and so allowing them to get a better feel of what the model could look like once finished. This can be done effectively by, for example, translating Building Information Modelling (BIM) into virtual experiences, providing everyone from designers to clients with beautiful and interactive walkthroughs.

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. ITIA-CNR (IT), for example, studies human psychological and emotional states and creates VR to test whether certain spaces fit the requirements for ambient assisted living.

The Industrial group Bouygues (FR) uses immersive technologies to transform and upgrade construction processes, but also to view real estate property. Dreamplex (PL) combines VR with 3D printing to truly emerge a client into their real estate or architecture presentation. INOD (FR) and DIAKRIT (SE) are further examples of companies enabling their clients to visit real estate in virtual reality, improving their experience of buying and renting, reducing their insecurity to do so and, perhaps above all, saving them a lot of time. Based on a live poll at a recent event on VR and real estate at London’s Realities Centre, people would be more than willing to pay for the convenience of making a collection of virtual visits before visiting a select few in person.

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. Education and training applications can be accessed by anyone owning a pair of VR glasses or a smartphone with VR cardboard device. In terms of learning, special apps are being created in VR that serve as a unique interactive platform. For teenagers, educational apps in VR are already coming up, like for example the traffic rules learning experience by WeMakeVR (NL). School and universities have been experimenting with adding VR as a teaching tool or making VR lectures a part of the curricula. Companies such as Labster (DK), which created virtual labs for experiments, Immersive Education (IE) and Lifeliqe (CZ) take the concept of VR education even further by providing a whole new interface for learning and exploring.

Another place where education takes place are museums and galleries. The Virtual Dutch Men (NL) have created a fictional virtual museum for the EuropeanaFoundation (NL) gathering masterpieces from different museums and exhibitions such as the works of Rembrandt and Vermeer. Other galleries such as Serpentine Galleries (UK) and Zabludowicz Collection (UK) are also collecting pieces in VR. Art Graphique & Patrimoine (FR) also specialises in digitalisation of art work and creation of VR experiences for the Louvre (FR) and other museums and landmarks in France and abroad.
VR and AR can also enhance this visiting experience. From the world famous Parthenon in Athens, Greece or the Colosseum in Rome, Italy to less known historical sites such as la Bastille in Grenoble, France or Spilberk Castle in Brno, Czech Republic, VR & AR help to tell better stories of monuments’ long history. Virtual reality can also be used in tourism. Regions and cities create VR experiences to promote themselves to potential visitors, travel agencies such as Thomas Cook (UK) offer virtual mini-trips to promote sales of their travel services. The start-up YonDr (BE) is building a virtual travel agency with VR travel tours around the world that can be used both for virtual

and a teaser for real exploring. Destinations VR (PL) offers a VR application enabling tourists to visit hotels and resorts prior to booking them, so as to better be able to choose their place to stay for their next holidays.

Software such as Holostoria by Ocsuscope (FR) uses 3D content for the creation of VR experiences and can also be useful for the design and scenography of museums and exhibitions. Companies such as Timescope (FR) and Realtime Robotics (FR), create hardware for exploring cultural content in VR.

5.2.4 MEDICAL FIELD

MEANS OF USAGE
Treatment • Training

ADVANTAGES OF USING VR
Less medical errors • Better interdisciplinary and patient-doctor understanding • More efficient treatment and rehabilitation

WHO DEMANDS
Patients • Healthcare professionals • Hospitals

KEY PLAYERS

ESTABLISHED COMPANIES
- Philips (NL), MindMaze (CH), Medical Realities (UK), Sim for Health (FR)
- C2Care (FR), Royal Hospital (UK), South General Hospital (SE), HRV Simulation (FR)

START-UPS
- SciVR (SE), L’effet papillon (FR), Immersive rehab (UK), MDlinking (NL)

UNIVERSITIES
- King’s College (UK), University of Portsmouth (UK), École Polytechnique Fédérale de Lausanne (EPFL)

Many VR companies and research institutes aim to enhance the medical sector. Already a number of medical trainings are available and are widely adopted by universities and hospitals. Apart from trainings, VR can also be used to enhance interdisciplinary communication as well as directly for the treatment of patients.

VR has great potential for health professionals and hospitals, ranging from trainings to better collaboration and mutual understanding. Philips’s (NL) healthcare department has developed the first augmented-reality surgical navigation technology that helps surgeons perform image-guided open and minimally-invasive spine surgery. Amongst other companies, HRV simulation (FR), SimForHealth (FR), VirtaMed (CH) and the start-up SciVR (SE) in cooperation with the South General Hospital (SE) in Stockholm develop trainings varying from simple consultation simulations to performing surgeries on virtual patients using special input devices. 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. Simulating and preparing for crisis situations such as working in a hospital after a major accident (e.g. terrorist attack) is another additional possibility offered by VR. The communication and visualisation possibilities that VR offers can enhance the efficient interdisciplinary dialogue in the medical sector as well as the better understanding and empathy between doctors and patients. Doctors from any location and any seniority can access VR videos of real surgery procedures provided by Medical Realities (UK), a company that collaborates with the Royal Hospital (UK) in London. Their first live VR surgery was watched by 150,000 people in 130 countries around the world and their training is becoming incorporated in many university curricula. MDlinking (NL) is also using VR to enhance the dialogue and knowledge sharing between healthcare professionals for free.

VR is also being applied to the treatment of psychological disorders such as phobias, addictions, eating disorders and stress. C2Care (FR) has developed applications for treating these conditions since 2012, King’s College (UK) in London and Hôpital de la conception (FR) in Marseille have been using VR for this purpose for years. Another VR application helping patients is the Bliss project developed by L’effet papillon (FR), which immerses patients before and after medical operations into paradisic VR experiences, having positive results on pain and stress relief. The third area where VR can be very beneficial for patients is rehabilitation. For instance MindMaze (CH), a spinoff from the École Polytechnique Fédérale de Lausanne (EPFL), which is one of the global pioneers in the medical use of VR, uses VR for rehabilitation of stroke patients and its VR solution is fully certified as a medical product. Rehabilitation VR applications can be also useful to patients with moving impairment or phantom limb syndrome and Immersive Rehab (UK) and University of Portsmouth (UK) are active in this area. Lastly, the awareness-raising and fitness applications of VR that are elaborated in the sections below can contribute to the purposes of preventive medicine.

The BBC (UK) collaborated with Oscar-winning Aardman Animations (UK) in order to dramatise the story of a Syrian family about to embark on a boat to Greece, publishing this alongside other VR experiments on its Taster website. In a similar vein, Sky News (UK) collaborated with Jaut (with offices also in the UK) to create the VR experience “Migrant Crisis”, where one can experience in VR how boats, packed with refugees, land on a beach in Greece, together with the fear and struggle of families fighting to stay alive. The Guardian (UK) has developed a series of immersive, educational experiences that emotionally engage viewers in, for example, the problem of solitary confinement in prisons, called “6 x 9”. This VR experience puts viewers in the shoes of inmates that live alone in their tiny cells - sometimes for decades at a time - so they can learn first-hand about the dangers of psychological damage that can occur from prolonged periods of extreme isolation.
VR/AR technologies are also used to educate and spur action from viewers concerning issues that can feel far-removed yet have a direct impact on humanity, such as climate change. For example, *Sweden Virtual Reality (SE)* is a VR development community arranging an international VR competition with the theme of sustainability. The aim of the competition is to encourage developers to create immersive experiences to facilitate sustainable development. These may range from 360-degree videos showing how glaciers have retreated over time, to fully immersive VR experiences, where one may swim through the deteriorating coral reef.

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 film making.

Production studios already create 360-degree film experiences, the BBC (UK) has launched a tester website including several VR films and experiences such as “We wait” produced with the help of Aardman (UK) studio. Similarly, ARTE (FR-DE) is co-producing VR films such as “I Philip” with OKIO-STUDIO (FR) or “Notes on blightness” with Novelab (FR) which can be found in ARTE’s 360-degree content library. These short films immerse the viewer into the main characters’ perspective, inciting empathy. Another example is “Les Falaises de V.” by Gengiskhan Production (FR), co-funded by the National Centre for Cinema and Animated Image (FR), Virtelio (LU) is a start-up that enables filmmakers to create different scenario depending on viewer’s attitude thus influencing the story.

Artists have the opportunity to express themselves in new creative ways through VR, this leads to new pieces of art. *Protrait (é)mouvant (FR)* by Joséphine Derobe is an example of such an artistic VR experience. A collaboration between two universities has led to the creation of a master’s degree in Art, Virtual Reality & Multi-User Systems (GR – FR), which led to the creation of the project Enter the Game. Enter the Game offers an artistic experience that combines real urban environment with the virtual world. Another example is Makropol (DK) which brings live art performances to the audience in innovative ways.

Organisations furthering humanitarian efforts and/ or engaged in public services are making use of these technologies for similar reasons and in similar ways. Charities seeking to incite empathy among the public have been among the early adopters, including the National Autistic Society (UK), that in 2016 in collaboration with Happy Finish (UK) a film showing people what it was like to live with autism. Similarly, Alzheimer’s Research (UK) created the VR experience “A Walk Through Dementia”, which puts viewers in the shoes of someone with the condition. Nokia (FI) and Humanitarian Cooperative (UK) made a VR film about Syrian child refugee and Amnesty International (UK) created a VR experience showing the devastation in Syria, in order to incite humanitarian relief response and charitable contributions for the cause.

5.2.7 ART AND STORY-TELLING

**MEANS OF USAGE**

Cinematic entertainment

Art distribution

**ADVANTAGES OF USING VR**

Empathy creation - New form of expression and storytelling

**WHO DEMANDS**

Mass market

**KEY PLAYERS**

**ESTABLISHED COMPANIES**

ARTE (FR-DE), BBC (UK)

**START-UPS**

Backlight (FR), Novelab (FR), Gengiskhan Production (FR), Virtelio (LU), Makropol (DK)

**UNIVERSITIES**

Master’s degree in Art, Virtual Reality & Multi-User Systems (GR – FR)

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.

Business meetings in VR can provide remote users with efficient ways to collaborate by using a set of tools and allowing them to visualise any type of files. Teemew (FR) enables users to take advantage of such an opportunity and Mimesys (BE) takes it one step further by allowing users to participate in the virtual meeting as holograms, making these meetings more personal and similar to real-life ones. VRbnb (FR) is a platform linking businesses in need of VR equipment and communication tools with providers of such equipment. In this way they aim to facilitate doing business with VR by tackling the high cost issue.

Social VR is another sector where VR aims to reach out to the mass consumers. An example of social VR is VIRTUALOZ (FR), which brings avatars of people from all over the globe together in a virtual environment allowing them to interact with each other as well as with the surroundings. Beloola (FR) allows users to build in a simple way their own VR environment, decorate it as they want, insert the content they wish and invite their friends and family for a VR hangout, e.g. to watch a film or a live football match together. Also, Mimesys’s (BE) hologram meetings can be used for social purposes, for example playing a game of chess or tennis with friends and family from abroad. An alternative to holograms is provided by Wolfprint 3D (EE), which focuses on affordable 3D scanning of humans that can be used as VR avatars. Splash (DE) aims to make 360-degree videos easy to record and share through smartphones, thus promote their creation and distribution and tune up the public’s interest for VR.
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.

**DIASKY (FR), a start-up active in e-commerce, believes that incorporating VR/AR technologies into the online shopping experience is currently the only way to remain competitive against big players in the industry (e.g. Amazon). The start-up creates virtual environments within which a customer can walk around, and which, thanks to Big Data technologies, reconfigure themselves for each individual so as to allow them to experience a unique and tailored visit.**

After introducing virtual reality elements to their customers, Diasky reports it has experienced a 400% increase in the time its customers spent on its site, as well as a 27% increase in consumer activity. Similarly, **Savvy (UK), a retail and shopper marketing agency, has been one of the key drivers of consumer adoption of VR headsets and has been one of the leading providers of immersive experiences for advertising.**

Numerous big brands are also investing a lot into advertising campaigns incorporating VR/AR, and are therefore important contributors to the development of VR/AR. Currently, the biggest clients of many start-ups focusing on immersive story-telling and filming are big brands. For example, fashion brands like **Givenchy (FR) and Jean-Paul Gaultier (FR)**, consumer brands like **Nestlé (CH)**, and **J&B Whisky (UK)**, and automobile brands such as **Peugeot (FR)** and **Renault (FR)**, have collaborated with production house **OKIO-STUDIO (FR)** in order to expand the reach of their brands through elaborate immersive advertisements promoting their companies. This involves, for example, taking the ultimate virtual test drive with the new Renault, filmed in 360-degree video. Advertising activities can range from simpler 360-degree videos to fully immersive experiences incorporating CGIs, such as the recent branded VR campaign for **Beeefeater (UK)** brought to life by VR studio **Future Lighthouse (ES)**. Some other examples of VR studios producing promotional content for established brands - which are often automotive brands - across Europe include **Scopic (NL)**, who have created the **Volvo (NL)** Ocean Race, **Ignite (DE)**, who have produced 360-degree video content for **Audi (DE)**, and **Gardner Creative (UK)**, who have produced the **Rolls-Royce (UK)** Serenity campaign. According to immersive media lab **Polar Effect (NL)**, immersive means of advertising provide 100% viewer interaction, and can result in a 400% increase in returning views and 700% increase in sharing.

Large established gaming companies often come from the Nordic countries – **Force Field (NL)**, **Rovio (FI)**, **Starbreeze Studios (SE)**, **Dice (SE)**, **CCP Games (IS)**. They started their activities already in the late 1990’s and currently also develop VR games with their dedicated teams growing every year. The demand is driven on the one hand by the gamers and consumers themselves, and on the other hand by large hardware producers who are interested in quality VR content and who make large investments in supporting the development of VR content in Europe. The challenge for established gaming studios is the need to change their traditional gaming narrative and adjust it to the VR environment.

The blooming VR gaming scene also motivates new start-ups to develop new games and investors seem to see the high potential in some of them. The start-up **SRVIVE (SE)** won a venture capital investment of 5 million EUR with their VR game prototype and has the ambition to become one of the global VR game leaders. Other interesting start-ups, such as **Neat Corporations (SE)** or **Fast Travel Games (SE)**, are popping up around Europe (especially in Northern Europe) and other smaller gaming players, for example **Warhorse (CZ)** with their VR horror game in development, are experimenting with gaming in fully virtual worlds. Smaller specialised players have the advantage of learning how to make VR experiences from scratch and are less “burdened” by habits from traditional gaming. There is an interesting phenomenon of some gaming studios focusing exclusively on one hardware provider, such as **London Studio (UK)** that is developing virtual games for Sony. Other studios use their expertise to make gamified trainings, such as **The Farm 51 (PL)**, which makes training applications used by the Polish army. Introducing gaming elements to training programs in VR makes them more enjoyable for the participants.

VR games for mobile phones also exist and are likely to boom once smartphones are equipped with more powerful processors, better graphics, precise motion tracking and long-lasting batteries. However, already now, VR mobile games are an important VR sector. The games are more simple, with more “hexagonal” graphics, but they can currently reach a larger audience and can be easily downloaded. The VR fishing game **Bite!** by the current market leader **Resolution Games (SE)** has more than a million downloads and proves that mobile games have potential. Other interesting VR gaming-related areas are VR escape games, such as **Incarna (FR)** or **Vortex (CZ)**. There is also a rise of traditional games in virtual spaces, including games like **Casino VR Poker (CH)**, and VR cafes and entertainment centres where everyone can play VR games, paying for the time spent.

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.
Content, software and hardware development for VR games is very fast-paced, driven by the desire to make games smoother, faster, more realistic and more immersive. This eventually also benefits other application areas as well as basic research.

5.2.10 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. An example of the huge appeal of this application is Manchester United, which globally has about 400 million fans, most of whom would probably never be able to experience a game live. 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 display the live stream of the Grammys red carpet was able to successfully be experienced through unique games, escape rooms and team building. That same year, Europe had its first virtual reality experience centre that opened up in an old Philips factory in Eindhoven. Providing unique team-building experiences, Enversed is a large virtual reality experience centre that opened up in an old Philips factory in Eindhoven in late 2016. At the Enversed Centre, the power of virtual reality can be experienced through unique games, escape rooms, team-building environments, workshops, and training sessions. The centre is designed for general recreation as well as the corporate market. There are also many places all over Europe offering virtual escape games, including ENIGMA and VORTEX VR (CZ), Vroom and MystiqueRoom (HU), and AdventureRooms (IT). Meanwhile, Up The Game is the first real-life gaming and escape room conference in the world, having gathered more than 500 creators from all over the world in 2016 and 2017.

5.2.11 OTHER AREAS OF VR & AR APPLICATION

Sports can also be revolutionised by VR as we can, for example, instantly ski or cycle in the mountains thanks to a VR headset. Unfortunately, hardware does not seem to be comfortable enough to fully develop its potential for a sport experience in VR. For now, simulators such as Birdy, which allows flying, offer short term whole-body immersive experiences. Holodia (FR) has already developed fitness applications for VR and offers its customers a workout with a headset.

In the future, VR can revolutionise child education. However, current headsets are often not recommended for small kids apart from simple applications allowing city or museum visits for a short period of time. Start-ups such as Kodama (FR), which creates an interface where physical objects managed by kids appear in a virtual world, try to solve the psychological development issue and give rise to learning apps for kids.

Potential also lies in big and complex data visualisation where extra dimension and virtual space can help capture flows in time and relations. This area is being explored by big players such as SAP (DE) and smaller companies such as Outlier Collective (ES). Similarly, for example complex company processes and management processes flows can be better presented and understood in VR. Spacesys (CR/US) experiments with providing complex business processes visualisation in VR. Applications created by the adult industry are definitely less visible to the general public, but should not be forgotten as they are important drivers of the design of new technologies, similar to smartphones. Examples of VR adult entertainment companies such as VR Girlz (UK) or VirtualReal Porn (ES) are popping up quietly all around Europe, and gaining popularity.

More applications and ideas are to follow ranging from banking and defence to anything where the benefits of immersive VR technologies can add value or provide an additional experience.
Providing the right conditions to reap the full potential of VR and AR in Europe is essential for such an emerging industry. In addition to national policies and strategies, the EU environment determines to what extent and how the development of VR in Europe will unfold.

6.1 The EU policy environment

The European Commission supports European researchers and entrepreneurs to help scale up the ICT innovation ecosystem in Europe by reinforcing actions for ICT innovation through Horizon 2020 (the EU Research and Innovation programme) with nearly €80 billion of funding available for the time period 2014–2020. Horizon 2020 also supports SMEs through a new dedicated €2.8 billion SME Instrument, which is targeting innovative SMEs. Open Disruptive Innovation is a scheme under this SME Instrument, which aims to support fast-growing, innovative SMEs with close-to-market ideas bearing high disruptive potential. Additionally, other SME support initiatives are available through the European Commission.

In 2017 the EC introduced a new instrument in cooperation with the European Investment Fund (EIF). The market-driven Pan-European Venture Capital Funds-of-Funds has been designed to boost levels of investment in new generations of highly innovative European firms. VR companies focusing on content creation can also benefit from the Media Programme.

Broadband Europe and Wireless Europe are other initiatives which feed into the wider Digital Single Market strategy of the Commission and strive to ensure progress in internet access and connectivity. Important aims include offering gigabit connectivity in key economic nodes, the introduction of 5G networks, and internet access of at least 100 Mbps for all European households by 2025.

Next to a focus on strengthening the Digital Single Market, the European Commission initiated its Creative Europe programme in 2014, with a budget of €1.5 billion. The programme aims to support Europe’s cultural and creative sectors to seize the opportunities of the digital age and globalisation.
6.2 Challenges to facilitate growth

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.

Despite the availability of public research funding in general, research and development support for individual (start-up) companies rather than research consortia is not always equally accessible. Where it is available it is often highly result-oriented, allowing for little experimentation and failure on part of the start-up. As a result, start-ups tend to either become absorbed by larger, often foreign, companies, or they seek funding outside of Europe. Of the companies based in Europe that took part in our survey, most of them either self-funded their VR activities (21%) or were able to undertake them as part of other activities within the company (32%). Only 25% indicated to have benefitted from venture capital opportunities from within Europe, and almost half of the companies surveyed said they would have benefited, or could benefit in the future, from better access to such opportunities.

Weak links between research and the market.

A considerable amount of public money goes into research institutions and universities across Europe, which are developing incredible technologies. These, however, often do not make it to the market. Based on our survey and interviews with public research institutions and universities, there is a much more pronounced focus on fundamental than applied research, and research outcomes often do not make it past the prototype stage. Only 29% of the companies surveyed actively cooperate with universities and research centres, while 61% of the companies carry out R&D internally, indicating a real need to improve the links between research and the market.

A lack of cooperation across the different countries in Europe.

Despite the high levels of cooperation observed within the various hubs and countries in Europe, cross-border collaboration could be improved further. Most supplier/customer relations are also either national or global, further hindering at limited European networks. Interviewees indicated that the VR landscape is currently so fragmented and fast-evolving that much time is spent by companies simply looking up contacts. One third of the companies surveyed indicated a need for more networking opportunities. Apart from collaboration across Europe, further collaboration should be encouraged between the three VR/AR global ‘bubbles’: of Europe, Silicon Valley and Asia. This will require additional attention when the UK leaves the EU, as currently London and Palo Alto form the strongest channel of transatlantic collaboration for VR/AR.

Current and expected needs for adequate infrastructure and resources.

An adequate infrastructure can strongly facilitate the uptake of VR along with the spread of VR hardware among consumers and businesses. Furthermore, the education of technicians, designers and developers fluent in VR/AR technologies is essential for the future growth of the industry, with 36% of the companies surveyed saying they would greatly benefit from workers with the necessary technical skills.

6.3 Way forward

To stimulate growth in VR/AR and to address current bottlenecks, policymakers may take on board the following suggestions put forward by VR/AR stakeholders from different European countries, including academia, companies, incubators, associations and specific VR/AR industry experts:

- To make funding more accessible for companies and entrepreneurs in VR/AR, funding schemes for start-ups could be re-addressed so as to allow sufficient space for experimentation and (initial) failure.
- To accommodate the fast-evolving pace of the VR/AR sector, it would be useful if the application processes to obtain funding could be shortened for fast-growing, innovative start-ups, while a stronger focus on supporting incubators and accelerators would be especially valuable.
- To help deploy new technologies, it is suggested to fund more applied research and demonstrators, which are closer to market introduction and hence create a stronger bridge between research and innovation.
- To help boost cooperation between the technical, creative and business fields, as well as grow a skilled labour base, it would be useful to support educational and training programmes with a practical orientation that would lead students to design and produce novel VR/AR/360-degree film applications. If combined with training on entrepreneurial skills, this would allow students to take their projects further in the real world.
- To encourage and increase knowledge sharing, and thereby indirectly facilitate the development, standardisation and quality of VR/AR, it would be particularly useful to support networking, with the priority of supporting much needed pan-European collaboration. This could be done by funding and helping organise events, as well as supporting spaces for open source software and tools.
- To stimulate innovation and development within the VR/AR industries in Europe, it would be beneficial to help showcase success stories across Europe, inspiring budding entrepreneurs to realise their creative ideas.

Once the market surrounding these emerging technologies further develops, different policy issues will inevitably arise. For VR/AR these issues will concern in particular guidelines on VR/AR ethics because of the fact that, to provide as immersive and enjoyable an experience as possible, these technologies may aim to incorporate protected and/or personal data.

As the above areas of concern and emerging policy issues are addressed, and stakeholders across the region continue to innovate, the potential that may be unlocked across the VR/AR ecosystem in Europe is major. This study may be taken as a starting point for continuing to understand this growing sector, and to help ensure a favorable development thereof in the EU and across Europe.
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. 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. Other areas of application are still to come.

Augmented Reality (AR) refers to a real-world environment enhanced with computer-generated information such as sound, video or graphics.

The first generation of AR uses smart devices such as tablets or smartphones as a magic lens that adds an informational layer over our reality. Upcoming devices in the form of glasses-like headsets add holograms right in front of our eyes, creating a mix and interaction of virtual world and reality. AR has an almost limitless range of uses in a wide variety of areas, be it commerce, technical applications, work processes or education.

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 & AR serve both consumers and professional users that can be private and public. AR in its more advanced glasses-like version is currently available for businesses and developers only, while VR made its way to both consumers and businesses. VR products, and indeed also AR solutions for businesses build up a growing market for consumers and professional users, with dynamically developing business models.

VR for consumers is mainly referring to applications such as games, travel experiences, short movies or adult entertainment. Upcoming products include medical and training applications or educational application. Consumers also purchase hardware such as head-mounted displays (HMD), HMDs for smartphones, 360-degree cameras etc. or specific software (for example Tilt Brush).

The different distribution channels and business models adopted to reach out to consumers can be divided according to the type of VR product:

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Direct sales</th>
<th>Direct sale of consumer hardware via a website</th>
<th>HMD, cameras</th>
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<td>Intermediary</td>
<td>Using an online or physical retailer</td>
<td>HMD, cameras</td>
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<td></td>
<td>“Free gift”</td>
<td>Offer to a phone subscription or other services</td>
<td>Mobile HMD</td>
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<tr>
<td>Content, apps</td>
<td>Direct sale</td>
<td>Single purchase of an app/content</td>
<td>Travel, gaming</td>
</tr>
<tr>
<td>Subscription</td>
<td>By paying a period fee, consumer can access an online library</td>
<td>Travel, education</td>
<td></td>
</tr>
<tr>
<td>Freemium/demo</td>
<td>Basic content for free, more advanced content for a fee</td>
<td>Travel, gaming</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“Free”</td>
<td>Promotion purposes, consumer pays with attention or data</td>
<td>Advertising</td>
</tr>
<tr>
<td>VR experience</td>
<td>Pay for time</td>
<td>Pay for time spent enjoying experience</td>
<td>Cinema, arcades, VR café</td>
</tr>
<tr>
<td>Rental</td>
<td>Pay for VR gear with content for a period of time</td>
<td>VR rental</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“Free”</td>
<td>Promotion purposes, at fairs and public spaces</td>
<td>Advertising</td>
</tr>
</tbody>
</table>
VR for professional users includes applications and content, software, hardware or a combination of these. For example, in the medical field a training application for surgeons includes CGI (computer generated image) with haptic input so the surgeon can train in VR but on a real dummy mannequin. A professional solution can also be a high specs 360-degree camera or an external device rented to a VR production company which then uses it for its business.

For professional use distribution channels and business models depend on the consumer market. The table below gives a brief introduction to some of the most important mechanisms.

<table>
<thead>
<tr>
<th>Professional solutions</th>
<th>Sell of IP/ rights</th>
<th>Single sale</th>
<th>Rental models</th>
<th>Royalties model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sale of whole sol ution with rights to it</td>
<td>One or multiple solutions are sold, seller owns IP</td>
<td>Solution rented for a fee on a long or short-term basis</td>
<td>Resellers monetise and pay back royalties</td>
</tr>
<tr>
<td>Professional content or software</td>
<td>Direct/licence sale</td>
<td>Access to content or SW with updates for a periodic fee</td>
<td>Professional SW</td>
<td></td>
</tr>
<tr>
<td>Freemium/demo</td>
<td>Basic version free, advanced for a fee</td>
<td>Professional SW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VR experience</td>
<td>Pay for time</td>
<td>Rent VR gear with content for a period of time</td>
<td>VR rental</td>
<td></td>
</tr>
<tr>
<td>“Free”</td>
<td>Promotion purposes, at fairs and public spaces</td>
<td>Advertising</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Often products and technical solutions are not even developed with a direct revenue model in mind, but rather as a means to “grow and get bought”, aiming to be purchased by larger companies once the technical solution proves to be feasible.

Annex B: Quantitative assessment of the AR/VR market

The quantitative market development estimates are based upon a VR & AR industry growth prediction model, constructed specifically for this study. The model measuring the growth for the near future (2015-2020) is based upon both quantitative and qualitative information from different sources and growth assumptions.

The quantitative and qualitative inputs used for estimating VR & AR yearly growth rates, turnover and impacts on the economy and jobs include:

- Comparative assessment of growth rates from a set market reports listed in Annex D;
- Existing econometric analysis commissioned by Facebook modelling growth of sales of HMDs;
- Results of the survey of VR & AR companies run by Ecorys as a part of this study;
- Critical assessment of the future VR & AR market development by relevant academic and industry experts;
- Analysis of the VR & AR market based upon a detailed analysis of around 900 relevant entities;
- Qualitative assessment of development of different VR & AR applications based upon 70 interviews;
- Assessment of growth and economic impact of three hi-tech industries similar to different VR & AR applications.

Three high-tech industries were selected based on their similarities with different VR & AR application areas. Their development over time and direct contribution to the economy was then examined and used to estimate the effects of the VR & AR industries on the economy (in particular in terms of indirect employment and value added). These industries were:

1. The mobile apps industry representing VR and AR applications which are content intensive and aim at the consumer mass market (e.g. real estate, journalism, advertising, communication). The data for the size and contribution of the mobile apps industry was retrieved from the reports of Vision Mobile on the EU economy. Due to the price sensitivity and mass market nature of this VR market, it is only starting to take off now. However, much like in other comparable markets, this part of the VR market is expected to grow very fast.

2. The video games industry, representing the maturing and high value mass market of VR and AR (e.g. gaming, engineering and manufacturing applications, entertainment). The data for the size and contribution of the video games industry was retrieved from the reports of the Entertainment Software Association of Canada on the contribution of video games to the Canadian economy and the Association for UK Interactive Entertainment on the contribution of video games to the UK economy. This part of the VR market is estimated to be the most developed to this day. Having said that, there is still maturing and steady growth to be had as the potential of this VR market is fully explored.

3. The flight simulation industry for the highly specialised VR market which includes application areas characterised by a high degree of technical sophistication (e.g. security, specialised medical trainings). The data for the size and contribution of the flight simulation industry was retrieved from the published accounts of CAE which is one of the major players in the industry and a number of other public sources. Due to the sophistication and high technological demands, this VR market is in its infancy. However, it is foreseeable that Europe will play a strong role in developing this sector, precisely due to its complexities and need for top quality and high price tag.

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5. Usk factsheet http://usk.de/research/factsheet
Unfortunately due to the early stage nature of the two industries, data gaps, at such a granular level, remained. It was therefore necessary to make several growth assumptions of the VR & AR market. These included:

- Market for VR & AR professional applications, such as in manufacturing industries, construction or healthcare is a maturing market with a steadily growing adoption rate;
- Consumer mass-market for VR & AR is still in need of a “killing-app” that would drive mass adoption, as well as access to affordable and comfortable hardware, to start a steep growth. Fulfilment of these conditions cannot be estimated quantitatively;
- In terms of professional applications, Europe is likely to be one of the global leaders in R&D and precise technology manufacturing;
- In terms of the global consumer mass-market, Europe is less likely to drive the growth in manufacturing but rather in content production and some software development;
- With the growth of the VR & AR market, higher proportion of population will be equipped with hardware every year. Once a significant part of the consumers and professional users are equipped by a hardware, the growth of the sector will be increasingly by creation of content and to some extent by software development;
- Europe will hold or slightly increase its global market share in VR & AR.

These two steps meant that we had our disposal a database of information on key data points (turnover, annual growth rates, share of the market, employment and value added) at granule level (geographical region, year, type of sector). Based on this data, two growth scenarios were constructed. These are:

- The baseline scenario counts on the steady growth of professional applications of VR, for example in industry and medical training, and on moderate growth of the mass market of consumer applications.
- The optimistic scenario, assumes that a technological breakthrough will lead to optimal conditions for the growth of the mass VR/AR market. For instance, more user-friendly and comfortable hardware will lead to further price decreases, software optimisation will allow minimal motion sickness, and consumer applications (like social VR) and new content will spur the purchase of headsets by a large number of consumers.

The results from the scenarios were discussed and validated with different industry and academic experts. The estimates for VR & AR development in the world and Europe are presented on the next page.

The scenario modelling also included calculations of value added and employment per each of the granular levels mentioned earlier. As well as the assessment of the size of the indirect supply chain impacts. To do this a rather conservative multiplier of 1.6 was used (based on other studies), what has not been valued in the calculations are the induced employment and value added impacts, which occur from personnel working in VR and AR spending their earned salaries.

### Annex C: List of interviewees and events visited

#### Name of the event | Place | Focus
--- | --- | ---
Dutch VR days | Amsterdam, NL | VR & AR fair; talks and panels on VR & AR applications
VR Evolution | London, UK | Talks and panels on VR & AR applications
Virtuality | Paris, FR | VR & AR fair; short presentations on VR application areas
Laval Virtual | Laval, FR | VR & AR fair; round tables on Industrial VR and Near future of VR; Investment forum; VR awards

#### Name of the interviewee | Place | Company/ Institutions | Focus
--- | --- | --- | ---
Noel Schepers | Charleroi, FR | CHU Charleroi | VR application in psychological treatment
BrucenaParis | Gengiskhan production | VR production studio
Jean-Baptiste Nicolas Zuber | Laval, FR | Laval Virtual University | VR trainings
Frederic Blin | Lille, FR | Plain Images Incubator | VR and AR, R&D and applications
Pierre-Julien Marine Haverland | Brussels, FR | Impulse Brussels Brussels' audiovisual cluster | VR applications; VR & AR academic publications
Amand Bordeaux | | VRbnb | VR online platform
Niels Julien-Saint-Laurent Chretien | Laval, FR | Laval Virtual VR & AR event/cluster | EC expert on VR & AR
Rémi Rousseau | Paris, FR | Light & Shadows; Pixyz | Virtuality Paris; short presentations on VR application areas

### Additional Information

- **Virtuality**
  - Talks and panels on VR & AR applications
  - Virtuality Paris: Talks and panels on VR & AR applications
- **Laval Virtual**
  - VR & AR fair; round tables on Industrial VR and Near future of VR; Investment forum; VR awards
- **Dutch VR days**
  - VR & AR fair; talks and panels on VR & AR applications
## Annex D: List of references

- **Cheap ‘mixed reality’ headsets that support AR and VR are coming in 2017, 2016**, [https://mashable.com/2016/10/26/cheap-vr-headsets-windows-10/#hl.deWE6a94](https://mashable.com/2016/10/26/cheap-vr-headsets-windows-10/#hl.deWE6a94)
- **Future Proof Yourself: Tomorrow’s Jobs, 2016**, [http://enterprise.blob.core.windows.net/whitewpoints/futureproof_tomorrows_jobs.pdf](http://enterprise.blob.core.windows.net/whitewpoints/futureproof_tomorrows_jobs.pdf)
- **Augmented Reality and its Potential in Europe**
- **Virtual Reality and its Potential in Europe**
- **Future Proof Yourself: Tomorrow’s Jobs, 2016**, [http://enterprise.blob.core.windows.net/whitewpapers/futureproof_tomorrows_jobs.pdf](http://enterprise.blob.core.windows.net/whitewpapers/futureproof_tomorrows_jobs.pdf)


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