European Commission

The Virtual and Augmented Reality Industrial Coalition

Strategic paper

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ECORYS — Answering tomorrow's challenges today

VR/AR Industrial Coalition

Strategic paper

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The European VR/ AR market was worth around €7.1 billion in 2021 and saw a 26% increase from the previous year. Growth levels are expected to increase by 37% up until 2026.

Sources: Ecorys calculations based on multiple sources
Danish Technological Institute, 2022 – Calculation based on extraction of patents from global patent databases

THE EUROPEAN VR/AR ECOSYSTEM
Key Findings

VR AR
INDUSTRIAL COALITION

MAIN CHALLENGES AND OPPORTUNITIES

Ecosystem fragmentation
Opportunities to boost cooperation

Sovereignty of EU VR/AR industry
Metaverse; access to EU hardware and platform

Education
Aimed at responsible market uptake

Awareness-raising
On characteristics of and opportunities provided by VR/AR

VR/AR talent
Brain-drain and attracting foreign talent

Availability of private financing
Deep-tech and risk financing

AREAS FOR POLICY AND INDUSTRY ACTION

Ensuring sovereignty
of the EU industry

Create an attractive investment environment

Improve awareness of VR/AR uses
and impacts on the ways we live and conduct business

Boost the EU VR/AR industry's unique features
(high-quality, ethical and sustainable solutions)
and promoting those in a global context

Improve VR/AR digital literacy
and educate talents with the right skills

Ensure the deployment of VR/AR
is in line with EU's rule of law

Promote standards
and interoperable solutions

Sources: Ecorys calculations based on multiple sources
Danish Technological Institute, 2022 – Calculation based on extraction of patents from global patent databases

2. Introduction

VR/AR technologies are becoming more prominent in the EU and globally, and contribute both to artistic and cultural purposes, and to industry-related digitalisation of working processes. Understanding their evolution, the most important trends that characterise them, their still untapped potential, as well as the challenges and opportunities faced by the industry, is paramount to ensure the uptake of VR/AR in Europe.

To guide both policymakers and the industry in future actions to support the VR/AR industry, the European Commission (EC), Directorate-General for Communication Networks, Content and Technology (DG CONNECT), has commission the 'VR/AR Industrial Coalition' assignment. This strategic paper sets out its research findings.

The strategic paper is structured as follows:

- The rest of Chapter 2 (Introduction) sets out key facts about virtual reality and augmented reality (VR/AR), describing how immersive technologies work, which components they include, and some features of the industry both at the global and European level. The introductory chapter concludes with a short overview of the European Commission's Media and Audiovisual Action Plan and the objectives of the VR/AR Industrial Coalition.

- Chapter 3 includes findings related to the market assessment exercise based on a variety of sources, including desk research, market reports, a survey launched in the context of this assignment, and stakeholder consultations. The market assessment includes statistics and figures about the size of the market and its trends; description of the main challenges and opportunities experienced in the sector; the innovation potential of VR/AR, as well as innovative business models to promote it; a section on investment instruments and access to funding; and lastly, a focus on existing and required skills in the ecosystem.

- Chapter 4 presents the first case study considered, that is the VR/AR media, creative and cultural ecosystem. The case study presents eight subsectors, exploring for each of them the most important VR/AR applications, the main users, the level of maturity of VR/AR, and European use-cases.

- Chapter 5 presents the second case study, i.e., architecture and design. Structured as the first case study, it presents five subsectors.

- Chapter 6 lays out, based on the study findings, a set of policy assessment and recommendations.

- Methodological notes and the summary reports from the VR/AR Industrial Coalition workshops can be found, respectively, in Annex I and Annex II.

2.1. Context − VR and AR technologies

This subsection provides some background information on the nature of VR/AR as a group of technologies, to clarify its importance for the industry, EU policymakers, and especially creative ecosystems.

Virtual reality and augmented reality are the key technologies when it comes to innovative immersive experiences. Building on the academic definition of the reality−virtuality (RV) continuum (see figure below), it is possible to picture a spectrum with the real environment and VR (a fully digital immersive environment) at its extremes, with AR being in the middle, blending digital content with the real environment.

Figure 1 The reality−virtuality continuum[1]
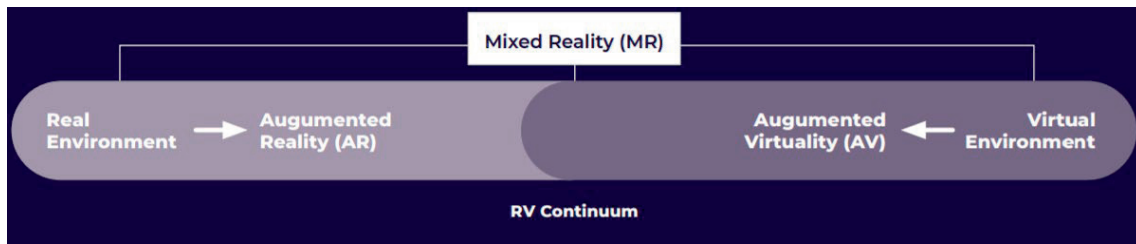
The two main technologies of the RV continuum can be defined as follows:[2]

- **Virtual reality**: An immersive technology that creates an interactive and fully digital environment accessible through different devices. Most of these, at the current state of play, involve the senses of sight and hearing. However, additional hardware exists to involve additional senses, thus enhancing the immersive experience. These include haptic gloves, virtual rooms, and treadmills. Typical examples of VR applications are videogames where users can interact with the completely digital environment around them, or training applications where users can be immersed into a digital simulation of a real-life situation to improve their skills and behaviour.

- **Augmented reality**: A technology that overlays digital information to the real world through a screen of surface onto which the digital information is projected or shown. Smartphone cameras are commonly used as a piece of hardware, as well as head-mounted displays, which are especially useful for enterprise use cases. The best-known AR application has been Pokémon GO,[3] a worldwide experience that allowed to interact with digital Pokémon, framed by smartphone cameras in the real world. Other frequently used applications include overlaying digital images or data to help workers perform their tasks while keeping their hands free.

The other two technologies are included in the continuum, **augmented virtuality** and **mixed reality** (MR). The former refers to the merging of real-world objects into the virtual world,[4] but its consumer awareness and marketisation are limited. Mixed reality, on the other hand, is defined in at least two different ways and together with VR/AR generally falls under **the umbrella term of XR**. While, according to the academic definition presented above, it encompasses all technologies featuring the real-time interaction of physical and digital objects, the term gained market popularity in relation to the Windows Mixed Reality platform. In this sense, MR is its technology, different from VR and AR, rather than an umbrella term. MR as technology is understood as a highly interactive AR application, where virtual objects realistically blend into, and interact with, real objects and/or with the user.[5]

As in most digital technologies, VR/AR entail three basic components at the core of its market composition: hardware, software and content.

Hardware always includes a computing device, which at the current state needs to be high-performing and represents the main source of energy consumption of VR/AR devices. Such a device carries out specific tasks prompted by the software and processes input and outputs. These are provided by dedicated devices, which make up for the rest of the hardware. Output devices show the result of the user interaction with the virtual environment or objects and include displays, speakers and haptic devices. Input devices allow for the

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[1] Milgram and Kishino (1994)*, A taxonomy of mixed reality visual displays*, available <u>here</u>.
[2] Definitions are based on XRA (2020), *XR at a glance*, available <u>here</u>.
[3] Pokémon GO website available <u>here</u>.
[4] Milgram and Kishino (1994)*, A taxonomy of mixed reality visual displays*, available <u>here</u>.
[5] Ecorys (2020), *The potential of XR for Europe*, available <u>here</u>.

interaction to occur in the first place, and could include a camera, microphones, controllers and sensors.

A typical hardware setup for using VR and AR content includes a headset or head-mounted display, equipped with handles to navigate the digital world in the case of VR. Most headsets are produced outside of Europe, with five companies dominating the market in terms of production volumes: Microsoft (US, specialised in AR and MR); Meta (US, which bought in 2014 one of the pioneering companies in VR, Oculus); HTC (Taiwan, one of the early developers of VR headsets in collaboration with Valve); Sony (Japan, mostly involved in videogame applications with its PlayStation VR), and Google (US, which entered the scene with its now discontinued USD 15 Google Carboard, remained with its business-to-business (B2B)-focused Google Glass and heavily invests in AR components of smartphone apps and games). Other manufacturers include Samsung, Magic Leap, and WorldViz. European companies are also in the headset game, with Varjo (Finland, producing high-tech VR headsets) and Lynx (France) being examples of European-produced hardware. Also, AR via mobile is among the most promising areas of augmented reality and projected to grow considerably over the next years,[6] given the high potential of widespread AR-enabled devices such as smartphones.

Software is then developed, either for specific hardware or cross-platform use. Dedicated VR/AR development platforms have been created over time, allowing for the creation of specific content. The higher the user-friendliness of these platforms, the lower the level of technical skills required from the user to create or consume VR/AR content. The most popular three-dimensional (3D) engines used to create VR/AR content are Unity and Unreal, followed by others such as Lumberyard and the German-developed CryEngine.[7]

Software platforms are used to create **content**, which hugely varies depending on its scope. It can regard training sessions to be conducted in VR, guidelines to assemble or disassemble machinery in AR, VR films and artistic experiences, therapeutic sessions, videogames, tools to conduct interactive meetings, and so forth. Content creation typically entails technical development (i.e. coding and development of the architecture behind a VR/AR experience) and graphic design components (i.e. creation of virtual avatars and design of virtual environments and objects).

2.2. The VR/AR industry

The VR/AR industry has matured and expanded over the last few years, both in Europe and globally. At a global level, market forecasts indicate that the **industry is expected to boom**, having the potential to hit the **EUR 766 billion mark in 2025**[8] and to add around EUR 1.3 trillion to the global economy by 2030.[9] Some of the world's biggest companies have been heavily investing in the VR/AR market. For instance, Meta has explicitly linked its future to the metaverse, planning to invest USD 10 billion (EUR 8.7 billion) this year and at least USD 50 billion (EUR 44 billion) in the next years in immersive technologies.[10] It has also released, in late 2021, a new generation of smart glasses in collaboration with Ray-Ban, connected to Meta's social media ecosystem. Google and Microsoft have been in the VR/AR game for the last years, with products such as Google Glass, Google Cardboard and the Microsoft Hololens mixed reality headset series, one of the best-known VR/AR products for enterprises. In early 2022, Sony announced its

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[6] Statista (2022), *Mobile augmented reality (AR) market revenue worldwide from 2019 to 2025,* available here.
[7] Sevreality (2021), *The best game engines for virtual reality applications*, available here.
[8] Market Research Future (2021), *ARVR Market research report – Global forecast till 2027*, available here.
[9] PwC (2019), *Seeing is believing*, available here.
[10] CBS News (2021), *The Metaverse is already here: 5 companies building our virtual reality future*, available here.

PlayStation VR2 headset, and Apple could be entering the market in the coming years with its alleged AR glasses.[11]

In Europe (including non-EU countries), **according to previous Ecorys estimates, the VR/AR industry market size was estimated at EUR 9.6 billion in 2021**, with a 26 % growth from the previous year, and its market value is expected to increase between EUR 35 billion and EUR 65 billion by 2025, directly creating employment for 440 000 to 860 000 people.[12] The EU features a dynamic and growing market ecosystem led especially by companies located in France and Germany, with important developments happening also in the Nordic countries, the Benelux area, Spain and Italy. Among the most important hubs in Europe, main ones include Paris and Laval in France; Berlin, Munich and Hamburg in Germany; Amsterdam in the Netherlands; Helsinki in Finland; Madrid and Barcelona in Spain; and Milan in Italy.

In recent years, VR/AR technologies have become more mature, thanks to an increasing interest from the enterprise world and the introduction of cheaper and smaller headsets for the consumer market. The following table summarises the main developments in the VR/AR world to show the evolution of the technology and the industry.

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[11] Mac Rumors (2022), *Apple Glasses*, available here.
[12] Ecorys (2020), *The potential of XR for Europe*, available here.

Table 1 VR/AR timeline

1974
Myron Krueger establish the Videoplace, an artificial reality laboratory

1986
The Air Force Super Cockpit program applies HMD to create a virtual environment for military purposes

1990
Boing employee, Tom Caudell, introduces the term "Augmented Reality"

1968
The first AR head-mounted display (HMD) system is invented, Sword of Damocles

1977
Electronic Visualization Laboratory develops the first wired glove

1988
Nasa develops the Virtual Interface Environment Workstation

1992
US Air Force designs the first fully immersive AR system

1995
Nintendo launches Virtual Boy

Virtual Reality Modeling Language emerges, precursor to the X3D

2008
BMW launches one of the first marketing campaigns using AR

2007
Google releases Google Street View

1999
ARToolKit emerges, one of the first AR SDKs for mobile

2001
Z-A Production creates t first PC-based cubic room

1997
Virtual reality is used for post-traumatic stress disorder therapy

2014
Facebook (now Meta) acquires Oculus

2015
Google releases Cardboard

Samsung releases Gear VR headset

Sony launches the PlayStation VR

Pokémon Go is released

HTC and Valve release HTC Vive

2016
Oculus Rift is released

Microsoft releases HoloLens

GENERAL SOURCES:
Forbes (2021), The fascinating history and evolution of Extended Reality (XR)
https://www.forbes.com/sites/bernardmarr/2021/05/17/the-fascinating-history-and-evolution-of-extended-reality-xr--covering-ar-vr-and-mr/?sh=466e1f674bfd
HQSoftware (2018), The history of AR and VR: a timeline of notable milestones
https://hqsoftwarelab.com/blog/the-history-of-ar-and-vr-a-timeline-of-notable-milestones/
Verdict (2020), History of virtual reality: Timeline
https://www.verdict.co.uk/history-virtual-reality-timeline/

Apple and Google release respectively ARKit and ARCore, AR development apps

Facebook releases Oculus Go for the masses

2017
IKEA Place app is released

2018
Magic Leap One is released

2019[1]
5G is introduced

A drastic increase in try-on apps (e.g., IKEA Place)

Increased use of AI in VR/AR applications

The Oculus Quest is released

Mobile VR is almost completely abandoned

Varjo releases the world's first human-eye resolution headset [2]

All users of Oculus devices are required to login with their Facebook account

The Oculus Quest 2 is released

Facebook releases Horizon Worlds (social media VR experience)

2020
The COVID-19 pandemic hits

Microsoft HoloLens 2 is released

2021
Full-body tracking technologies are developed by Tundra Labs and HTC

VR arguably leaves the early adoption stage and enter the early mainstream phase

The social VR developer Rec Room becomes a VR unicorn
– a startup valued over USD 1 billion

Several new headsets are expected to be launched: the Sony PlayStation VR2, Magic Leap 2, Meta's Project Cambria (or Oculus Quest Pro), VRgineers' XTAL3, and others.

Facebook rebrands as Meta and claims VR/AR will be the future of the internet in the next years – the metavers

Meta announces it will create 10.000 jobs in Europe to build the metaverse

11 million VR/AR devices sold in 2021.[5]

2022
Qualcomm and Microsoft partner up for the development of lightweight AR chips

NVIDIA launches Omniverse XR, a 3D design and collaboration platform

Meta is dominating the VR standalone consumer headsets (Quest and Quest 2) and is by far the biggest player in terms of VR consumer headsets in general[3], challenged by Valve and Sony, and potentially by iQIYI in the Asia Pacific market.[4]

[1] 4Experience (2020), Where do we stand on with AR in 2019? https://4experience.co/what-happened-in-ar-in-2019/
[2] 4Experience (2020), Varjo headset: The cost of getting 20-20 vision in VR, https://4experience.co/varjo-headset-the-cost-of-getting-20-20-vision-in-vr/
[3] Bloomberg (2022), Meta's Oculus unit faces FTC-led probe of competition practices, https://www.bloombergquint.com/business/meta-s-oculus-unit-faces-ftc-led-probe-of-competition-practices
[4] PR Newswire (2021), iQITI launches new all-in-one VR headset QIYU 3, https://www.prnewswire.com/news-releases/iqiyi-launches-new-all-in-one-vr-headset-qiyu-3-further-expanding-its-premium-vr-gaming-ecosystem-301366852.html
[5] Counterpoint Research (2022), XR (VR/AR) headset shipments to grow 10 times to cross 100 million units by 2025, https://www.counterpointresearch.com/xr-vrar-headset-shipments-grow-10-times-cross-100-million-units-2025/

The general forward momentum of VR/AR can be explained by looking at two main issues:

- the ongoing **technological developments**, which make VR/AR technologies more accessible, more comfortable, and cheaper;

- the **increasing awareness of the potential and benefits of VR/AR** in a wide range of areas – not only in entertainment but in many industry verticals and consumer markets.

VR/AR is also proving to be useful in many application areas (explored in the next section) **and mature enough to become the navigation technology of the future**. This trend is highlighted by the cross-sectoral nature of the technology, as well as its close relationship with other emerging technologies, such as artificial intelligence (AI), the Internet of Things (IoT), big data analysis, 5G, and robotisation. The relation of VR/AR to these technologies is different, also depending on the application considered. For instance, AI can enhance and optimise tools used to create VR/AR content, while 5G enables higher-quality and faster streaming of VR/AR. In many other cases, VR/AR's innovativeness does not stand in the specific content created through it, but in the way it can revolutionise user−machine interaction, potentially making it the navigation tool of the future.

Generally, the COVID-19 pandemic has increased society's digital literacy and awareness due to the need to keep people connected and interact in remote environments. On the VR/AR side, during the onset of the pandemic, COVID-19 disrupted the supply chain, leading to a global logistical collapse. A subsequent disruption of hardware production followed it due to chip shortages, which greatly affected the production of VR/AR hardware. Regardless of the initial disruption, the pandemic increased demand for VR/AR, with VR/AR headset shipments increasing significantly both in 2020[13] and 2021.[14]

2.2.1.1. Introduction to VR/AR applications and sectors

VR/AR encompasses a wide variety of different applications both for the enterprise and the consumer market. Immersive technologies show a high potential when it comes to storytelling,[15] which explains its increasing popularity among consumers of movies, news media, videogames and new kinds of social media platforms built around virtual worlds. Serious implications linked to this aspect relate to the acquisition of **biometric data** from VR/AR technologies, which can tailor the experience for single users based on the acquired inputs.

Both Meta[16] and Apple[17] are showing increased interest in this aspect, which includes eye-tracking, facial recognition, heartbeat, and sweat response. While tapping into and implementing the potential of VR/AR in storytelling, biometric data collection raises serious concerns in terms of privacy and data ownership. The main reasons are two. The former regards the type of information collected by VR/AR sensors, which are sensitive and personal since they involve vital parameters, health-related information and can identify individuals. The second reason is linked to the quantity of information collected and computed, which is much more extensive in comparison to other technologies.

Another crucial VR/AR application is design. Designing 3D objects has great implications both for artists willing to sell their VR/AR content and for designers for the enterprise world,

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[13] Forbes (2021), *Augmented And Virtual Reality After Covid-19,* available here
[14] IDC (2021), *AR/VR Headset Shipments Grew Dramatically in 2021*, available here
[15] Arcagni, S., & D'Aloia, A. (2021), *VR Storytelling: Potentials and Limitations of Virtual Reality Narratives*, available here; Liestoel, G. (2019), *Augmented Reality Storytelling Narrative Design and Reconstruction of a Historical Event in situ*, available here.
[16] Protocol (2022), *Meta is looking into eye-tracking and product placement to make money in the metaverse*, available here.
[17] Biometric Update (2021)*, Apple patents user biometrics-based content engine for VR*, available here.

who can, for instance, model and simulate damage on a 3D model of a car, rather than building a prototype. Moreover, the possibility to conduct otherwise tiresome or dangerous training sessions in VR and all the benefits associated with superimposing digital information on the real world thanks to AR are making these technologies more integrated into the workflows of companies interested in changing the way certain activities are carried out.

Positive trends of VR/AR adoption are slowed by a series of negative factors, which have hindered its uptake among both consumers and businesses. The most important include the cost of the hardware, the lack of killer applications[18] for private use, the discomfort experienced by users (even though the technology and design of headsets have greatly improved in this regard), the direct and indirect costs involved in integrating VR/AR in traditional workflows, and the social acceptance of the technology among both employees and senior management.

One key aspect of VR/AR, emphasised in the next section, is its cross-sectoral nature – making it highly flexible in terms of possible applications and use cases. However, this aspect is often overlooked or misunderstood both by consumers, industry actors and policymakers, who perceive VR/AR as exclusively related to entertainment and video games. Therefore, this trans-disciplinarity often means that projects face additional difficulties in terms of access to finance, or that not all aspects of VR/AR product development are properly addressed.

2.2.1.2. Manufacturing

The inclusion of VR/AR technologies in manufacturing processes has the potential to greatly benefit adopters, especially in terms of increased efficiency and productivity, thanks to traditional processes being carried out in a cheaper and faster way. Employees can also benefit from VR/AR adoption, obtaining higher-quality training, increased security in the workplace, and having an opportunity to upskill their digital knowledge.

A whole range of manufacturing processes can be revolutionised by VR/AR. **Assembly and maintenance** enhanced by AR information can minimise mistakes while reducing the need for on-site support for experts, especially in combination with IoT and AI technologies. Personnel getting at-a-glance details on a specific product or material could also be more efficient in **raw material preparation**, and in **setting up and production** processes.

Product development already highly benefits from VR, since industrial **product design** allows for a more intuitive design phase and an easier customer−manufacturer interaction. The utilisation of 3D models during the **prototyping phase** (referred to as digital twins) brings numerous benefits. Particularly, the creation of sophisticated virtual product models is instrumental in bridging the gap between design and manufacturing and reducing material waste, which is noticeable in cost and time savings.[19]

Another family of applications in manufacturing relates to collaborative working. Several actors are usually engaged during the first stages of prototyping and product designing. Solutions like Varjo-developed headsets allow for an immersive virtual collaborative environment. **Meetings** conducted in a 3D and interactive environment let design teams from around the world to come together in photorealistic virtual spaces, thereby minimising the reliance on physical models and prototypes. Further industry deployments of more established VR/AR applications are **remote guidance** and **activity supervision.** Operators on the manufacturing chain can be assisted by experts remotely when dealing with

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[18] Killer applications are defined as pieces of content and/or software so indispensable or superior to rival products to justify, with their own presence, the purchase of VR/AR headsets or hardware.
[19] B. Schleich et al. (2017), *Shaping the digital twin for design and production engineering,* available here.

equipment issues. Similarly, VR/AR enables remote assistance by highlighting objects or locations in real time or overlaying information in a mixed-reality environment.

Likewise, VR/AR show great potential in terms of **marketing and advertisement** – where its strength in storytelling comes into play. Many manufacturers have started advertising their products using immersive technologies, which is useful in terms of both B2B and business-to-consumer (B2C) communication. Moreover, they can also increase the **customer experience** they provide, offering virtual tours or allowing customers to build their products by customising 3D models.

Other activities enhanced by VR/AR include **training** (one of the most popular, given how personnel tends to learn faster and better, and without incurring safety risks when conducting training sessions), **administrative tasks and logistics**, as well as improved **safety** procedures.

2.2.1.3. Healthcare

Several applications mentioned above are relevant in the medical and healthcare field as well, especially when it comes to training and to some manufacturing activities related to pharmaceuticals.

Training in VR/AR is particularly used in this field, as these technologies allow training under a multitude of different scenarios in a safe environment, helping healthcare professionals to experiment specific situations in a realistic and safe manner. Moreover, **remote collaboration** shows great potential, with specialised surgeons able to provide their inputs possibly from the other side of the world, without needing to travel. Several activities related to running a hospital can also be enhanced by VR/AR, such as in the case of **logistics**, **administrative tasks**, and improved **safety** procedures.

Medical imaging has developed rapidly to play a central role in medicine today, by supporting diagnosis and treatment of diseases through various technologies such as magnetic resonance, ultrasound imaging, etc.[20] However, these information technologies produce two-dimensional (2D) images. The uptake of VR/AR solutions enables the representation of 3D structures, such as tissues or organs, thereby facilitating more effective procedures and treatments. In this field, the European Tampere University is leading a research consortium, with other relevant European players like Varjo, to explore ways to present medical imaging data in combination with 3D methods.[21] The project aims to leverage VR, multi-sensory presentation, 3D printing, and haptic feedback to provide new ways to interact with medical imaging.

VR/AR is also used directly to **treat and assist patients**. It is particularly useful in cases of psychological disorders such as phobias, addictions, eating disorders, or people with compromised physical capabilities. The technology has already been providing positive results on pain, stress relief and rehabilitation. For example, there are modern rehabilitation techniques that involve VR/AR: it can help optimise rehabilitation protocols, accelerate patients' recovery, promote treatment adherence, and ease reintegration into daily life.[22]

Medicine can also use VR/AR to **enhance better lifestyle** habits and even prevent the insurgence of specific pathologies. Virtual environments are used to deal with obesity patients in order to stimulate physical activity by means of gamified experiences. In a comparative approach, the Horizon 2020-funded project Holobalance employs AR technology to create a personalised hologram coach platform for the rehabilitation of elderly people with balance disorders.

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[20] World Health Organisation (WHO), *Strengthening medical imaging,* available here
[21] Tampere University (2019), *Tampere University is revolutionising medical imaging with the help of virtual reality and AI*, available here.
[22] As stated in the VR4REHAB project, available here.

2.2.1.4. Construction and architecture

In construction and architecture, the application of VR/AR technologies is similar to that in manufacturing, where they have a specific applicability during the **product design** and **prototyping** stages. The integration of immersive technologies in building information modelling (BIM) is a key element to create a digital representation of a facility.

Collaborative working applications, such as **VR meetings** and **remote guidance** to on-site personnel, are starting to be used. **Marketing** and **consumer experience** potential of VR/AR is being used to show customers how a building could look once finished, or to allow 3D tours of a facility. The **storytelling**, implicit especially in VR, can be applied to design-related aspects of interiors, creating visual experiences for customers. IKEA Place, an AR app, is a notable case in point. The app makes use of AR to virtually place true-to-scale 3D models in the device. This enables the user to experience how the furniture will look in their space.

Moreover, **training** and other horizontal activities conducted in VR/AR are also used in construction and architecture, allowing unlimited practice at no additional cost and improving safety in more realistic and job-site specific environments. In construction, for instance, VR/AR can be used for various training purposes, such as to inspect equipment, practice proper safety procedures and hazard avoidance, working under extreme conditions and experience consequences.[23]

More details on architecture and design are provided in the dedicated in-depth case study in Chapter 5.

2.2.1.5. Learning

The biggest VR/AR applications in the education sector relate to the development of pupils and students and the **awareness-raising and learning** potential of stories and content produced in a fully interactive environment. For instance, science or history lessons can be made more engaging if delivered in VR, or salient information of the framed piece of art could appear through an AR application. VR/AR could also revolutionise the way teaching and classroom activities are conducted, with **remote conferencing** settings becoming more important after the COVID-19 pandemic.

The potential of VR/AR as a tool for **remote learning**, coupled with factors such as the reduction of cost and the spread of the technology, enables its applicability to other areas, such as supporting education in remote and rural areas, improving access to education, and bringing further equality of opportunities.[24]

VR/AR can be used both in **higher education, universities and in vocational training sectors**. These technologies allow learners to explore content through a multi-sensory experience. This has proven beneficial among students, as it enhances the learning effectiveness process and positively changes learners' attitudes towards learning[25] The technological applications are significantly appropriate for vocational training, as they allow digital content to be embedded in real or virtual environments, thus enabling content visualisation and interaction. VR/AR enable learning-by-doing processes, which include the interiorisation of movements and practical activities as opposed to theoretical-only studies, generally associated with an overall better learning experience.[26]immersive).

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[23] PIXO VR (2019), *Virtual Reality for Construction Training*, available here
[24] Iping Supriana (2007), *The Use of Virtual Reality System for Education in Rural Areas*, available here.
[25] Kuleto et al. (2021), *Extended Reality in Higher Education, a Responsible Innovation Approach for Generation Y and Generation Z*, available here.
[26] Fehling, Christian & Müller, Andreas & Aehnelt, Mario (2016), *Enhancing Vocational Training with Augmented Reality*, available here.

2.2.1.6. Retail

In retail, the most relevant applications mainly exploit the possibilities offered by AR. Generally displaying more potential than VR, AR is applied primarily in **customer care**, **advertising** and **marketing**. Customers can use VR/AR applications to browse a store's content without physically visiting its facilities, try out clothes and other articles from home, and even see what a certain piece of furniture would look like in a room.

In this context, try-before-you-buy VR/AR-powered experiences are becoming more widespread, such as the L'Oréal augmented reality experience that allow customers to try products through the use of their smartphones. Linked with e-commerce opportunities, these experiences can facilitate purchases and result in higher revenues for retailers.

In addition, non-fungible tokens (NFTs)[27] can take advantage of VR to create new opportunities for retailers, who can sell entirely digital products through e-commerce practices. In terms of advertising, VR/AR tend to surprise the audience due to the novelty effect of immersive technologies, increasing brand recognition and sales.

Virtual solutions allow retailers and customers to explore, experience and discover a wide range of products. They permit retailers to reach remote customers without the need for new physical shops or additional staff. Moreover, new forms of advertisement in VR are being developed with the increasing importance of the metaverse, for example in the form of mini-games advertising a specific product.

2.2.1.7. Cultural and creative ecosystem and media

The **storytelling** potential of VR/AR makes it particularly attractive to this sector. Emerging formats such as 3D movies, VR/AR pieces of narrative, **awareness-raising** films, and videogames can benefit from the added immersion granted by these technologies. VR/AR also shows potential in augmenting books and stories, adding drawings or animating characters. Many cultural activities already benefit from VR/AR content, such as museums, schools, exhibitions, and tourist locations, and some traditional activities are being revolutionised by the use of VR/AR in the workflow.

This sector, which entails media, cultural activities and video games, and its applications are explored more in detail in its dedicated in-depth case study in Chapter **Error! Reference source not found.**.

2.3. The European Commission's Media and Audiovisual Action Plan and the VR/AR Industrial Coalition

The European Commission's dedication to promoting digitalisation in Europe is reflected by the **Europe fit for the digital age**[28] political priority, which is regarded as crucial by the Von der Leyen Commission. The digital transformation could bring major competitiveness advantages, and help to provide solutions to social and environmental issues.

This priority has taken the form of the EU's long-term strategy **Shaping Europe's Digital Future**.[29] Under this approach, many different programmes envisage funding for digitalisation purposes: these include the Digital Europe Programme, Horizon Europe, the European Structural and Investment Funds, the European Funds for Strategic Investments, and the Connecting Europe Facility.

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[27] These are further explored in Case Study 1.
[28] European Commission (2019), *A Europe fit for the digital age*, available here.
[29] European Commission (2020), *Shaping Europe's digital future*, available here.

Another sign of the European Commission's activities in fostering digitalisation are **Europe's Digital Decade targets for 2030**,[30] a set of objectives for the digital transformation revolving around four main areas – skills, government, infrastructure and business. Achieving these targets, especially those related to infrastructure (given the importance of bandwidth and high connectivity in VR/AR) and skills (as digital literacy and awareness are crucial for spreading immersive technologies) would prove extremely beneficial for enhanced uptake of VR/AR.

Specific attention has been devoted by the Commission to the cultural and creative sectors, including the media sector, a driver for the development of digital technologies and content. The most important programme on a European level in the field is Creative Europe. The programme's Cultural and Media strands are designed to support, among other things, small and medium-sized enterprises (SMEs), businesses, and content creators in digitalisation efforts, also in terms of VR/AR. Also the European Commission's flagship research programme, Horizon Europe (and its predecessor Horizon 2020) play an important role in supporting digitalisation and the development of VR/AR technologies.

Additional efforts from the Commission include the 2018 revision of the Audiovisual Media Services Directive[31] and, especially, the **Audiovisual Media Action Plan**,[32] designed to achieve three overarching goals – recover, transform, and enable and empower the media sector, ensuring its resilience and paving the way for future digitalisation through ten actions.

The **VR/AR Industrial Coalition** and the **VR Media Lab** are two key initiatives within the **Audiovisual Media Action Plan** aiming to boost the performance of the VR/AR industry in Europe and support its optimal deployment. The VR/AR Industrial Coalition is a platform for structured dialogue between the European VR/AR ecosystem and policymakers. It aims to inform policymaking, encourage investment, facilitate dialogue with stakeholders and identify key challenges and opportunities for the European VR/AR sector. It does so by taking a broad cross-sectoral approach involving industries, technology providers and creatives. The coalition has several components:

- workshops with stakeholders organised from November 2021 to February 2022;

- this strategic paper with a market assessment of the European VR/AR ecosystem;

- an event organised in April 2022, where the results were presented and key industry actors were able to commit to objectives for optimum deployment of VR/AR.

All these activities are intended to inform policymaking in terms of next steps to be undertaken to favour the integration of VR/AR technologies in Europe, as well as to foster dialogue within the industrial ecosystem and fill the gaps caused by the fragmentation of the ecosystem. The rest of the strategic paper provides a picture of the current market situation, deep dive into two case studies (media, cultural and creative ecosystem, and architecture and design), and conclude with policy recommendations to foster VR/AR in the near future.

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[30] European Commission (2021) *2030 Digital Compass: The European way for the Digital Decade*, available here.
[31] European Commission (2018), *Audiovisual Media Services Directive (amendment)*, available here.
[32] European Commission (2020), *Europe's media in the digital decade: An Action Plan to support recovery and transformation*, available here.

3. Market assessment of the VR/AR industry and ecosystem

The following sections present the results of the market assessment, which aim to examine the current state of play of the European VR/AR ecosystem. In particular, the objective is to assess the fast-changing landscape of immersive technologies in Europe by addressing the following topics:

- **assess the VR/AR market size and importance** by providing a snapshot of the key market trends and how the industry look like in 2021, as well as investigating the conditions for the future optimal deployment of these technologies;

- **identify key challenges and opportunities** that could hamper or stimulate the development and uptake of VR/AR solutions in Europe;

- **analyse the innovation potential of VR/AR technologies** and provide some insights on business models;

- **assess financing/funding opportunities and trends** for VR/AR companies in Europe and their characteristics;

- **assess the need, availability and access to relevant skills** in the ecosystem.

The market assessment relies on a combination of various information sources,[33] including targeted desk research, a survey of 109 VR/AR organisations in Europe, expert interviews, a series of workshops organised to cover relevant research topics, tech mining, and insights collected through relevant event attendance.

3.1. Size, importance and trends

Following a short-term setback and slowdown driven by the pandemic, the EU VR/AR industry has bounced back to a steady level of growth. This growth is driven by Europe's leading role in several industries and service sectors where VR/AR demand is trending upwards, such as increasing demand for remote collaboration and online digital interaction as a result of the pandemic, as well as the continuing advancements in hardware, software and content creation.

Both **VR and AR technologies are no longer considered emerging, but rather maturing technologies**. It is important to note that, according to different estimates, the maturity phase has not been reached yet, but it is not likely to happen before the next 5 to 10 years.[34] On top of technological maturity, social awareness and acceptance play a key role in the adoption rates of VR/AR.

To determine the size of the growing demand for VR/AR solutions, the current size of the market has been assessed based on the analysis of different market studies and estimates, complemented by insights collected via expert consultations. **The EU VR/AR market size was estimated at EUR 7.1 billion in 2021**, with a 26 % growth rate from the previous year (see figure below). This **growth is expected to continue** over the next years **at an estimated 37 % CAGR**[35] **between 2021 and 2026**.

According to previous Ecorys estimates, over 2020-2025, the market growth can also be expected to generate a **gross added value of roughly between EUR 20 billion and**

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[33] More details on the methodological approach are provided in Annex I.
[34] Ecorys based on Gartner Hype Cycle.
[35] Compound annual growth rate (CAGR).

EUR 40 billion, and directly create new **employment for 440 000 to 860 000 people**.[36] These forecasts were based on two scenarios, a baseline and an optimistic, considering different parameters and potential future developments mostly related to the growth of the mass market for consumer applications and their take-up.

Figure 2 EU VR/AR market size – billion EUR (2020−2026)
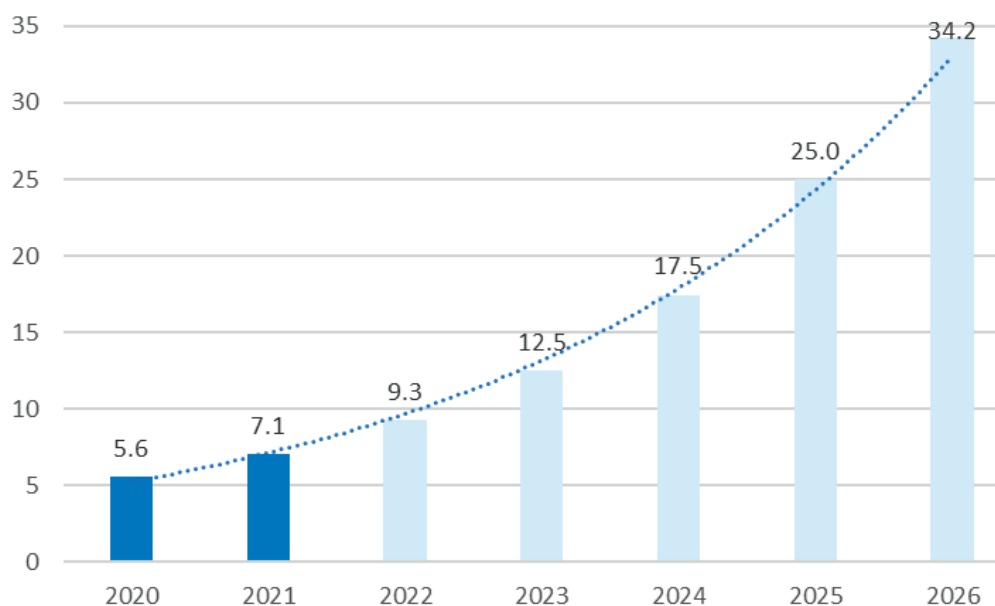
Ecorys calculations based on multiple market reports[37]

VR/AR hardware has improved considerably in recent years, with advances spanning from inside-out tracking, improved chipsets and more powerful processors. **More affordable, powerful, standalone and wireless VR headsets** to produce immersive experiences (e.g. Meta's Quest 2[38] featuring a lighter weight and a display with a higher refresh rate[39] and per-eye resolution), as well as increasingly **sophisticated AR devices** are being made available by big tech companies (e.g. Microsoft's HoloLens 2[40] featuring a wider field of view and improved holographic processing unit).

This is leading to higher levels of performance and consumer demand for headsets, driving more innovation and investment in VR hardware, especially in techniques and designs to make the next generation hardware for mass adoption, which is expected to come by further reducing the size, weight and price of devices while maintaining or improving capabilities.

In Europe, there are companies highly active in the research and production of more advanced hardware, although the vast majority of the hardware market share is still held by the non-EU tech giants.

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[36] According to previous Ecorys estimates, available here.
[37] See methodological annex.
[38] https://www.oculus.com/blog/five-years-of-vr-a-look-at-the-greatest-moments-from-oculus-rift-to-quest-2/
[39]The refresh rate refers to the frequency that a display updates the onscreen image, i.e. how many times per second the display is able to draw a new image (measured in hertz).
[40] Hololens website available here.

Examples of EU hardware providers

Varjo[41] (Finland) is producing high-tech VR headsets and solutions for the enterprise market across various industries for different purposes, such as training and simulation, design and engineering, and research.

- Lynx[42] (France) is at a pre-production phase, meaning that the design and the components have been validated and are ready to be manufactured. The first batch is planned to be dispatched in April 2022 to those who backed Lynx's Kickstarter campaign.

- VRgineers[43] (Germany) is a VR engineering company developing high-end VR gear and training systems for professional pilots.

- EU SME examples include companies such as Lightspace[44] (Latvia), a deep-tech company leader in volumetric, multi-focal and light field technologies for AR, and Iristick[45] (Belgium), which is designing and manufacturing smart safety glasses for various industrial and professional purposes (e.g. remote assistance, step-by-step workflow guidance and pick-by-vision).

Advancements are also being made in software/content development, with **more high-quality and compelling content, less motion sickness, and significant work being conducted on quality standards**. Various successful consumer products are having an impact on expanding the consumer market and promoting familiarisation with immersive experiences. For instance, despite some controversies,[46] Pokémon GO helped popularise AR technology, at its height sending over 250 million players into the streets in search of virtual monsters.[47]

The European ecosystem relies on a maturing industry strong in software and content development, and on a creative culture with high research and innovation potential. Various important cultural events are promoting the use of VR/AR technologies. La Biennale di Venezia, for instance, promotes the development and production of VR projects for cinema within the framework of the prestigious Venice Film Festival.[48]

Similarly, NewImages Festival[49] is a festival created by the Paris Virtual Film Festival and is entirely dedicated to all forms of digital creation and virtual worlds. Moreover, there are various examples of successful immersive experiences, such as the recent VR concert performed by Finnish band Nightwish, with Finnish company Zoan[50] being responsible for the technical implementation and creation of the virtual world.[51] The event, fully moved into a virtual format due to the pandemic, attracted more than 150 000 viewers on the first night.

Nevertheless, despite Europe's large potential industrial market for VR/AR, the **adoption of these technologies is still relatively low compared with other digital technologies**, as found for instance by the annual European Investment Bank (EIB) Investment Survey.[52]

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[41] Varjo website available here.
[42] Lynx website available here.
[43] VRgineers website available here.
[44] Lightspace website available here.
[45] Iristick website available here.
[46] CBS News (2016), *The dark side of Pokemon Go*, available here.
[47] Business of Apps (2022) available here.
[48] La biennale di Venezia (2021), *Biennale College Cinema - Virtual Reality: The International Section New Call*, available here.
[49] NewImages Festival website available here.
[50] Zoan website available here.
[51] Helsinki Times (2021), *Nightwish's virtual concert broke records*, available here.
[52] EIB (2021), *Digitalisation in Europe 2020-2021*, available here.

As shown in the figure below, only 9 % of the digital[53] companies interviewed adopted any VR technologies, lower than all the other digital technologies investigated. Similarly, other studies also show that the actual use of VR and AR is still somewhat limited, especially among SMEs, with most companies not using these technologies or doing so either rarely or occasionally.[54]

Although VR/AR adoption rates are very heterogeneous across EU countries and industrial sectors with various success stories in many of them, these numbers suggest that the general uptake of these technologies in the EU is still far from its full potential and optimal deployment, compared with other advanced digital technologies.

Figure 3 Adoption of digital technologies in the EU (% of firms already using at least one advanced digital technology)
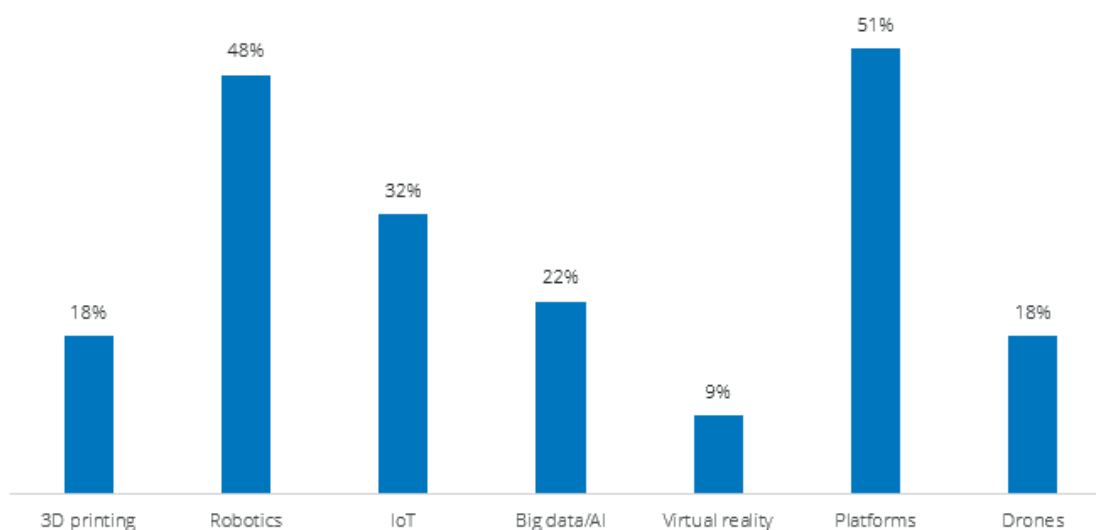
Source: Ecorys based on EIB data

The performance of the European ecosystem and its optimal deployment of VR/AR technologies in the coming years will depend on the ability to meet and address some conditions and challenges on regional, national and European levels. Notably, **several drivers will affect the best possible uptake of VR/AR technologies**, including:

- **Technological**: The ecosystem will need to advance the deployment of necessary infrastructure and enabling technologies (e.g. 5G and wireless networks) instrumental for the optimal deployment of VR/AR, but also other advanced technologies as those listed above. As found by the European Court of Auditors, for instance, all Member States except four[55] met the 2020 intermediary objective of having at least one major city with 5G access, but many are not on track with the deployment of their 5G networks and achievement of 2025 objectives.[56] In addition, the ecosystem will have to develop more interoperable solutions (e.g. across Member States and industrial sectors) and play a greater role in developing state-of-art hardware and platforms. Notably on the latter, **boosting EU platforms/hardware would be a gamechanger** that has not been considered yet in future estimates of the market and could **potentially stimulate a completely different trajectory of the industry**.

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53 In the EIB report, a firm is identified as digital if at least one advanced digital technology is implemented in parts of the business
54 VAM Realities (2021), *The State of Augmented Reality, Mixed Reality and Virtual Reality adoption and use in European small and medium-sized manufacturing companies in 2020,* available here
55 Cyprus, Lithuania, Malta and Portugal.
56 European Court of Auditors (2022), *Press release*, available here.

- **Financial:** Increasing the breadth, relevance and adequacy of public and private funding and financing opportunities will be crucial to speed up further maturity and wide adoption of the technologies.[57] Addressing the financing needs of companies and improving access to the right opportunities will likely **ease the scaling up of companies** from small to medium/large players, with more of them potentially **reaching new markets and driving exponentially up the market size**.

- **Social**: **Raising awareness**, **expanding the potential user and customer base** by improving VR/AR literacy and skills, and **increasing accessibility** to these technologies will be key for public acceptance and retention. The optimal deployment will be defined by the social impacts of these technologies, namely their ability to accommodate and respect important principles, such as diversity and inclusiveness, safety and security, privacy, as well as ethical applications.

Looking at the importance of the different industrial sectors (see Figure 4), according to this paper's estimates, **gaming is capturing a relative higher share of the VR/AR market in Europe (29 %)**, followed by media and entertainment,[58] retail, healthcare, manufacturing, and military and defence. In the consumer market, gaming appears as the main adopter and more mature market segment.

Various sectors are trending upwards and, in the future, more uptake is expected for social interactions and entertainment purposes. In particular, **the VR/AR media and entertainment sector[59] is estimated at EUR 1.32 billion**, accounting for **18.6 % of the overall VR/AR market**. This figure represents a small share of the overall EU media and entertainment industry (less than 1%[60]), suggesting a still rather limited deployment and uptake of these technologies from the sector, but it is **expected to increase substantially in the coming years,** according to stakeholders.

Figure   4   European   VR/AR   market   size   per   sector,   2021   (%   of   total)
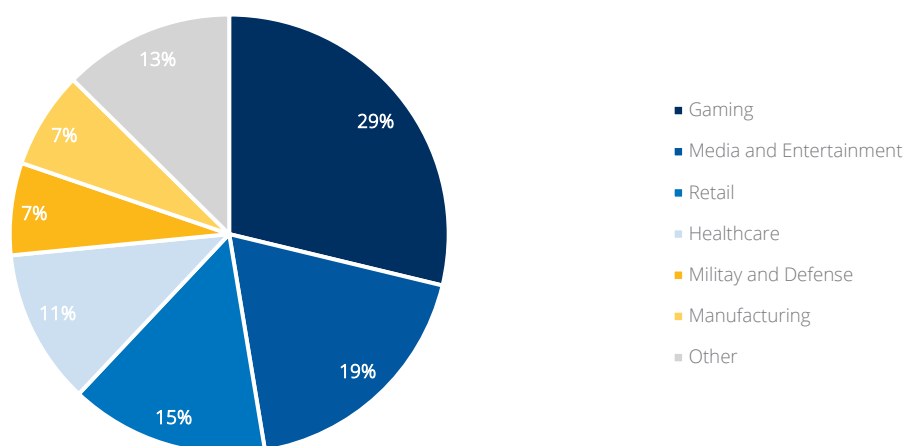
Source: Ecorys calculations based on multiple market reports

While not intending to draw an exhaustive nor representative picture, the survey indicates the characteristics of VR/AR actors operating in Europe. According to responses (Figure 5),

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[57] For further details, see chapter 3.4 on *Investment instruments and access to funding*.
[58] For the relative importance of the different media subsectors, see Chapter 4.
[59] Note that the estimates of the VR/AR media and entertainment sector are based on multiple sources that use a sectoral scope which cannot be precisely matched with the Eurostat classification and sub-sectors presented in Case Study 1 of this strategic paper.
[60] Compared to turnover generated in 2019 by enterprises in the following sub-sectors: i) Printing and reproduction of recorded media; ii) Book publishing; iii) Publishing of newspapers, publishing of journals and periodicals; iv) Motion picture, video and television programme production, sound recording and music publishing activities; v) Programming and broadcasting activities; vi) News agency activities. Source: Eurostat

the size of most organisations is small (up to 50 employees), with **a vast majority of micro-companies** (up to 10 employees), and fewer respondents represent medium (50−250 employees) or large entities (more than 250 employees).

On the latter, note that respondents from larger organisations mainly came from research centres or universities, while few were representing large companies. This is complemented by the finding that more than half of respondents generate an annual turnover lower than EUR 1 million (

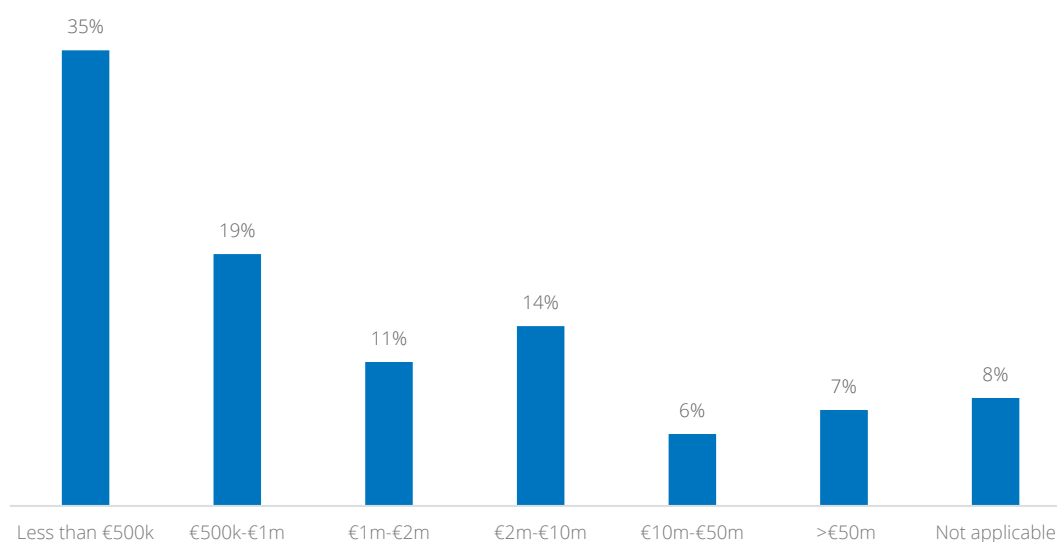Figure 6).

On average, 70 % of respondents' work is related to, or makes use of, VR/AR technologies, with the majority of them focusing on both AR and VR (59 %), less only on VR (30 %), and a small percentage focuses purely on AR alone (11 %).

Figure 5 How many people are employed in your organisation?
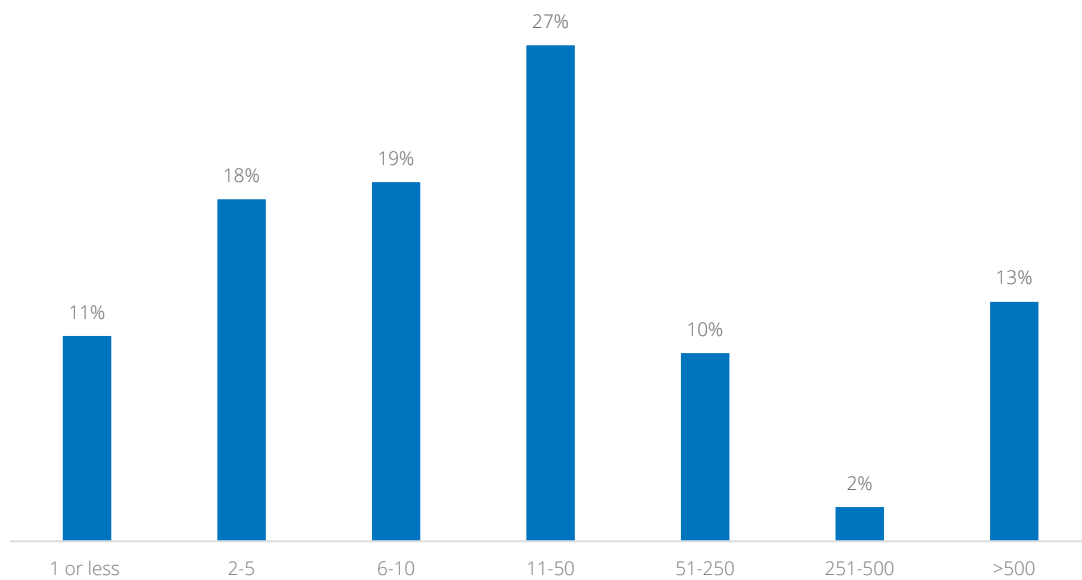
Source: Ecorys survey (N=109)

Figure 6 What is your organisation's annual turnover?

Source: Ecorys survey (N=109)

3.2. Challenges and opportunities

This section presents the main challenges to be addressed and opportunities that could be exploited to favour the technological uptake of VR/AR. The main sources have been the various forms of stakeholder consultations such as workshops, interviews and survey.

These challenges and opportunities encompass different aspects of the technology and the ecosystem, and range from technological to business, societal, financial and legal. Five categories of challenges and opportunities are described in the next sections to highlight the reasons for their importance, the potential impact caused by not addressing them, and the perceived role they have according to the main actors in the VR/AR ecosystem.

Different stakeholders tend to perceive topics of interest in different ways, depending on their expertise and line of work – meaning that it is not always possible to clearly state whether something is perceived as a challenge rather than an opportunity by the whole VR/AR community. However, it is possible to identify which topics, items and aspects should be prioritised by either policymakers or the industrial community, according to stakeholders.

One overarching aspect, which runs horizontally among the categories just described, relates to the **sovereignty of the EU VR/AR industry**, or rather the lack thereof. While the European ecosystem is very strong when it comes to talent, research, and content development,[61] it presents more challenges in terms of software development (the most important marketplaces and platforms are not European) and especially hardware development.

The EU industry is dependent on hardware coming from non-EU countries, both in terms of pieces required to assemble a headset and of headset selection itself.[62] **Most VR/AR headsets come from the US or Eastern Asia** (Japan, South Korea and Taiwan being the most active producers). The same applies to most hardware required to use VR or AR technologies (for instance smartphones, computing-related hardware, sensors, etc.). This notion of technological or digital sovereignty, while applicable to the VR/AR ecosystem,

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[61] As demonstrated by Meta's efforts to enter the EU labour market.
[62] Interview findings.

relates to a general issue of European dependence on non-EU actors – often, Chinese hardware is used to connect devices and consume content on US-based platforms.[63]

The risk to the European leadership and strategic autonomy in the digital field (including the VR/AR technologies), is associated with the economic and social influence of non-EU companies to EU citizens and businesses. Several stakeholders consulted and other sources point to concerns related with EU's independence in the digital or in this case the virtual world. The list of potential issues associated with the absence of big European headset producers and platforms is long and impacts citizens, businesses as well as public authorities. Concerns include the EU citizens' control (or lack of it) over their personal data, growth and innovation potential of companies in the digital field as well as difficulties of national and EU rule-makers to enforce their laws.[64]

In addition, large market players in VR/AR, such as the companies that currently produce headsets and marketplaces, or those (if not the same) that will develop and operate virtual worlds, will likely be the ones who shape the market and commence trends. For instance, types and forms of content that will be made available, allocation of benefits between creators and platforms, payment models etc. are some issues which could be heavily influenced by these large companies, not only within their activities and direct sphere of influence but also in the market as a whole.

The emergence of large VR/AR companies such as hardware producers and platforms within Europe is essential from the sovereignty perspective. Succeeding to get a significant portion of the global market share would have significant positive economic impact, including direct and indirect employment creation and value added for Europe. In addition, these players would act as marketplaces and content and software development platforms, unlinked from specific pieces of hardware or tied to European ones, should they become successful in the market in the near future.[65] Therefore, they would be able to co-lead in the global developments of VR/AR reduce dependency on non-European actors and act as catalysts for the European leadership and strategic autonomy in the VR/AR industry.

The main challenges and opportunities are summarised in the table below, which includes the most important challenges and opportunities identified. Annex II provides a description of the methodology used and of the dimensions considered, alongside a long list of items identified throughout the data collection process, which are also deemed as significant from stakeholders consulted but after thorough assessment of their relevance to and importance for the VR/AR industry as well as frequency in occurrence in the sources considered are not shortlisted.

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[63] BertHub.eu (2021), *Europe's software problem*, available here.
[64] *European Parliamentary Research Service (2020), Digital sovereignty for Europe, available here.*
[65] The most promising companies in terms of headsets are Varjo (Finland) and Lynx (France).

Table 2 Most important challenges and/or opportunities facing the EU VR/AR sector

	Item	Challenge/opportunity/ nuanced	Impact of not addressing	Specificity of measures to VR/AR	Occurrence in sources
Horizontal	**The sovereignty of EU VR/AR industry** Metaverse, access to EU hardware and platform, etc.	Challenge	Very High	No	Very frequent
Technological	**Infrastructure** Enabling networks, 5G, etc.	Challenge	High	No	Frequent
Technological	**Accessibility** Cost and availability of VR/AR hardware, user experience, etc.	Nuanced	High	Yes	Frequent
Technological	**Interoperability** EU-wide standards and common formats	Nuanced	Medium	Yes	Frequent
Technological	**Content development** High-quality content development	Opportunity	Medium	Yes	Frequent
Business	**Ecosystem fragmentation** Opportunities to boost cooperation	Challenge	Very High	No	Very frequent
Business	**Absence of scale-ups and unicorns**	Challenge	High	No	Frequent
Social	**Education** Aimed at responsible market uptake	Opportunity	Very High	Yes	Very frequent
Social	**Awareness-raising** On characteristics of, and opportunities provided by, VR/AR	Nuanced	Very High	Yes	Very frequent
Social	**Ethical applications** Data protection, user-centred applications, etc.	Opportunity	High	No	Frequent
Social	**VR/AR talent** Brain drain and attracting foreign talent	Challenge	Very High	No	Very frequent
Social	**In-depth understanding of impacts of VR/AR** Environment, educational, psychological, etc.	Nuanced	Medium	Yes	Frequent

	Environmental sustainability VR/AR applications, incentives for businesses	Nuanced	Medium	Yes	Less frequent
	Diversity in the VR/AR industry VR/AR applications, incentives for businesses	Opportunity	Medium	Yes	Less frequent
Financial	**Availability of private financing** Deep-tech and risk financing	Challenge	Very High	No	Very frequent
	EU level funding schemes Availability, adequacy and multi-disciplinarity	Challenge	High	Yes	Frequent
Legal	**EU level strategy and coordination** At regulation, strategic and policy level	Nuanced	High	Yes	Frequent
	Enforcement of EU regulation Preparedness of enforcement authorities in the virtual world	Challenge	High	No	Frequent
	Regulatory burden for innovation Legal uncertainty, innovation-enabling framework	Challenge	High	Yes	Less frequent
	User safety Safety of the user in the physical and digital space	Nuanced	Medium	Yes	Frequent
	Security Security in the metaverse era, cybersecurity	Nuanced	Medium	No	Frequent

Acknowledging and addressing these challenges and opportunities could be very beneficial for the overall ecosystem. Many of them have direct relation to the **Europe's Digital Decade targets for 2030**[66] – especially those regarding skills, digital transformation of businesses, and secure and sustainable digital infrastructures. Reaching these targets would in fact contribute to the development of VR/AR technologies in Europe, fostering their uptake and improving the overall ecosystem.

The following sections provide more details on the key challenges and opportunities identified across the five categories.

3.2.1. Technological

Immersive technologies have greatly developed in the last few years. After the 2016 great hype in VR/AR and the following wave of disillusionment that took hold of the market,[67] **VR/AR is now much more mature**, as it has had the time to fix many of the technical issues that hindered its uptake. This is the case especially for VR,[68] as it attracted interest from the market at an earlier stage and can count on more hardware and software platforms. But AR technologies are also getting more mature and market-ready, with many cases in enterprise and applications for the consumer market (e.g. Pokémon Go), as well as improvements being made available for AR devices, such as Apple's LiDAR for smartphones and iPads,[69] delivering a new type of depth-sensing for AR and 3D scanning.

This position is confirmed by the fact that none of the key challenges and opportunities highlighted as the most important in Table 2 relate to the technological category. **The technology is there and perceived to be developed enough to foster additional VR/AR uptake in the market**. Further efforts can **improve aspects related to accessibility**, such as the cost of hardware, **remaining (marginal) motion-sickness issues**, and the **design and comfort of headsets**.[70] Today, immersive technologies mostly involve two senses – sight and hearing. More technological development is necessary to ensure the additional rollout of existing haptics devices and to involve more senses, such as touch.

The most pressing issue identified relates to **supporting infrastructure**, crucial for unlocking the true potential of many VR/AR applications. The relatively slow rollout of 5G in Europe is a cause of concern among VR/AR stakeholders,[71] as the streaming of VR/AR content, especially in the 8K era, requires high-speed download and upload, as well as large bandwidth.

For instance, European telecommunication giants Orange and Deutsche Telekom made an 'extended reality (XR) partnership', advocating for the importance of 5G for the further development of immersive technologies.[72] The rise and popularisation of blockchain infrastructure is also perceived as important for the further development of VR/AR. The de-centralised payment system allowed by blockchain is the key aspect behind the purchase of digital content ownership rights – the concept of NFTs, expected to be highly important

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[66] European Commission (2021), *2030 Digital Compass: The European way for the Digital Decade*, available here.
[67] Wired (2017), *2016 was the year Silicon Valley's hype machine sputtered*, available here.
[68] Jabil (2021), *What is the future of Augmented and Virtual Reality Technology?*, available here.
[69] Apple (2020), *Apple unveils new iPad Pro with breakthrough LiDAR Scanner and brings trackpad support to iPadOS*, available here
[70] Design News (2020), *Researchers are looking for ways to make VR less painful*, available here.
[71] Workshop and interview findings.
[72] Orange (2020), *From smartphones to glasses: 5G supports the development of extended reality (XR)*, available here.

in the VR/AR-enabled metaverse.[73] The importance on NFTs is further explored in Case Study 1.

An area seen as a major opportunity by most stakeholders is that of **content development**. Europe can nourish talented workforce able to produce high-quality content though top-notch educational programmes. European companies taking advantage of the rich cultural heritage in the region and the available infrastructure and talent are excelling in producing creative VR/AR content. In addition, the access to one of the most technologically advanced global market with long industrial tradition creates high demand of professional VR/AR applications. These conditions create an ideal landscape for high-quality content development. .

3.2.2. Business

While the technology readiness is improving rapidly, the **European market is not reacting as fast**. To become a mainstream technology, VR/AR needs to have a mature business environment where start-ups are supported, possibilities of cooperation between Member States are encouraged, and a strong EU-wide ecosystem (encompassing hardware, software, and content creators) is created to connect the whole value chain and ensure equal access to the digital single market. According to most stakeholders, this is currently not the case, or at least there is wide room for improvement.

Fragmentation of the EU VR/AR ecosystem is one of the major challenges encountered by companies willing to develop, apply, promote or invest in immersive technologies.[74] Some occasions for cooperation and exchange exist, fostered, for instance, by EU-wide initiatives such as XR4ALL[75] before, and now its continuation XR4Europe[76]), or other associations (i.e. EUROXR, Euromersive) and fora of exchange such as events (i.e. VR Days). However, the rapid technological and business developments require more intense and deeper forms of collaboration.

Potential objectives of such an intensified collaborations could include the creation of apan-European platform – able to bring together several players from the European ecosystem, while respecting shared EU values, such as data privacy and ownership. Such a platform would encompass European hardware (a headset), coupled with EU-owned software platforms where content creators would be able to sell their games or experiences.

European software platforms do already exist, often targeting a specific market area. One of them is VRdirect,[77] which provides an editor, a native app, a cloud-based infrastructure, and a player for internet browsers to easily allow customers to create their own VR experiences tailored to their specific use case. However, such a platform has to rely on non-EU headsets, which entails limitations for creators and lack of control over the way data are collected and used.

Another challenge in the European VR/AR business environment is the **difficulties for companies to scale-up their operations**. Aspects of the business environment such as the aforementioned fragmentation, lack of a European platform which acts as a marketplace and networking tool for VR/AR creators(as opposed to the US, where such platforms exist[78]) are reinforcing this challenge. Moreover, such fragmentation does not only exist across the value chain but also within the European Single Market. Due to differences in regulation

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[73] Medium (2021), *NFTs and Virtual Reality*, available here.
[74] Workshop and interview findings.
[75] Website available here.
[76] Website available here
[77] Website available here.
[78] Workshop and interview findings.

and entrepreneurial traditions among Member States, it is particularly complicated to scale up business ideas to reach the European market, rather than just the national one.[79]

Another area where joint EU efforts could improve the business environment as well as the efficient technological development, is the **establishment of standards**. At this stage of development of the VR/AR industry there is still an opportunity to learn from the mistakes of other digital sectors, agree on and adopt an aligned approach the development of software and hardware along common standards. While defining the exact areas and types of those standards would go beyond the scope of this strategic paper, it is crucial to refer to some basic principles and insights mentioned by consulted stakeholders in relation to standards. For instance, while standards should promote the ethical development of VR/AR and respect to privacy, they should also not be EU specific and ensure compatibility and accessibility in a global market. In addition, these standards should be guided by reinforcing interoperability and be open and accessible by all types of companies in the VR/AR industry, including SMEs.

3.2.3. Social

The social dimension of VR/AR technologies is wide and encompasses numerous important aspects, such as access and availability of skills, social impact, as well as education and awareness in the consumer and B2B market.

The ecosystem-wide issues regarding EU sovereignty are the key to understanding the biggest challenge identified by stakeholders, and repeatedly found through other sources, and in the wider social domain. An issue is the **brain drain of VR/AR talent**[80] with its corollary − the difficulty to attract talent to the European VR/AR sector. Ecorys estimates[81] suggest an overall increase in the people employed in the VR/AR sector – from the 300 000/400 000 people of 2020 to a figure surpassing the one million mark in 2025. However, this progress can be hindered or slowed by potential brain drain. This is widely regarded as a challenge due to the two main risks. The first is geographical in nature and concerns European talent leaving the continent to join US and Asian tech giants. More attractive salaries and working opportunities, combined with the healthier and richer VR/AR ecosystem, are the main reason behind the drive away from the EU.

This is demonstrated by an increasing demand of European talents originating from abroad, for instance by Meta's announcement to hire up to 10 000 people in Europe to build the metaverse.[82] Implications regard the risk of losing European talent present and available on the market to non-EU players. Section 3.5 discusses the need and availability of skills more in depths and points to shortcomings when it comes to having sufficient talents to fill the needs of VR/AR companies in Europe. This could heavily hinder European ambitions regarding the sovereignty of the industry in the production area where Europe is currently stronger – that is, content development. Increased competition for talents would also disproportionately disadvantage smaller companies who cannot compete with tech giants.

The second dimension is sectoral. **Competition for talent is fierce** not only amongst immersive experience producers (e.g. gaming, movies) but also more traditional sectors and engineering disciplines such as automotive, due to the transferable expertise in key areas.[83] Thus, people with the right skills to join the VR/AR community often prefer other sectors that require similar skillsets and are more competitive in terms of salaries and

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[79] Ecorys (2021), *XR and its potential for Europe*, available here.
[80] Foreign Policy (2021), *It is Western Europe's turn for a brain drain*, available here.
[81] Ecorys (2021), *XR and its potential for Europe*, available here.
[82] The Guardian (2020), *Facebook to create 10,000 jobs in EU to help build 'metaverse'*, available here.
[83] *Idem*

working opportunities. The main competitor in this sense is the video games industry, generally considered more attractive for professional with the technical skills required to work with immersive technologies.[84]

In addition, consulted stakeholders claim that another challenge relates to the ambitions and vision of companies. There are a few examples of companies which prefer to be bought by non-EU players, formally removing European players from the overall ecosystem, rather than continue their operations and attempt to grow and scale-up in Europe. While producing successful indigenous start-ups that attract capital and are sold for some times high amounts of money is not a challenge in itself, in combination with the limited number of successful scale-up and unicorns in the digital field compared to the US, it can pose a threat in the growth of VR/AR industry in Europe.

Important aspects include also the **environmental impact of VR/AR technologies and their potential role in fostering diversity**, the big room left by non-European players with regard to **ethical applications** (especially in the context of personal data and privacy protection), and the remaining need to **better understand how all these impacts could be measured and quantified**. Consulted stakeholders point at the opportunity of ensuring the VR/AR industry is developing in an inclusive and diverse way – for instance, through diversity of its workforce - as well as with a focus on the environmental sustainability and ethical aspects. This would promote better aligned development and use of VR/AR with these principles.

However, the two other main topics which emerged from the analysis are the potential of **education** and the need to improve **awareness-raising** on VR/AR. These two aspects, while similar, entail different angles.

The former concerns both the way VR/AR technologies can contribute to **delivering better learning opportunities in schools, universities and companies**,[85] and the need to increase digital literacy and skills among possible users and consumers of VR/AR. This increased knowledge would be crucial for a better understanding of the needs of the market and responsible market uptake. To achieve this, it is paramount to extend the VR/AR community of developers. Tech staff should be accompanied by sectorial experts able to provide their specific expertise to ensure applications are tailored to the needs of the market and reflect the state-of-the-art in their sector.[86]

The second aspect takes into consideration aspects related more directly to the **knowledge of VR/AR as a technology among both consumers and potential business users**. In many cases, CEOs are hesitant about undergoing the expenses necessary to implement VR/AR into their workflow because they are unaware of its numerous benefits,[87] which often include increased productivity and efficiency together with cost and time savings. Moreover, most potential users still associate VR/AR solely with entertainment and gaming,[88] neglecting the wide variety of applications across many industry verticals.

To increase awareness on VR/AR, various initiatives could be taken by policy and industry actors, such as organising more networking events or investing more in marketing, currently conducted mainly by US tech giants.[89] Moreover, the adoption of the technology among

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[84] FourPointZero (2021), *How can XR companies win the 'Epic' battle for Unreal Talent?* available here.
[85] BW Education (2021), *AR and VR: The next big thing in education*, available here.
[86] Interview findings.
[87] CG Sinc (2021), *Top 6 biggest challenges to implementing AR technology*, available here.
[88] Source: various stakeholder interviews.
[89] Skarredghost.com (2021), *The metaverse hype is attracting investors*, available here.

professionals could bring it closer to the wider public, making it more accepted and known in the market.[90]

It is worth noting that the EU is trying to raise awareness and tackle many of these societal challenges. The most recent efforts relate to the European Commission proposal, presented to the European Parliament, to sign a declaration on European digital rights and principles.[91] Such a document sets out the type of digital transformation envisaged by European institutions – a fair and safe transition, mindful of European values.

3.2.4. Financial

The possibilities of generating both private and public (especially EU-level) funds are perceived by most stakeholders as being rather low, therefore making both aspects a clear challenge. **The biggest problem seems related to the availability of private financing**, with low opportunities of obtaining risk and deep-tech financing.

Venture capital (VC) funds do not tend to trust VR/AR companies enough to provide them with finance, as they perceive VR/AR technologies as not being mature enough and as an unsafe investment.[92] Moreover, there is still disagreement on the viability and profitability of investing in VR/AR at the moment, with different VCs and investors often displaying different opinions on the subject.[93] Consulted stakeholders hint to a lack of awareness of the industry, lack of market data and misconceptions about the wide scope and growth potential of VR/AR as underlying reasons for the limited trust.

Various stakeholders point out less of an entrepreneurial mentality in Europe, as opposed to other markets such as the US. European investors are less risk-averse and willing to accept that innovative start-ups face the possibility of going bankrupt or not being profitable in the first years.[94] Larger actors seem to have more chances of obtaining funding, given their sounder financial situation.

This last observation is also valid for EU-level funding schemes. **The red tape and the level of resources needed to apply for funding** (which does not necessarily lead to winning the grant and obtaining funding) are perceived by some stakeholders to favour bigger companies, more likely to have the necessary time and expertise to go through the whole process.

VR/AR-related opportunities do exist at EU level, offered especially by Horizon 2020 / Horizon Europe and Creative Europe (analysed in more detail in Section 3.4.3) and by initiatives funding disruptive technologies, such as the European Innovation Council. However, many stakeholders observed how **calls regarding VR/AR tend not to take into account the specificities of these technologies**, which feature a combination of innovative business models, digital content and artistic creation.[95] The **current EU framework for public support is perceived as not fully adequate for this field**, as most instruments mainly address either R&D funding for technological development or cultural content support for content creation, rather than a combination of the two.

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[90] Interview findings.
[91] European Commission (2022), *Declaration on European digital rights and principles*, available here.
[92] Workshop and interview findings.
[93] TechCrunch (2020), *7 investors discuss augmented reality and VR startup opportunities in 2020*, available here.
[94] This aspect is not specific to VR/AR but is rather common for deep-tech financing. It has been mentioned by several different stakeholders and has been explored during workshops and can be found in literature. See, for instance, DigitalEurope (2021), *Scaling in Europe*, available here or Hello Tomorrow (2021), *Is Europe ready for the next deep tech champions?*, available here.
[95] Interview findings.

These calls could, therefore, be recalibrated and structured in a way to better match the needs of European creators and developers. National funding initiatives have sometimes been indicated as better placed and closer to the needs of the industry, especially in countries with a stronger VR/AR scene, such as France, Germany, and the Nordic countries.[96] A more structured analysis on challenges regarding access to funding and investment instruments can be found in Section 3.4.

3.2.5. Legal

In the area of legal challenges and opportunities, the main elements raised were the need to ensure that the rule of law is applied in virtual environments and that virtual worlds operating in the EU are secure, trusted and respecting the rights of their users. While there is a need for safeguarding interactions in virtual and augmented reality applications, it is also important that the EU's legal framework affecting the technologies does not have negative impacts on their competitiveness, allows innovation, and supports EU industry's competitive position in a global context.

The large volumes of data collected and processed through VR and AR technologies, including personal data, biometric and cognitive data (e.g. through eye tracking) add a layer of complexity for deploying the technologies in compliance with legislations around the **protection of personal data and privacy** .[97] Some stakeholders highlighted Europe's opportunity of having the most advanced data protection regulation in the world, the General Data Protection Regulation.[98]

The existence of such a regulation is setting a comprehensive protective framework and provides confidence to users of European VR/AR providers that their data are collected and processed in an ethical manner. However, in the domain of protection of personal data and privacy, further guidance would be required on how to apply the existing legal framework, tailored to VR and AR technologies. This is becoming quintessential, due to the potential growth of the industry and the impact it could have on the way we live and conduct business. In addition, authorities should be prepared to enforce it in new contexts, such as in virtual worlds.

The **protection of intellectual creations** of individuals in the online space, such as a virtual environment, is another issue. Examples of potential issues with VR and AR intellectual property include deceptive marketing (i.e. virtual items appearing of higher quality than the real ones or deceptive association with branding and trademarks), intellectual property violations (i.e. through the reproduction of virtual assets in different virtual environments) as well as deep fakes (i.e. recreating artists' or public figures' moves and voice could lead to copyright infringement).[99] Potential legal challenges in this field often go beyond the VR/AR technologies, as they also encompass digital creations in general as well as blockchain and artificial intelligence applications.

In addition, as virtual worlds are emerging and VR/AR solutions are being used, there is a series of ethical concerns around legal certainty and how the existing framework will be applied and enforced in virtual words, universal access to VR/AR, liability debates (e.g. in accidents while performing tasks assisted by VR/AR), and all aspects around transposing

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[96] However, this aspect has not been thoroughly investigated, as it was out of the scope of the analysis. Therefore, evidence in this regard is incomplete and often anecdotal.
[97] Information technology and innovation foundation (2021), *Balancing user privacy and innovation in augmented and virtual reality*, available here.
[98] Some aspects to be considered can be found in Hanes Snellman (2019), *Legal issues to consider regarding Augmented/Virtual Reality*, available here.
[99] EUIPO (2020), *Intellectual property infringement and enforcement tech watch discussion paper 2020*, available here.

rights and freedoms in a virtual setting.[100] Stakeholders indicated that a deeper understanding of the technology and its impacts is lacking to assess the need for regulation.

Other crucial legal aspects to be considered relate to **user safety** and digital **security**. The former is understood in terms of physical and/or psychological harm which could result from consuming VR/AR content.[101] This impact and potential harms could be severe in the case of children using VR/AR. The latter focuses on cybersecurity and ensuring the digital space (with all the data it contains) is properly regulated and protected (i.e. from cybersecurity attacks).[102]

3.3. Innovation potential of VR/AR and sustainable business models

This section presents some insights on the different streams through which VR/AR promotes innovation in Europe. This refers to both innovative VR/AR products and services as well as innovation induced by the technology. The findings presented here are the outcome of tech mining and analysis, patent databases at a global level, as well as an survey findings analysis, interviews and workshop findings.[103]

Previous sections showed that there is strong evidence suggesting that the VR/AR industry will keep evolving and growing rapidly in the coming years. The basis of this growth is the technological innovation behind the development of high-tech hardware, which in turn enables applications with the potential to change the way we live and conduct business. The following main streams of innovation potential through VR/AR are identified:

- **VR/AR product or service innovation**: This relates to the development of more efficient products by the VR/AR industry (e.g. improved hardware and high-quality virtual experiences).

- **VR/AR business model innovation**: This refers to the establishment of unprecedented value propositions or value-capturing methods (for example, by reaching out to consumers through new media).

- **Innovation through businesses/consumers using VR/AR**: This refers to all types of innovation the technology brings to their users (for example bringing new services to them, improving existing processes, and conducting tasks more rapidly or effectively).

In the stakeholder survey, more than half of respondents from VR/AR companies perceive their solutions' innovation either as disruptive (i.e. having the potential to disrupt an existing market) or incremental (i.e. creating gradual and continuous improvements on existing products and services). Some respondents consider their solution causing radical innovation, meaning that the technological breakthrough could transform an industry or even create a new market. Only a few respondents characterised their innovation stream as sustaining – i.e. significantly improving a product that aims to sustain their market position.

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[100] Lemley and Volokh (2018), *Law, Virtual Reality, and Augmented Reality*, available here.
[101] Anses (2021), *What are the risks of virtual reality and augmented reality, and what good practices does ANSES recommend?*, available here.
[102] Kaspersky (2021), *What are the security and privacy risks of VR and AR*, available here.
[103] More information on the methodology is available in Annex I.

3.3.1. VR/AR product or service innovation

At a global level, the innovation trend, as indicated by the patents applied for and issued during the last 10 years, indicates that innovation associated with VR and AR technologies continues at a reduced pace. In recent years, fewer applicants and assignees have been observed. However, according to projections, the number is expected to increase and overpass 2019 levels from 2022 onwards.[104] The innovation speed illustrates a sign of a maturing technology in line with the market size estimates presented in Section 3.1.

This is expressed by the transitioning in the patent technology life cycle from the growth stage (which is characterised by a steep increase of applications and applicants as the market expands) to the maturity stage (which entails the involvement of fewer companies investing in research and development and, thus, a slower growth rate in patent applications).

Figure 7 Number of patents in VR/AR globally (applications and issued patents)
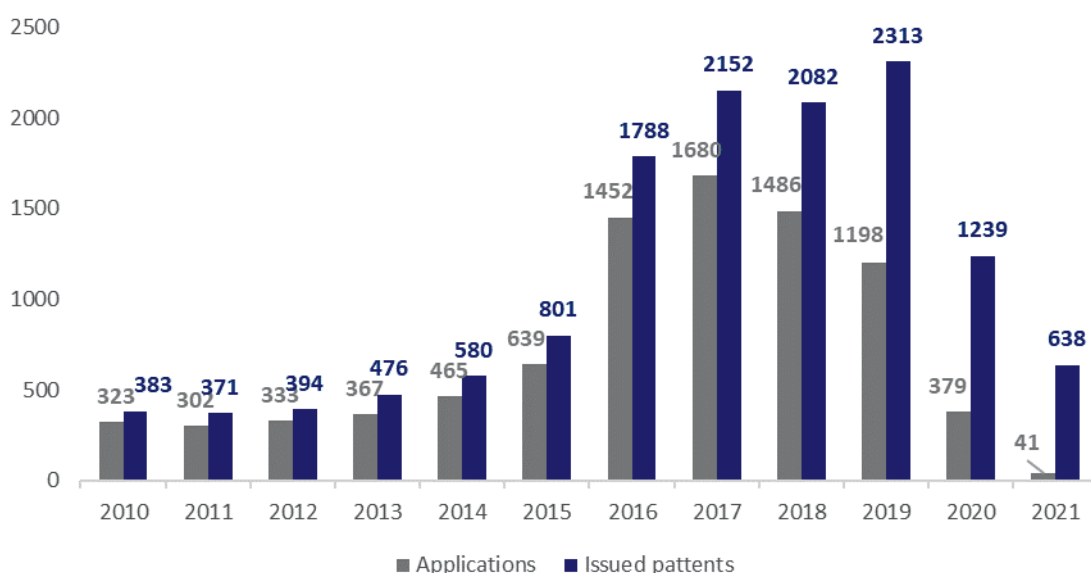
Source: Danish Technological Institute, 2022; calculation based on extraction of patents from global patent databases using PatSnap

Note: International databases are at all times 1-2 years behind, so the number of patents for 2020 – 2021 might end up significantly higher.

While major developments are occurring globally, the innovation activity as expressed by the VR/AR patents is concentrated in the US, followed by South Korea and China. In the EU, such innovation has been relatively low and stable, concentrated in a few leading European countries, such as Finland, France, Germany and the Netherlands. In the following figure, each patent is placed on the map as a 'hotspot' illustrating a concentration of patents. European companies with high numbers of patents in relation to VR/AR technologies between 2010 and 2021 include Nokia Technologies (123 patents), Siemens

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[104] Projection by PatSnap 2022.

(36 patents), Philips Electronics (35 patents), Ericsson (16 patents), Bosch (12 patents) and Orange S.A. (11 patents).

Figure 8 Global hotspots of VR/AR innovation
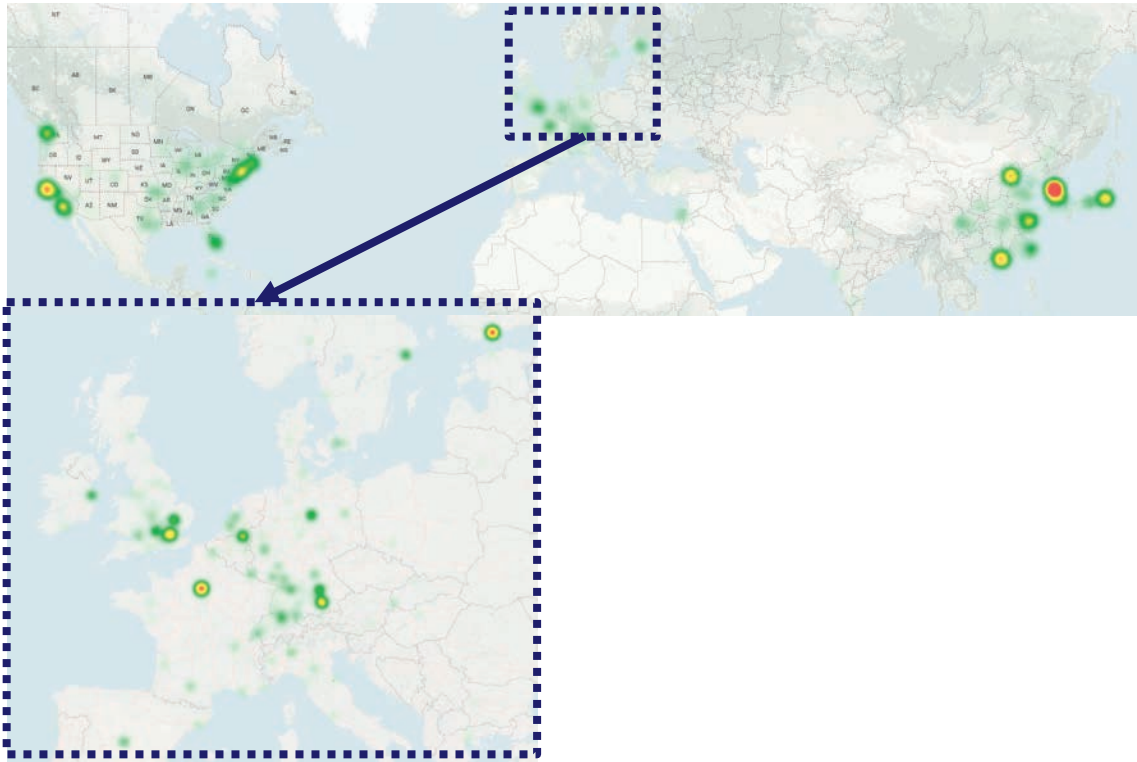
Source: Danish Technological Institute, 2022; calculation based on extraction of patents from global patent databases

Looking into the types of patents applied for and issued by European companies, these seem to be almost equally distributed between VR and AR. Most patents relate to horizontal technological development, such as input arrangements for transferring data, image capture, and analysis. Some patents linked to specific sectors or applications are also observed. These tend to relate to sectors, such as automotive and healthcare. Due to the complexity of these sectors' processes and high need for precision, they require VR/AR applications tailored to specific business processes. Some examples of large companies with a high number of patents are presented in the textbox below.

Companies with VR/AR patents in Europe

Nokia Technologies is mostly known as a telephone device producer as well as network provider. While the company is leading 5G network deployment in Europe, which is key for the operation of VR and AR, it has also been the EU company with most VR/AR-related patents, according to the tech mining analysis. Some of those patents are probably associated with the discontinued Nokia OZO 360-degree camera, designed to create virtual reality content. According to the company's website, OZO Audio uses spatial audio capture technology and OZO Playback allows an immersive audio experience, regardless of the content or device.[105]

Philips Electronics is another large European company which is a front-runner in terms of patents in VR/AR. Philips is deploying and showcasing VR/AR solutions not only for

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[105] See https://www.nokia.com/networks/5g/use-cases/immersive-experiences/ and https://www.nokia.com/ozo/.

product design and marketing, but also in the healthcare sector. For instance, Philips Azurion is an image-guided therapy platform, which can be accessed by healthcare professionals through VR and AR with the aim to bring together all stages of a procedure and optimise the process of image-guided therapy through enhanced user experience and collaboration between professionals.[106]

3.3.2. VR/AR business model innovation

The majority of current VR/AR business models tend to replicate business models that are functional in the sector or technological segment they are in. According to the survey findings, business models often follow two basic approaches regarding hardware, which are either through direct sales (i.e. company website) or through an intermediary (i.e. online or physical retailer). In some cases, alternative strategies occur, such as offering the hardware for free through a subscription or other services, especially for B2B users.

When it comes to software and applications or content, according to the survey, the business models are also frequently based on a direct sale principle, where a single licence is sold or a single purchase of the application or content occurs. Other options include subscription services (e.g. through a periodic fee) and, to a lesser extent, freemium or demo approaches, where the user gets basic content for free and may need to pay a fee for more advanced functions. Licensing business models are more frequently applied by companies producing intellectual-property (IP)-protected applications or content.
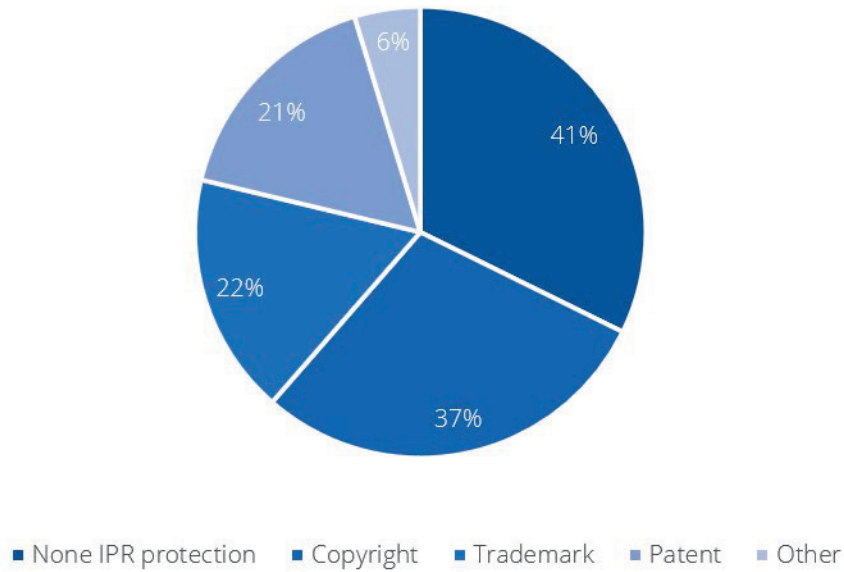
Figure 9 Main IP rights revenue streams of survey respondents
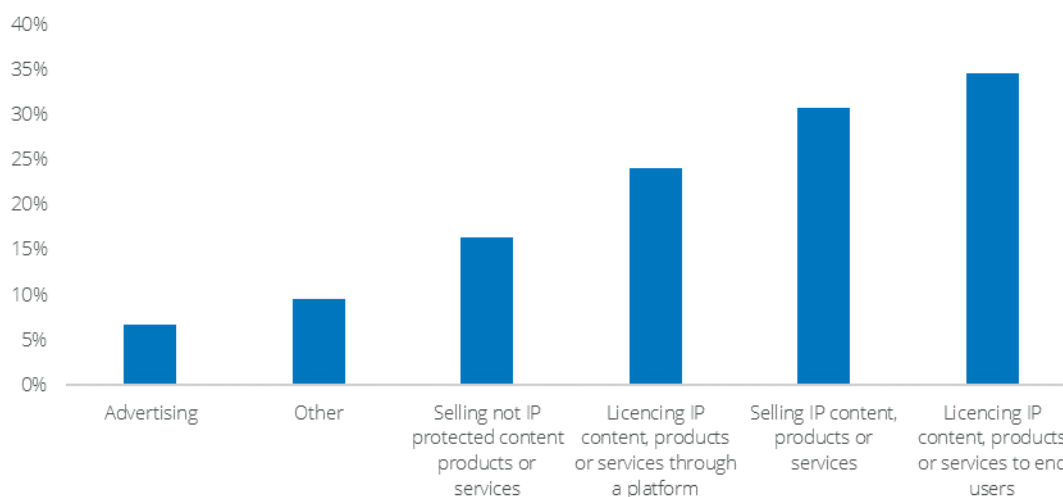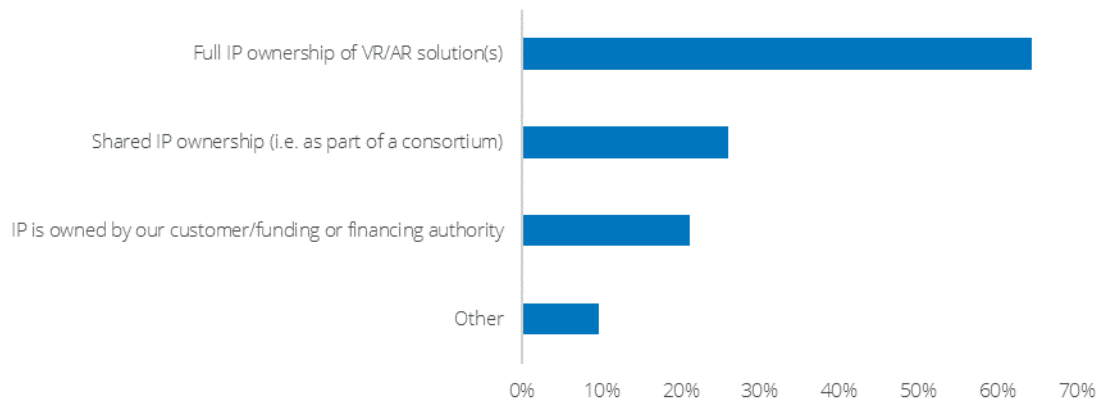

Source: Ecorys survey (N = 104)

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[106] See https://www.usa.philips.com/healthcare/resources/landing/azurion/vr.

Figure 10 Type of IP protection of survey respondents

Source: Ecorys survey (N = 104)

Figure 11 Ownership structure of the IP rights

Source: Ecorys survey (N=104)

In new technologies and creative content creation, IP is a key component of business models and their valorisation. According to the survey findings, the three most frequent revenue streams of respondents relate to selling or licensing IP-protected content. This is reflective of the valorisation potential of IP-protected outputs.

At the same time 41 % of respondents indicated producing exclusively or also non-IP-protected outputs, which would refer to outputs that do not entail any technological innovation or creative component. For instance, this could refer to operations of trading, reproducing, or providing access to VR/AR content and applications, which are not produced or created by the company in question. The protected outputs relate to a large extent to creative content production and design elements being protected either by copyrights (37 %) or trademarks (22 %). A smaller number of respondents (21 %) indicated

that their products or services are related to a patent. Some respondents indicated other schemes of protection, including open source and NFTs.

Regarding the ownership of IP rights, two out of three respondents indicated having full ownership over their product or service, while one out of four seem to have a shared IP ownership. While this illustrates the capacity of companies to produce comprehensive solutions and content on their own, it is also in line with the industrial fragmentation challenge that was raised in Section 3.2.

According to the survey findings (Figure 8), licensing IP rights products or services through a platform was the third most frequent revenue stream among respondents. The business model innovation landscape could change drastically, depending on the establishment of various virtual platforms or marketplaces and potentially on the deployment of virtual worlds or metaverses. The types and structures of virtual platforms are playing a defining role in who has access to applications and content, and what the specifications and standards for the content are. In addition, depending on their design and structure, they have different levels of openness and accessibility.

For instance, platform models may be associated with a specific headset or be accessible through different devices; they may select or require specific characteristics for the applications they host, or follow an open principle and allow any types of applications; or in relation to users, they may require an access fee or be based on a pay-per-use principle. All these aspects have an impact on both what companies and applications can be part of the platform, as well as who the potential customers or users can be. As intermediary platforms grow, their business model could also impact content providers and users in various ways. Some examples are outlined below:

- **Economic benefits:** Platforms may acquire revenue through various streams, including, user fees for access to the platform, access fees for content that goes on their platform, as well as advertisement and profits associated with the data collected through the platform. Depending on the platform's specificities, the volume of such income sources and the distribution between the platform and content providers may vary. In addition, the legal regime that platforms operate under also has an impact on taxation (e.g. app and content providers could be double taxed).

- **Competition and dominant position:** Impacts on competition may be like those of other platform economies, such as collusion, self-preference and exclusion. As virtual worlds and platforms grow in size, new types of competition issues may arise. The level of openness and market practices of a platform or virtual world could either be an opportunity for a fair marketplace where smaller providers have an opportunity to easily access users, or for the creation of a virtual world monopoly, which could entail new ways of transacting and businesses becoming so strong that they tamper with competition in the physical world.[107]

- **Gatekeeping of content and ethical aspects:** The role of virtual platforms and worlds in setting community norms, and in defining and gatekeeping what is allowed on their platform is also crucial. From what types of apps and businesses have access to each platform, to what type of content is perceived as sensitive and is being censored or banned, the first virtual worlds are setting a paradigm, which has an impact on these apps and type of content. Other ethical aspects, such as practices in dealing with users' data, enforcing legal principles in a new virtual

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[107] See https://www.politico.eu/article/metaverse-new-competition-challenges-margrethe-vestager/.

world's setting, and ensuring users' safety and security in a virtual environment, are also impacted by the structural characteristics of platforms.

In the case of the potential deployment of metaverses or virtual worlds, the innovation potential could be more radical. While there is no established definition of a metaverse, it is commonly understood as a 3D digital environment using VR/AR technologies, where individuals can interact, communicate, collaborate, conduct business, and attend cultural or entertainment experiences. The concept is also often associated with blockchain technology, especially in relation to the valorisation of digital assets and the use of cryptocurrencies as a means of value exchange.

Several companies have entered the race for creating a version of a metaverse. Facebook has changed its name to Meta and announced large investments for the creation of a metaverse. Similar to virtual platforms, the types and structures of the metaverses and virtual worlds that might become dominant market players might have an impact on who can be part of those and under what function.

An indication of the potential impact of virtual worlds can be given by the volumes of investment that is already going into NFTs, with virtual property prices skyrocketing. Estimates point that USD 1 trillion or more is already being traded for virtual assets.[108] This rapidly evolving market is not rooted in tangible products and services or in IP-protected content. Thus, in the future, VR/AR business models, in particular regarding content creation in virtual worlds, could look much different. For instance, tradable content in virtual worlds could be also valorised on digital ownership of the NFT. This does not imply that the current IP legal framework would not apply to NFTs, but rather that the balance between IP-based and other forms of valorisation could change, with the introduction to digital ownership. NFT's digital ownership can be parallelised to a holder of a painting in the physical world, who has bought it from an artist, thus is the exclusive owner of the original painting, but does not hold the creative rights associated with it.
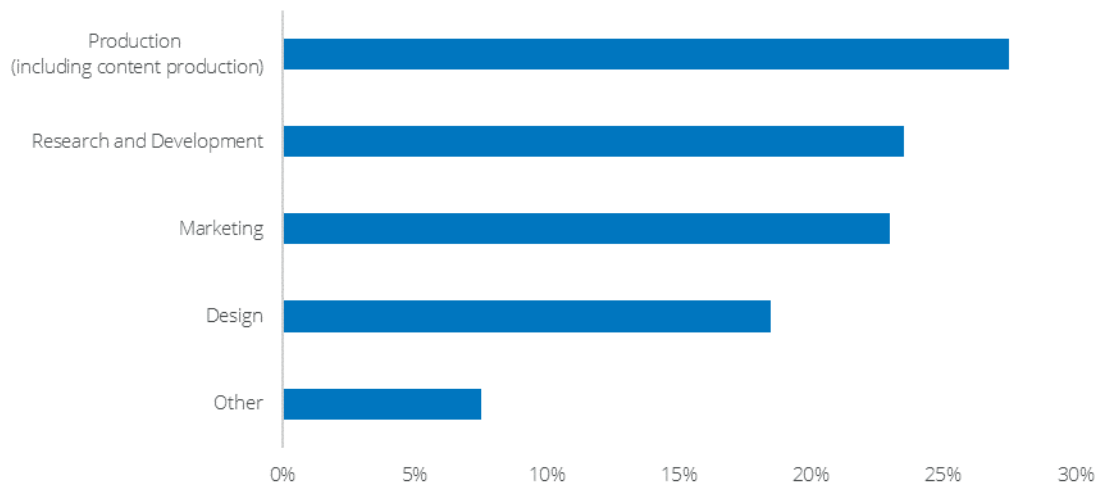
3.3.3. Innovation through businesses using VR/AR

Mapping all types of innovation that VR/AR solutions are aiming to promote for their B2B users could be an entire study on its own. VR/AR companies declare various streams and the increasing market uptake indicates that those are acknowledged by users. Some figures from the survey indicate at what stage of the business processes VR/AR solutions are used. The most frequent response is production, referring to either support in the manufacturing (e.g. assisted assembly and maintenance, or trainings for manufacturing processes) and production of physical products or content production.

This is indicative of the contribution of VR/AR in the core processes of businesses. Respondents also pointed at VR/AR technologies contributing to innovation in the R&D, marketing and design. Some respondents indicated other parts of the business experiencing innovation through the use of VR/AR, such as in customer relationships and horizontal processes like administration, virtual interactions and management. More details are analysed and included about specific sectors (creative and cultural, and architecture and design) in the sections below.

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[108] See https://www.economist.com/business/2022/01/01/virtual-property-prices-are-going-through-the-roof and https://www.nytimes.com/2021/11/30/business/metaverse-real-estate.html.

Figure 12 Departments of B2B VR/AR users

Source: Ecorys survey (N=109)

The survey also asked about VR/AR providers' perspective on the gains of their customers from these technologies. This is an indication of the motivation of businesses to adopt VR/AR solutions, as well as of the technologies' innovative potential. In most cases, respondents indicated more than one type of gains, with higher efficiency being the most frequent response.

Together with the lower costs (which was indicated by 17 % of respondents) and improved employee performance (which was indicated by 15 % of respondents), this shows that **VR/AR solutions have the potential to impact the profit margin of businesses either by lowering costs or increasing production**. Other areas where VR/AR solutions support gains to their adopters are better consumer engagement and brand fidelity, indicated respectively by 18 % and 12 % of respondents.

Another area where VR/AR have the potential to have significant impact is environmental sustainability. Through activities, such as awareness raising on environmental matters, remote operations (e.g. maintenance, trainings and collaboration), reducing needs for travel, and virtual prototypes reducing material and other physical resources used.

In the survey, 13 % of respondents indicated that their solution provides gains in these areas. The gains on environmental sustainability can be more challenging to derive than the economic ones, as there is a negative impact (i.e. energy consumption), which needs to be weighted in.[109] During some consultations conducted during this study, **the need to better understand the footprint of the VR/AR industry and promote sustainable applications and uses was highlighted.**

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[109] Ecorys (2021), *XR and its potential for Europe*, available here.

Figure 13 Identified gains brought by VR/AR solutions
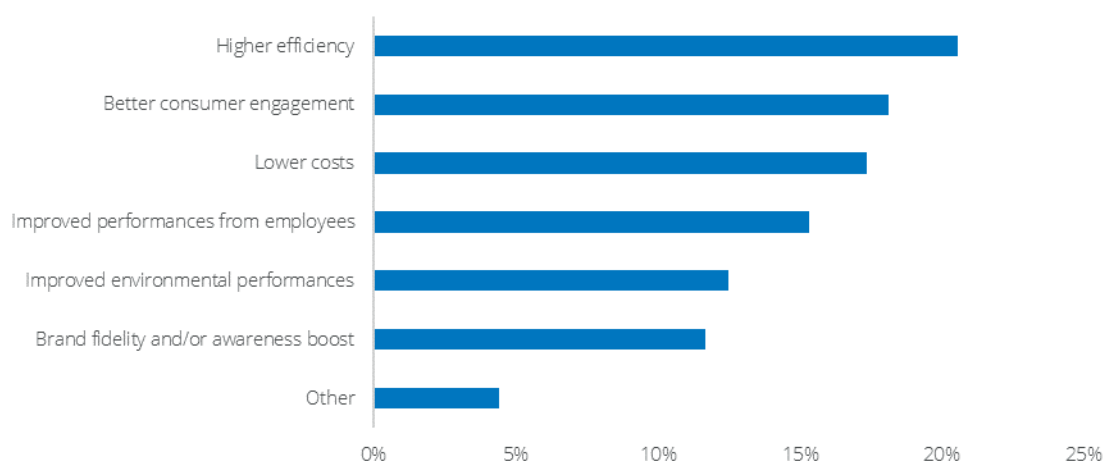
Source: Ecorys survey (N=109)

3.4. Investment instruments and access to funding and financing

In a fast-evolving and growing industry such as VR/AR, **improving access to the right private** (e.g. deep-tech and risk financing) **and public** (e.g. need for multi-disciplinary approach) **funding opportunities for companies will be crucial to speed up the maturity and wide adoption of these technologies**. This spans from large-scale infrastructure funding needs (for instance for deploying pan-European 5G networks) to financing and funding opportunities for innovative R&D, applications and projects such as those with high digital transformation potential.

Thus, this section aims to identify the financing/funding opportunities and trends for VR/AR companies in Europe and assess their characteristics, such as the volume, geographical origin, the recurrent type and stage of funding, and their accessibility. This intends to inform both policymakers and the industry on funding and financing trends, needs and challenges. It also aims to shed light on current possibilities to enhance their visibility and improve access to capital.

3.4.1. Funding trends

According to available data, **funding need for VR/AR companies in Europe has been steadily growing over time** (see

Figure below), following the recent trends and expectations for sustained growth in the industry.[110] Notably, funding raised by VR/AR companies witnessed a sharp increase starting from 2016, coinciding with the hype that surrounded immersive technologies as of that year, and kept growing the following years and throughout the pandemic, registering **in 2021 almost EUR 400 million**, with an increase of **more than 80 % in 2019**.

Of total funding raised from 2010 to 2020, roughly 45 % was captured by the top 20 companies,[111] encompassing various sectors and specialisations, such as

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[110] Ecorys (2021), *XR and its potential for Europe*, available here.
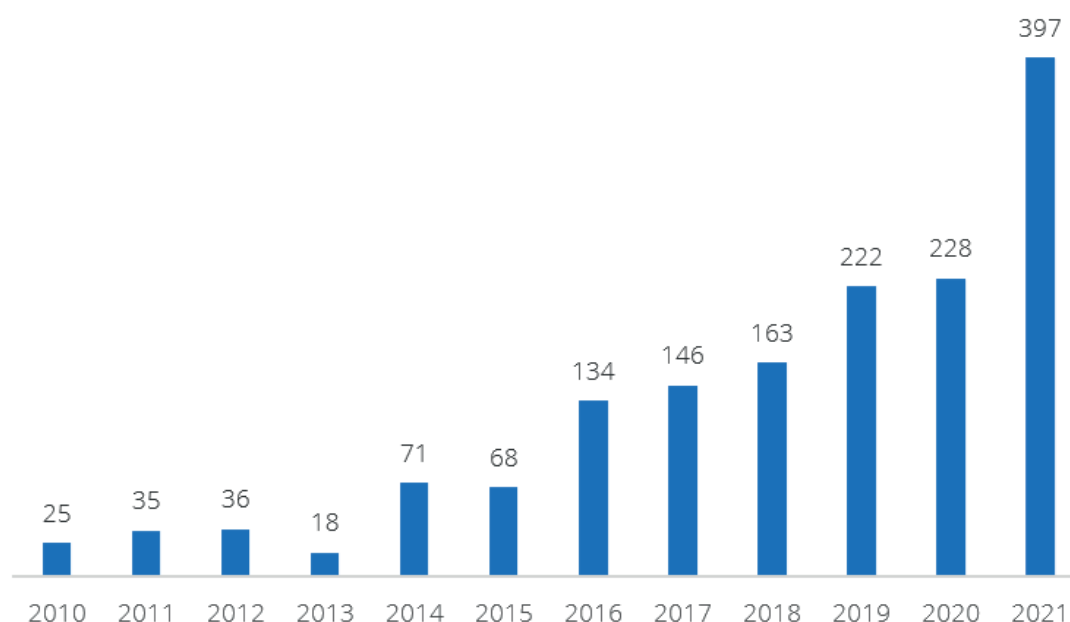[111] Calculations based on Crunchbase.

manufacturing/engineering, education, training, gaming, and healthcare. The highest amount raised by a single company is reportedly EUR 53 million, recently obtained by Copenhagen-based Labster,[112] which sells virtual science laboratory simulations to schools.

Nevertheless, despite the recent exponential growth, **Europe is still lagging in access to finance** (e.g. venture capital) **for VR/AR companies compared with other regions**. In the US, for instance, VR/AR companies have raised over EUR 25 billion[113] during the same period, roughly 14 times higher than the amount raised in Europe. This gap represents a general issue, which also applies more widely to other tech sectors and digital technologies. However, this seems more pronounced when compared with specific sectors, such as cloud data services and business information systems companies, for which this gap is lower.[114]

The majority of funding happens at early stages (see below

Figure 15), with more than two thirds being at (pre-)seed or early-stage VC, given also the relative novelty of the industry and technology possibilities, where a lot of experimenting is taking place and start-ups are rising. However, this shows the **difficulties to access finance for mid-sized companies** (e.g. platforms and hardware providers) **to support their potential scaling-up.** While this is arguably a more widespread issue beyond the VR/AR industry,[115] it is perceived as a very pressing challenge faced by the sector from both private and public sources. Investments come from different actors, including venture capitalists, angel investors, accelerators, private equity firms and incubators.

Figure 14 Funding raised by VR/AR companies based in the EU over 2010-2021 (million EUR)

Source: Ecorys based on Crunchbase and Dealroom data (January 2022)

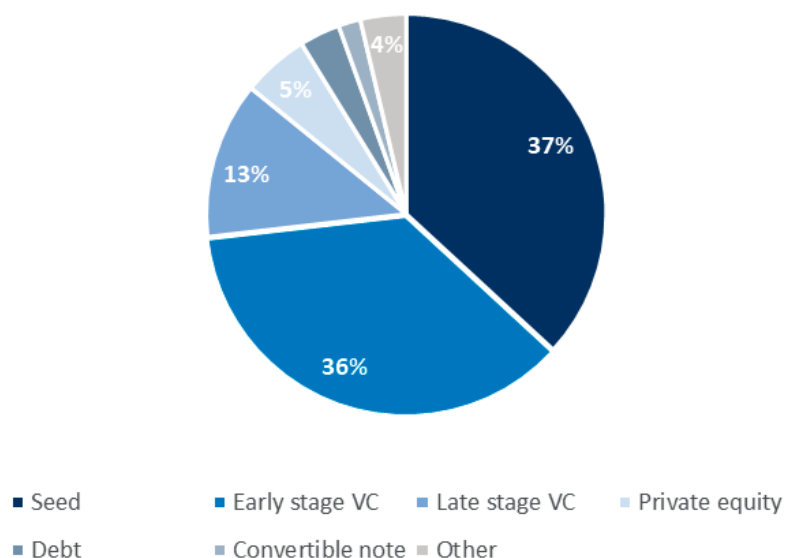
[112] Labster (2021), *Labster gets millions from a16z to bring virtual science lab software to the world*, available here.
[113] Calculations based on Dealroom.
[114] Crunchbase.
[115] DigitalEurope (2021), *Scaling in Europe*, available here.

*Figure 15 Funding round types[116] (% out of total number)*

Source: Ecorys based on Crunchbase data (December 2021)

The geographical origin of investors varies greatly. Overall, if looking at the total number of investors in VR/AR technologies in Europe (see figure below), **a relatively large share (almost 30 %) are based outside the EU**, with the **US being the main country of origin (15 %)**. Other relevant non-EU countries include Norway, Switzerland and the UK and various Asian countries, such as China, Japan and South Korea, which are reportedly becoming more interested in investing early in VR/AR technologies in Europe. Regarding main European hubs, funding is coming from some of the more developed European VR/AR markets, such as France, Germany, Spain and the Nordics, especially Finland and Sweden.

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[116] **Pre-seed**: Earliest stage of funding; pre-institutional seed funding round that either has no institutional investors or is a very low amount, often below EUR 130 000. The most common pre-seed funders are the founders themselves, as well as close friends, supporters and family. **Seed**: Among the first rounds of funding; first official equity funding stage, generally while the company is young and working to gain traction; generally ranges between EUR 8 000 and EUR 1.8 million. **Early-stage VC**: Series A and B; once a business has developed a track record (e.g. established user base, consistent revenue figures), past the development stage; generally between EUR 1 million and EUR 30 000. **Late-stage VC**: Additional larger funding for already established and successful businesses (e.g. develop new products, access new markets); generally over EUR 10 million. **Private equity**: Led by a private equity firm or a hedge fund and is a late stage round; less risky investment as the company is more firmly established; rounds typically upwards of EUR 45 million. **Debt**: An investor lends money to a company, and the company promises to repay the debt with added interest. **Convertible note**: 'In-between' funding round to help companies hold over until they want to raise their next round of funding.

Figure 16 VR/AR investors' country of origin (% out of a total number of investors)
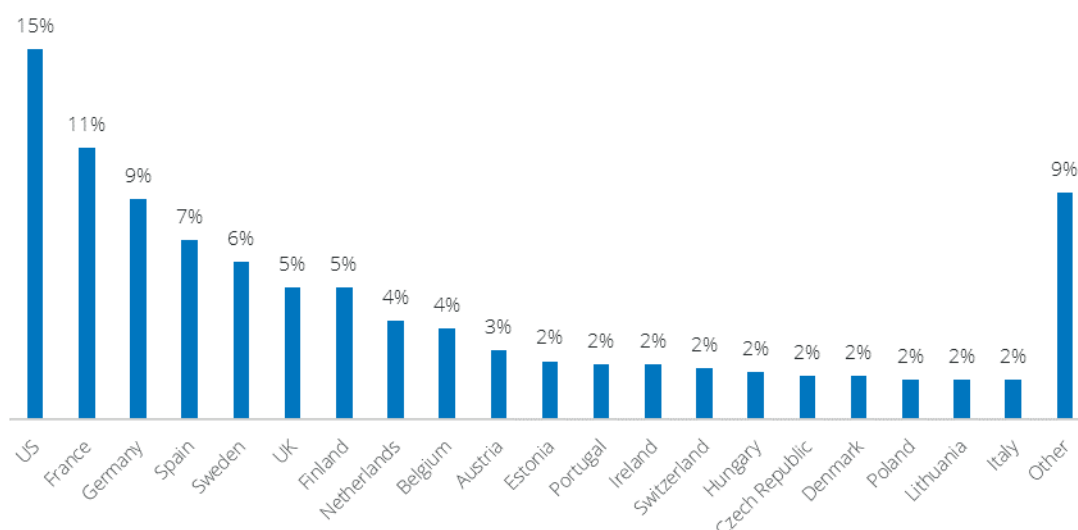
Source: Ecorys based on Crunchbase data (December 2021)

Similarly, looking at the geographical origin of the overall funding and its dynamic over time (Figure 17 below), it can be noted that **funding comes primarily from domestic**[117] (47 % on average from 2010 to 2021) **and European**[118] (25 % on average) **sources**. However, **a relatively large share** (28 % on average) **is provided by foreign investors**, with the US being the main provider. Notably, on average, almost 24 % of total funding is provided by US investors, although they account for a lower share of the total number of investors (15 %, as noticed above). Such trends can be observed across the time span considered, with few exceptions, such as for 2020 where the pandemic arguably may have played a role in discouraging international investments from abroad.[119]

In 2021, almost half of the total funding raised by VR/AR companies in Europe came from outside the EU. This highlights the growth potential and ability of European VR/AR companies to attract investments from abroad but also points towards the difficulty to access European VC and funding, which is a recurrent issue raised by stakeholders in the industry. This also poses some concerns related to the risk of losing EU ownership over companies with high growth potential. Although VC investors do not seem to include ownership as a major goal in their mission, as found by the Joint Research Centre,[120] target companies are owned by the VC or a different investor in up to 30 % of cases after raising a VC investment, reaching a peak in the VC seed and earlier stages.

[117] Domestic − when the investor's country and the target firm's country coincide.
[118] European − the investor's country does not coincide with the target firm's country but it is still a European country.
[119] Bellavitis, C., Fisch C. and McNaughton, R. B. (2021), *COVID-19 and the global venture capital landscape,* available here.
[120] Joint Research Centre (2021), *Venture Capital in Europe*, available here.

Figure 17 Geographical origin of VR/AR funding from 2010 to 2021 (% out of total funding)
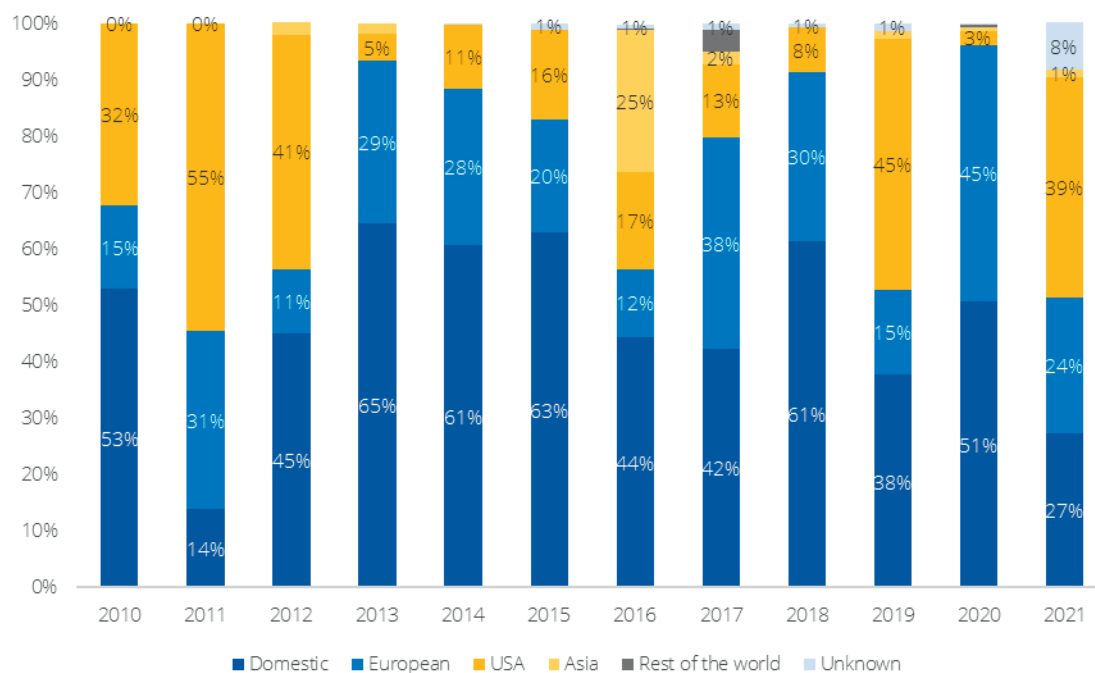
Source: Ecorys based on Dealroom data (January 2022)

3.4.2. Current status, challenges and expectations for the future

Roughly **60 % of consulted companies state that they have made use of external funding or financing** for the establishment or operation of their VR/AR activities (see Figure 18 below). Out of these, the volume of the funding or financing received in terms of percentage of VR/AR annual revenues exceeded 25 % for almost half of them, highlighting the importance of access to these sources. In terms of the origin of funding, a relatively low share of respondents (12 %) indicated using purely private resources, as opposed to public ones (31 %), while slightly less than one fifth (17 %) have used a combination of both.

Among private sources, consulted companies relied mostly on angel investors, business incubators and venture capital, while other sources such as bank loans scored relatively lower. Arguably, this is also due to the nature of the sector, which is still to a large extent in an experimental research and development phase in terms of technological opportunities, constraints and business models. For this reason, as also shown in the previous section, early-stage types of financing (e.g. seed, early-stage VC) are more common.

Looking in more detail at **public sources**, respondents **primarily obtained funding (predominantly grants) from regional or national authorities** (47 %), **or a combination of national/regional and European sources** (42 %), while only a minority (11 %) received funding exclusively from European sources. Reportedly, the main European funds accessed were Horizon 2020 / Horizon Europe, although stakeholders pointed out mixed experiences, with some indicating difficulties to access these funds (e.g. due to high competition). These were followed by Creative Europe and Erasmus+, while stakeholders report relatively less experience with other funds such as those from InvestEU and the EIB.

Other public sources reported include funds from various national ministries (e.g, the Finnish Ministry of Culture and Education, the German Federal Ministry for Economic Affairs

and Energy, Danish Ministry of Culture, the Italian Ministry of Scientific Research and Education), regional / city authorities (e.g. City of Helsinki, Brittany Region), business agencies (e.g. Business Finland, Vienna Business Agency, Netherlands Enterprise Agency) and industry specific funds (e.g. FilmFernsehFonds Bavaria, Dutch Creative Industries Fund, Finnish Film Foundation).

Although 40 % of consulted companies reported having relied on their own sources for the establishment or operation of their VR/AR activities, overall expectations for the future point towards an increasing need and reliance on external funding or financing (see

Figure 19), with **75 % of respondents expecting or planning to grow their external funding or financing in VR/AR technologies by 2026** (some even strongly or exponentially).

Figure 18 Did your company use external funding or financing for the establishment or operation of VR/AR activities?
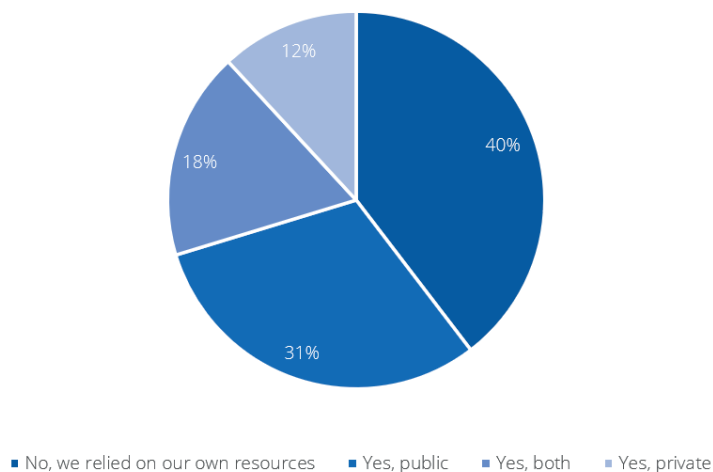
Source: Ecorys survey (N=109)

Figure 19 What is your expectation/plan for the growth in your external funding or financing in VR/AR technologies by 2026?
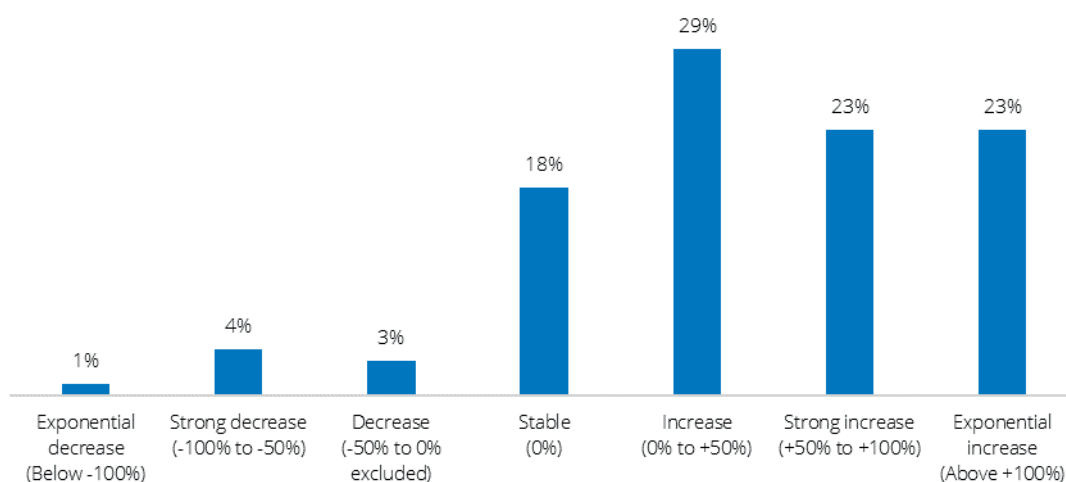
Source: Ecorys survey (N=109)

To accommodate these future financing/funding needs, the European VR/AR ecosystem will have to focus on some of the most pressing challenges that still exist in the sector for accessing external funding sources:

- **Bureaucracy**: Despite the availability of public sources for funding, red tape and complicated application processes are reported to be an obstacle. The complexity of applications and time-consuming requirements reportedly impose excessive administrative burdens on companies looking for funding, especially on SMEs and start-ups.

- **Fierce competition**: Strong competition for public funds compared to the limited budget available is raised as an important issue by stakeholders in the sector. Moreover, some SMEs/start-ups report difficulties accessing funding due to its setup, which is perceived to be more accessible to universities, non-profit organisations, or large businesses.

- **Lack of communication/awareness of possibilities:** Many stakeholders indicate the lack of information on the funds/grants available as a major issue. Given the overlay of multiple funding sources with no centralised search tool/visibility, finding the right call for funding is seen as challenging.

- **Lack of (private) European venture capital:** Companies struggle to find the right investor and report difficulties to access European VCs due to various factors, including the risk aversion/low-risk acceptance, the underdeveloped VC culture and availability in Europe, and the lack of long-term vision/understanding of what VR/AR technologies can do or need to evolve from the point that the project is presented. This generates an important gap with foreign competitors such as US companies, which have greater access to this type of financing.

- **Lack of multi-disciplinary approach to funding:** On the public funding side, the current EU framework for public support is perceived as not fully adequate for this field. Despite few exceptions such as the future Knowledge and Innovation Community for Cultural and Creative Sectors and Industries,[121] different instruments are mainly addressing either R&D funding for technological development or cultural

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[121] Available here

content support for content creation. Various stakeholders raised the need for a combination of the two, leading to a more multi-disciplinary approach and more innovative and flexible support instrument.

- **Difficulty to access later stages of funding for scaling-up**: Venture capital and more general funding are reported by some stakeholders in Europe to be particularly missing or increasingly difficult to obtain for later stages of funding (e.g. series C or D), slowing down the potential scaling-up and expansion from medium-sized companies to big players, and exposing companies to being bought by larger foreign entities at early stages. Reportedly, this is particularly true, for instance, for potentially bigger platforms and hardware providers. In terms of EU sources, the European Innovation Council Accelerator and the EIB are mentioned as the only potential sources providing larger funding amounts, although some stakeholders report difficulty to access those and/or very strict terms.

- **Ecosystem fragmentation**: This leads to a difficulty in finding the right partner to set up consortia for calls. This is an issue particularly relevant for EU funding, as various stakeholders point out the lack of awareness and visibility of actors along the value chains as a major issue for cooperation across borders (seemingly less prominent within national borders).

3.4.3. Creative Europe and Horizon 2020 funding for VR/AR

Public funding opportunities exist for companies operating with VR/AR technologies. According to the survey, **the most accessed European fund by VR/AR companies was Horizon 2020 / Horizon Europe, followed by Creative Europe** (most used by companies in the media sector).

The 2021−2027 Creative Europe programme will have an increased budget of EUR 2.44 billion, compared with EUR 1.47 billion of the previous programme (2014−2020).[122] According to the Creative Europe project database, during the previous programme 2014−2020, 103 projects (~2% of total) with a VR/AR component[123] were financed (see Figure 20), with an average value of EU grant award equal to EUR 110 000 (median value). This trend started to increase significantly as of 2016, similarly to the overall funding trend (see

Figure *14*), with a peak in 2019 and a natural decrease towards the end of the programming period, although still comparable in size to the previous years. The main beneficiary hubs were France, Germany and Italy, followed by the UK (see Figure 21).

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[122] European Commission, *About the Creative Europe programme*, available here.
[123] This is meant as VR/AR technology as part of the project, not necessarily the main focus. Projects were identified by filtering per relevant key words (e.g. augmented and virtual reality).

Figure 20 Number of projects with VR/AR component funded under Creative Europe, per year
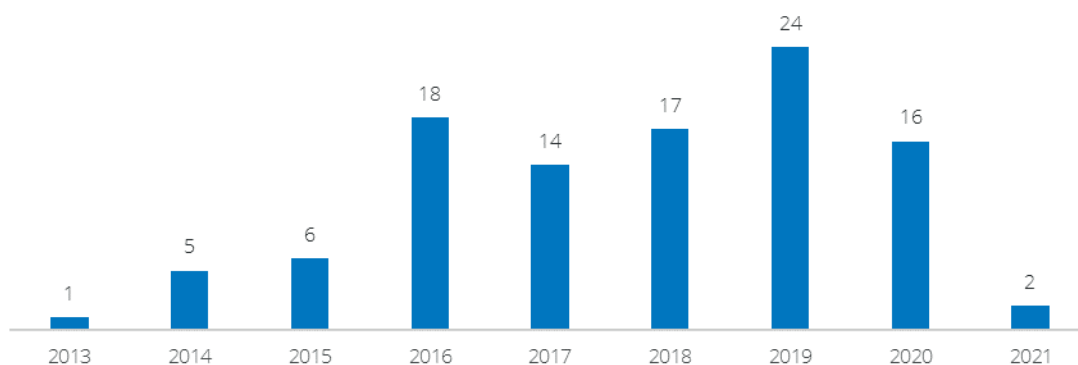
Source: Ecorys calculations based on Creative Europe project database

Figure 21 Funding awarded to projects with VR/AR component under Creative Europe, per country of beneficiaries (% of total)
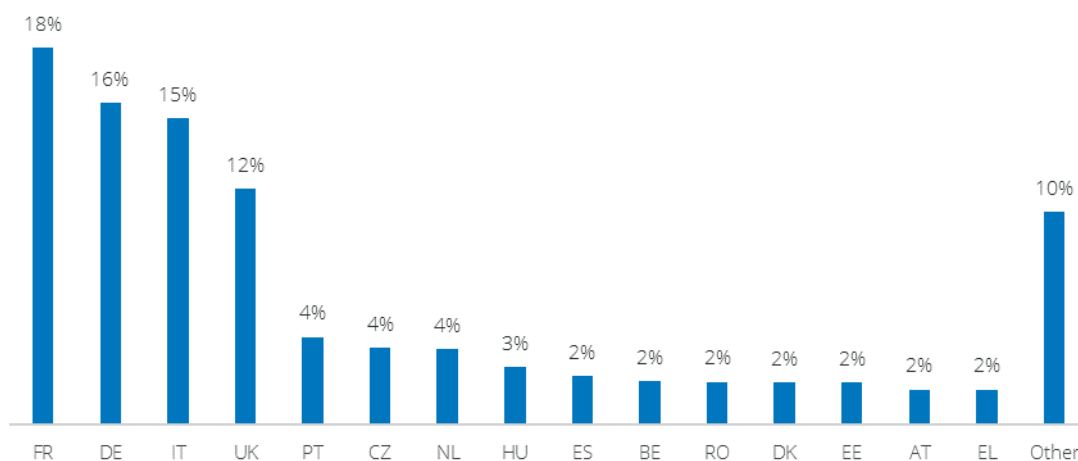
Source: Ecorys calculations based on Creative Europe project database

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Examples of VR/AR projects financed under Creative Europe

- Biennale College Cinema – Virtual Reality[124] has received funding from the Creative Europe programme for various years. The initiative, managed by *La Biennale di Venezia*, promotes the development and production of virtual reality projects for cinema. Various calls are launched to select VR projects presented by teams of directors and producers, coming from all over the world.

- Selected projects and teams benefit from a hands-on workshop with a dedicated group of tutors, including story developers, creative technologists and visual advisors, to fully develop their projects from all perspectives. The core training is complemented by a programme of presentations given by invited guests, focusing

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[124] La biennale di Venezia (2021), *Biennale College Cinema - Virtual Reality: The International Section New Call*, available here.

> on different aspects of VR production, as well as a pitch-training module to learn how to introduce their projects to potential partners.
>
> - Finally, the Venice International Film Festival director selects up to three VR projects to attend a second international development workshop, and following the workshop, one project is considered for further production support.

Looking at the Horizon 2020 database, a similar trend can be noticed (see figure below), with the number of projects with a VR/AR component starting to gain momentum particularly as of 2016 and reaching a peak in 2019. Out of the 318 projects identified, the majority focused on VR (50 %), while a relative lower share dealt with AR (36 %) and MR (14 %). In terms of sectoral coverage, projects span across various industrial ecosystems, with healthcare being the most prominent (23 % of projects), despite accounting for a smaller share of the estimated market size[125] (11%) compared to the other sectors. Healthcare is followed by VR/AR projects applying horizontally to multiple sectors (21 %) or general research (18 %).

Figure 22 Number of projects with VR/AR component funded under Horizon 2020, per year
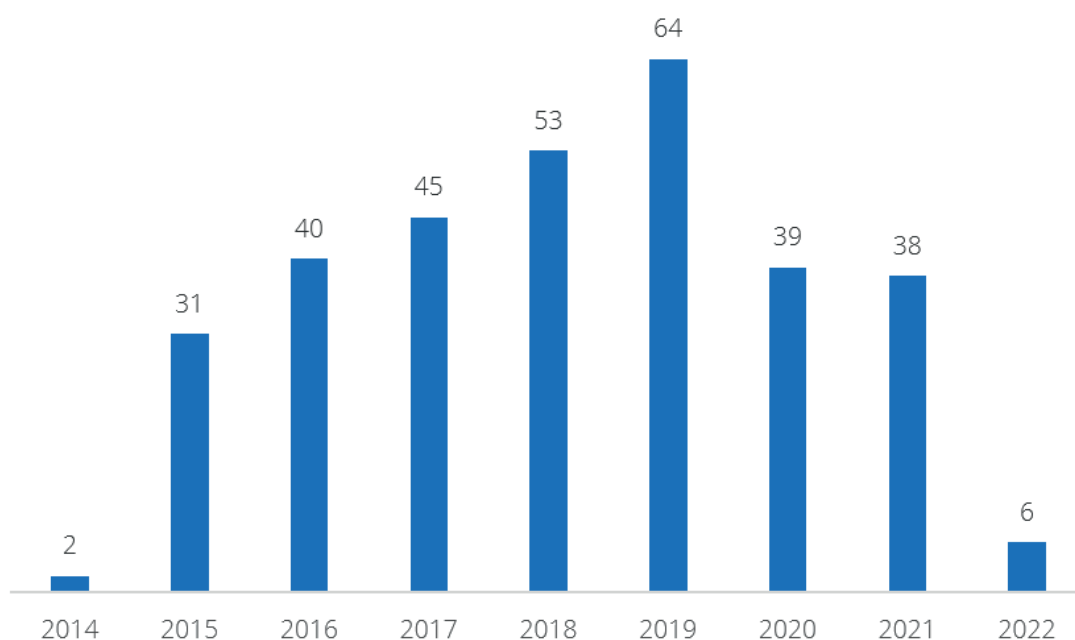
Source: Ecorys based on Horizon 2020 database

Figure 23 Breakdown of projects with VR/AR component financed under Horizon 2020, per sector (% of total)

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[125] See section 3.1

Sector	Percentage
Healthcare	23%
Horizontal	21%
Research	18%
Engineering and manufacturing industry	9%
Aeronautic, aerospace, defence	6%
Education and culture	5%
Security	4%
Entertainment and experiences	3%
Automotive and transport	3%
Other	9%
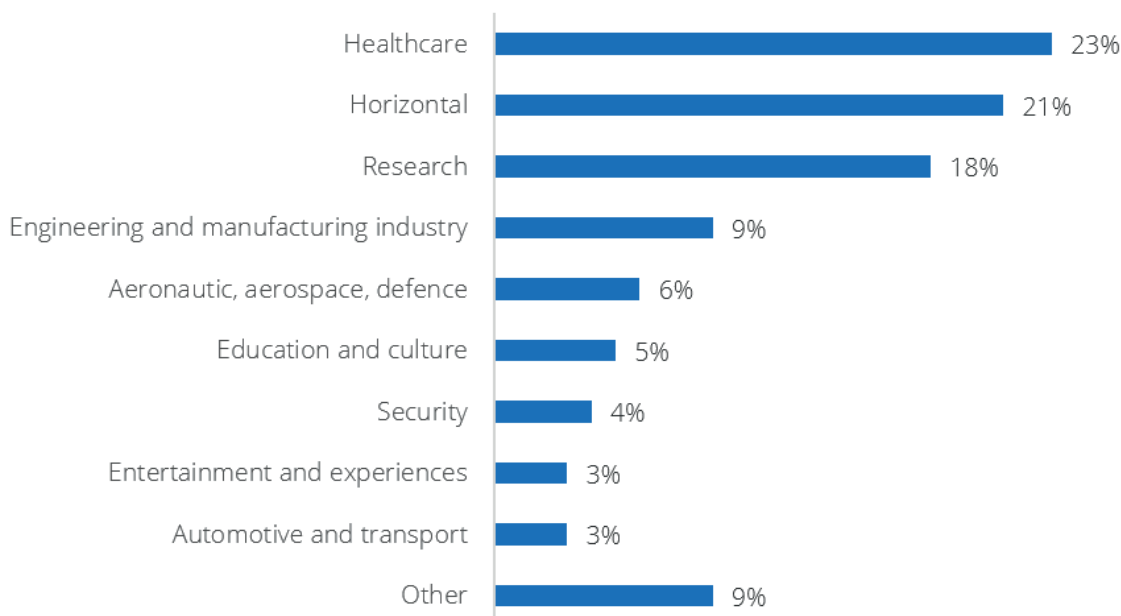
Source: Ecorys based on H2020 database

3.5. Need and availability of skills

3.5.1. Industry needs

To capitalise on the growth opportunities, it will be crucial for the European VR/AR ecosystem to **keep promoting relevant skills, in terms of education, training and professional development**, as the fast-paced growth of these technologies, combined with their relative novelty in many sectors, may generate an equally rapid **skills gap that could widen if left unaddressed**.[126]

Over the next years, VR/AR technologies are expected to have a profound impact on the labour market, creating new jobs and completely changing and enhancing existing ones, by increasingly promoting new and cross-disciplinary profiles and allowing people to **learn physical skills** (including low-skilled tasks) **through digital means** (e.g. training, teaching, remote assistance and maintenance).

From an industrial perspective, making the EU VR/AR industry more attractive for talents and nurturing the right skills will be key for companies' growth, as they seek access to the talent needed to develop, implement and make content for these technologies. **Interdisciplinarity is the keyword** here because of the diversified sets of skills required to create VR/AR. Companies look for talents that can approach VR/AR from different perspectives, **working across a wide range of technical, creative, social and business disciplines**. These technologies cannot be looked at purely from a technical standpoint. Creativity, as well as business and managerial skills, will be needed. **Involving social**

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[126] Ecorys (2021), *XR and its potential for Europe*, available here.

**science and humanities will also be key** as to create cross-disciplinary figures that can bridge the gap between customers and developers.

University classes dedicated to VR/AR can easily become obsolete due to the technology's fast development, and it is still rather difficult to find VR/AR university programmes, even if the number of courses is growing. Existing courses are starting to be less theoretical and more focused on teamwork and entrepreneurship and many universities are adding XR studios, especially in France and the UK,[127] responding to the challenge of designing courses that blend the necessary range of disciplines and appropriate levels of science and arts.

However, despite the notable achievements of university research and the existence of great talent pools in Europe (e.g. engineers and software developers), there is still **distance between education systems and industry/market needs** and **companies, and stakeholders do not perceive a widespread availability of the key skills needed on the market currently** (see Figure 24 below).

While this issue extends more widely to other key digital technologies in Europe,[128] it is perceived to be a particularly pressing challenge for VR/AR technologies. Over 50 % of survey respondents consider the availability of talents with VR/AR-related skills to be low or very low in their sector. At the other end of the spectrum, a minority of respondents indicate high availability of required skills, although it must be noted that such responses come primarily from companies operating in the gaming sector, which remains the main adopter of VR/AR technologies and the more mature industry segment.

Figure 24 How do you consider the availability of talent with VR/AR-related skills in your sector?
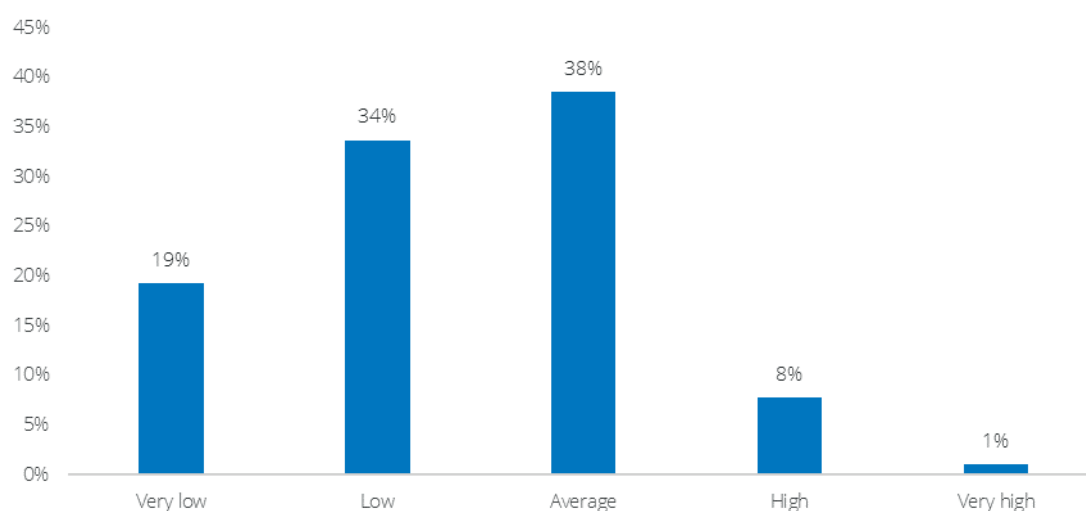
Source: Ecorys survey, N=109

Currently, the landscape of profiles sought on the market is very complex, reflecting the wide range of perspectives and angles from which XR technologies are developed. Businesses look for a combination of relevant skills, such as software and programming languages, engineering, 3D modelling and design, for which there is a relatively higher availability perceived,[129] although still unsatisfactory.

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[127] Workshops insights.
[128] AI Watch − Monitor the development, uptake and impact of Artificial Intelligence for Europe, avaialble here.
[129] Ecorys (2021), *XR and its potential for Europe*, available here.

Meanwhile, they struggle more when it comes to business skills such as VR/AR market and legal framework knowledge, or specific creative or technical skills (e.g. configuration and test management, technical troubleshooting in VR/AR and user experience / user interface). Moreover, **important challenges relate to interdisciplinary expertise**, which is required when it comes, for instance, to social sciences, humanities, ethical guidelines, privacy and security. Therefore, many stakeholders call for the need of a comprehensive and multi-disciplinary approach to educate and nurture the right skills.

3.5.2. Users' skills and VR/AR in trainings

From a customer/user perspective, **training sessions and setup assistance are the most commonly sought type of support to set up and use VR/AR solutions**, followed by after-sale support and additional support material (see Figure 25). Respondents also indicate that the **most important developments from the customers'/users' side** that would help reduce difficulties in setting up and using VR/AR solutions would be **increased awareness of VR/AR technologies** (78 % of respondents) **and increased digital skills** (50 % of respondents), which are recurrently raised by experts in the industry as fundamental actions to be pursued.

Figure 25 What kind of support do your customers/users need to set up and use your VR/AR solution? (% of respondents out of total)[130]
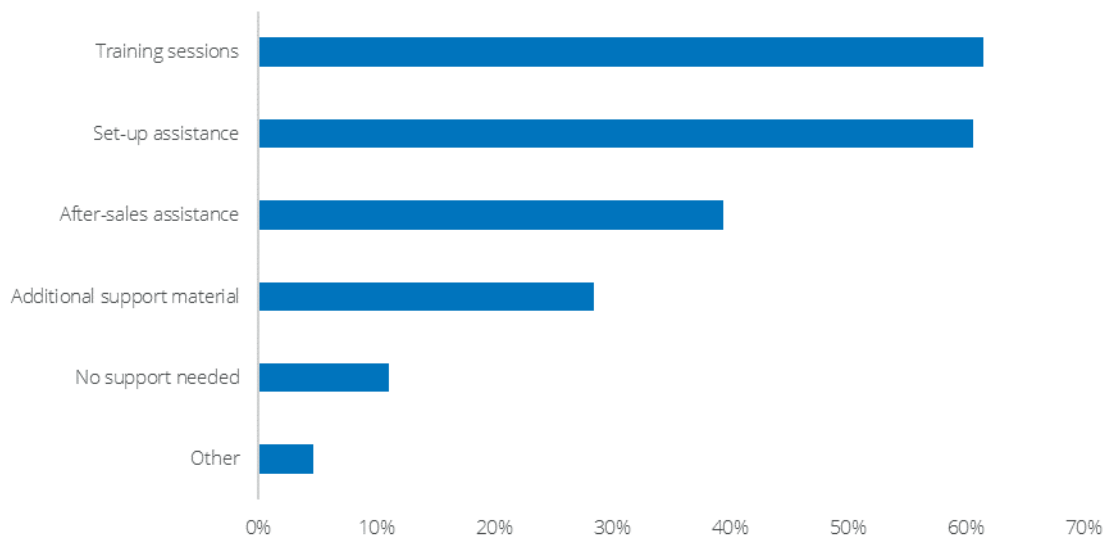
Source: Ecorys survey, N=109

VR/AR technologies **enables users to develop their skills through different means**. One of the most **common channels is through VR/AR training**. By providing meaningful enhancements to physical experiences, VR/AR technologies have the potential to upskill and augment users' abilities. These technologies facilitate immersive simulations and hands-on ways of training under different scenarios in a safe environment, helping people to face specific situations more easily and remotely, allowing a better understanding of their results and much better communication with colleagues as well.

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[130] Please note that percentages do not add up to 100 %, as multiple selection was allowed.

VR/AR trainings are expected to become an increasingly valuable tool in learning and development, especially with new solutions expanding improving training possibilities. An example of innovations in this space is the HP Omnicept G2 VR. This is a VR headset (often called head-mounted display or HMD) combining physiological sensing with machine learning to create human-centred AI solutions, allowing individuals and teams to better understand their users, predict behaviour, and optimise performance. [131] The HMD includes a sensor system that measures biometric data, such as muscle movement, gaze, pupil size, and pulse. It then seamlessly transfers this data to the HP Omnicept platform. Data from the headset is interpreted via machine learning to give real-time insights on cognitive overload in a VR session, with actionable insights on cognitive loads tailored to each user's experience. [132]

Workplace scenarios that were once too difficult, expensive, or dangerous to train for (e.g. emergency protocols and disaster preparedness, hazardous material spills, flights trainings, etc.) will become vastly more practical, cost-effective, and safe in an immersive environment simulation.

Enhancing pilots' skills in a safe environment: First VR qualified flight simulator

- Virtual reality simulation has been identified as a real enabler and potential game-changer for aviation training. The European Union Aviation Safety Agency (EASA)[133] has for the first time officially qualified a virtual reality-based flight simulation training device, developed and built by VRM Switzerland, featuring Varjo's latest human-eye resolution virtual reality headsets, Varjo XR-3, as well as unique technology developed by the Swiss flight training solution provider. [134]

- The suitability of the VR concept was verified through a training evaluation programme involving pilots from industry and aviation authorities. They confirmed the suitability of the concept for training purposes, particularly for cases like autorotation, hovering and slope landing where exact height perception and wide field of view are required.

- Pilots can benefit from increased flight safety, as this solution opens up the possibility of practising risky manoeuvres in a virtual environment. This addresses a key risk area in rotorcraft operations, where statistics show that around 20 % of accidents occur during training flights. [135] At the same time, training can also enjoy the flexibility of the immersive solution, allowing pilots to test their skills under different scenarios. It takes place in a more cost-effective and environmentally friendly way, with training time credited to pilots' flight training.

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[131] HP Omnicept VR platform: Get Cognitive Load insight to adapt training experiences, available here.
[132] HP Omnicept − data-driven insights, revolutionary VR, available here.
[133] EASA website, available here.
[134] Varjo (2021), *Varjo and VRM Switzerland make history with the first Virtual Reality simulator officially qualified by European Union EASA*, available here.
[135] EASA (2021), *EASA approves the first VR based flight simulation training device*, available here.

4. Case study 1: VR/AR media, creative and cultural ecosystem

4.1. Introduction and landscape

The objective of this case study is to deep dive into the VR/AR ecosystem in the context of media, creative and cultural applications. This ecosystem is understood as a general category encompassing several cultural and creative sectors – including horizontal ones such as creative arts, and advertising and marketing – in fields such as audiovisual production and distribution, publishing, music, and performing arts. Hence, the subsector selection entails some overlaps in terms of main applications and use cases of immersive technologies. The decision to keep this segmentation lies in the different and specific nature of each subsector identified. In fact, while VR/AR applications can be similar or sometimes even identical, they interact differently with the main products and activities of each subsector.

The cultural and creative ecosystem includes all those sectors whose activities are based on the development, creation, production, dissemination and preservation of goods and services which embody cultural, artistic, or other creative expressions,[136] as well as all collateral activities and functions. The basis of the sectoral segmentation are the NACE Eurostat categories,[137] partly reflected in the definition to be found in the Annual Single Market Report.[138] The subsectors presented hereby, are adjusted compared to the two sources mentioned above to reflect the specificities of the VR/AR cultural and creative applications and uses.

It is important to flag some methodological difficulties encountered when opting for this subsector segmentation. The classification process aimed at highlighting those areas of the media, cultural and creative ecosystem which are most affected by VR/AR technologies. This caused, for instance, the exclusion of the "reproduction of recorded media" subsector, included among the cultural activities by the NACE classification; the incorporation of different NACE categories into one subsector or, vice versa, the separation of bigger categories into more specific subsectors; and, the removal of several categories mentioned in the Annual Single Market Report focusing on manufacturing activities which were not in the scope of this case study. Consequently, quantifications presented below in terms of various indicators such as market size and employment are not perfectly aligned with the definition of each subsector. These quantifications, provide an indication on the relative size and importance of each subsector.

These subsectors are:

- creative and visual arts;

- advertising and marketing;

- libraries, archives, museums and other cultural activities;

- motion picture, video and television programme production;

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[136] European Commission (2013), *Regulation establishing the Creative Europe Programme (2021 to 2027)*, available here.
[137] Eurostat website, available here.
[138] European Commission (2021), *Annual Single Market Report 2021*, available here.

- live entertainment and performing arts;

- publishing activities;

- programming and broadcasting activities, and news media;

- video games.

The cultural ecosystem plays an important economic and social role in Europe. It brings EUR 477 billion in added value (around 4 % of the European total), counting 1.2 million companies and over 8 million employees.[139] Among the main markets in terms of sales, visual arts are the biggest, representing 23% of the sales, followed by advertising (17%), TV-related products (16%), and newspapers and magazines (13%). The other markets, such as books, performing arts, music, films, and radio, make up the rest of the ecosystem, each representing less than 10% of the total sales.[140] The ecosystem's contributions, however, are not merely economic – as it participates in the socio-cultural development of the continent, European integration, the promotion of the European lifestyle, and the definition of common values.

Digitalisation is a key driver for change. Digital revenues have added EUR 30 billion to overall revenues of the cultural and creative ecosystem between 2001 and 2011,[141] and many products are now being purchased online. For instance, 35% of shoppers have bought books online, and 25% of online shoppers visit websites of venues and ticket retailers for concerts.[142] In this context, VR/AR technologies can bring about change in two ways: by further digitalising existing activities (for instance, by integrating e-commerce with VR/AR features[143]), or by creating entirely new digital activities, boosting further digitalisation of the ecosystem. In this latter sense, VR/AR technologies offer artists new means to express their art, change the way journalism is conducted, allowing for a new digital medium to be used in movies and cinemas, and even re-organise libraries. They could even create a new way to perceive the internet, visualising its contents and allowing users to move in an entirely interconnected virtual world – a concept known as the metaverse.

The market and the activities of VR/AR in the media, cultural and creative ecosystem are generally divided into two categories, according to the final user:

- **B2B market**: In this case, applications are directed from VR/AR developers or artists to other businesses. These businesses use immersive technologies to improve their workflow, change the way they conduct traditional tasks, and in general hope the introduction of VR/AR will lead to clear benefits – in terms of productivity, efficiency, increased sales, etc.

- **B2C market**: This market sees developers selling, lending, or sharing their content not to other businesses but directly to consumers, who are the end-users of their content. In this case, the focus is not on efficiency or productivity gains, but rather on the quality of the content and its intrinsic artistic value.

The VR/AR media and the cultural and creative ecosystem has a sizeable B2C market because of the nature of some of its biggest subsectors, such as video games and film production, whose VR/AR applications are mainly directed to consumers. The B2B market

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[139] European Commission (2021), *Annual Single Market Report* 2021, available here.
[140] Calculations consider slightly different definitions of the markets and are based on EY (2014), *Creating growth – Measuring cultural and creative markets in the EU*, available here.
[141] EY International website, *Media & entertainment knowledge center*, available here.
[142] EY (2014), *Creating growth – Measuring cultural and creative markets in the EU*, available here.
[143] See some examples in Synoptek (2018), *How AR and VR are transforming e-commerce*, available here.

in VR/AR has been steadily growing in the last years, and in many ways is leading in terms of technological development. Moreover, many industry specialists consider the B2B market as more reliable for creators, due to the better penetration of the technology, which make for more viable business cases.[144] Such a trend, while still relevant for the media, cultural and creative ecosystem, is less pronounced thanks to the high volume of sales of video games and immersive creative experiences, with the market size of the ecosystem accounting for almost EUR 5.5 billion globally in 2020.[145]

This trend, combined with the fact that the consumer market mostly focuses on VR headsets while the enterprise applications mainly use AR and MR,[146] explains why the proportion in the use of AR in the ecosystem has been steadily growing (in comparison with VR) and is expected to continue to do so.[147]

The B2B and B2C markets feature some common and specific challenges.

For instance, the success of the consumer market is dictated by the popularity obtained by its biggest applications – currently to be found in the video games world. While some of these have achieved worldwide success, such as in the case of Beat Saber or Pokémon GO, most users and critics agree that the lack of a consistent inflow of killer applications is one of the key reasons behind the wider adoption of VR technologies.[148] Content is, therefore, the key aspect in the ecosystem, with new ways of consuming it, such as in the case of VR streamers.

Another issue mentioned in Section 3.2, is the fragmentation of the overall ecosystem which, according to stakeholders, is not addressed enough by the industry and policymakers, reducing its relative importance in the global context. This is emphasised by the fact most VR/AR developers in Europe are SMEs (as demonstrated by Figure 26 below) as opposed to bigger and more influential companies, all located outside of the EU. Therefore, both B2B and B2C markets are missing a European platform able to connect hardware manufacturers, software developers and content creators.

Figure 26 Media, gaming and entertainment sector – How many people are employed in your organisation?
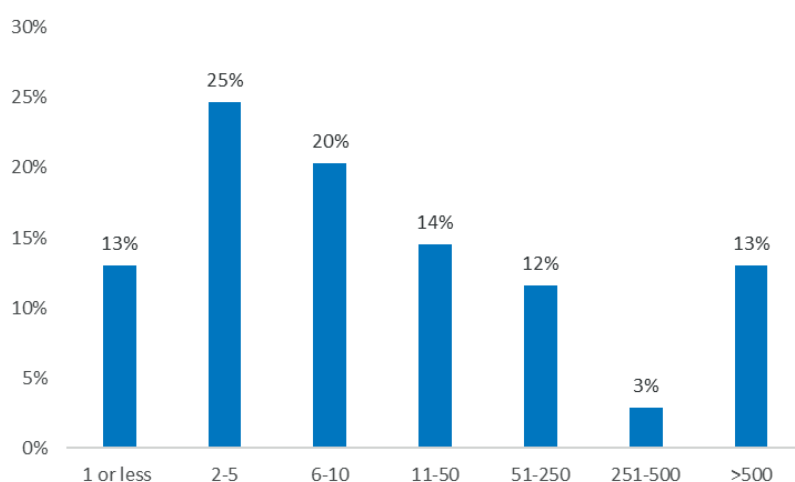
Source: Ecorys survey (based only on respondents from the media, gaming and entertainment sector, N=69)

[144] PWC (2017), *Growing VR/AR companies in the UK*, available here.
[145] Fortune Business Insights – Virtual Reality in gaming market, available here.
[146] Deloitte (2021), *From virtual to reality: Digital reality headsets in enterprise and education*, available here.
[147] Ecorys findings based on Mordor report.
[148] Techcrunch (2018), *VR, presence and the case of the missing killer app*, available here.

Before detailing the characteristics of each of the subsectors, some applications and challenges that are typical of the media, creative and cultural ecosystem are hereby explored.

Horizontal applications typical of the media, creative and cultural ecosystem

One of the most important horizontal applications of VR/AR typical of the ecosystem which, are encountered in almost all subsectors. Is **storytelling**, as VR/AR immerses the audience in the experience, transforming it from a passive witness to an active part of the narrative structure.[149] AR has the potential to make a narrative more compelling by adding pictures, videos or other multimedia to traditional means of telling a story, as well as a degree of interactivity which increases users' attention span and involvement.[150] VR can be understood as a medium able to induce a "sense of being there", and to make users experience presence within the digital environment.[151] This enhances the notion of participation and arguably can prompt greater empathy to the user[152] – even though no scientific consensus has yet been reached on this aspect.

This storytelling potential has various corollaries that can be applied across the identified subsectors. For instance, authors or artists that want to prompt a strong response and to **raise awareness** in the audience about political, social or cultural subjects could do so effectively through VR/AR.[153] Other than the emotional aspect, factors such as the level of enjoyment and entertainment experienced by users are particularly important in this regard. For instance **advertising and marketing** activities,[154] which are being conducted through digital means can heavily benefit from new ways of targeting and interacting with audiences.[155] Immersive technologies are likely to raise the audience's interest due to their novelty and interactive features, as well as to stimulate communication among consumers through social media sharing and word of mouth.[156]

Lastly, immersive technologies have a high **educational value**, which has a positive impact in terms of learning, training, and effectively promoting and popularising many of the cultural and artistic products and services. The educational potential of immersive technologies through new and effective types of learning experiences, focused on concepts such as learning-by-doing and gamification is recognised in the research community.[157]

Challenges typical of the media, creative and cultural ecosystem

The media, creative and cultural ecosystem features most of the challenges that are presented in Section 3.2, since it is one of the most prominent in terms of use of VR/AR technologies, such as the excessive fragmentation of the European market, the ongoing difficulties in terms of access to finance, and a general lack of skills and awareness about immersive technologies.[158] The COVID-19 pandemic has exacerbated many of these

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[149] Educause Review (2018), *VR and AR: The art of immersive storytelling and journalism*, available here.

[150] Liestøl, G. (2019), *Augmented reality storytelling – Narrative design and reconstruction of a historical event in situ*, available here.

[151] Riva, G. et al. (2007), *Affective interactions using virtual reality: The link between presence and emotions*, available here.

[152] Schutte, N. S, Stilinovic, E. J. (2017), *Facilitating empathy through virtual reality*, available here.

[153] For instance, see Rauscher, M., Humpe, A. (2021), *Traveling the past: Raising awareness of cultural heritage through virtual reality*, available here.

[154] Importantly, advertising and marketing is both one of our subsectors and a general application of VR/AR technologies used to promote products and services and to meet customer needs.

[155] Yussof, F. M., Salleh, S. M., Ahmad, A. L. (2019), *Augmented Reality: A systematic literature review and prospects for future research in marketing and advertising communication*, available here.

[156] Scholz J., Smith A. N. (2016), *Augmented reality: designing immersive experiences that maximize consumer engagement*, available here.

[157] See Elmaqaddem, N. (2019), *Augmented reality and virtual reality in education. Myth or reality?*, available here.

[158] These challenges have also been underlined in European Commission (2021), *Annual Single Market report*, available here.

aspects, while, at the same time, prompting a wave a digitalisation that benefitted non-location-based VR/AR solutions.[159]

Issues revolving around the process of platformisation – that is, **the growing integration of business models, infrastructures, algorithms and social practices through digital platforms**[160] are particularly important for this ecosystem. The owners and operators of these platforms are often non-EU big tech companies and VR/AR hardware manufacturers, which gives them the privileged position of influencing business models, payment schemes, content pricing and distribution of revenues (e.g. between the platform and the artists or content creators. Many consulted stakeholders advocate for the establishment of one or more European platforms to ensure European values and business ethics are also represented and influence the ways such platforms operate.

Moreover, platformisation processes have an impact on the type of content, its cultural diversity and customers' choices, and not all types of contents or artists have benefitted from the growth of digital platforms to the same degree, with minorities often being underrepresented.[161] Since Europe already tends to protect the rights of content creators over those of distributors in comparison to the US[162] or China,[163] this existing basis can be instrumental to attract artists and content creators in Europe. he establishment of European platforms would mitigate the perceived lack of representation of European players in the VR/AR industry., and spread European values in terms of content and data ownership, copyright and IP protection..[164] The following section addresses the specificities of the various media subsectors falling under the aforementioned classification.

4.2. Media subsectors: applications, users and impacts

The different subsectors that are defined in the section above are often very different in the nature of the services they offer to their public. Consequently, VR/AR applications also differ, reflecting the core businesses of the subsectors and presenting different levels of maturity and relevance. The **majority of respondents of the survey operate in the creative arts subsector**, **followed by advertising and marketing**. **Cultural activities**, such as libraries, archives and museums, also emerge as a relatively important subsector, together with **motion picture, video and television programme production and live entertainment**. Other sectors, such as broadcasting, news media, reproduction of recorded media, and publishing activities, are less frequently covered by the respondents of the survey.

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[159] Ecorys (2021), *XR and its potential for Europe*, available here.
[160] Chia, A. et al. (2020), *Platforminsation in game development*, available here.
[161] Bouquillion, P., Moreau, F. (2019), *Digital platforms and cultural industries*, available here.
[162] For instance, see Forbes (2020), *I may destroy you's Michael Coel rejected Netflix's $1 million offer in favour of the BBC because of ownership*, available here.
[163] Gonzalez, S. M. (2013), *Copyright protection for creative industries: Comparison among China and Europe*, available here.
[164] Senftleben, M., et al. (2022), *Ensuring the visibility and accessibility of European creative content on the world market: The need for copyright data improvement in the light of new technologies and the opportunity arising from Article 17 of the CDSM Directive*, available here.

Figure 27 Which of the following media and entertainment subsector(s) are your VR/AR products or services focused on? (% of respondents out of total)[165]
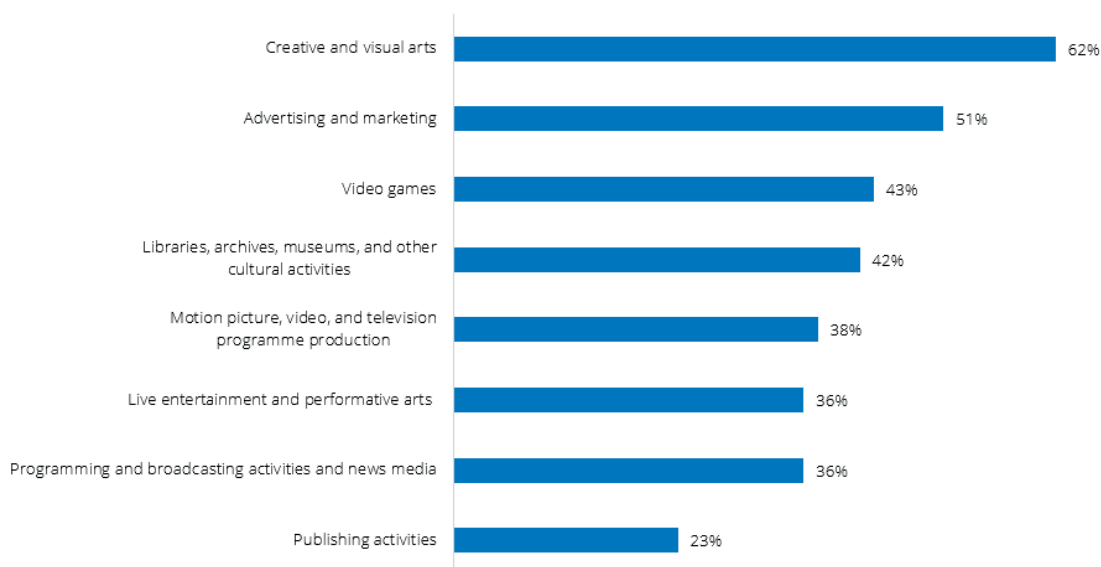
Source: Ecorys survey (based only on respondents from the media, video games and entertainment sector, N=69)

Our analysis describes the main features of each subsector in relation to the VR/AR market, underlining a variety of relevant aspects, such as the level of awareness and maturity of VR/AR, the main adoption trends, the most important applications, the main users, and the existing and potential impacts of immersive technologies.

4.2.1. Creative and visual arts

Level of awareness and maturity of VR/AR: VR/AR is starting to be used more consistently as a creative tool, as well as to create immersive art, especially in relation to NFTs. Many applications are becoming more mature and known among artists, designers and creatives.

Main adoption trends: The subsector has many B2C applications destined for single customers interested in a specific work of art. Some of the most promising applications of VR/AR are related to creative arts, which are in turn exploring the technology even more. The increasing importance of digital universes and the possibility of selling creative content as NFTs are helping adoption even more. In terms of B2B, the value chain is very developed and includes aspects such as distribution, production, and exposition which can benefits from VR/AR as well.

Main applications: storytelling, awareness raising, education and design.

Main users: content creators, artists, app developers, post-production experts and companies, designers, exhibitors.

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[165] Please note that percentages do not add up to 100 %, as many respondents operate in multiple subsectors.

> **Main impacts of VR/AR:** more virtual engagements, the emergence of a new medium for creating art, more digital and traditional markets for selling products, and increased efficiency in creating 3D art.

This subsector encompasses those art forms that focus on the creation of works that are visual in nature[166] excluding literary and musical fine arts, and including, all those pieces of art existing only in a digital form – i.e. virtual art. A knowledge-intensive sector, it focuses on creating original pieces of art (such as in the case of visual arts or designers) and on providing cultural and creative services to clients by selling or exploiting their intellectual property for a fee.[167] This subsector often overlaps with others in terms of activities conducted, which complicates statistical observations – with different sources using slightly different definitions. Therefore, while some sources indicate that the sector employed 1.2 million people and accounted for a EUR 127 billion turnover in 2011,[168] Eurostat indicates 969.6 thousand people employed as of 2020.[169]

The first aspect to be considered in this subsector regards content creation production, in which two main actors can be seen as crucial:

- Professionals and artists in the arts ecosystem;

- Users producing what is generally known as user generated content (UGC). These pieces of content include those created on social media platforms such as YouTube or Instagram.

For both types of users, VR/AR represents a new medium to express their creativity. Two main VR/AR-enabled aspects are crucial in creating new forms of art: being able to paint or work in a 3D environment, and the possibility to move away from static pieces of art, making them interactive and animated. These opportunities are democratised and made more accessible both for professionals and users thanks to an increasing number of tools and software at their disposal.

The textbox below presents some of these tools, with a focus on two European examples:

> ### VR tools for creating and designing
>
> Artists and creators now have the possibility of using a VR headset and some dedicated tools to design and bring their visuals to life directly in the immersive 3D environment. This allows the artist to visualise and interact with the 3D model in real time, approaching it from different angles. Not only immersion is enhanced, arguably helping the artistic process itself, but the intuitiveness of these tools often reduces the technical barriers needed for 3D modelling.
>
> The best-known tools are usually developed in the US, either by big tech companies or the same companies manufacturing the hardware and the headsets. Examples here include TiltBrush, Quill, Medium and SculptVR.

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[166] UNESCO (2009), *The 2009 UNESCO framework for cultural statistics*, available here.
[167] Artscapediy, *Defining the creative and cultural sector,* available here.
[168] Moreover, data from 2011 included the UK. See EY (2014), *Creating growth – Measuring cultural and creative markets in the EU*, available here
[169] Eurostat website, available here.

> However, many VR tools are being developed by European companies. For instance, PaintingVR,[170] a painting simulation game that supplies 3D canvases and different sets of brushes, is developed by the Belgian company Oisoi. A similar tool, Vermillion VR,[171] has been created by a Dutch developer and simulates analogue painting in a digital setting. The British company Valkyrie Industries created Argil,[172] a VR sculpting tool that integrates not only VR controllers and finger tracking, but also proprietary haptic gloves to increase immersion and facilitate creation.
>
> Another European tool of a different nature is Minsar Studio,[173] developed by the French company Opuscope – now in the process of rebranding into Wanderland. Minsar Studio is a collaborative platform that does not require any kind of code input to easily create and share VR/AR experiences to be viewed on the web or embedded in a smartphone application. Gravity Sketch,[174] a British application, combines the designing aspect with the collaborative platform one, allowing different teams to seamlessly work on the same design project, collaborating and communicating in real time.

Both categories see great potential in VR/AR technologies, as they revolutionise the way art and artistic content is created by the artist and experienced by the user.[175] They are an altogether new medium, different from traditional ways of creating art. For instance, canvases could express not only a still and specific moment captured in the frame, but a whole journey – simply by looking at them through a screen and adding AR functions.[176] VR art has the clear benefit of being completely immersive and offering a 360-degree experience, which can be enjoyed by the user without the need for big pavilions or even leaving their homes. Moreover, creators themselves can use the new tools to create their art – such as in the case of the Google Tilt Brush, which uses motion-tracking controllers to allow three-dimensional strokes in a digital space.[177] Especially for professionals, VR/AR is extremely useful in terms of design, as it naturally integrates the third dimension, crucial when designing 3D objects.[178] Therefore, VR/AR design could set out new standards and create a completely new industry – in this case, focused on designing 3D art.

The second aspect in terms of the value chain regards content or pieces or art distribution, dissemination, and monetisation. Here, opportunities for artists and professionals are very different than those regarding UGC. Artists, that is "persons that consider themselves as visual artists, and who are also considered as visual artists by some peers"[179] usually sell their creations through various actors such as promotion and sales galleries, art dealers, art fairs, and auction houses, and promote or exhibit them via organisations, festivals, biennale events and online media.[180] The way these cultural organisations are using VR/AR is explored in Section 4.2.4.

However, new digital tools allow both artists and more casual users to create purely virtual content to be used in virtual worlds and metaverses, which represents a new way to

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[170] PaintingVR website available here.
[171] Vermillion VR website available here.
[172] Argil website available here.
[173] Minsar Studio website available here.
[174] Gravity Sketch website available here.
[175] Yun, B. (2021), *Design and reconstruction of visual art based on Virtual Reality*, available here.
[176] For instance, Artivive is an AR platform developed specifically for art. Website here.
[177] Crispinlord, *The role of Virtual Reality in visual art*, available here.
[178] Kim, B. (2019), *Virtual Reality for 3D modelling*, in Varnum, K. J., *Beyond Reality: Augmented, Virtual, and Mixed Reality in the Library,* available here.
[179] Laermans (1996)
[180] European Commission (2017), *Mapping the creative value chains – A study on the economy of culture in the digital age*, available here.

monetise on the art they create. This could be done thanks to NFTs, non-replicable and cryptographic tokens existing on a blockchain, which certify the validity of a given asset and can be sold or traded online. In practice, NFTs transform digital art into something unique, labelled as authentic and easy to trade online on blockchain infrastructure.

Digital art sold through NFTs has potential on at least two levels: in the real and the digital world. In the first case, AR-enabled pieces of art, despite their lack of physical presence, can be displayed in the real world by the owner – may it be an individual, a cultural entity or even a museum. A famous example in the industry as seen an Argentinian designer selling 3D models of artistic furniture as NFTs to be used in VR or AR settings, as well as in development platforms.[181] The interaction between VR/AR and NFTs could be even more profound, when fully digital worlds are considered. In that case, immersive experiences can be the final output of the artistic process[182] and the content to be displayed and bought. These could be 360-degree images, videos, 3D models, all of which could be used and showcased by users' avatars in a metaverse setting.

4.2.2. Advertising and marketing

> **Level of awareness and maturity of VR/AR**: Companies are increasingly starting to use VR/AR to advertise their products in an innovative way, meet their customers' needs, and improve the overall customer experience thanks to immersive features. This remains a rather niche approach, with the success of VR/AR advertising campaigns remaining unclear. Wider adoption of VR/AR in these contexts remains limited by the need of specific hardware, or by the fact users are often required to purchase or download dedicated applications to try the immersive experience.
>
> **Main adoption trends:** The B2B and B2C features of advertising and marketing are similar for VR/AR. More companies are starting to diversify their promotion strategies by including VR/AR because of its novelty effect on potential customers. Applications in terms of customer experience have increased due to the COVID-19 pandemic.
>
> **Main applications:** advertising, marketing, customer experience.
>
> **Main users**: advertisers and marketers (clients), advertising and marketing companies, and audience.
>
> **Main impacts of VR/AR**: increased audience engagement and outreach, enhanced customer experience, increased sales, and more virtual engagements.

Advertising and marketing refer to the promotion of products and services through one-way channel communication (advertising) and to the identification, prediction and meeting of customers needs, as well as the general improvement of customer experience.[183] According to Eurostat, the sector employs 1.130 thousand people in Europe, generating a turnover of EUR 161.000 in 2016.[184] Statistics suggests that advertising represents the leading segment in terms of AR revenues, accounting for around EUR 1.3 billion globally.[185]

Many companies already use VR/AR art to **promote their products** – for instance, by placing them in a digitally-recreated environment or creating hologram-like experiences.

[G] Dezeen (2021), *Andrés Reisinger sells collection of "impossible" virtual furniture for $450,000 at auction*, available here.
[182] Circuit Stream (2021), *The power of immersive technologies for NFTs*, available here.
[183] American Marketing Association (), *Marketing vs advertising,* available here.
[184] Eurostat (2016), *Advertising and market research statistics*, available here.
[185] Artillery Intelligence (2022), *AR usage and consumer attitudes, Wave V*, available here.

VR/AR is particularly effective because of the sense of novelty that still surrounds it, which increases potential customers attention and allows for increased interaction between them and the product.[186] The growing acceptance of the technology and the concept of metaverse can also create new forms of advertising, which could be integrated into the digital experience. An interesting experiment in this regard has been conducted by the film studio Lionsgate, which created an interacting VR experience to promote its upcoming Saw movie.[187] Future advertisement efforts could integrate VR/AR even more, by making ads more personalised thanks to the information collected in the metaverse and by including the promotion of entirely digital items (NFTs) that can be worn by one's digital avatar in the metaverse.[188]

On the other hand, business models that rely on advertisement-related revenue generation could promote future VR/AR uptake. For instance, video advertising can be integrated in a digital environment recreated through VR, and mobile-friendly ads displayed through AR features. Given the amount of data that especially VR devices can collect, ad-driven business could be hugely interested in VR/AR, as it could allow for even more tailored and targeted ads, delivered in a non-disruptive way for the user. Future discussions on the topic will need to consider important aspects such as the sensitivity of the data collected and data ownership[189] – an area where the EU is already leading.

The other main application in this sector regards **customer experience**, which can be greatly enhanced thanks to the integration of VR/AR. Typical examples include AR apps that allow customers to see what a product could look like in their home or what clothes or accessories could look like on themselves. This allows customers to identify, try and purchase products without ever leaving their houses. This is especially useful in post-COVID-19 times, and it also reduces the need for travelling around, reducing each one's carbon impact. In general, VR/AR-enhanced customer experiences provide deeper connections with brands, help customers to make more informed decisions, and can provide post-purchase services.[190]

Client engagement using AR

Research shows that product promotion through immersive technologies positively influences brand engagement and increases customer experience satisfaction.[191] For this reason, an increasing number of companies are partnering with VR/AR studios to advertise their products and captivate customers.[192]

The famous sports clothes retailer Adidas uses AR as a marketing technique. Their shop app includes a feature that allows customers to visualise how digital versions of the products fit them. In a similar form, the British company Aardman[193] developed an AR application for the promotion of its Shaun the Sheep character, which displayed short animations when framing specific pictures with a smartphone. Furthermore, numerous

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[186] The potential effectiveness of VR/AR in this sense is so high that it is raising concerns in terms of audience manipulation. See Mhdaidli, A., Schaub, F. (2021), *Identifying manipulative advertising techniques in XR through scenario construction*, available here.
[187] Mobile Marketing (2017), *Lionsgate and Unity want to play a game with Jigsaw 'virtual room' ad*, available here.
[188] Ad Tech Explained (2021), *Advertising in the Metaverse*, available here.
[189] Mhaidli, A. (2021), *Studying the privacy and security risks of XR advertising*, available here.
[190] Future Visual (2021), *Transforming customer experience using VR/AR*, available here.
[191] Mclean, G. and Alan, W. (2019), *Shopping in the digital world: Examining customer engagement through augmented reality mobile applications,* avaiable here.
[192] Ekmeil, R. et al. (2021), *Augmented reality and virtual reality revolutionize rusiness transformation in digital marketing tech industry analysts and visionaries during Coronavirus (COVID 19)*, available here.
[193] Aardman website available here.

retailers, including well-known brands such as Ikea,[194] Westwing[195] and Coolblue,[196] use ARKit-based 3D product previews to enable clients to experience products live in their space.

4.2.3. Video games

Level of awareness and maturity of VR/AR: Video games is the most common use case for VR/AR in the B2C market. Technological developments and commercialisation of VR headsets in the last years by major actors such as Oculus/Meta, Sony, HTC and Valve brought VR/AR closer to the wider public. VR gaming is perceived by many stakeholders as the next big revolution in video games, as emerged from desk research as well.

Main adoption trends: Almost entirely B2C market. The VR and AR markets are very different, with VR gaming more dependent on headsets and AR on smartphones. Gaming is the single biggest market for VR/AR technologies.

Main applications: storytelling, entertainment, social platform.

Main users: videogame developers, videogame publishers, post-production experts and companies, 3D designers, artists, consumers.

Main impacts of VR/AR: increased sales, creation of a new market, more virtual engagements, and new social opportunities.

The video games sector encompasses all those industry activities involved in developing, marketing and monetising video games. It is a market employing almost 87 thousand people in 2019 and worth EUR 23.3 billion in 2020 in Europe.[197] According to this study's estimates, the sector represents around 29% of the total VR/AR revenues (see Figure 4). Gaming as an activity has skyrocketed over the years, starting from a niche entertainment activity to a mass phenomenon that is widely accepted and consumed. According to some estimates, on average slightly more than 10 % of local game developer studios develop games on VR/AR platforms, indicating a relatively advanced level of deployment in the sector, although with some differences across countries (e.g. 20 % in Germany).[198] Riding the video gaming wave, the submarket of VR/AR games has also grown in the last years and represents the biggest source of earnings for the whole technology – according to some estimates around EUR 11 billion globally.[199]

Given the relative importance of video games as a market share of VR/AR, innovation in the two ecosystems is closely related. Many technological advancements in the video games sector could have clear consequences for the future of VR/AR. For instance, advancements in graphics, facial recognition and 3D graphics will increase the level of immersion, optimising VR/AR experiences and making them smoother and more easily

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[194] Ikea website available here.
[195] Westwing website available here.
[196] Coolblue website available here.
[197] Interactive Software Federation of Europe (2021), *Key facts 2020*, available here.
[198] Calculations based on EGDF (2019), 2019 European videogames industry insights report, available here. It has to be noted that figures are based on a limited sample of countries (10) for which VR/AR data are available.
[199] IDC (2020), *Worldwide spending on Augmented and Virtual reality forecast*, available here.

accessible.[200] Experiments in terms of gesture recognition can impact VR/AR experiences, allowing for a reduction, or altogether removal, of the use of controllers and tracking even small hand movements. Moreover, advancements related to wearable technologies can be further integrated into VR/AR gaming to increase the senses involved in immersive experiences.

Another important aspect linking video games and VR/AR content regards **platforms**. In the context of gaming, these are mostly understood as marketplaces where developers can sell their games or VR/AR experiences. Platforms connecting suppliers, developers and users are often owned by hardware manufacturers – in VR/AR, the most important being Meta's Oculus Store and Valve's Steam, both US owned. Since these platforms guarantee high levels of revenues,[201] these same companies are often those who can afford to research hardware development, an activity considered by entrepreneurs as very capital-intensive.[202] This situation can harm VR/AR game developers, since they need to face an uneven power dynamic with these big tech companies – as platformisation processes are contributing to the monopolisation of digital media distribution in the hands of these players.[203] Additionally, this entails limitations or imperfect optimisation for content creators, which, according to stakeholders, would prefer open data solutions ensuring more freedom in terms of game development.[204] In Europe, this issue could be addressed by creating European platforms to effectively link hardware manufacturers with software and content creators. This is perceived by many stakeholders as a market gap that could be occupied by one or multiple European players, which could also increase the European share of VR/AR gaming revenues.

Below, the differences between VR and AR when it comes to gaming are explored.

The strength of VR is in the way it immerses players in a 3D environment, widely magnifying the emotional impact potential of narrative-based single-player games.[205] The ever-increasing power of VR gaming headsets, alongside developments in computing power and other technologies such as AI and 5G, can now render almost photorealistic 3D worlds and transpose them in VR even in the cloud, something that was impossible only a few years ago. VR video games can be appealing for non-gamers as well, given the unique player experience they provide, which can be engaging while being more intuitive that traditional games.[206] Therefore, VR games key features include both the immersivity of the experience and the potential innovativeness of the gameplay.

Moreover, the fact that VR encourages interaction with the environment is fertile ground for multiplayer games, which can become more similar to new **social platforms** where people can party, see concerts and meet up with virtual friends. Interesting cases in this sense are the success of the social VR developer Rec Room, which recently became the first VR unicorn,[207] or the Travis Scott concert, which was held entirely in the blockbuster game Fortnite.[208] The non-existence of a European platform acting as a catalyst for these activities is a cause of concern for many actors in Europe.[209]

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[200] Skywell Software (2019), *Unbelievable video games innovations to watch for in 2020*, available here.
[201] For instance, Apple retains 30% of many in-app purchases. See The Verge (2021), *A guide to platform fees*, available here.
[202] Forbes Councils (2020), *Finding a niche: What it means to be the only hardware investor in L.A.*, available here.
[203] Chia, A. et al. (2020), *Platforminsation in game development*, available here.
[204] Workshops and interviews findings.
[205] Hemenover, S. H., Bowman, N. D. (2018), *Video games, emotion, and emotion regulation: expanding the scope*, available here.
[206] The Washington Post (2021), *Virtual reality is starting to see actual gains in gaming*, available here.
[207] Meaning its annual revenues surpassed the USD 1 billion mark. See Freethink (2021), *Rec Room is VR's first 'unicorn' startup. Who are they and what makes them special?* available here.
[208] BBC (2020), *Fortnite's Travis Scott virtual concert watched by millions*, available here.
[209] As mentioned by many stakeholders interviewed.

> **Most successful European realities in VR video games**
>
> Given the strong focus of the European VR/AR and video games ecosystems on content, it is not surprising that many of the world's most successful developers are based in the EU. Many of these companies have a background in traditional video games and have decided to invest part of their resources in VR/AR to explore the possibilities given by the new medium.
>
> The French company Ubisoft,[210] the most valuable European gaming company together with the Polish CD Projekt Red,[211] is one of these examples. The developer and publisher of some of the biggest video game realities in the world announced, for instance, a new VR game, part of the Star Trek franchise, called Bridge Crew.
>
> Another similar example is the Amsterdam-based Guerrilla Games,[212] developer of the best-selling Killzone and Horizon series. It recently announced a new VR game as part of the Horizon franchise, set to be named Call of the Mountain.
>
> Other European teams with a similar experience include Ninja Theory[213] (UK), IO Interactive[214] (Denmark), and Arkane Studios[215] (France). Slightly different is the situation of Crytek,[216] a German company famous for developing the Crysis series and the first Far Cry game, which also created its proprietary CryEngine game engine, used by VR/AR developers all around the world.
>
> Other game developers have made VR/AR their core business since the beginning, sometimes with excellent results. Among the best cases are Beat Games,[217] the Czech developer (now acquired by Oculus) of the best-known VR killer application Beat Saber, or the Polish company SUPERHOT[218] Team, developer of the homonymous award-winning game. Other similar realities include Fast Travel Games,[219] founded by former members of big players in the sector such as Rovio, EA, DICE and Avalanche, the Stockholm-based Antler Interactive,[220] developer of The Deus Helix, one of the longest VR games in circulation, and the Dutch Vertigo Games.[221]

AR applications in gaming mostly regard increasing the level of interactivity, allowing players to do things differently, and generally improving (as opposed to revolutionising) traditional ways of making and playing games. The AR gaming industry, estimated in almost EUR 3 billion globally in 2020,[222] is particularly important for in terms of mobile, with gaming being the most popular AR app category – 25% for iOS, and 21% for the Google Store.[223] 60% of the video gamers in Europe play on smartphone or tablets, or at least on portable

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[210] Ubisoft website available here.
[211] CD Projekt Red website available here.
[212] Guerrilla Games website available here.
[213] Ninja Theory website available here.
[214] IO Interactive website available here.
[215] Arkane Studios website available here.
[216] Crytek website available here.
[217] Beat Games website available here.
[218] SUPERHOT website available here.
[219] Fast Travel Games website available here.
[220] Antler Interactive website available here.
[221] Vertigo Games website available here.
[222] Cision (2020), *Global AR Gaming Market Report 2020 – Mobile AR Gaming Market Projected to Grow at a 41.9% CAGR to Reach $21.7 by 2027*, available here.
[223] GoGlobe (2018), *The state of mobile gaming industry – Statistics and trends*, available here.

consoles gaming[224] (such as in the case of the Nintendo Switch console), an important data for AR, since smartphones are ubiquitous AR devices.

The first killer application in both VR and AR has been the AR smartphone game Pokémon GO, which in 2016 was the cause of both the popularisation of AR within the mainstream public, and of much of the excessive hype that surrounded immersive technologies in those years with its peak of 147 million monthly active users in 2018 and its over EUR 5 billion in revenues by 2020.[225] Since then, both Apple and Google released developer kits (ARKit and ARCore respectively) to facilitate the creation of AR mobile games. In many cases, mobile AR games make use of built-in smartphone features, such as the gyroscope or the user's GPS location, to increase the level of immersion and make the transition between the real and the augmented world as seamless as possible.[226]

The highest added value of AR games is their **appeal towards casual gamers**, who can have a different and interactive experience instead of the traditional way of gaming. AR gaming is an important industry with high revenues, which offers a relatively low variety of different applications – mostly due to the implicit limitations of gaming through a smartphone. It is plausible to think that, in the future, AR headsets will become popular in gaming as well – whereas at the moment headsets are only VR – increasing the options at the disposal of game developers.

Another area of interest where VR/AR and video games intertwine is game engines. This is the software frameworks used for the development of video game experiences. The best-known and most widely used by developers are Unity, created by Unity Technologies,[227] an American-owned company that started in Copenhagen in 2004, and Unreal, developed by the US company Epic - with the former having a 43% market share of the whole video games sector and claiming 60% market share in terms of VR/AR video games[228], and the latter standing at 13% market share in the whole sector[229]. Among European players in the field, the German company Crytek developed one of the most popular VR/AR game engines in the world, its proprietary CryEngine. Other examples include UNIGINE,[230] headquartered in Luxembourg, and the Budapest-based Apertus VR.[231]

4.2.4. Libraries, archives, museums and other cultural activities

Level of awareness and maturity of VR/AR: Museums are starting to implement more VR/AR exhibitions to attract more public and offer more innovative experiences. Open-access opportunities allow access to remote virtual tours and 3D reproductions of art. In other contexts, the use of VR/AR remains rather limited. Cultural venues have the potential to act as first contact points to the wider audience, potentially increasing awareness about the educational applications of VR/AR.

Main adoption trends: Some cultural activities, especially museums and art galleries, have started to integrate VR/AR exhibitions and immersive interactive content. However,

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[224] ISFE and EDGF (2021), *Key facts 2020 – The year we played together*, available here.
[225] Levvvel (2022), *Pokémon GO statistics and facts 2020*, available here.
[226] Narrasoft (2021), *What are Augmented Reality video games?* available here.
[227] Unity website available here.
228 Circuit Stream (2022), *Unity vs Unreal Engine for XR development*, available here.
229 Extern Labs Inc (2022), *Unity vs Unreal: What to choose in 2022*, available here.
[230] UNIGINE website available here.
[231] Apertus VR website available here.

most venues do not have a VR/AR area, and applications for libraries and archives are relatively limited as of now.

Main applications: storytelling, administrative tasks, logistics and management, data visualisation, and customer experience.

Main users: libraries, archives, museums, schools, tourism destinations, and other cultural entities.

Main impacts of VR/AR: increased productivity and efficiency, improved learning experience, increased audience engagement and outreach.

This subsector, employed around 535.4 thousand people in 2020,[232] revolves around the organisation of location-based cultural activities, and around the provision of consultation, documentation and information services to the general client or specialised clientele.

VR/AR applications can be new ways of experiencing traditional content in the galleries, libraries, archives, and museums sector, such as cultural exhibitions, tourism or immersive content made available by libraries. Therefore, museums can offer immersive experiences that allow people to visit famous paintings[233], and add interaction and layers of information to works of art. Here, VR/AR can enhance the experience by allowing the organisation of virtual tours (presented in the textbox below) and the creation of innovative experiences to present original and traditional pieces of art. These experiences can be individual, through the use of a headset or smartphone, or collective. Similarly, libraries can tap into the educational potential of VR/AR and enhance images and pictures from books, as well as to convey information in a new and effective way. For instance, VR is used to present libraries in a more entertaining way, in the form of virtual tours or of interactive educational content. This could reignite interest in libraries, as well as allow, in the future, for a new way to collect and present literary content.[234] VR/AR technologies can also be used in information literacy activities, showing the way around the library, finding library resources on the stacks, or increasing library efficiency by analysing the content of shelves in real time.[235] Art and education galleries hosted in libraries can also be enhanced through immersive content, by creating a blended learning environment taking advantage of many different digital tools such as 3D objects, avatars, PowerPoint, Wikipedia, and many others.[236]

An effective tool for all potential users under this subsector is Google Arts and Culture,[237] an online and openly accessible database of pieces of art and culture featuring both VR and AR functions. Museums can be visited in a VR setting by using Google Cardboard, whereas several 3D models related to arts and culture can be projected into the real world through a smartphone camera. The European initiative Europeana,[238] financed by the Connecting Europe Facility, has a similar database, featuring galleries, exhibitions, and culture-related posts from all around the continent.

European applications for virtual tour

Virtual tours are one of the main applications of VR/AR for museums. They combine an immersive experience with the comfort of not leaving one's flat. Depending on the level

[232] Eurostat (2020), *Cultural employment by NACE Rev. 2 activity, available here.*
[233] Workshop findings.
[234] Peachey (2016), *Virtual Reality in the library*, available here.
[235] Oyelude, A. A. (2017), *Virtual and augmented reality in libraries and the education sector*, available here.
[236] Massis, B. (2015), *Using virtual and augmented reality in the library*, available here.
[237] Google Arts and Culture ebsite available here.
[238] Europeana website available here.

of each given tour, these can allow direct interaction with the exhibition, or display a 360-degree video experience.

Many European companies and VR/AR studios have dived into this market, often with spectacular results. For instance, the French Emissive studio[239] collaborated with the Louvre Museum in partnership with HTC Vive on the Mona Lisa VR project, an animated experience offering insights into the world's most famous painting. Similarly, the British company Preloaded[240] joined forces with the Tate Modern Museum and designed an immersive tour dedicated to the Modigliani exhibition, suitable for different audiences – tech savvy, unaware of VR/AR, art connoisseurs and newcomers.

Other European companies designing and implementing virtual tours include, among the others: Moyosa Media[241] (the Netherlands), which created the Kremer Collection VR Museum; Sensory Odyssey[242] (France), which collaborated with the Paris Museum of Natural History to design an immersive experience focused on biodiversity; and Zoan[243] (Finland), designers of an immersive experience on R. W. Ekman's painting 'The opening of the diet 1863 by Alexander II', hosted at the National Museum of Finland.

These applications have proved popular with the general public. They gamify the learning experience and often lead to better results and enhanced engagement, bringing people who normally would not indulge in cultural activities to try them out. Many European museums have started to explore new formats to attract new audiences, especially after the COVID-19 pandemic. For instance, the Grand Palais Museum in Paris started a new branch of activities completely dedicated to digital exhibitions in an immersive format.

Therefore, museums, exhibitors and other cultural entities are often the main distributors of the VR/AR experiences and tours, and co-finance or co-produce exhibitions in collaboration with VR/AR studios. An important aspect to underline is the replicability of location-based exhibitions in different venues. Such an aspect needs to be integrated at the conceptual phase (when designing the exhibition) to ensure a certain degree of flexibility in adapting the content to the physical location.

These efforts, and in general the wider introduction of VR/AR applications in museums and cultural locations, can spread awareness of the technology among the wider public and can attract new people to cultural venues. Cultural activities can, in fact, be an effective first point of contact with VR/AR technologies, and can spread knowledge, social acceptance and awareness of the potential of immersive technologies.

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[239] Emissive studio website available here.
[240] Preloaded website available here.
[241] Moyosa Media website available here.
[242] Sensory Odyssey website available here.
[243] Zoan website available here.

4.2.5. Motion picture, video, and television programme production

Level of awareness and maturity of VR/AR: Integration of VR/AR-related technologies (specifically virtual production) in major film productions are increasing the level of awareness and maturity of the technology. However, the situation differs in relation to purely VR/AR experiences, which, according to most stakeholders, are still part of a niche and largely unexplored market.

Main adoption trends: In terms of B2C market, the use of VR/AR is still tied to traditional ways of producing content. VR/AR is being carried forward by pioneers and established awards have been created in the last decade. But a paradigm shift in the way 3D content is created is required to get wider acceptance of the technology. B2B and corporate VR/AR film and video production is an emerging sector, as it enhances product presentation and exhibitions and tours.

Main applications: storytelling, awareness-raising and advertising.

Main users: TV channels, movies and ads industry, content creators, awareness-raising entities, and post-production experts and companies.

Main impacts of VR/AR: increased audience engagement and outreach, more accessible and cheaper visual effects, more virtual engagements, and increased sales.

This subsector includes all the activities necessary to produce films, videos, and TV programmes, and experiences. The main goal in the use of VR/AR in this context is to produce creative content before exploiting the intellectual property thus created through mass consumption. This subsector, according to Eurostat, sees over 387.5 thousand people employed, and represented, in 2019, EUR 58.3 billion in turnover. There are at least two ways of seeing how VR/AR can interact with the film industry.

The first views VR/AR as a new technology at the service of the traditional industry. For instance, filmmakers can use **virtual production** (VP) to establish a film in a digital environment before going on a physical set[244] and to visualise in real time (while filming) a blend of the virtual environment previously set and the material being shot. Virtual production allows for quick interactions with a preview of the final result, for instance changing the background, and adding and editing visual effects.

The technology used for VP is mostly the same as that of VR/AR – that is, in a nutshell, the possibility to render content in real time from the point of view of the camera.[245] The use of VR/AR and VP entails greater creative freedom (for instance, when considering lighting issues, art design, and world building), as well as cost savings during the pre- and post-production phases. It also reduces location costs and visual effect errors on set and increases immersive interaction.[246]

Virtual productions and VR Cinema

Virtual production has established itself as an essential tool in the audiovisual industry given its creative capabilities, especially in action or science fiction content.Virtual -

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[244] TCS Talent (2019), *Virtual Production 101: How does it work, how can it revolutionise VFX?* available here.
[245] Studio Giggle (2021), *The difference between XR and Virtual Production for film*, available here.
[246] Mo-Sys (2021), *Cinematic XR*, available here.

production processes have become a standard norm rather than an exception, and, as a market, surpassed the EUR 1.5 billion mark globally in 2021[247] . Likewise, VR Cinema has emerged during the last years. Filmmakers have embraced virtual technology, as it enables them to create more immersive situations than the traditional methods. It has become such a relevant trend that internationally renowned film festivals have begun to dedicate parallel sessions exclusively to immersive technologies, such as Cannes XR and Venice VR Extended.

A growing number of studios have appeared on the European scene that address these developments. El Ranchito,[248] a company based in Spain, has specialised in supporting major audiovisual productions with virtual production processes. Their contributions to major international productions, such as Game of Thrones (produced by HBO) and Lost in Space (created by Netflix), have resulted in numerous awards, including an Emmy and an HPA (Hollywood Professional Association Award). Similarly, the Parisian studio Atelier Daruma[249] has become a point of reference for immersive storytelling. Other content producers, such as Faber Courtial[250] and French Touch Factory,[251] a studio creating VR/AR narrative experiences, are prominent in the European immersive production scene.

These techniques can also be used to add VR/AR elements to traditional film production by adding a third dimension and drastically increasing the level of immersion of the movie. VR can be particularly effective in this sense, as its immersivity has great potential in generating empathy in the viewer, thus increasing emotional involvement.[252] However, approaching VR/AR experiences in this way gives way to several issues, as immersive technologies are an altogether different medium than traditional 2D films. Different skills are needed, and new challenges and solutions arise. For instance, the 3D experience director cannot predetermine the main line of perspective, i.e. where the user is going to look at any given moment. This can cause the spectator to miss a particularly important moment in the story, but also challenges the director to solve this in new and creative ways.

Therefore, the second way to look at VR/AR experiences is to consider them as a separate way of creating stories. VR/AR storytelling is different from 2D films in that they rely on the fact that users need to be able to create their own experience and roam the digital environment, exploring it independently. Different sources and stakeholders claim that especially VR can revolutionise the industry, as it can be more emotionally engaging to the viewers.[253] This can be used to raise awareness on environmental and social issues, and delivering powerful stories.

In this sense, stakeholders have suggested that the film industry is still anchored to traditional ways of viewing the media and is often unable to recognise the potential of VR/AR experiences – which are then treated as secondary and not backed by strong financing opportunities.[254] Further exploring this direction would separate traditional and VR/AR filmmaking, potentially creating a niche market and value chain.

These two visions of the role of VR/AR in film production lead to different interactions and expectations from the traditional industry. When used as a tool to facilitate production and integrate virtual environment in real time (mostly through VP applications), expectations on

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[247] Grand View Research (2022), *Virtual production market size, share and trends analysis report*, available here.
[248] El Ranchito website available here.
[249] Atelier Drama website available here.
[250] Faber Courtial website available here.
[251] French Touch Factory website available here.
[252] Meien Li (2021), *The role of VR/AR technology in film industry*, available here.
[253] Ciaran Gillespie (2020), *Virtual Humanity – Access, empathy and objectivity in VR film making*, available here.
[254] Interview findings.

further VR/AR developments are high. The success of the first productions that integrated VP and VR/AR, such as The Mandalorian and The Lion King, paved the way for further integration of these technologies in the traditional industry. On the other hand, the creation of purely VR/AR experiences is still perceived as an extremely niche market, and stakeholders in the field think it should be treated as separate from traditional filmmaking because of the completely different nature of the final product and the different mindset required.

Both ways of conceiving production in VR/AR require a specific set of skills from producers. Skillset from traditional filmmaking is needed – from direction to acting, lights placement, immersion in the context, storytelling, screenwriting, effective on-set communication, sound editing, and pre- and post-production. However, integrating immersive technologies entails additional skills to properly put VR/AR at the service of the final content − for starters, the additional technical expertise needed to effectively use VR/AR software in the production. In addition, the skillset required encompasses handling lighting in a virtual environment and overcoming some of the limitations caused by VR/AR – such as the general lack of experience in using the technology, the differences between what is possible in a virtual and a physical environment, and creative limitations linked to reduced camera angles or shadows.

4.2.6. Live entertainment and performing arts

Level of awareness and maturity of VR/AR: Concert and sports event organisers, and theatres have found in VR/AR a way to attract the public in innovative ways. This trend has been accelerated by the COVID-19 pandemic. Immersive technologies are becoming increasingly utilised to enhance location-based events, or for completely moving them in a virtual setting – a trend which could be strengthened by more people moving to metaverse-like settings.

Main adoption trends: The best-known VR/AR applications relate to the B2C market, but the subsector has a developed B2B niche. Implementation of VR/AR features at live concerts or sporting events is becoming more popular, and immersive technologies have the potential to partly replace (or support, in COVID-19 times) regular events.

Main applications: marketing, advertising, betting, enhanced sporting events, and training.

Main users: music event organisers, artists, sporting event organisers, theatres, and cultural gatherings organisers.

Main impacts of VR/AR: enhanced customer experience, increased sales, and increased outreach.

Live entertainment and performing arts entail all those activities provided for leisure or cultural reasons by a person or a group of people that is physically present to deliver said activity. The most common examples include sporting events, concerts and other music performances, whereas performing arts include activities performed in front of an audience such as dance, drama, music and theatre activities. The performating arts sector employed 1.81 million workers, entailing a EUR 44.7 billion value added in 2017.[255]

In all these activities, VR/AR technologies can be used either to enhance and enrich the live experience or to replace it altogether with a digital version, viewed through immersive

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[255] EIF (2021), *Market analysis of the cultural and creative sector in Europe*, available here.

headsets. These two different uses of VR/AR are not mutually exclusive. VR concerts show big potential especially in comparison to traditional virtual ones due to the technology's ability to "induce a sense of presence" able to elicit an emotional response to the user.[256]

Therefore, especially VR has been used to capture the motion of artists to present them to virtual audiences wearing headsets, or, through cinematic VR, to present video content in 3D environments.[257] In economic terms, they could be more lucrative due to the immersiveness of the experience, which in turn could justify higher ticket prices.[258] In addition, some VR concerts have proven a success,[259] such as in the case of the French electronic music artist Jean-Michel Jarre.[260] The further development of the metaverse could increase the appeal of these kind of events. This could, for example, see users' avatars visit virtual worlds with a high degree of immersion, while allowing the audience to avoid travelling and save money on tickets. Realities, such as the Sensorium Galaxy[261]

On the other hand, live events can also be enhanced by AR, rather than being replaced by a virtual one. At the moment, this happens especially in the sports business, with games featuring AR to provide real-time information on what is happening on the pitch and additional details, such as the background of the game or the names of the players.[262] However, in the music business as well some bands have started using AR features to augment their live concerts. For instance, the Irish band U2 included them in their Experience + Innocence Tour: when framing a giant iceberg projected on a giant screen with their smartphones, the audience could see an image of the band's frontman[263]

VR/AR in sports events and broadcasting

The implementation of VR and especially AR features in sports broadcasting has been steadily rising over the last years. Immersive features are being used in studios by presenters to explain or explore techniques of players by using hyper-realistic 3D models of players to be viewed in AR, as done by the English Cricket Board in collaboration with Sky Sports.[264]

The German Deutsche Telekom[265] has livestreamed a basketball game in 360 degrees, allowing users to watch it through a VR headset and immerse themselves in the experience as if they were in the stadium.[266] Many other national broadcasters integrated some elements of VR/AR. For instance, ZDF[267] employed a Robycam camera system during an international football match to overlay real-time information on the screen;[268] the French channel Canal+[269] aired a programme featuring floating graphics integrated with the studio and the audience;[270] and the Spanish top-flight football association, La Liga,[271] is working to offer data-enhanced game coverage, VR/AR applications, and 3D replays.[272]

VR/AR, therefore, offers several advantages to broadcasters and the public: they make sport more interactive, immersive, and easily understandable by neophytes; they deepen and enhance the experience by adding real-time information and statistics; and they allow new and modern interaction during studio shows.

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[256] Riva, G., et al (2007), *Affective interactions using virtual reality: The link between presence and emotions*, available here.
[264] The Hundred website available here.
[265] Deutsche Telekom website available here.
[266] Sportspromedia (2018), *Deutsche Telekom takes virtual reality streaming to BBL*, available here.
[267] ZDF website available here.
[268] APB News (2018), *German broadcaster scores big in bringing AR graphics to international football friendly*, available here.
[269] Canal+ website available here.

Lastly, VR/AR shows great potential in theatre and performing arts. A new discipline called immersive theatre is being born – its main feature being the elimination of the distance between performers and the audience, creating a sense of intimacy otherwise impossible for traditional theatre.[273] Theatres and companies producing immersive theatre experiences quickly realised the value that VR/AR technologies could bring. Here, AR and VR serve different purposes. AR can be used to integrate new features in traditional immersive theatre, blending the physical space with digital objects. An effective example of this integration is the collaboration between Punchdrunk, a UK-based company considered among the pioneers of immersive theatre, and the AR company Niantic, developers of the first AR killer application, *Pokémon Go*.[274]

On the other hand, VR can revolutionise immersive theatre by replacing the intimacy of physical space with the immersivity of the digital one – as long as creators manage to properly use the new virtual space.[275] Moreover, VR allows users to enjoy these experiences remotely from their houses, reducing the need for travelling and expanding the potential viewer base. According to some, the leap from physical to digital is more natural to do in theatre rather than in the movie industry: both in VR/AR performing arts and in theatre, in fact, creators cannot control the point of view of the audience, whereas in film productions directors do, and face additional challenges in transitioning from traditional to VR/AR film-making..[276] Additionally, theatres are exploring some new ways to integrate immersive experiences in performances, such as in the case of the Royal Shakespeare Company's Dream experience,[277] VR_I, a location-based dance piece,[278] the All Kinds of Limbo experience organised by the UK National Theatre,[279] the Finnish Opera Beyond[280] project, or the Current, Rising experience brought by Chroma[281]

4.2.7. Programming and broadcasting activities, and news media

Level of awareness and maturity of VR/AR: VR/AR technologies are being used to enhance aired shows in real time with AR and to create immersive virtual settings in VR. While during the VR/AR hype years, around 2016, VR was considered by many as the future of media for news outlets and journalism, it has so far struggled to attract a sufficient critical mass of the public. However, the commercialisation of headsets and the interest in the metaverse could provide an opportunity to increase the popularity of VR/AR in this sector.

Main adoption trends: Most applications refer to the B2C market, as TV and news channels are directed towards the general public. B2B broadcasting activities are directed to a niche audience and generally take the form of digital broadcasting. In recent years,

[263] AR Post (2020), *Using augmented reality to elevate the concert experience*, available here.
[264] The Hundred website available here.
[265] Deutsche Telekom website available here.
[266] Sportspromedia (2018), *Deutsche Telekom takes virtual reality streaming to BBL*, available here.
[267] ZDF website available here.
[268] APB News (2018), *German broadcaster scores big in bringing AR graphics to international football friendly*, available here.
[269] Canal+ website available here.
[270] News Cast Studio (2018), *Canal Football Club enhances sports coverage with augmented reality*, available here.
[271] La Liga website available here.
[272] La Liga (2021), *La Liga teams up with Microsoft to digitally transform football globally*, available here.
[273] Contemporary Performance (2021), *What is immersive theatre?*, available here.
[274] The Verge (2020), *Niantic partners with Sleep No More creator to build immersive AR theatre experiences*, available here.
[275] Amt-Lab (2021), *How VR and AR are changing the world of immersive theatre*, available here.
[276] The Skinny (2017), *How VR could be the future of theatre*, available here.
[277] BBC (2021), *Royal Shakespeare Company to stage virtual reality show*, available here.
[278] VR_I website available here.
[279] All Kinds of Limbo website available here.
[280] Opera Beyond website available here.
[281] Chroma's Current, Rising website available here.

> many big outlets and channels created VR/AR-dedicated channels, but the impact on the public has been limited, leading to reduced investments.
>
> **Main applications**: storytelling, awareness raising, live broadcasting, marketing and advertising.
>
> **Main users:** VR/AR distribution platforms, sports/events channels, post-production experts and companies, news channels, journalists.
>
> **Main impacts of VR/AR:** increased audience engagement and outreach, customer experience, increased sales and revenues, increased awareness-raising effect.

This subsector takes into consideration those activities revolving around creating or acquiring the rights to distribute content, and later broadcasting it through means such as radio, TV, and others. Moreover, it encompasses the creation and distribution of news media, meant to be communicated to the general or a target public. Programming and broadcasting activities employed 285.3 thousand people and accounted for a EUR 63.6 billion turnover in 2019, while news media and publishing generated around EUR 33 billion. Such a definition encompasses two main aspects:

- the creation (or acquisition) of VR/AR content to be broadcast, including news-related media;

- the integration of VR/AR into traditional broadcasting activities.

The first case heavily overlaps with other subsectors, such as creative arts, and motion picture, video and television programme production. Content creation in VR/AR enjoys can engage the audience in new and innovative ways then use broadcasting opportunities to disseminate it. Specific to this subsector is the potential in terms of news media and journalism. Several outlets, such as the Guardian,[282] El País and Deutsche Welle, or TV channels such as Sky News and RedBull TV, have invested in VR/AR to create dedicated products and build stronger engagement with their audiences. VR allows users to experience a situation through immersion, rather than being external spectators. AR, on the other hand, can enhance the content that is already printed by adding context or showing related content. Experiments conducted in the field, while in many cases being a success and winning acclaim from both audiences and critics,[283] often have the same drawback in common: they struggle to reach a large audience. This is caused by a variety of factors, such as the cost of VR hardware and the wider public's relative lack of awareness of the technology and these experiences. On the other hand, the use of AR relies on dedicated apps to be downloaded on users' smartphones – removing problems in terms of accessibility to hardware. Therefore, 3D images and data visualisation can allow consumers to view their daily content in an innovative way, increasing immersion.

> **Virtual Reality, immersive journalism and documentaries**
>
> As mentioned in the paragraph above, many news outlets in Europe have started producing or commissioning VR content and documentaries. The objective is to tap into the storytelling potential of immersive technologies to offer powerful experiences that captivate and engage the audience. The potential of VR for engaging journalism and of

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[282] Forbes (2020), *Is immersive technology the future of journalism?*, available here.
[283] Some award-winning projects can be found here: Online Journalism Award, *Excellence in Immersive storytelling*, available here.

the effective integration of VR and journalistic techniques has been the subject of an EU-funded research project called PersVR [284]

Among the outlets that invested the most in VR documentaries, the British newspaper The Guardian[285] has been at the forefront, co-producing and distributing VR documentaries on a variety of topics, ranging from the experiences of asylum seekers and virtual experiences of autism to awareness-raising pieces on the ever-shrinking Arctic ice caps.[286]

The Spanish El País[287] launched a VR smartphone application allowing viewers to experience immersive documentaries. The first of this kind was dedicated to the nuclear disaster of Fukushima Another example of a European news outlet integrating VR is Euronews,[288] which published several 360-degree videos in six different languages to engage audiences from all around Europe.

VR documentaries are not only produced by news outlets. Some European companies have specialised in producing high-quality VR experiences to raise awareness of certain topics or to report news in an innovative way. One of the best examples is the French company Targo,[289] an Emmy-nominated studio author, and their VR experience Rebuilding Notre Dame, focused on the reconstruction efforts on the French cathedral after the fire in April 2019. Other examples can be found in the lists of VR/AR experience winners presented, for instance, at the Venice Biennale or at the Cannes XR festival.

VR/AR is being used not only by traditional media to enhance their experiences. Digital content creators and streamers are starting to include immersive technologies in their activities. Not only are they streaming VR/AR content and games on popular platforms such as Twitch, popularising these games and immersive content; they also use MR[290] to capture themselves within the game environment, so that viewers can see them interacting with it.[291] The use of MR in **live broadcasting** is not limited to videogame streamers. Remote conferences, exhibitions, and events can feature MR to show the presenter in a virtual environment – a service offered, for instance, by the German company Neumann and Mueller, specialised in digital live events.[292]

The second aspect presents some overlaps with the live entertainment subsector, especially when it comes to broadcasting and augmenting sporting events.[293] More users expect a higher level of interaction with the event being broadcast – nowadays they mostly achieve this through their smartphones, where AR content already exist. But in the future immersive headsets could be more part of the game. Future developments could bring in more personalised experiences and ads, or completely recreate games in 3D through video capturing, allowing users to display them on their tabletops.[294] Such a way of viewing broadcasting activities requires a complete paradigm shift of the way content is created. At the moment, the basic assumption is that the audience passively receives the broadcast content. VR/AR content, on the other hand, inherently sees the audience as an active entity

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[284] Information on the PersVR project can be found here.
[285] The Guardian website available here.
[286] A full list of available Guardian documentaries can be found here.
[287] El País website available here.
[288] Euronews website available here.
[289] Targo website available here.
[290] A form of immersive technology where real-world objects are blended in digital environments.
[291] The leading tool in this sense is the US platform Liv, website available here.
[292] Neumann and Mueller website available here.
[293] Technically, in most of these cases the term augmented reality is inaccurate, as broadcasters augment a video with additional data, as opposed to the user's true point of view.
[294] Immersiv.io (2020), *The future of sports broadcasting: Innovate with AR*, available here.

able to interact with the digital world.[295] Such a change is still in the making and requires a novel way to see VR/AR: not as an extension of traditional media, but as a new medium with its characteristics and language.[296]

4.2.8. Publishing activities

Level of awareness and maturity of VR/AR: The higher potential in this subsector lies in the possibility to augment books and magazines through AR and to promote these products through dedicated advertising. Immersive technologies are seldom implemented and are not consistently used by most publishers. The metaverse could offer an opportunity to increase awareness and outreach of immersive ways of presenting publishing material.

Main adoption trends: VR/AR applications tend to be dedicated to the B2C market, since books are directed to the wider public. There are examples of publishers using AR in illustrated books and comics, usually in combination with a dedicated smartphone app, but VR/AR functionalities are limited and not very popular. B2B market is involved in terms of distribution of VR/AR content, and in the field of some professional activities such as translation.

Main applications: storytelling, marketing and advertising, and customer experience.

Main users: publishers, book authors, schools and education providers.

Main impacts of VR/AR: increased sales, improved learning experience, increased audience engagement, increased number of VR/AR-compatible book platforms, creation of extra revenue streams.

Publishing activities relate to making information, literature, music, software and other content available to the public, either by sale or for free. This market employed 565.8 thousand people in 2020,[297] and generates a turnover of around EUR 35.5 billion in 2019 (including book publishing and publishing of journals and periodicals).[298]

Many literary publishers have been interested in engaging readers with immersive technologies – especially readers of comics and graphic novels[299] − but sometimes in the context of illustrated children's books, enriching and making more vivid the learning experience.[300] In some cases, books or comics were released in parallel with a downloadable smartphone app, which expanded some elements of the narrative and allowed for a deeper level of integration.[301]

AR-augmented books

Many European publishers have started to integrate AR technologies in their books to enhance the experience and add an additional level of immersion. Books with the most potential in terms of VR/AR interaction are those based on images, rather than on plain text, such as comics and children's books.

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[295] The same paradigm shift occurs in motion picture and in the film industry.
[296] France TV Lab (2019), *How can VR and mixed realities be integrated into television productions?* available here.
[297] Eurostat (2020), *Cultural employment by NACE Rev. 2 activity*, available here.
[298] Eurostat (2019), *Value added and turnover of enterprises in the cultural sectors by NACE Rev.2 activity*, available here.
[299] Publishers Weekly (2021), *A Virtual Reality check for publishing*, available here.
[300] For instance, see Dong, C., Si, Z. (2018), *The research and application of augmented reality in 3D interactive books for children*, available here.
[301] Maxazine (2018), *Black Eyed Peas launch AR app for the 'Masters of the Sun' European tour*, available here.

> The German publisher Oetinger, who specialise in children's books, is among the most successful examples. It developed a series of tools (the Tigerbooks technology, the Tigercreate software, and the Onilo digital reading platform), allowing an easy integration of immersive technologies in book content. The publisher even started a dedicated spin-out called Storydocks[302] to manage its VR/AR-related activities. Similar technologies have also been developed by other publishing companies around Europe, such as in the case of the uARe[303] AR platform created by Gruppo Mondadori (Italy).
>
> The educational potential of VR/AR for children is also being explored. For instance, Cleverbooks[304] is an Irish company that supports pupils aged 5 to 12 in studying science, technology, engineering and mathematics through the integration of VR/AR features in books and classes. Another example includes the Cypriot company AmayaSoft,[305] who worked with the UK-based brand Koko Rose Media to enhance a series of English-language learning books for children with immersive content.

In these context, VR/AR is particularly useful in promoting traditional published products. In the cases mentioned above, the presence of a downloadable app not only improved the storytelling, but it also increased the appeal of the book itself through the integration of immersive technologies. While these aspects show potential, business viability should always be considered. Developing an AR application can be expensive (especially for smaller publishers), therefore careful calculations are necessary to ensure the costs do not outweigh the benefits. Launching a paid app, as opposed to a free one to recover costs, could sink the popularity of the app itself, with users perceiving it as a way for publishers to make extra profit, rather than a positive add-on.[306]

Publishing activities could be revolutionised by Web 3.0 and the metaverse. Books, magazines and audiobooks enhanced with AR can be sold through dedicated digital platforms or subscription services such as Audible or Storytel, facilitating purchasing options and offering publishers a new valuable business model. Publishers will be able to sell subscriptions to readers already connected to each metaverse's integrated payment system, facilitating the process of attracting new subscribers.[307] Furthermore, allowing interaction with the user's metaverse avatars through VR/AR features may further boost consumers' interest in magazines or books sold online. This will be strongly encouraged by the ever-reducing costs of creating and publishing VR/AR experiences, enabled by the progress of other technologies such as AI, 5G and edge−cloud processing. Publishers could create virtual newspapers, magazines and other written articles, directed to their virtual customers. This is already happening in the famous simulation game Second Life[308] and could be further integrated in the avatar-inhabited metaverses.

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[302] Storydocks website available here.
[303] uARe website available here.
[304] Cleverbooks website available here.
[305] AmayaSoft website available here.
[306] BISG (2018), *Virtual and Augmented Reality in publishing*, available here.
[307] Web Publisher Pro (2021), *Magazine publishers prepare for the Metaverse – Are you ready for the future?* available here.

[308] Twipe (2022), *Are there opportunities for publishers in the Metaverse?* available here.

5. Case study 2: Architecture and design

5.1. Introduction and landscape

The architecture and design sector comprises a wide range of professions that involve conceptualising and giving visual form to ideas by determining a final product's technical and functional characteristics. More specifically, architecture focuses on the **construction of buildings, spaces and other architectural structures** that combine functionality with aesthetic appeal.

Architecture serves and links to a multiplicity of other industries, such as **engineering, construction, real estate and interior design** among the main ones. This case study covers the most common applications of VR/AR to architectural consulting and design activities and to specialised design activities, as defined by the NACE classification. These include the following subsectors:

- building design and drafting;
- town and city planning; landscape architecture;
- interior design and decoration activities.

In addition, the case study explores VR/AR applications in a series of industrial sectors linked to architecture, in which use cases and innovative business models are emerging in Europe. These include construction and engineering activities, and real estate activities.

The market for architectural services in Europe is worth over EUR 16 million and employs 562 000 professionals registered as architects only.[309] More than 50 % of the sector's turnover is generated by the private housing segment. About 40 % of the turnover is generated through new buildings and 40 % through refurbishment work respectively; a remaining 15 % through heritage work. Concept and detailed design generate about 30 % and 25 % of the sector's turnover; about 6 % is generated by interior design activities, and the remaining share by other architecture-related activities.[310]

Through its current policies, the EU is developing a new integrated and people-centred approach to a sustainable built environment, which supports the design of buildings, public spaces and urban landscapes that contribute to citizens' quality of life. In this context, architecture is a cross-cutting field which through its potential to contribute to a high-quality built environment links to many other EU policy objectives that support the implementation of the green transition, including energy efficiency, climate change, research and cohesion.[311]

The architecture sector is especially relevant in the framework of the **New European Bauhaus**,[312] an EU initiative that brings citizens, experts, businesses, and institutions together to identify and imagine new aesthetical, sustainable and inclusive solutions for **living spaces**, while helping to deliver on the European Green Deal. In addition to creating a platform for experimentation and connection, the initiative supports positive change by providing access to EU funding for designers, planners and entities developing new typologies of living spaces.

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[309] ACE (2020), *The architectural profession in Europe 2020 – ACE sector study*, available here.
[310] ACE Observatory on Digitalisation, available here.
[311] European Council (2018), *Plan for Culture 2019-2022*, available here.
[312] Europa website (2021), *New European Bauhaus*, available here.

VR/AR applications in architecture and design based on the typology of final users are mainly implemented in the **B2B market**. Applications offered by VR/AR developers are, therefore, directed to architecture companies and other sectoral enterprises. Immersive technologies are used by businesses to improve their design processes and the delivery of traditional tasks, which include modelling, prototyping, visualisation, training implementation and sales.

Due to the market and value chain structure of the architecture and design sectors, as well as the present lack of mass adoption of VR/AR solutions, VR/AR applications to the **B2C market** for the architecture and related industries is limited. Emerging B2C applications of VR/AR are mainly linked to marketing activities in these industries, which are less popular compared to VR/AR B2C applications in other industries. They encompass, for instance, real-time visualisations or testing of structures and objects, and e-shop sales.

5.2. Architecture and design subsectors: applications, users and impacts

New technologies have repeatedly transformed what and how architects and designers can create, starting with the adoption of 2D and then 3D computer-aided design (CAD) models, moving to Building Information Modeling (Building information modelling (BIM), and now experimenting with IoT and other innovative solutions.[313] Existing digital tools allow architects and designers to develop more accurate configurations of buildings, spaces and objects. These facilitate the observation of how the proposed design solutions affect the regularity and resistance of structures and the evaluation of the extent to which the solutions meet the structures' functional requirements and aesthetic demands.

Building on the foundation that earlier digital tools have built, VR/AR applications enable architects and designers, as well as other stakeholders in related industries, to perform tasks in more advanced, accurate and precise ways, impacting the whole product or building development life cycle. Architects are already seeing, and have started exploiting, the benefits of VR/AR technologies. Based on a 2018 report,[314] 16 % of architecture firms globally are currently using VR in their practice. In addition, more than 25 % of firm leaders surveyed state that VR/AR is having an important impact on the industry today, and 66 % believe that the technology will have a significant impact within the next five years.

Evidence from desk research and interviews conducted with stakeholders engaged with the development and use of VR/AR applications to date suggests that there is already a relative spread use of immersive technologies among innovative European businesses operating in the **design building and drafting**, **real estate**, and **town and city planning** sectors. Although adoption of these technologies in other European sectors, such as **construction** and **interior design and decoration activities**, appears to be more limited, important trends are emerging together with a general awareness of the benefits and potential impacts of VR/AR applications in these industries.

This chapter digs into VR/AR in the hereby covered subsectors, underlining a variety of relevant aspects such as the most important applications, main users, and existing and potential impacts of immersive technologies.

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[313] Microsoft and RIBA, *Digital Transformation in Architecture*, available here.
[314] AIA (2020), *Firm Survey Report*, available here.

5.2.1. Building design and drafting

Level of awareness and maturity of VR/AR: VR/AR solutions are expected to become increasingly more used by architects and interior designers[315] thanks to the intuitiveness of VR/AR 3D design, the easier interaction with customers, and the integration of immersive technologies with the overall construction workflow and BIM. Still, the relatively low levels of digitalisation in the construction sector[316] as a whole hamper wider usage of the technology.

Main adoption trends: Mainly in B2B markets, designers and architects are using VR/AR to support the creation of prototypes and building design. The benefits offered by the technologies relate to structure visualisation, stakeholder collaboration, decision-making and training.

Main applications: configuration and prototyping visualisation, navigation, training, and decision-making.

Main users: architects, planners, designers, companies, and dealers.

Main impacts of VR/AR: reduced need for design iteration, leading to savings in resources and time; increased collaboration capacity; enhanced decision-making.

Building drafting and design refer to the architectural and technical applications to the design of all typologies of buildings. Drafting, a process in which mainly architects are involved, entails the graphical representation of a building and its parts. Through configurations, architects define elements of a building as size, shape, and how it fits in a specific location or context to convey its structure before construction. Compared to drafting, the building design phase requires a stronger collaboration effort between various stakeholders to plan the installation and fabrication of the building to be developed based on the draft model. Building design also requires calculations and analyses of requirements, codes and regulations, and the application of best practices and standards.

VR/AR trends are emerging in relation to both the drafting and design of buildings. With VR/AR, architects and designers can transform traditional CAD and BIM models into immersive virtual representations that allow the **prototype of interactive architecture elements** and can **conceptualise, analyse and plan design processes** in simulated environments.[317] The use of VR/AR technologies provide more advanced 3D representations of the working design compared to traditional renders, scaled models or animations.

In fact, the immersive environment gives a much more accurate and representative feeling of spaces, providing individuals with a real sense of scale, depth and spatial awareness that can support the configuration and design processes. In addition, VR/AR makes it easier for stakeholders involved in prototyping (other than designers or architects) to understand the details of the processes, which can be useful for **training** of resources,[318] and to **evaluate** the proposed models, which is useful to determine whether the process is going in the right direction.

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[315] *Idem*
[316] EIB (2021), *Digitalisation in Europe 2020-2021* available here.
[317] de Klerk, R., Duarte, A. M., Medeiros, D. P., Duarte, J. P., Jorge, J., and Lopes, D. S. (2019), *Usability studies on building early stage architectural models in virtual reality*, available here.
[318] Delgado, J. M. D., Oyedele, L., Demian, P., and Beach, T. (2020), *A research agenda for augmented and virtual reality in architecture, engineering and construction*, available here.

VR/AR a collaborative instrument for designing processes

It is common practice for architectural firms based in different locations around the world to work on joint projects. VR/AR has quickly evolved as a tool that can bring together distributed teams in an immersive collaborative environment. This is especially relevant to the initial design phase of projects, which requires greater cooperation, as several architects are involved.

Squint/Opera, in collaboration with the Dutch and Danish architecture studios UNstudio and BIG Group, have developed Spaceform − a virtual workspace platform that features an immersive 3D environment for real-time collaborative design reviews and stakeholder presentations.[319] The platform played an integral role in the design process of UNStudio's Korean National Football centre project. SpaceForm enabled UNStudio architects to collaborate with the Korea Football Association in real time, working remotely from around the world and without the need to travel. The teams were able to immerse themselves in their 3D virtual working environment, imagining a virtual workshop space in which 3D models of the project were displayed and manipulated together.[320]

VR/AR solutions are not only useful for remotely visualising and interacting with projects simultaneously. They also have the potential to seamlessly connect different visualisation software such as Rhino 3D, Rivet, or Sketchup. These allow the creation of digital twin models, instant sharing of data, and diving into the 3D models. Arkio, an architecture software developed in Reykjavik, facilitates seamless workflow integrations with different 3D design models.[321] Similarly, Enscape creates software that links 2D CAD architectural plans to real-time walkthrough 3D renders.[322]

VR/AR applications in this subsector contribute to saving time and costs related to building prototyping and design, including the costs of human resources and building physical prototypes. In addition, while CAD and BIM software is currently still needed for architects to draft virtual configurations of buildings, in the future, VR/AR might move beyond being used as a support tool for the configuration stage and instead support the building drafting phase as well.

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[319] UnStudio (2021), *UNStudio Invests in SpaceForm, Virtual Workspace for Architects,* available here.
[320] The B1M (2022), *South Korea's Quest to Build the Future of Football,* available here.
[321] Arkio website available here.
[322] Enscape website available here.

5.2.2. Construction and engineering activities

Level of awareness and maturity of VR/AR: Notwithstanding its capacity, the adoption of VR/AR in the construction sector in Europe is modest. Reliability and robustness of the technologies, coupled with the lack of technology awareness by companies and the implementation period, are the main factors behind the low uptake of the technology.

Main adoption trends: VR/AR is used in architecture, engineering and construction to support the planning of operations and project implementation, detect risks and errors, and provide remote assistance and maintenance. As engineering and construction activities are mainly addressed to dealers or property or site managers, the applications are mainly B2B oriented.

Main applications: planning, visualisation and navigation, training, safety, and assistance and maintenance.

Main users: planners, engineers, builders, dealers/property managers, and customers.

Main impacts of VR/AR: reduced need for planning iteration; error prevention; remote assistance/collaboration, leading to savings in resources and time; and enhanced decision-making.

Other key application sectors of VR/AR linked to architecture and design are construction and engineering. One added value of VR/AR over classic 3D models, which reflects the main potential of these technologies in architecture-related fields, is that they strengthen the possibility for immersion and interaction within and with a structure before its physical deployment. This also allows to anticipate more accurately the effort involved in the potential work to be performed. Visualising a structure through VR/AR enables users to experience it in its full size and characteristics in a virtual environment. In the case of a building, it allows stakeholders to navigate through it and engage with it, for example, through collaborative visual tools, such as virtual arrows or pointers.

As in many high-risk industries, VR/AR can be used in architecture, engineering and construction by engineers at the design stage to **reduce the risk of errors and hazards** possibly occurring at later stages of project planning and implementation.[323] Similarly, in planning and construction, VR/AR can be used to facilitate operations and management of projects, **providing on-site and potentially real-time assistance** to builders, support operators and end consumers dealing with various maintenance aspects.

Environmental data can be included in the virtual environment, simulating, for example, natural light or heat, and allowing to see and evaluate how future structures will perform in real-life environmental conditions. Finally, VR/AR models facilitate the **examination and validation** of a construction project and its **deployment feasibility**, enhancing collaboration and shared understanding among architects, engineers, contractors and other stakeholders involved in construction projects.

These benefits result in saving time for both planners, designers and clients by highlighting potential problems linked to the aesthetics, functionality and safety of structures, and addressing them before construction. They also help to save human and natural resources, including raw materials and energy.[324] Despite its potential, the market uptake of VR/AR in the architecture, engineering and construction sector in Europe is limited. Reliability and

[323] Sacks, R., Perlman, A., and Barak, R. (2013), *Construction safety training using immersive virtual reality*, available here.
[324] Mordor intelligence report.

robustness of VR/AR technologies are one of the main factors preventing adoption, considering the requirements of construction environments.[325] Other factors are the lack of construction businesses' awareness of these technologies, time commitment for implementation, and the unwillingness to accept virtual substitutes by a sector where 60 % of operating companies are non-digital (compared to slightly more than 30% for the manufacturing sector).[326]

Setting the way for VR/AR in the European construction industry

In the construction and engineering industry, so as in industries linked to the building value chain, such as real estate and design, some VR/AR solutions, especially AR solutions that include software extensions and phone applications, have seen some, although moderate, implementation in Europe. In fact, while the development of software extensions of 3D models using AR appears to be relatively reasonable from the effort and resource perspective, the market is still relatively compact, with only a few European AR solution manufacturers able to secure consumers committed to adopting these products in their business practices.

One example is Dalux, a Danish company developing various types of products for the construction industry.[327] Among its solutions, the company developed a high-speed mobile BIM viewer and a BIM-based AR solution for mobile devices that can be used in field work during construction projects. The Dalux app enables the user to require information from BIM objects using AR, in form of real-time reporting through forms on-site, online or offline.

The Swedish company Hägring is another European AR solution developer. It offers AR tablets for on-site visualisations and a product designed to add BIM models to drone movies, through which architects, project managers and property developers can illustrate and explain projects to builders, engineers and clients.[328]

Apart from buildings and living spaces, VR/AR can shape the future of construction in other ways. One example of this is the Steampunk pavilion at the fifth edition of the 2019 Tallinn Architecture Biennale. The pavilion was entirely built with steam-bent timber strips using unskilled labour and basic construction tools and a high-precision MR environment.[329] This innovation shows how designers may work in the future, combining precise digital models and human craftsmanship to produce complex constructions.

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[325] Mordor intelligence report.
[326] EIB (2021), *Digitalisation in Europe 2020-2021* available here.
[327] Dalux website available here.
[328] Hägring website available here.
[329] Doshi, A. (2019), *Winning Tallinn Architecture Biennale using augmented reality*, available here.

5.2.3. Town and city planning and landscape architecture

Level of awareness and maturity of VR/AR: The main actors involved are increasingly using VR/AR applications to complement visualisation models. Yet, not all players have embraced the technology, thus maturity is not reached.

Main adoption trends: In B2B markets, VR/AR is used by urban planners and designers, as well as stakeholders involved in urban and landscape projects to visualise spaces and structures in real life or simulated natural/urban environments.

Main applications: visualisation and navigation, planning, decision-making.

Main users: urban designers, planners, city officials/administrators, private sector producers, civil society, academia.

Main impacts of VR/AR: increased collaboration and planning capacity, audience engagement and outreach, awareness-raising, enhanced decision-making (in addition to impact-linked subsectors).

The value of the digital transformation in the architecture and related industries is that it allows to imagine and, therefore, to create what could not be created before. This includes designing new kinds of spaces and transforming the environment to meet the global challenges of urbanisation and sustainability,[330] in line with the New European Bauhaus objectives. In this context, VR/AR is a powerful technology that is already revolutionising urban planning and landscape architecture activities. VR/AR solutions can be applied to traditional digital urban and landscape planning tools like Geographic Information System (GIS)-based models.

In city planning, VR/AR enables planners to create advanced 3D city model visualisations by merging GIS content into tools that support VR/AR applications, such as Unity and CityEngine. 3D city models offer different ways of visualising urban landscapes. Photorealistic or illustrative visualisations make it possible for non-experts to better **understand how spaces and structures can look like** once realised. 3D visualisations can also be used to **embed information and data** in the model, which is more relevant for the planning and design processes.[331] Visualisations of urban projects are necessary to run activities and interventions in diverse fields, from tourism to cultural heritage and entertainment. In landscape architecture, VR/AR 3D models can be used in landscape restoration, parks and recreation, green infrastructure, and site and residence planning. The inclusion of VR/AR in traditional visualisation models can serve various uses, for instance, to create **large-scale visual representations** of existing landscape views or of **landscape changes over time** under diverse natural circumstances.[332]

In addition to the benefits of VR/AR in related sectors, such as construction or engineering, the potential of VR/AR applications specifically to town and city planning and landscape architecture is significant. VR/AR models can support urban and landscape design processes by creating a shared understanding of the planned use of space among the many stakeholders involved in such large-scale projects.[333] This is done by strengthening

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[330] Ficarra, M., Rückert, D., Weiss, A., and Weiss, C. (2021), *Digitalisation in Europe 2020-2021*, available here.

[331] A., Van Dessel (2019), *The Use of Virtual Reality in Urban Planning Review paper on the (dis)advantages and a new perspective for future research*, available here.

[332] Portman, M. E., Natapov, A., and Fisher-Gewirtzman, D. (2015), *To go where no man has gone before: Virtual reality in architecture, landscape architecture and environmental planning,* available here.

[333] Knack, A., Deshpande, A., Hoorens, S., and Gunashekar. S. *Digital age Virtual and augmented reality: Implications of game-changing technologies in the services sector in Europe*, available here; Pour Rahimian, F. and Ibrahim, R. (2011),

communication between actors involved in design and implementation operations and policymakers, leading to improved collaboration and decision-making processes.

AR-enhanced digital visualisation solutions are also a powerful tool for informing non-technical experts and civil society, proving valuable for public participation in urban planning with. AR methods are well suited to provide citizens with more comprehensible information about projects involving physical and spatial transformation, providing better public understanding and, consequently, greater involvement. [334]

VR/AR in urban city planning

The adoption of VR/AR technologies in urban planning is closely linked to the concept of smart cities. A smart city is referred to as an urban development vision, integrating multiple digital tools to manage a city's assets, like its transportation systems, power plants, water supply networks, waste management systems, and other community services. [335] In smart city planning, VR/AR technologies have been increasingly used in the recent years to target real-time simulations and visualisation requirements at early urban design stages. As of February 2020, Barcelona and London, followed by Amsterdam and Berlin were considered the pioneer European cities using smart city immersive technologies. From hosting the first Smart City Expo and World Congress in 2011 to other more recent events, such as the 2011 360-degree VR and AR Market [336] and the 2022 Mobile World Congress, [337] Barcelona is still often regarded as being at the forefront of global smart cities, with multiple VR/AR offers in the context of culture, history and tourism.

Several EU-supported initiatives emerged in the last decade, aimed at promoting the use of VR/AR technologies in urban and city planning. For instance, the Horizon 2020-funded MindSpaces project, prompted by the Greek Centre for Research and Technology, Hellas, aims to develop a VR environment to help engage users in urban and architectural design. The simulated digital urban environment will capture user preferences and behaviour, which will be embedded in the design of the space/structure. [338] The Augmented Urbans project, co-funded by the European Regional Development Fund, aims at co-developing through XR integrated urban planning practices in Central Baltic cities, bringing together the urban planning aspects of timeframe, participation and technology. [339]

Impacts of VR 3D sketching on novice designers' spatial cognition in collaborative conceptual architectural design, available here.

[334] S. M. Saßmannshausen et al. (2021), *Citizen-Centered Design in Urban Planning: How Augmented Reality can be used in Citizen Participation Processes,* available here.

[335] Jamei, E., Mortimer, M., Seyedmahmoudian, M., Horan, B., and Stojcevski, A. (2017), *Sustainability*, available here.

[336] 5th Barcelona 360-degree Virtual Reality and Augmented Reality Market website available here.

[337] MWC Barcelona website available here.

[338] Cordis, *MindSpaces - Art-driven adaptive outdoors and indoors design*, available here.

[339] Augmented Urbans website available here.

5.2.4. Interior design and decoration activities

Level of awareness and maturity of VR/AR: The uptake of VR/AR-related technologies by major designers and furniture manufacturers is raising its awareness and maturity. However, adoption levels are comparatively low across the sector.

Main adoption trends: In both B2B and B2C markets, VR/AR is used by internal designers, decorators and retailers as a supporting tool to create and develop products, receive customer feedback, and reach out to potential customers who benefit from better (immersive) purchasing experiences.

Main applications: prototyping, visualisation, marketing and sales, and decision-making.

Main users: interior architects, designers, decorators, builders, dealers/property managers, and customers.

Main impacts of VR/AR: reduced need for design iteration, leading to savings in resources and time (including time-to-market of products); increased collaboration capacity; better expectation management; increased audience engagement and outreach, customer experience and decision-making.

From prototyping and design to sales, VR/AR applications in interior design and decoration activities have similar positive impacts to those offered to other architecture-linked sectors. In addition, immersive experiences in interior design create notable benefits for final customers.

VR/AR enables designers and decorators to engage with spaces and products in ways that can **support visual reasoning** in prototyping, **empowering design thinking** and stimulating designers to a higher degree and level of abstraction, also reducing potential ambiguity before a minimum viable configuration of a structure is created. They also allow designers designers to **perform aesthetic and ergonomic verifications**[340] to the level of details that cannot be achieved through regular 3D modelling. For instance, through direct manipulation, VR allows to fully engage users with holographic representations of structures and objects, and to potentially **refine the design in real time**. Another advantage of real-time manipulation through VR is that designers and decorators can modify and add attributes that are not usually brought to the structure until its physical stage.

VR/AR can also facilitate the process of **error identification** at the stage of both product design and implementation, enabling early corrections and adaptation, and preventing unexpected delivery delays and costs. Finally, VR/AR offers multiple opportunities in terms of remote design processes. Interior architects and designers can imagine how solutions will be developed and placed in existing buildings and spaces without having to physically be present. They can bring the whole design thinking process to the virtual world by placing their prototypes in a VR scenario.

From the commercial perspective, VR/AR can be used by customers to **provide feedback** to designers on an internal design solution's functional and aesthetical characteristic, and as a supporting tool for **sales** through virtual channels. Since VR/AR visualisations provide a much richer and more accurate sense of presence than a traditional 2D or 3D models, they strengthen both customer power and engagement. Evidence shows that individuals' sensory perceptions (e.g. temperature, size, touch, and weight) about real-life objects are

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[340] Kaleja, P. and Kozlovska, M. (2017), *Virtual reality as innovative approach to the interior designing*, available here.

affected by the design and appearance of their representation in VR[341] and can, therefore, affect positively their purchasing experience and give them bigger decision-making power.

Immersive experiences in interior design

Interior designers and furniture producers are adopting the 3D projection method as a tool to improve communication and idea sharing with their customers. VR/AR technology enables viewers to better understand how pieces of furniture will look and feel in clients' apartments and homes by placing virtual reproductions of products in the real environment.

In the European context, Ikea Place has become the reference app for immersive interior design.[342] The app employs AR to virtually place true-to-scale 3D models, allowing users to experience how the furniture adapts to their space.

Another example of European excellence in virtual interior design is provided by French interior designer Fabrice Ausset, who partnered with the immersive technologies studio Light & Shadows to create a digital showroom where clients can preview how the exclusive designer's furniture could shape their home.[343]

Likewise, VR/AR companies started populating this market, directly offering their services to interior designers or furniture manufacturers. For example, the German company Roomle has developed a market-leading platform for displaying photorealistic products in digital environments. Another relevant case is Ro0omy, a Dutch company that offers designers an aggregation platform that integrates 3D models of prestigious furniture firms' catalogues with their studio software. Therefore, designers can easily present and exhibit these proposals to their clients.

5.2.5. Real estate activities

Level of awareness and maturity of VR/AR: The real state agencies are embracing VR/AR technology to carry out marketing activities that encompass virtual staging and interactive visits. Additionally, COVID-19 has intensified the use of remote visualisations, increasing their adoption in the sector.

Main adoption trends: In both B2B and B2C markets, VR/AR is used in real estate to show remote or virtual visualisations of proprieties to current or potential/prospective tenants through virtual walkthroughs, interactive visits, and showrooms. Other applications of VR/AR in real estate include training of employees and other propriety management operations.

Main applications: visualisation (including virtual tours), design and planning, marketing and sales, and decision-making.

Main users: dealers/property managers, real estate agents, customers.

Main impacts of VR/AR: reduced need for design iteration, leading to savings in resources and time; better expectation management; increased audience engagement and outreach, customer experience and decision-making.

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[341] Wolf, K., Funk, M., Khalil, R., and Knierim, P. (2017), *Using virtual reality for prototyping interactive architecture*, available here.
[342] Retail Innovation (2021), *IKEA Place remains world leading Mixed Reality shopping*, available here.
[343] Fabrice Ausset (2018), *Virtual Realistic Showroom*, available here.

VR/AR solutions are perceived as true game-changers for the real estate segments, including activities of buying, renting and selling properties as well as other real estate management activities. Visualisation is among the most popular applications of VR/AR in the B2C market linked to indoor and outdoor living (e.g. virtual visits, staging and showrooms).

Through VR/AR, property managers and owners can enable clients to see and feel what buildings will look like once constructed. The immersive experience is helpful for dealers to **receive customer feedback** on the functional and aesthetic characteristics of a building or propriety, hence strengthening the expectation management of customers at the early stages of project implementation.

In addition to updating and engaging prospective owners or tenants with construction or renovation processes, 3D VR/AR renderings can be used by real estate agencies to attract potential tenants. Applications of VR/AR in marketing and selling houses include **virtual staging** of empty proprieties with VR simulations of furnished and decorated interiors; **guided visits** of proprieties offered in VR, and **interactive visits**.

Lastly, VR/AR can also be used to conduct virtual or remote **training** for new real estate employees and to simulate visitor interaction with a space, allowing agents to better grasp behavioural dynamics of customer experiences and more easily put in place procedures for effective customer engagement. **Remote visualisation** of existing priorities is also a key application field of VR/AR in recent times. With the COVID-19 pandemic, remote activities have intensified in many industrial sectors, including indoor living, architecture and design-related industries. VR/AR enables us to visualise existing spaces and buildings as immersive experiences through extremely accurate reproduction of the real structures.

The impacts of VR/AR applications in real estate are major: from reducing the need for design and planning revisions in building construction or renovation to the benefits of remote visits and information sessions. The savings in terms of time and costs are significant for propriety owners, lenders and customers. Overall, 81 % out of 1 000 surveyed German and British real estate customers[344] state that they would be more likely to purchase a product or service if it included a VR experience. However, only 2 % of them had taken part in a VR experience when purchasing a product or service at the time of the consultation, shedding light on the fact that the potential of immersive technologies is yet to be truly embraced by European real estate businesses.

Experiencing the future of indoor living through VR/AR

In Europe, real estate companies have started integrating VR/AR solutions into their customer offer as virtual walkthroughs and tours of underdeveloped properties, as well as AR videos, advanced 3D models and 360-degree panoramas. Solutions come in the form of website platforms as well as mobile applications and are addressed to buyers, renters and investors.

Belgium-based companies Nirli[345] and Nodalview[346] are examples of providers of VR/AR solutions for middle- and high-range real estate, as well as French Artefacto[347]

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[344] Rozbicki, B. (2019), *Virtual Reality is changing the face of real estate*, available here.
[345] Nirli website available here.
[346] Nodalview website available here.
[347] Artefacto website available here.

and Swiss-based Hegias.[348] Immersive technologies have impacted the luxury segment of the real estate sector as well: high-end Portuguese real estate provider Prometheus,[349] for instance, offers interactive 360-degree tours of villas and apartments accessible for customers with or without VR headsets.

[348] Hegias website available here.
[349] Prometheus website available here.

6. Policy assessment and recommendations

This section is proposing a series of recommendations in different areas (i.e. legal, financial, business, etc.) with the aim of boosting the performance of the EU VR/AR industry and supporting the optimal deployment of the technology. These recommendations are an outcome of the research process conducted for this market assessment as a whole.

Insights from stakeholder consultations, such as interviews, the survey, workshops and other research activities, have defined optimal deployment and shape these recommendations. The optimal deployment of technology goes beyond a steep increase in the volume of VR/AR applications or number of users and entails components of ethical, sustainable and responsible deployment, ensuring an inclusive, safe and secure space for European citizens and businesses that engage with VR/AR and virtual worlds or are affected by it. The criteria for the selection of the policy and industry recommendations are the following:

- The recommendations aim to address one or several of the main challenges/opportunities as summarised in Section 3.2.

- The recommendations are complementary to existing initiatives and should not duplicate equivalent actions.

- The recommendations are concrete and operational to the extent possible.

According to the analysis of the above inputs, the following recommendations came forward as the most prominent. The recommendations are not presented in a ranked order, as they would all need to be addressed to achieve optimal deployment of VR/AR in the EU.

Ensure sovereignty of the EU industry

A key challenge faced by the VR/AR industry in the EU, which came up in several workshops and several other forms of consultation, is the sovereignty of the EU industry. This strategic paper has indicated that despite there being strong potential within the EU VR/AR ecosystem, the global market is dominated by non-EU companies. This is the case in terms of the main commercial hardware, platforms and possibly virtual worlds/metaverses in the foreseeable future.

This reliance on non-EU companies entails the risk of handing over control and ownership of data, as well as influence on developments such as technological development, business models, payments schemes distribution of revenues and profits etc. In addition, from a market penetration perspective, unless EU initiatives are promoted in the coming years, rapid developments as a consequence of heavy investments from big tech companies would increase their competitiveness and dominance in the global market.

- Policy action: **Support the scaling-up of companies with existing solutions with the potential to develop into VR/AR hardware, platforms or virtual worlds**. Virtual and augmented reality should be targeted directly by flagship initiatives, such as the Digital Europe Programme, and be within the scope of the European Digital Innovation Hubs.

Create an attractive investment environment

Various financial challenges are identified in Section 3.4. Many of those are not unique to the VR/AR industry, such as the limited European venture capital or other financing opportunities in large volumes to support deep-tech and high-risk projects, compared to other markets (e.g. the United States). These are also prominent issues in the VR/AR industry and their impact could be major on optimal deployment in Europe. Existence of

such financing could support the creation of European scale-ups (potentially including hardware providers or platforms), who manage to retain and grow their activities in Europe. While large financing opportunities cannot guarantee the creation of successful EU unicorns in VR/AR, and it is possible that some of the funded projects could fail, absence of such opportunities would make it harder for potential for unicorns to evolve and thrive in the EU. Some increase in venture capital is observed in recent years and boosted in early 2022, which is a positive step towards the creation of an attractive investment environment.

In addition, other challenges described in Section 3.4 are more closely related to the specificities of the industry and the need for tailored funding opportunities. In some cases, funding instruments covering the VR/AR industry simply replicated existing funding schemes, such as schemes targeting film production or traditional research grants for technological development. In the consultations stakeholders mentioned the lack of funding to bring together a range of disciplines as a barrier. The VR/AR industry is in need of a multidisciplinary approach, blending technological development with content creation.

VR/AR applications often also entail the need for collaboration across professions and technical roles in various sectors (e.g. construction engineers or doctors). Moreover, in the setting of virtual worlds, there is need for opportunities that support the use of VR/AR in combination with other technologies (e.g. blockchain and AI).

- Policy action: **Adjust funding schemes targeting the VR/AR industry to reflect the multidisciplinary nature of the industry** and/or facilitate the blending of different funding sources, for instance funding schemes addressing jointly technical development of solutions and creative content components.

- Policy action: **Increase the number of small funding opportunities** without highly specific requirements and simple application procedures, reducing red tape and ensuring wider accessibility of those by all types of stakeholders active in VR/AR development.

- Policy and industry action: Take actions to **make available large financing opportunities suitable for risk-taking and supporting the scaling-up of companies.** For instance, providing guarantees, tax or other incentives would promote the attractiveness in investing in VR and AR. Another concrete action, would include educating investors by collecting and making available market data and trends regarding the adoption and growth of the technology.

- Industry action: **Continue creating opportunities** through exhibitions and other events where start-ups and any VR and AR companies can **exchange with potential investors**.

Improve awareness of VR/AR uses and impacts on the way we live and conduct business

This strategic paper indicates that awareness of the potential of VR/AR to transform industries remains rather limited and so do the adoption rates and social acceptance. There seems to be limited awareness of the wide spectrum of VR/AR applications outside the industry and its early adopters. VR and AR are often associated with gaming and entertainment applications in non-experts' minds. Wider awareness of VR/AR potential benefits (e.g. cost savings, conducting tasks efficiently) could lead to wider adoption of VR/AR solutions.

However, there are also several potential risks and unexploited territories regarding the impacts of the technologies. For instance, there could be potential negative impacts on human rights in the digital world, safety and security threats, as well as potential negative environmental impacts associated with the use of the technology. Understanding and raising awareness of the benefits and potential risks of VR/AR technologies along with ways of mitigating these is the first step towards an increased ethical and sustainable uptake of VR/AR technologies.

- Policy and industry action: **Conduct analyses of the potential impacts of VR/AR** (including virtual worlds/web 3.0/metaverse) **on society, human rights and the environment** to shed light on potential risks and identify areas where guidelines for proper use of the technology might be needed.

- Industry action: **Conduct joint awareness-raising initiatives** (e.g. through associations) **to communicate success stories** (e.g. through pilot demonstrators) **and the specific benefits for business VR/AR users**. Promote VR and AR exhibitions and other relevant events to a wider public, for instance, including decision-makers from non-digitalised companies or other potential adopters. Promote any other opportunities connecting the VR and AR industry with other sectors, potential adopters or other relevant stakeholders.

Boost the EU VR/AR industry's unique features (high-quality, ethical and sustainable solutions) and promoting those in a global context

The European VR/AR industry is already globally renowned for high-quality creative content and applications building on the cultural heritage and history of the region, as well as highly specialised industrial applications. In a global setting, the EU is also a front-runner when it comes to the protection of personal data and privacy in a digitalised world as well as the deployment of digital technologies in an ethical manner with respect to human rights.

The digital decade targets set by the European Commission include a set of rights and principles for Europeans, such as a safe and secure digital environment, supporting sustainability and digital transition, and putting people at the centre of digital transformation. Setting targets along these values, also in the way VR and AR are deployed, is key for contributing to the digital decade objectives and the optimal deployment of VR/AR.

- Policy action: **Continue and expand the focus on VR and AR of existing support schemes** and mechanisms such as Horizon Europe and Creative Europe which have been proven successful in promoting R&D and content development in VR and AR.

- Policy and industry action: **Create an EU quality label for the development and deployment of VR and AR**. This effort could be made by a multidisciplinary pan-European body providing guidelines for high-quality, ethical and sustainable development and deployment of VR and AR.The high-level expert group on AI could inspire the structure of such a committee. This initiative could be within the scope of the VR/AR industrial coalition, with the participation of external experts in a consultative role where necessary (e.g. bringing in environmental sustainability expertise).

- Policy and industry action: **Promote opportunities where the EU's top-performing companies can gain visibility** in global exhibitions, fairs and other opportunities as a team with common labelling, highlighting the excellence in quality, ethics and sustainability of the solutions.

Improve VR/AR digital literacy and educate talents with the right skills

The VR/AR industry is rapidly growing and with the development and deployment of virtual worlds a steep increase in demand is expected to lead in shortages of appropriately skilled labour force. EU companies are competing for talent not only against other industrial ecosystems and digital technologies but also the VR/AR industry from abroad.

Ensuring companies have access to talents and increasing the diversity of the workforce (e.g. increasing proportion of female and minority workers) is key for the optimal deployment of VR/AR in Europe. To achieve this, both short and mid-/long-term actions are needed. In

addition, apart from the workforce, VR/AR digital literacy initiatives should target potential users and the wider public, ensuring equal opportunities in ripping the benefits associated with the use of VR/AR.

- Policy action: **Create incentives to incorporate VR and AR technologies as tools to assist teaching and familiarise students with the technology**. Incorporate coding and digital skills in school curricula and create formations for teachers to be prepared for teaching this. Increase the number of university programmes specialising or entailing the skills needed by the VR/AR industry, and actively promote the participation of people with diverse backgrounds in these programmes.

- Industry action: **Invest in the upskilling and reskilling of workforce** through apprenticeships targeting individuals from different sectors who are interested in changing their career path.

Ensure the deployment of VR/AR is in line with EU's rule of law

There are a few legal challenges associated with VR/AR technologies. These are due to the large volume of data, including biometric and cognitive data that are collected and processed; aspects related to users' safety and security in virtual worlds; and harms associated with the use of the technologies.

Issues of legal clarity and interpretation of existing legislation in the context of virtual worlds or other VR/AR-related settings are arising. However, at this stage of development of VR/AR technologies, there does not seem to be a need for additional legal actions. Due to the rapid growth of the VR/AR industry, it is difficult to predict the exact impacts on people's lives and on the ways we work and interact in a virtual setting.

Even though this study does not identify a specific need for additional legislation, enhanced clarity on how the existing legislation and legal principles should be applied in the context of VR/AR is needed. It is essential to have continuous monitoring of VR/AR technologies and emerging applications, and actions to prepare policymakers, judiciaries and law enforcement to ensure compliant implementation of the legal framework by any company operating in the EU and to address future issues.

- Policy action: Develop and provide tools and trainings to prepare all stakeholders involved in the development, enforcement, and application of law in relation to VR/AR, and **enhance their knowledge on applying the EU's legal framework in the context of VR/AR.**

- Policy action: **Continuously monitor the VR/AR market in terms of identifying issues and challenges that are not addressed by the current legal framework** or the need for harmonisation among Member States, as well as malpractices which may take new forms and occur in unprecedented way (e.g. in the context of virtual worlds).

Promote standards and interoperable solutions

One of the challenges of the EU VR/AR industry is its fragmentation, which is a well-known issue in various European industrial ecosystems. The linguistic and cultural diversity as well as differences in legislation and other structural issues among Member States in some cases hampers collaboration. Apart from initiatives promoting joint projects and increased collaboration, it is key to ensure that developed solutions are interoperable and despite some level of fragmentation, all companies, including SMEs, have fair access to the EU's digital single market.

A way that this could be achieved is through the establishment of standards. These standards should follow some basic principles, such us promoting the ethical and

sustainable development of VR/AR and respect to privacy, promoting compatibility and accessibility in a global market. In addition, these standards should be guided by reinforcing interoperability and be open and accessible by all types of companies in the VR/AR industry, including SMEs. Any standards should avoid adding complexity or additional burden and where possible be based on existing market practices.

The risk of not advancing the work on standards development and adoption is having to comply to existing dominant market standards which may not always follow the principles mentioned. Non-EU countries, such as China in recent years have intensified their efforts in the development of standards in various sectors and technologies.[350]

- Policy action: Support the industry in **identifying areas where there is need for standardisation** and promote the adoption of those which are aligned with the principles described. Also, **promote the development of interoperable solutions** throughout the EU through guidelines or other supporting material.

- Industry action: Lead the efforts on **building common open pan-European standards for the development and operation of VR and AR platforms** in line with the principles mentioned above.

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[350] Arjun Gargeyas (2021) China's 'Standards 2035' Project Could Result in a Technological Cold War, available here

Annex I – Methodological approach

Desk research

Extensive desk research has been conducted to create the necessary bases of analysis and to validate findings. Sectoral reports, academic papers and articles from online sources have been consulted. Information has then been arranged and catalogued to underline the study parts where each source could be relevant. In addition, some particularly important sources have been bought to support research activities.

Interviews

To gather hands-on information on the latest developments in the VR/AR industry, several stakeholders were interviewed. To guide discussions, a dedicated questionnaire was used that includes all the dimensions of the strategic paper (market size, challenges and opportunities, access to funding and financing, skills, business models, best practices, and policy framing), as well as some dedicated questions related to the case studies (media/cultural and creative sector, and architecture and design) when relevant. The table below presents all the stakeholders interviewed:

Table 3 Stakeholders interviewed

Name	Organisation
Astrid Kahkme	European Creative Lab
Jari-Pekka Kaleva	EGDF – European Games Developer Federation
Urho Konttori	Varjo
Mart Lume	EEVR – Estonian VR and AR Association
Mikko Luukonen	Softability
Michael Swierczynsk	New Images Festival
Stan Larroque	Lynx
Stephan Sorkin	EDFVR – Erster Deutscher Fachverband für Virtual Reality
Jørgen Jakobsen	CollectiveFlow ApS
Julie-Jeanne Regnault	European Film Agencies
Riccardo Falconi	Door Insider
Florence Girot	Freelance/New Images Festival
Tapani Nevanpää	City of Helsinki
Tom Janssens	Virtual Sales Lab

Workshops

One of the key components of this assignment was the organisation of a series of workshops, organised either directly by Ecorys or in collaboration with existing events. The main findings of the conducted workshops have been summarised and are presented in Annex II. The following table presents the topic of these workshops and the date and venue of their organisation.

Table 4 Workshops conducted

No	Topic	Venue	Date
1	Challenges and opportunities in the VR/AR industry	Virtual standalone event	4/11/2021
2	EU VR/AR optimal deployment by 2026	VR Days	15/11/2021
3	Competitiveness and unique value proposition	EuroXR	20/11/2021
4	Industry and policy initiatives and support	Stereopsia	9/12/2021
5	Media sector	Virtual standalone event	24/01/2022
6	Industry and policy initiatives and support – 2nd (to be held)	Virtual standalone event	8/02/2022

Survey

An online survey has been published to obtain quantitative and qualitative data from relevant stakeholders. The survey target was EU-based stakeholders producing, researching, and/or developing any form of VR/AR technologies (may it be hardware, software, or content) – examples being private companies, start-ups, universities, or research institutes.

The survey was divided into the following sections:

- identification of respondents' company sections, with questions regarding their country of headquarters, size, annual turnover, and type of engagement with VR/AR;

- funding and financing opportunities section, including information on funding and financing, received, challenges encountered, best practices, and plans;

- skills and training section focused on user experience and VR/AR-enabled skills;

- innovation and business models section, verging on two lines of questions:
- role of VR/AR in revolutionising traditional business models,
- role of innovative business models in promoting VR/AR content.

Some survey respondents who decided to leave their contact details have been contacted to further elaborate on their responses and to conduct interviews.

The following figures summarise key information on the survey sample. For all of them, the number of respondents is n = 109:
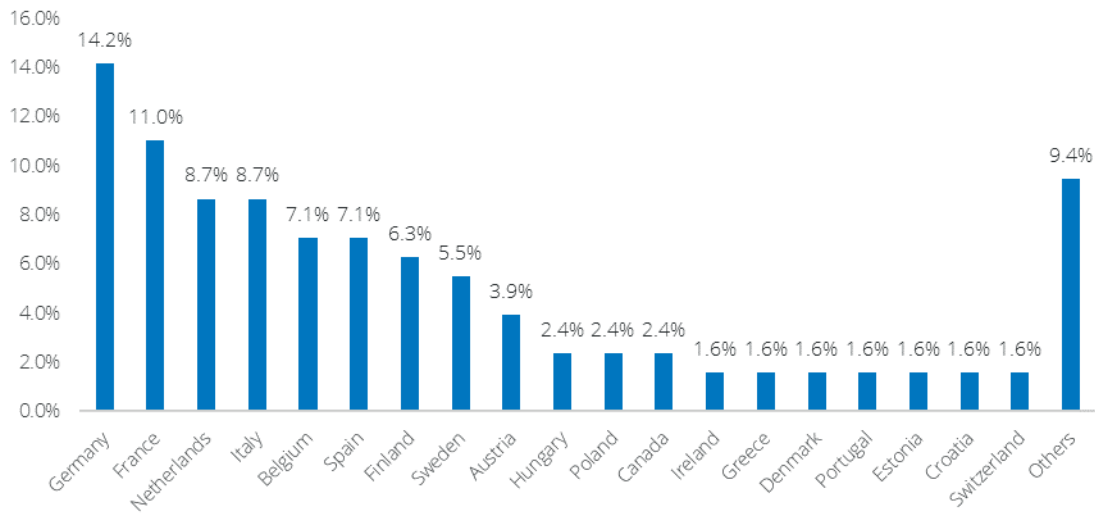
Figure 28 Respondents' country of origin
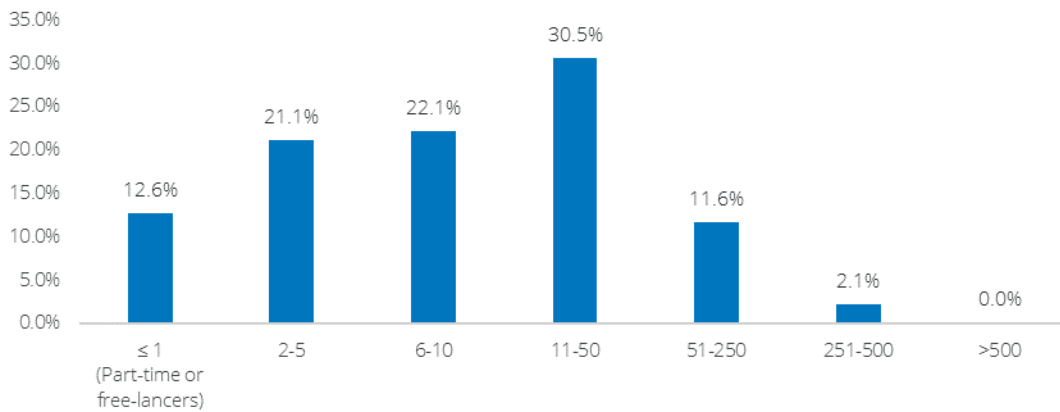

Figure 29 Organisation size

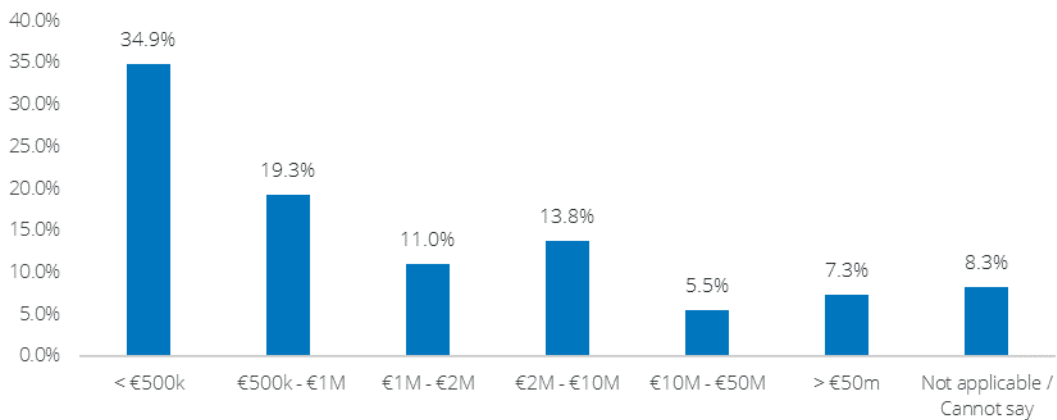*Figure 30 Organisation's annual turnover*
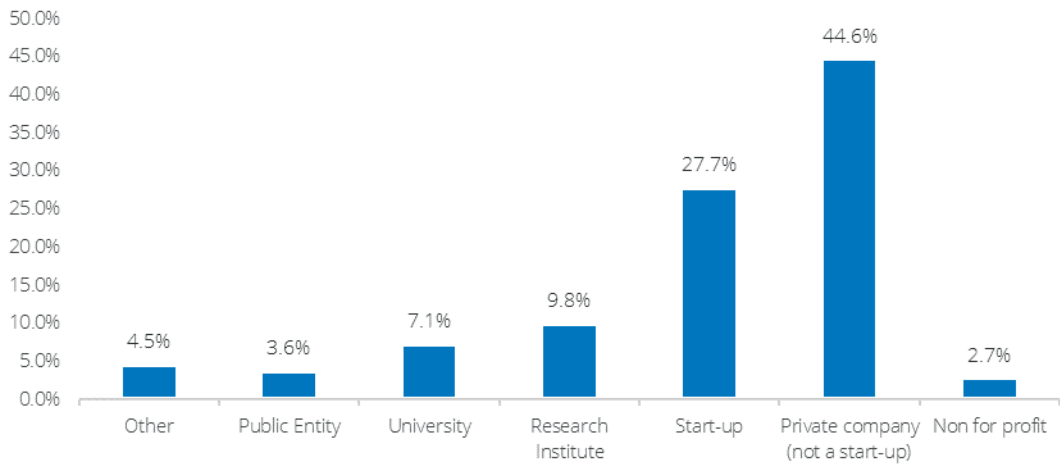
Figure 31 Type of organisation
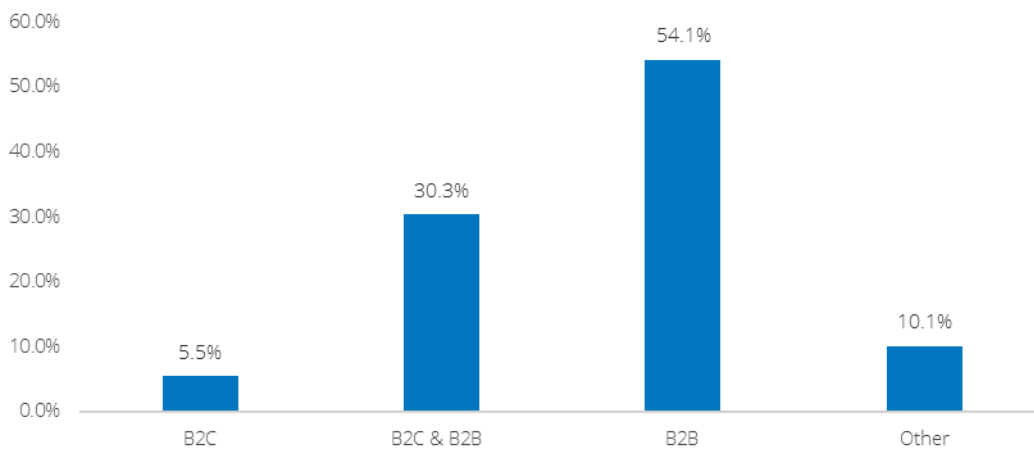

Figure 32 Focus of business

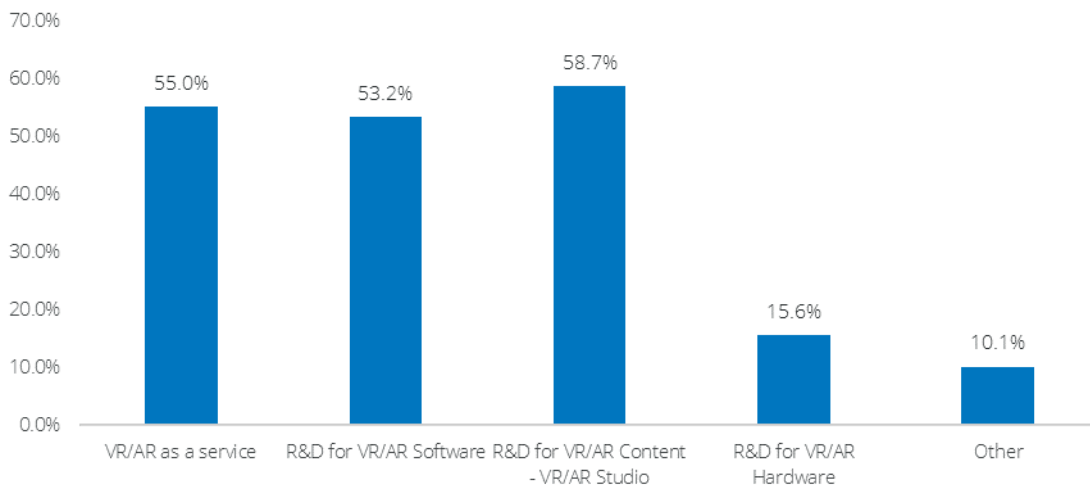*Figure 33 How organisations engage with VR/AR*

Figure 34 Percentage of organisation work related to VR/AR
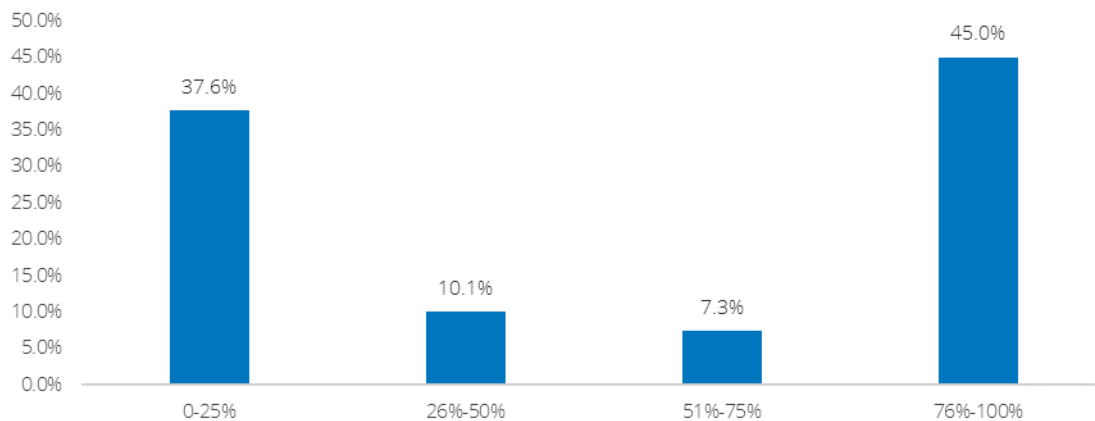
Tech mining

A scan of global patent databases was conducted to find patents related to VR/AR. The objective of the search is to get indicators of recent global innovation activities in relation to VR/AR. The word cloud below is an illustration of the most frequent keywords found in the sample of patents.

This analysis is based on 13 696 innovations (January 2021). A technology innovation can be patented in several countries. In order not to count the same technology more times the patents are grouped into families. Almost 45 000 patents are behind the 13 696 innovations, and in the text these innovations are reffered to as patents. The grouping into families is made by PatSnap. The result is calculated from simultaneous searches in 126 databases of patent authorities. A total of 1 411 patents are European.

Event attendance

Additionally, the project team attended relevant on-site and online events to join conferences and interview people on the stop. The following list includes all the events attended:

- SIDO, Paris, France;
- VR Days, Amsterdam, the Netherlands;
- Helsinki XR Centre, Helsinki, Finland;
- Stereopsia, Brussels, Belgium.

Quantitative assessment of the market

The market size assessment, defined by the European demand for VR/AR technologies, is based on quantitative and qualitative information from different sources as well as assumptions. The estimates of the European VR/AR market size, expected growth, as well

as breakdown per sector are based on a comparative assessment of growth rates and estimates from various market reports listed in the references used to draft this study, including Mordor Intelligence, Grace Market Data, Statista, as well as estimates from the previous Ecorys study. This was complemented with qualitative information, including an assessment of future VR/AR market development and trends by relevant academic and industry experts, as well as a qualitative assessment of the development of different VR and AR applications based on expert interviews.

Challenges and opportunities analysis

While the VR/AR industry has matured in recent years, it still presents room for further development, especially when it comes to the uptake of the technology among the wider public and to the financial sustainability of the mostly small companies developing it in Europe. Many aspects are important and should be considered by policymakers and by the industry to further promote VR/AR in Europe. These challenges and opportunities are varied and can change in perception, depending on aspects such as the sector, stakeholder or the specific technology considered (i.e., VR as opposed to AR). This means that many of the items identified and presented in this section can either be a challenge, an opportunity, or both, and their definition is often not binary.

This section aims at identifying and mapping items with the potential of being challenges and/or opportunities, and at providing analysis to assess their relevance and importance in relation to the VR/AR industry. The final goal of the exercise is to inform both policymakers and the industry in order to prioritise the ones that are perceived to be the most important and which should be included in the scope of the VR/AR Industrial Coalition.

To do that, the analysis focuses on three main research questions, which have been investigated throughout the data collection process:

- What are the main factors influencing the EU VR/AR market, and to what extent are they perceived as challenges and/or opportunities?

- How important is the impact of these challenges and/or opportunities on the industry?

- To what extent are these challenges and/or opportunities specific to the VR/AR industry – as opposed to being common with other technologies or ecosystem?

Answers to these questions have been looked up by using four main sources: desk research, expert interviews, notes from the workshops organised as part of the activities of the VR/AR Industrial Coalition, and attendance to relevant events in the sector.

Each item in Table 2 (see Section 3.2) is placed into one of five macro-categories used to sort them. These categories of challenges and/or opportunities are technological, business, social, financial, and legal. For each item, an indication is provided as to whether it is mostly perceived as a challenge or an opportunity, or the result is too nuanced to allow such a categorisation. An indication of the impact of not addressing the item – by either public authorities or the industry – allows for a first indication in terms of prioritisation. However, such an assessment should be based on the following aspect considered as well: 'Specificity of measures to VR/AR'. This column specifies whether measures able to tackle a specific item can be limited to the VR/AR ecosystem itself (in this case, a 'Yes' indication is provided), or whether they should involve other ecosystems and areas beyond the scope of action of authorities and industries dealing only with VR/AR. Finally, the last column describes the occurrence of each given item across the various sources used in the analysis.

All the items included in Table 2 have already been shortlisted and identified as important, to be taken into consideration in the future development of the VR/AR industry. However, an additional prioritisation indication is provided in the table, with some items being underlined. These are the ones perceived as most important – in the logic of the analysis,

the items whose impact is 'Very high' and whose occurrence across sources is 'Very frequent'.

The following table includes a longer list of challenges and opportunities identified during the research, divided in the five categories considered:

Table 5 Long list of challenges

Category	Challenge/opportunity
Business	VR/AR are the future, but not yet there for B2C. The market value has been increasing but rather slowly. In B2B, there is more steep increase.
Business	In the next 5 years, we will see VR/AR established in some sectors, e.g. military technologies, architecture.
Business	How to build local hubs and ecosystems? Structures are there to support new companies. But how can we get these structures that boost and help the scale-up of the most innovative companies? How can they reach SMEs?
Business	Getting to the foreign market is an issue, some companies think small, lifestyle enterprise is common, companies are not that ambitious.
Business	Industrial case is a weakness as the industry is rather small in Estonia.
Business	Entrepreneurial spirit is missing, it is not like Finland where there is an established gaming sector.
Business	3D artists are missing. People don't have the skills to do this at world class level.
Business	There are two paths of innovation. One coming from the company and the second from university and research institutes. Making products out of scientific research (i.e. as university spin-offs) lasts probably too long. There is no European/German technology, thus we need to rely on the hardware and software from abroad. Open source would be an opportunity.
Business	The EU common market is not so easy to deal with. If one company has content/software provision, they do not have unique services as their product. In this market it is difficult to scale up this model of business.
Business	Probably, hardware is not an opportunity anymore. Better to investigate in which areas the EU wants to become a champion, and focus on those.
Business	R&D is very strong in Europe – marketisation of R&D much less. Behavioural innovation/user experience are areas where the EU could be an important actor.
Business	Storytelling is a key opportunity e.g. in advertising, education, tourism, reduction in travel.
Business	Technical and sector-specific skills should be brought together to enhance results.
Business	In Europe, we are missing companies acting as business integrators, creating a link between hardware manufacturers, software developers, and content creators.
Business	Silo mentality is harmful also in relation to business models – crucial to ensure VR/AR content is viable and profitable.
Business	Especially in cultural/artistic content, distribution and business model need to be integrated in planning since the beginning to ensure viability.
Business	Flexibility is key, so that creative and business narratives can go together in location-based experiences.

Business	Boost the connection between academics, schools, and industry, and foster cross-Member-State mobility
Business	EU players are more aware of data privacy issues, which can trigger innovative solutions.
Business	The EU's existing industrial base and knowledge is a great starting point for VR/AR development. Learning from other successful sectors would be positive.
Business	Europe already has successful platforms bringing together different perspectives (psychology, sectorial and technical expertise). This should be applied to VR/AR as well
Financial	We need risk-promoting funding system for the most innovative SMEs. We need some failure laws, creating an environment where companies can fail. The second round of start-ups is usually more successful. We have to acknowledge the reality that most VR/AR companies go bankrupt. These data require quite some digging.
Financial	Local seed funds for businesses, there is a clear market failure. The European investment scheme is not as risky as it should be, so a local scheme would be useful, backed by public funding.
Financial	Private funding is focusing on the start-up phase.
Financial	There are some first investments going from cultural world (cinema, museum).
Financial	Series A being raised in equity in private investor. It is hard to raise money because what they are doing is difficult. VC are not enthusiastic about it. In Europe they only do SW. In 2015−2017 a lot of VC lost a lot of money.
Financial	There are some private funding opportunities, but they are less interested in non-scalable business models.
Financial	Difficult for smaller actors to obtain funds – public and private.
Financial	European funding schemes (e.g. Horizon Europe) should be revised, as in their current form they do not adequately support the peculiar VR/AR combination of innovative business models, digital content and artistic creation.
Legal	Safety and security are crucial in terms of regulation and actions. This is about the handling of personal data and the security of the meta-net.
Legal	Unite as EU to harmonise admin and legislation. Smart contracts will be very useful.
Legal	Data access interfaces are necessary to introduce AR/AR technologies in Europe. This should be facilitated be the adoption of data security standards.
Social	Diversity: Early-stage first adopters are going to be young boys. How to attract young women to create content in VR/AR? If this is not done now, the first generation of creators are going to be male, which will shape the industry. We need to have more female founders in the first-round studios, so that we have more CEOs in the second round.
Social	Scepticism from parents in the uptake of VR/AR.
Social	School promoting coding (kood school) helping also the regional development in eastern Estonia, unity and 3D should be included in the curricula.
Social	Important to bring people from universities and science together, to have a discussion and network over the board of different scientific topics (i.e. business, coding, doctors etc.).
Social	How to play a strategic role in a global context and what is Europe's added value in a global context.

Social	Many companies try to focus on education and schools, and many failed. There is an opportunity to have a platform to engage with VR/AR and it is often seen as a means to have fun with. The focus is often not to develop a comprehensive education project.
Social	To achieve higher social acceptance, more focus should be put on the use of VR/AR by professionals (middle actor) who will bring it to the wider public.
Social	The EU has a lot of diversity in terms of its culture, languages, innovators and VR/ AR players. This diversity is both unique but also has its cons in terms of a lack of fragmentation.
Technological	Network infrastructure is key, when we talk about 8K content. It requires a lot of bandwidth, upload and download wise. This is a key enabler, and the EU is not performing well on this compared to e.g. South Korea.
Technological	Haptics – are at the moment in some high-end industry solutions, but at very early stage.
Technological	Basic structure for hackathons and accelerators is needed, involving youth more through schools (more school courses would be necessary).
Technological	Use of blockchain to de-centralise currency used in metaverses, in the context of NFTs
Technological	Immersive technologies are often ill-defined. Definitions should be defined more clearly, and to do this you need research and a multi-disciplinary approach to the subject.
Technological	The transition from Industry 4.0 to 5.0 has started – this entails ensuring a user-centric approach (i.e. developing the sector with the user in mind) and considering good usability, satisfaction and impact on the users of VR/ AR.

Annex II – VR/AR Industrial Coalition Workshops

This annex provides more detail on the workshops held by the VR/AR Industrial Coalition, mainly the list of workshops organised and the visual summaries produced for workshops one to six.

Table 6: List of workshops organised

Workshop number	Workshop title	Date	Location
1	The main identified challenges and opportunities faced by the EU VR/AR Industry	November 2021	Online
2	Defining EU VR/AR optimal deployment by 2026	November 2021	VRDays
3	EU VR/AR competitiveness and unique value proposition	November 2021	EuroXR
4	Industry-policy initiatives and support to the European VR/AR ecosystem (1)	December 2021	Stereopsia
5	Media sector	January 2022	Aurea Award
6	Industry-policy initiatives and support to the European VR/AR ecosystem (2)	February 2022	Online
7	VR/AR Industrial Coalition - Strategic paper and next steps	April 2022	Online

VR AR
INDUSTRIAL COALITION

November 2021
1ST WORKSHOP OF THE VR/AR INDUSTRIAL COALITION

The main identified challenges and opportunities faced by the EU VR/AR industry

17 participants across different sectors and parts of the VR/AR industry and parts of the value chain got together to discuss the major challenges and opportunities faced by the European VR/AR industry and ecosystem.

More than 50 technological, social, legal, financial, and business challenges and opportunities were discussed during the meeting, the following ones were the most prevalent:

COOPERATION AND ADDRESSING FRAGMENTATION
Increased collaboration across the value chain could support the development/ adoption of interoperable solutions within the EU

#Technological   #Business

SOVEREIGNTY OF EU INDUSTRY
Increased capacity for technological development would ensure fair access to high quality hardware, software and content

#Business   #Technological

READINESS TO ENTER THE VIRTUAL WORLDS ERA
A well-prepared VR/AR sector with access to a strong infrastructure and supported by a suitable legal framework would stimulate open, accessible and ethical virtual worlds and reduce legal uncertainty

#Legal   #Business

TECHNOLOGICAL ACCESSIBILITY
Improved infrastructure could increase the accessibility of VR/ AR hardware, software and technologies and facilitate an increased use of VR/AR solutions in the EU.

#Technological   #Social
#Business   #Financial

HIGHLY SKILLED EU TALENTS
Nurturing a workforce with the right technical, creative, and business skills, as well as creating and matching talents with the right opportunities in the EU VR/AR industry could fuel the rapidly growing sector.

#Social   #Technological

DIGITAL LITERACY AND AWARENESS
A market of digital savvy users, who are aware of the potential benefits and risks associated with VR/AR technologies is needed to boost the deployment of VR/AR solutions.

#Social   #Business

ETHICAL, SUSTAINABLE AND INCLUSIVE VR/AR
Development of VR/AR solutions in an ethical, sustainableand inclusive manner would match the needs of users with high awareness on their digital rights and a craving for the social good.

#Legal   #Social

POTENTIAL FOR SOCIAL CHANGE
Exploiting VR/AR technologies' potential, through storytelling, advertising and education can contribute to addressing pressing social challenges.

#Financial   #Legal   #Business

INNOVATION SUPPORT
Tailored support structures and funding schemes could support innovation, and contribute to the development of, successful EU VR/AR start-ups and scale-ups.

#Business   #Social

VR AR
INDUSTRIAL COALITION

November 2021
2ND WORKSHOP OF THE VR/AR INDUSTRIAL COALITION @VR DAYS
Defining EU VR/AR optimal deployment by 2026

19 participants across different sectors of the VR/AR industry and parts of the value chain got together to discuss and define the EU VR/AR optimal deployment by 2026.

Different ways and indicators for defining and achieving optimal deployment across different dimensions (including economic, uptake by different market segments, quality) were discussed, the following ones were the most prevalent:

MAINTAIN STRONG PERFORMANCE

Develop further VR/AR applications in a sustainable manner and focus even more on applications with positive environmental sustainability benefits.

Continue building applications in an ethical manner and with respect to users' rights, such as data privacy.

Keep producing innovative applications, such as tailored industrial applications and top-notch creative content.

Ensure the safety, security and openness of the European digital space to enter the virtual worlds' era.

BOOST PERFORMANCE

Expand the potential user base by improving VR/AR literacy and reaching out to new audiences who could benefit from the technology.

Promote the creation and development of highly innovative and scalable applications by unicorns within the EU ecosystem.

Develop more interoperable solutions across EU Member States and industrial sectors to strengthen equal access to the EU common market.

Advance the deployment of necessary infrastructure and enabling technologies, notably wireless networks and 5G.

Play an increasing role in the development of state-of-art hardware and platforms including virtual worlds.

Proactively educate the future workforce and nurture the right digital, creative, and business skills needed by the industry.
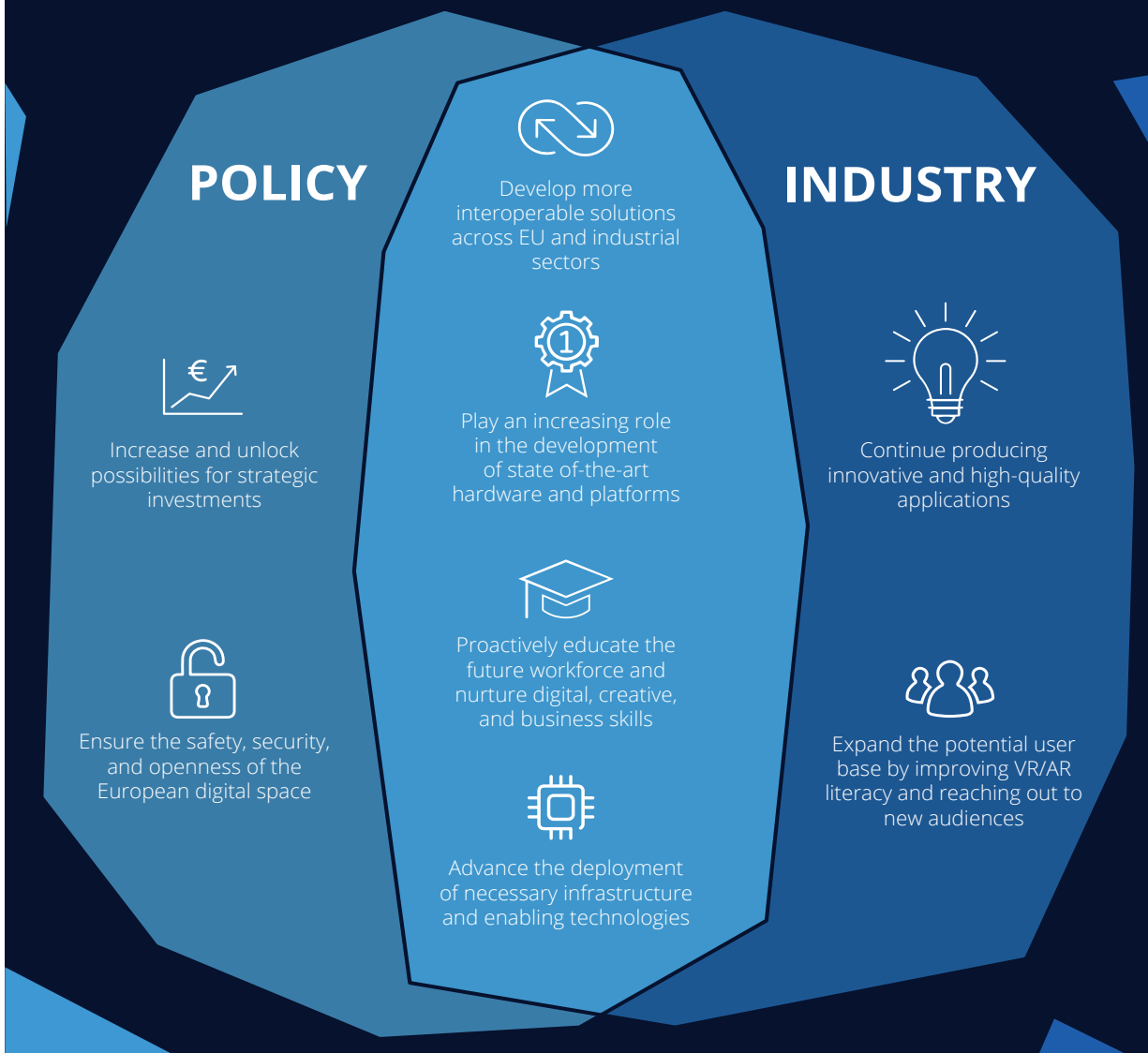
2021 2026

VR AR
INDUSTRIAL COALITION

November 2021
3ʳᵈ WORKSHOP OF THE VR/AR INDUSTRIAL COALITION
@EuroXR
EU VR/AR competitiveness & unique value proposition

25 participants from different sectors of the VR/AR industry and parts of the value chain got together to discuss the EU VR/AR competitiveness and its unique value proposition.

Many areas for intervention to ensure EU competitiveness were discussed, highlighting which actors are best placed to take action between the industry and policymakers. The following priorities were identified:

POLICY

INDUSTRY

Develop more interoperable solutions across EU and industrial sectors

Increase and unlock possibilities for strategic investments

Play an increasing role in the development of state of-the-art hardware and platforms

Continue producing innovative and high-quality applications

Proactively educate the future workforce and nurture digital, creative, and business skills

Ensure the safety, security, and openness of the European digital space

Expand the potential user base by improving VR/AR literacy and reaching out to new audiences

Advance the deployment of necessary infrastructure and enabling technologies

09/12/2021 + 08/02/2022
4TH & 6TH WORKSHOPS OF THE VR/AR INDUSTRIAL COALITION @STEREOPSIA & ONLINE
Industry policy initiatives & support to the European VR/AR ecosystem

VR AR
INDUSTRIAL COALITION

Participants from different segments of the VR/AR community got together on two different occasions to discuss existing and desired industry and policy actions needed to strengthen the European VR/AR ecosystem.

Many possible actions, to be undertaken by policymakers, by the industry, or by both, have been identified in a variety of areas. Here are the most important:

ACCESS TO FINANCE

More public funding to be made available and more easily accessible, with more interconnections between national funding opportunities

More private funding on commercialisation of products and increased awareness among investors

AWARENESS-RAISING

Create awareness of VR/AR across age groups and bridge gaps in gender behaviour

Strategic approach towards common goal – raise awareness on benefits of technology

BUSINESS ENVIRONMENT

Focus on coalitions, collaborations, building bridges

Support the emergence of industry champions

Set up a networking framework to reduce ecosystem fragmentation

ETHICAL AND ENVIRONMENTALLY SUSTAINABLE APPLICATIONS

Establish VR/AR ethics councils

EDUCATION, SKILLS, AND DIGITAL LITERACY

Platform: decentralised educational platform

Bridging people with soft and hard skills in education

Education system focused on interdisciplinarity and enabling upskilling and reskilling

INFRASTRUCTURE

Need for EU platforms, which could lower costs and increase accessibility

SAFETY AND SECURITY

Understand users views and needs in security

LEGAL BARRIERS AND REGULATION

Ensure equal access to data among all VR/AR players

Policy framework that makes sure EU common values are encouraged and user-centric

Define solid guidelines for data privacy and data ownership

Legislation and GDPR used to support European buyers and products

TECHNOLOGICAL DEVELOPMENT AND ACCESSIBILITY

Foster standardisation and adopt strategic thinking in terms of open data and VR/AR definitions

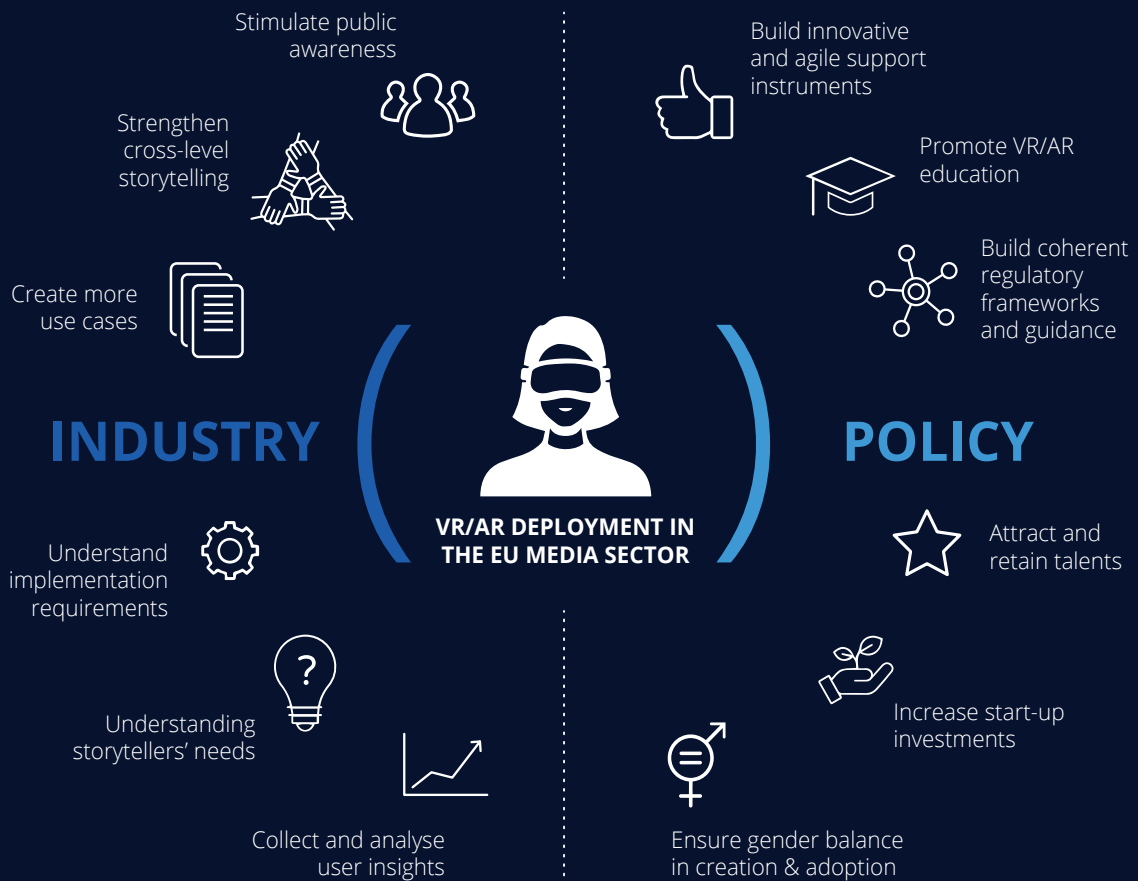**#BOTH   #POLICY   #INDUSTRY**

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January 2022
5TH WORKSHOP OF THE VR/AR INDUSTRIAL COALITION @AUREA AWARD
Media sector

20 participants from different segments of the creative and cultural and media industries got together to discuss current trends as well as desired industry and policy actions needed to strengthen the European VR/AR ecosystem.

Many innovative VR/AR applications and areas for intervention were discussed, highlighting which actors between policymakers and industry are best placed to take action. The following priorities and application areas were identified:

THE VR/AR MEDIA SECTOR

Videogaming Data visualisation Movie engagement Cultural heritage experiences

Immersive story-telling Volumetric capturing Production workflow Metahumans usage

INDUSTRY

Stimulate public awareness

Strengthen cross-level storytelling

Create more use cases

Understand implementation requirements

Understanding storytellers' needs

Collect and analyse user insights

VR/AR DEPLOYMENT IN THE EU MEDIA SECTOR

POLICY

Build innovative and agile support instruments

Promote VR/AR education

Build coherent regulatory frameworks and guidance

Attract and retain talents

Increase start-up investments

Ensure gender balance in creation & adoption

GETTING IN TOUCH WITH THE EU

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– at the following standard number: +32 22999696, or

– by email via: https://europa.eu/european-union/contact_en

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EU publications

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EU law and related documents

For access to legal information from the EU, including all EU law since 1952 in all the official language versions, go to EUR-Lex at: http://eur-lex.europa.eu

Open data from the EU

The EU Open Data Portal (http://data.europa.eu/euodp/en) provides access to datasets from the EU. Data can be downloaded and reused for free, for both commercial and non-commercial purposes.