D3.1: Report on Virtual Worlds Trends and Benchmarking

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Abstract	This deliverable titled Report on Virtual Worlds Trends and Benchmarking (D3.1) presents the outcomes of Task 3.1, which aimed to identify and analyse key trends shaping the development and use of the internet, with a particular focus on Web3 and Virtual Worlds-related factors. Led by IDC, with contributions from IDSA, Martel, IF, and INS, the deliverable covers the research conducted during the first 12 months of the OPENVERSE project.
Keywords	Market trends, Virtual Worlds, Ecosystem

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* R: Document, report (excluding the periodic and final reports)

DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

DATA: Data sets, microdata, etc.

DMP: Data management plan

ETHICS: Deliverables related to ethics issues.

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EXECUTIVE SUMMARY

The rapid evolution of digital technologies has created unprecedented opportunities for immersive experiences. Virtual Worlds, defined as persistent, 3D, real-time environments, are at the forefront of this transformation. This report presents an analysis of the current state and future trends of Virtual Worlds, focusing on their adoption, use cases, enabling technologies, and challenges.

Our research, conducted under the OPENVERSE project, involved a combination of quantitative surveys and qualitative interviews with industry experts, academia, and policymakers. We explored the adoption rates, key business priorities, challenges, and ecosystem leveraging of Virtual Worlds across various sectors.

Our findings reveal a significant surge in Virtual Worlds adoption, with 71% of European organizations planning to implement such solutions in the near future. The financial services and healthcare industries are leading the way, recognizing the potential of Virtual Worlds to enhance customer experiences, improve operational efficiency, and drive innovation.

Key findings from our research include:

- The adoption of Virtual Worlds is accelerating rapidly, with 71% of European organizations planning to implement such solutions in the near future.
- The financial services and healthcare industries are leading the way in Virtual Worlds adoption, recognizing their potential for innovation and efficiency.
- 5G, generative AI, and virtual reality are emerging as the most critical enabling technologies, driving the growth of Virtual Worlds.
- Cost and efficiency, along with improving customer experience, are the primary motivators for adopting Virtual Worlds.
- Technical limitations and a shortage of skilled professionals remain significant challenges that must be addressed.

To maximize the value of Virtual Worlds, organizations must focus on collaboration across different partners and address ethical, legal, and governance concerns. By fostering an open and human-

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centric approach, we can ensure that Virtual Worlds contribute positively to society and drive sustainable economic growth.

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ABBREVIATIONS

AR	Augmented Reality
VR	Virtual Reality
MR	Mixed Reality
AI	Artificial Intelligence
IoT	Internet of Things
BCI	Brain Computing Interfaces
GenAI	Generative AI
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
VW	Virtual Worlds
ML	Machine Learning

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1 INTRODUCTION

The OPENVERSE project is an initiative under the Horizon Europe framework, designed to pioneer a comprehensive, open, and human-centric Virtual Worlds. This endeavour is pivotal in shaping a future where digital transformation within the European Union is underpinned by principles of openness, inclusivity, ethical and environmental responsibility. At its core, OPENVERSE seeks to promote the technological sovereignty for the EU, ensuring that it stands at the forefront of the global digital arena. OPENVERSE emerges in response to the need for European Virtual Worlds that mirrors the region's values and aspirations. Unlike proprietary Virtual Worlds, OPENVERSE envisions a digital space that is democratic, where users maintain control over their data and digital identities, and where the barriers to entry are significantly lowered. This vision aligns with the European Union's broader strategies for digital transformation, which emphasise ethical standards, digital rights, and fostering an environment conducive to innovation and creativity.

1.1 PURPOSE AND SCOPE

This deliverable titled Report on Virtual Worlds Trends and Benchmarking (D3.1) presents the outcomes of Task 3.1, which aimed to identify and analyse key trends shaping the development and use of the internet, with a particular focus on Web3 and Virtual Worlds-related factors. Led by IDC, with contributions from IDSA, Martel, IF, and INS, the deliverable covers the research conducted during the first 12 months of the OPENVERSE project.

The purpose of this deliverable is to provide a comprehensive overview of emerging trends that will influence the evolution of the internet and Virtual Worlds. The scope of the research included desk research, semi-structured interviews, and distance focus groups, to gather insights from a diverse group of stakeholders. A survey was also conducted as part of the market analysis, identifying key use cases, driving business priorities, and gathering data on the current and future adoption of virtual world technologies. This effort provided a comprehensive view of the trends influencing both current internet infrastructure and the future Virtual Worlds, enabling the project to align with these developments.

The preparatory interviews with stakeholders and experts played a critical role in informing the design and validation of questionnaires, ensuring a diverse collection of viewpoints. These efforts also helped identify additional key stakeholders, covering various fields and regions.

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With contributions from 19 key stakeholders and experts, the findings provide valuable insights into the state of Web3 and Virtual Worlds adoption, along with the key drivers shaping the development of these technologies. These results will serve as a critical benchmark for comparing current internet developments against the evolving Virtual Worlds landscape and will inform future rounds of research, policy recommendations, and strategic planning within the broader project.

The deliverable includes an analysis of virtual world definitions, market trends, key use cases, and business priorities, as well as the critical requirements for building a sustainable European Virtual Worlds ecosystem. The insights gathered will guide future actions and contribute to the strategic direction of the project as it continues to explore the potential of the Virtual Worlds and Web3 technologies.

1.2 STRUCTURE OF THE DOCUMENT

This deliverable is structured as follows:

Section 1 | Introduction

The introductory section outlines the key objectives of this document, its relation to other deliverables, and provides an overview of its structure.

Section 2 | Methodology

Section 2 describes the methodology developed as an outcome of a comprehensive research process to identify key trends shaping the evolution of the internet, particularly regarding Web 4.0 and Virtual Worlds. This methodology included a literature review, desk research, semi-structured interviews with experts, and a quantitative survey.

Section 3 | Defining Virtual Worlds

This section focuses on exploring the definitions of Virtual Worlds and their relationship with the broader concept of the "Metaverse". A systematic review of existing definitions and literature was conducted to clarify the concept of "Virtual Worlds", highlighting the overlapping yet distinct nature of these terms.

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Section 4 | Market trends and Analysis

This section examines the current market landscape through a detailed literature review, alongside an analysis of organizational strategies and the development roadmaps of technology providers for Virtual Worlds technologies. By exploring these elements, the section provides a comprehensive understanding of the factors driving the adoption and growth of Virtual Worlds, technology roadmap, key use cases and challenges.

Section 5 | Key requirements for a sustainable European Virtual Worlds ecosystem

This section explores the role of strategic partnerships and the current Virtual Worlds ecosystem in facilitating the effective integration and expansion of Virtual Worlds technologies. By analysing the major collaborations and alliances within the sector, it provides insights into the elements that support the advancement and sustainability of this rapidly evolving domain in Europe.

Section 6 | Conclusions and next steps

The last section of this deliverable describes the key conclusions of the first phase of the desk research. Finally it also includes the upcoming actions and next steps.

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2 METHODOLOGY

In order to pinpoint key trends shaping the evolution of the internet, especially those related to Web 4.0 and Virtual Worlds, and cyber-physical systems, a methodology was developed by conducting a comprehensive research process. This included literature review, desk research, semi-structured interviews with experts, and a quantitative survey. The goal was to gather insights on Virtual Worlds, analyse these trends, and present a clear understanding of their potential impact. The comprehensive analysis required three main pillars to be investigated: Virtual Worlds market adoption, Virtual Worlds technology roadmap, and key use cases.

- Market Adoption: This aspect explores the rate at which Virtual Worlds are being adopted by European businesses.
    - Current Adoption: Analysing the prevalence of Virtual Worlds in European organizations across various industries, including government, education, healthcare, and business.
    - Future Adoption Trends: Forecasting the growth of virtual world adoption based on factors like technological advancements, regulatory changes, and changing user preferences.
    - Industry Perspective: Gathering insights from industry experts on the perceived benefits, challenges, and future outlook of Virtual Worlds in European organizations.

- Technology Roadmap: This pillar investigates the technological advancements needed to create robust and immersive virtual experiences. Research focuses on a selected range of technologies.
    - Key Foundational Technologies: In-depth analysis of technologies, including their technical capabilities, limitations, and potential for integration into Virtual Worlds.
    - Enabling Technologies: Exploring technologies such as cloud computing, high-speed networks, and data analytics that support the development and operation of Virtual Worlds.
    - Business and Social Impact: Assessing the potential business benefits and social implications of virtual world technologies, including productivity gains, cost savings, and ethical considerations.

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    - Key Benefits and Business Goals: Identifying the specific business goals that can be achieved through the adoption of Virtual Worlds, such as improved customer engagement, employee training, or product development.

- Key Use Cases: This area identifies potential applications of Virtual Worlds across various sectors like education, healthcare, training, and even social interaction. Analysing potential use cases helps predict the potential impact of Virtual Worlds on various industries and society as a whole.
    - Short and Medium-Term Use Cases: Identifying the most promising and practical applications of Virtual Worlds in European organizations within the next few years.
    - Foundational Technologies Maturity Assessment: Evaluating the maturity level of the necessary foundational technologies to support these use cases.
    - Key Challenges: Identifying and addressing the potential challenges and risks associated with implementing Virtual Worlds in specific use cases, such as technical limitations, cost, and user acceptance.

The methodology aligns with the European Commission's strategy on Web 4.0 and Virtual Worlds by focusing on understanding user needs, fostering technological advancement, and exploring potential applications that benefit European citizens and businesses.

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3 DEFINING VIRTUAL WORLDS

3.1 REVIEW OF EXISTING DEFINITIONS

The objective of Task 1.1 was to analyse the most popular virtual world platforms and their associated environments to extract an initial list of potential co-creation sites. Several criteria were established to rank the platforms, including their ability to support interaction, interoperability, immersion, identity management, and the creator economy.

Given the fragmented portrayal of "Virtual Worlds" and overlapping definitions with the "Metaverse", a systematic literature review was conducted as part of the task to identify a robust definition of "Virtual Worlds."

The concept of "Virtual Worlds" has long captivated both academic and industry interest, with recent technological advancements and the resurgence of the term "Metaverse" amplifying this attention.

This shift has led to the emergence of various definitions within literature. However, the inconsistent use of these terms and the blurred distinctions between them pose a significant challenge. Our review aimed to categorize the main characteristics and technologies identified by researchers, and to advocate for a comprehensive and standardized definition of Virtual Worlds.

The scope of the review included understanding different perspectives on the relationship between these terms, clustering definitions, and categorizing the key characteristics and technologies associated with each. The review drew upon interdisciplinary studies to ensure a comprehensive understanding, particularly focusing on fields most relevant to the conceptual discourse on Virtual Worlds.

To conduct this systematic review, we employed the PRISMA approach to ensure rigorous and transparent methodology. The search was conducted in March 2024, utilizing both the Scopus and Google Scholar databases. Below is an outline of the process:

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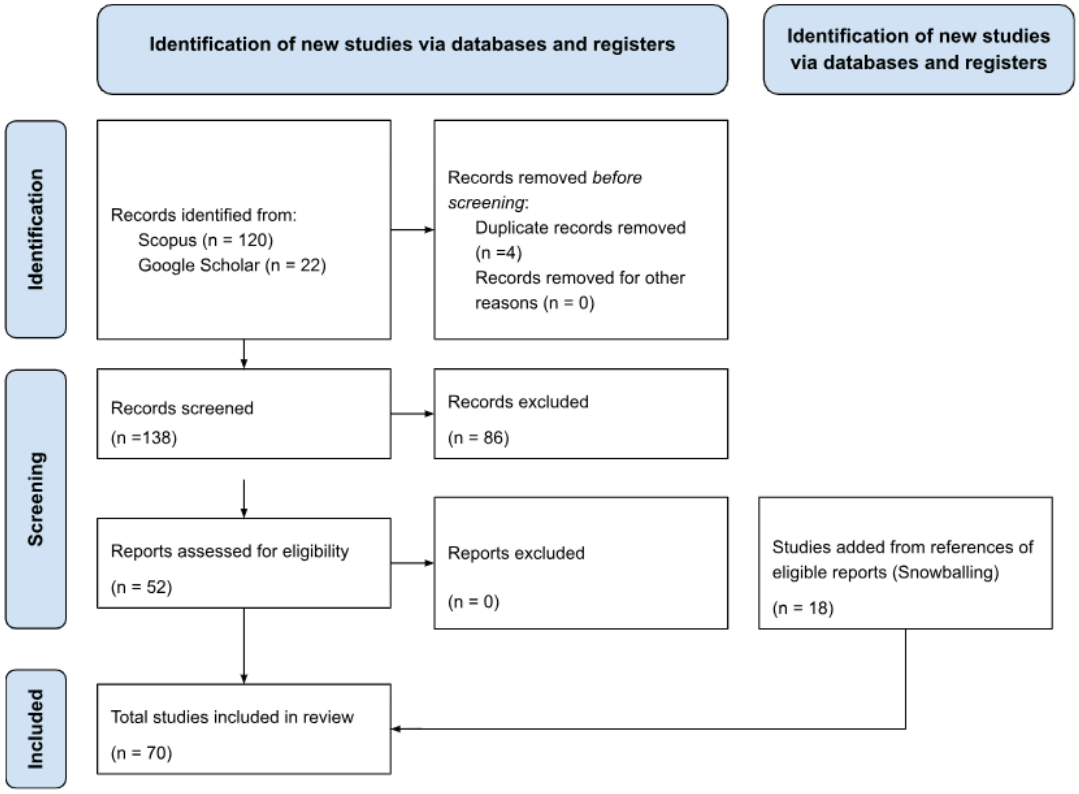
Figure 1 PRISMA 2020 flow diagram for the systematic literature review



Source: OPENVERSE, 2024

KEY FINDINGS:

- Relevant definitions emerged from both the grey literature and systematic review, with recurring terms such as "immersive", "persistent", and "avatar-driven", highlighting the fundamental features of Virtual Worlds.
- Key definitions from both reviews are as follows:

Figure 2 Definitions from Grey Review

Source	Title	Page	Definition
OECD 2022	Harnessing the power of AI and emerging technologies.pdf	p. 4	People now live alongside digital technologies in the physical and virtual worlds. These include machines pre-programmed to follow a precise set of rules, or that are fully autonomous and can operate without human intervention. They include immersive environments that combine features of the physical and virtual worlds to create realistic experiences, such as surgical training, that would be difficult to reproduce in real- world settings. Behind these and other innovations in the early phases of implementation are complex mathematical models trained on large computers with vast amounts of data to emulate human-like cognitive functions, i.e. Artificial Intelligence (AI).
OECD 2022	Harnessing the power of AI and emerging technologies.pdf	p. 7	Today, these immersive environments [Virtual Worlds] are based on augmented reality (AR), virtual reality (VR), mixed reality (MR) and other extended reality (XR) technologies that enhance the realism of virtual experiences, blurring the lines between the physical and digital worlds. They also increasingly rely on AI-enabled prediction and personalisation, interaction support, speech recognition and language translation and low-latency connectivity to augment the immersive experience. Immersive environments combine features of the physical and virtual world: they provide realistic experiences important for communication (e.g. in education) and experimentation (e.g. in medicine) with the comfort, safety and the cost- and time-saving value of not having to travel.
European Commission 2023	An EU initiative on virtual worlds: a head start in the next technological transition	p. 1	Virtual worlds are persistent, immersive environments, based on technologies including 3D and extended reality (XR), which make it possible to blend physical and digital worlds in real-time, for a variety of purposes such as designing, making simulations, collaborating, learning, socialising, carrying out transactions or providing entertainment.

Source: OPENVERSE, 2024

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Figure 3 Definitions from Systematic Review

Year	Authors	Title	Definition
2008	Bell	Toward a Definition of "Virtual Worlds"	A synchronous, **persistent network of people, represented as avatars, facilitated by networked computers**.
2008	Schroeder	Defining virtual worlds and virtual environments	Virtual worlds are persistent virtual environments in which people experience others as being there with them - and where they can interact with them. [...] This entails that **multi-user or collaborative or shared virtual environments** are environments or systems which users experience other participants as being present in the same environment and interacting with them – or 'being there together'(Schroeder 2006).
2010	Reis et al.	Comparing social virtual worlds for educational purposes	A virtual world is a **simulated persistent space based on the interaction by computer, inhabited by several user**s, who are represented by iconic images called avatars, who can communicate with each other and with the world in a synchronized way
2013	Comas & Tschang	The brief history, tumultuous present and uncertain future of virtual worlds (terrae fabricatae)	A virtual world is the network of avatars, creating **co-presence**, along with the virtually spatial and concrete qualities of a world. VWs are about people, but also about objects, places, and organizations.
2018	Girvan	What is a virtual world? Definition and classification	Thus the definition of a world comprises three key ideas: (1) A shared space which is inhabited and shaped by its inhabitants. (2) Experiences and interpretation of those experiences are not fixed but **mediated through our physical bodies and psychological responses**. (3) Through our physical bodies we move about the shared space, interacting with objects and others, with whom we construct a shared understanding of the world at that time. [...] we can define virtual worlds as: **Shared, simulated spaces** which are inhabited and **shaped by their inhabitants** who are represented as avatars. These **avatars mediate our experience** of this space as we move, interact with objects and interact with others, with whom we construct a shared understanding of the world at that time.
2018	Nevelsteen	Virtual world, defined from a technological perspective and applied to video games, mixed reality, and the Metaverse	A **simulated environment** where MANY agents can **virtually interact with each other**, act and react to things, phenomena and the environment; agents can be **ZERO or MANY human(s)**, each represented by **MANY entities called a virtual self (an avatar), or any software agents**; all action/reaction/interaction must happen in a **real-time shared spatiotemporal non pausable virtual environment;** the environment may consist of many data spaces, but the collection of data spaces should constitute a shared data space, **ONE persistent shared**.

Source: OPENVERSE, 2024

In parallel with the literature review, the European Commission organized the event *"Future Partnership for Virtual Worlds"* on March 27th, 2024. During this event, a comprehensive and inclusive definition of Virtual Worlds was proposed:

"Persistent, 3D, real-time, immersive environments, blurring the line between real and virtual, for socializing, working, learning, transacting, playing, and creating."

The consortium agreed to adopt this EU definition as the reference for all further OPENVERSE activities.

Criteria for Selecting Virtual Worlds:

Based on the review and the adopted EU definition, the following criteria were set for selecting Virtual Worlds:

- Persistency
- Real-time/Synchronized interactions
- Networked Environments
- Use of technologies such as AR/VR/MR, physical devices, AI, Blockchain, etc.
- Digital representation/avatars

SEARCH AND SELECTION:

A search for existing Virtual Worlds was conducted, identifying 118 platforms.

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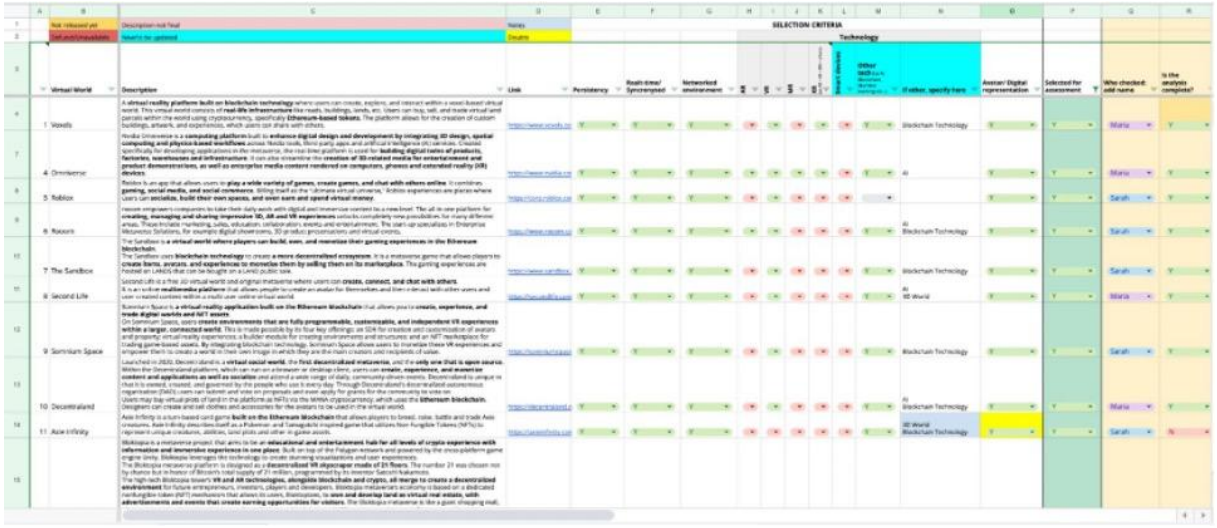
Figure 4 Snapshot of 118 VWs platforms identified



Source: OPENVERSE, 2024

Of these, 75 met the established criteria and were considered for further analysis (see section 3.3).

3.2 KEY TECHNOLOGIES INVESTIGATED

Virtual Worlds represent environments where multiple technologies converge to create immersive spaces, blending the physical and the digital worlds together. They have become technically, economically, and socially feasible thanks to a combination of key enabling factors that have rapidly evolved in recent years[i]:

- The availability of cutting edge technologies
- More intuitive and engaging use experiences through human-machine interfaces
- Greater computational power and data storage capabilities
- Rising interest from users' community

In an ecosystem founded upon trust and identity, and standards and protocols, the converging technologies include infrastructure and connectivity, devices, platform and creator tools, and interfaces and apps, as outlined in figure 5.

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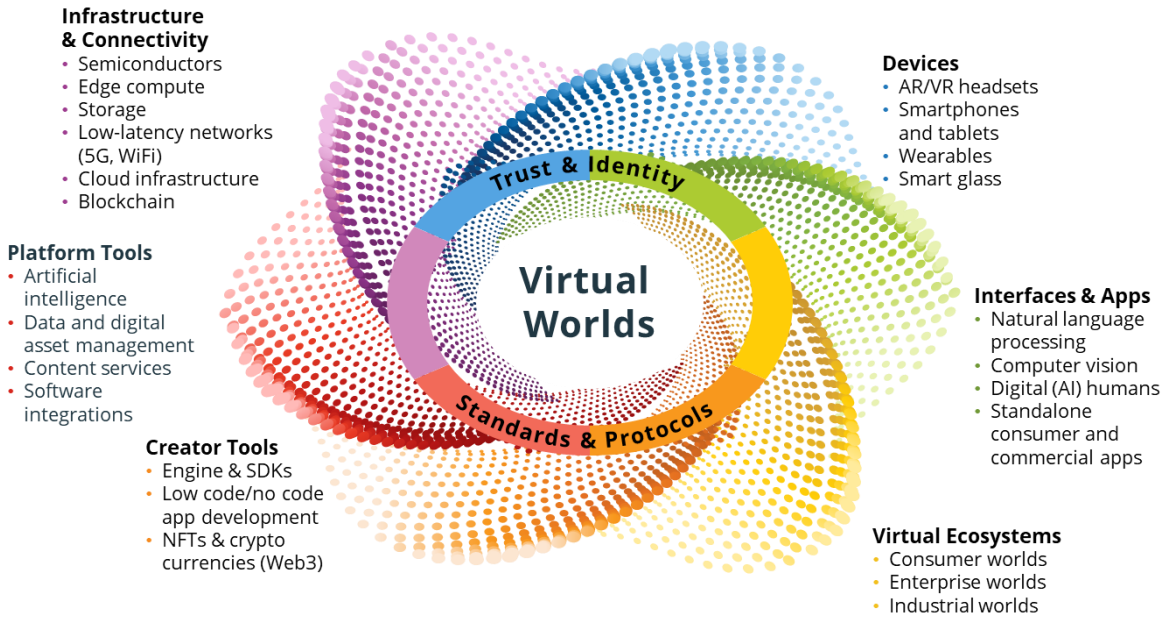
Figure 5 Converging Technologies around Virtual Worlds



Source: IDC Research, 2024

For this purpose, the technologies investigated for Task 3.1 include augmented reality (AR), virtual reality (VR), mixed reality (MR), digital twins, brain computing interfaces (BCI), internet of things (IoT), artificial intelligence (AI), and generative artificial intelligence (GenAI), distributed ledger (also referred to as Blockchain), Web3, and 5G, which are defined as follows:

- **Augmented Reality**[ii]: technology that overlays digital information or objects on a person's real-world view of reality.
- **Virtual Reality**[ii]: technology that places end users into a completely new reality, occluding the view of their surrounding real-world environment.
- **Mixed Reality**[iii]: these headsets are very similar to virtual reality, although they have the added benefit of allowing the user to view the outside world in full colour using outward-facing cameras (sometimes referred to as reprojection) and enable the user to switch between a fully immersive environment (virtual reality) and a mixed environment, where they can view and/or add objects into a projected view of their surroundings.
- **Digital Twins**[iv]: this is advanced digital simulation, a continuously learning system that can be queried automatically, or even by voice, for specific outcomes. A virtual representation of a physical product, component, asset, process, or even entire environments.

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- **Brain Computing Interfaces**[v]: interfaces that measure brain activity, extract features from that activity, and convert those features into outputs that replace, restore, enhance, supplement, or improve human functions.
- **Internet of Things**[ii]: a network of uniquely identifiable endpoints (or "things") that autonomously connect bidirectionally using IP connectivity.
- **Artificial intelligence**[ii]**:** systems that hypothesize and formulate possible answers based on available evidence and that can be trained through the ingestion of vast amounts of content, and automatically adapt and learn from their mistakes and failures.
- **Generative Artificial Intelligence**[vi]: a branch of computer science that involves unsupervised and semi-supervised algorithms that enable computers to create new content using previously created content — such as text, audio, video, images, and code — in response to short prompts.
- **Distributed Ledger**[ii]: a digital, distributed ledger of transactions or records. It refers to a database that is shared across many nodes in a network, where each node has a copy of the data that is continuously updated and synchronized.
- **Web3**[vii]: a collection of open technologies and protocols to support the natively trusted use and storage of decentralized data, knowledge, and value.
- **5G**[viii]**:** 5G refers to the fifth generation of cellular networks. The main 5G standards were proposed by the 3GPP industry consortium and globally adopted.

As it will be examined in depth in chapter 4, while these technologies are essential building blocks, it is the integration and optimization of their capabilities, combined with creative applications, that drive the development of truly immersive virtual experiences, and enable the creation of Virtual Worlds.

3.3 KEY EXISTING VIRTUAL WORLDS ENVIRONMENTS

The OPENVERSE Task 1.1 collected 75 Virtual Worlds to be analysed, as a first step to take stock of the existing situation regarding that sector. Although the number of Virtual Worlds is of course larger than this number (but not many times this number), we considered it a reasonably good lot to initiate our overview of the existing Virtual Worlds, both in terms of general characteristics and fine-tuning dimensions and sub-dimensions indicative of popular and human-centric candidate Virtual Worlds to work with in a co-creation perspective. The definition qualifying these 75 Virtual Worlds

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among many others envisaged in a first stage, is provided in section 3.1 of this Deliverable. The analysis that we conducted was based upon the systematic examination of the 75 platforms and a series of grey literature reviews when available. We started by apprehending the virtual world collection, as a whole, by merely counting the platforms according to specific criteria (domains of applications, countries, open source Virtual Worlds), while the next analytical phase, more sensitive, was based on a dedicated Analytical Framework (or AF), made of 10 dimensions and 29 sub-dimensions, each one characterised by a ranking of their relative importance, validated by the OPENVERSE Consortium in an ad hoc formal working session. The overall process was meant to identify a short list of Virtual Worlds fitting the European values for open and human-centric applications, which could be envisaged for co-creation purposes as part of different following tasks of the OPENVERSE Project, but in particular in its Work Packages 1 and 2.

This analytical process went through three distinct phases of development:

The first observations, including a reflection on the representativeness of the 75 VWs, an overview of the 75 Virtual Worlds as a significant whole, with observations concerning the domains of applications that they cover, a documented comment on the notion of « most popular » Virtual Worlds (17 successful platforms, mostly North American, identified on the basis of documented figures on the number of users, created and marketed assets, as well as the companies' turnover), with an analysis of their evolution and a country-based classification (country of domiciliation of the platforms).

A process of elimination to pass from 75 VWs to 30, based on a handful of criteria, starting with GDPR (non GDPR compliant were out), then the reject of 1) non European Virtual Worlds, except for a handful of US and most popular ones, 2) Virtual Worlds which were mainly dedicated to children, 3) massively multi-player online role playing platforms (or MMORPG), with argued-upon exceptions, 4) declining Virtual Worlds and 5) Virtual Worlds to tightly linked to a major IT company..

A systematic analysis of these 30 Virtual Worlds, based on the dimensions and sub-dimensions of the above-mentioned Analytical Framework. This step ended up with the identification of two slightly overlapping short lists of 15 Virtual Worlds, one for WP1 co-creation needs and another one for WP2 diverse requirements, all satisfying at best the principles of the Analytical Framework, as well as encompassing the characteristics to function in the targeted co-creation processes.

The observations that were made initially appeared rather straightforward: the 75 VWs involved a strong dominance of gaming, entertainment, socialisation and marketing-oriented VWs, with half of them being linked to American platforms (even more so when looking at the powerhouse of the « most popular » ones); in other words, a formidable challenge for EU creative technological and socio-

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economic actors. Another observation worth stressing is that only 4 VWs are open source, which leaves an enormous potential open for European players. Let's also acknowledge, concerning that aspect, that contrary to many VWs which are based on Blockchain-supported means of monetizing virtual assets (within an important diversity of virtual to real transferring schemes), and along with that, a clear mindset towards decentralised organisations and finance, there is still, in the virtual world arena, an important proprietary inclination. What we can observe is that a lot of VWs propose cross-platform access (meaning from diverse systems and devices, even without headsets), and/or cross-chain compatibility. We also saw that a few VWs are trying to partner with other VWs or other types of players, so as to overcome some audience and cross-VW limitations. For creators, SDK/API schemes, (for "Software Development Kit" and "Application Programming Interface") as well as some well-known game engines in the background (Unity, Unreal) help re-use capacities and probably too, some virtual assets. Let us also mention the strong emergence of Blockchain-related options, either within the Virtual Worlds themselves or as functional possibilities, to value and monetize virtual assets, and soon, much more (Decentralised Autonomous Organisation or DAO, Decentralised Finance or DeFi, as well as smart contracts). In the same mindset, it is interesting to observe how many Virtual Worlds are already using AI to enhance their features and their functioning (over one third, and for some of them, important investment in that direction). Already, the integration of GenAI within the creative processes of the VWs is coming as a new challenging step for the creators' market.

We also identified subtle stakes to consider for any further open and human-centric virtual world deployment. Within that human-centricity, there are issues that need to be clarified. The Analytical Framework inventoried a series of ethical objectives, such as accessibility, respect of privacy or trustworthiness and security. Let's examine briefly how these claims stand against real practices.

There is definitely a need for as much universal accessibility as possible to the Virtual Worlds. However, while most of the short-listed VWs are quite good in that respect, those which are more professionally oriented, more B2B or B2B2C inclined, have to take other criteria into consideration (e.g. productivity, sectoral performance). It does not mean that those less accessible (more technologically inclined, more costly also) are less valuable, that are merely pursuing a different goal than the end-user oriented Virtual Worlds. These less universally accessible VWs, are nevertheless keen at displaying their inclusive options and explaining their explicit efforts to integrate individuals or groups with some forms of disability or belonging to socio-cultural minorities. The lesson here, is that while the AF was correct in stressing essential human-centric requirements for Virtual Worlds, there is no absolute one-size-fits-all perspective satisfying all needs.

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There is another twist between requirements and real observed practices worth emphasizing. For the short-listing stage to pass from 75 to 30 Virtual Worlds, several criteria have been used, but the main and redhibitory one has, of course, been GDPR, creating a *de facto* more respectful cohort of VWs regarding data handling and privacy. Still, even with this constraint, we have seen reviews complaining about the leaking of data. This means that like for several AF requirements, e.g. trustworthy and safe Virtual Worlds, there is no guarantee of compliance based on the sole declaration of intention provided by the platforms. Virtual Worlds, even if the platforms often display real claims to cope with these diverse security and ethical issues, like the rest of the digital, are not yet a safe and sane arena (the legal being by nature always a bit behind reality, regulatory efforts taking time to exert their effect, especially worldwide). The lesson here is that we live in a complex world with always a possible leeway between what people say they do and the reality they are part of.

Despite these problems, Virtual Worlds are deploying their activity and the short lists we have come up with left us with a mix of European and non-European Virtual Worlds, dealing with five main categories of usages: gaming, marketing and fashion, socialising, professional purposes for, on the one hand, events and collaboration and, on the other hand, utility-oriented goals (in the construction, industrial, healthcare or educational sectors, in particular). The European Virtual Worlds are scarcer in the first three categories than in the last two, but if the purpose is to find a mix, there are enough candidates. However, we had to apply to these AF-based criteria another set of conditions, linked with the need to engage in an EU-efficient foresight process. Four types of factors were also considered: 1) technologies likely to shape Virtual Worlds' future, 2) EU digital sovereignty problems, 3) standard and IPR gaps to narrow down and 4) regulatory and governance efforts engaged by the EU to cope with digital issues, including dealing with Virtual Worlds.

Co-creation has been, all the way through, the project's core concern, and the Task 1.1 was no exception. At the end of the selection process, it is worth stressing that it may mean, with equal value: 1) The kind of creation involving end users and also professional creators, offering for that avatar customization, and tools to create, as well as community building and management resources; 2) A different business model, with just a similar value for European interest, the involvement of creative features or process of professional-grade level, different organisational or corporate configurations, in which the European Virtual Worlds identified are promisingly effective. We consider this observation as a positive result of the 75 VW analysis, with the stimulating idea, for EU players and communities of interest, to envisage how these two types of co-creation can eventually interact and enrich the potential of all VW-interested EU socio-economic actors.

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4 MARKET TRENDS AND ANALYSIS

The Virtual Worlds market is rapidly evolving, driven by technological advancements and growing consumer interest. This chapter delves into the key trends shaping this industry. We will explore the current state of literature on Virtual Worlds, analyse the strategies and investments of leading organizations, examine adoption rates across various sectors, and discuss the evolving business priorities, use cases, and challenges within this dynamic space.

4.1 LITERATURE REVIEW

The emergence of the Virtual Worlds marks a pivotal shift in digital interactions, promising a seamless fusion of virtual and physical realities. As an expansive and interconnected digital ecosystem, the Virtual Worlds leverages advanced technologies to offer immersive and persistent experiences. Recent scholarly work has explored different facets of this evolving concept, focusing on how artificial intelligence (AI), Blockchain, decentralised infrastructures, and other emerging technologies are transforming the development and deployment of Virtual Worlds platforms.

This review consolidates key findings from multiple studies, examining the conceptual frameworks, technological architectures, and ethical implications underpinning the Virtual Worlds. In IEEE Communications Magazine (2023), a study discusses the integration of AI and Blockchain as critical components to enhancing the efficiency, scalability, and security of the Virtual Worlds. The research proposes an AI-based approach for optimising video delivery, which is one of the core components in enabling immersive experiences within virtual environments. The study highlights that AI algorithms can dynamically manage bandwidth, reduce latency, and optimise content delivery based on real-time user data. Additionally, Blockchain technology ensures secure, transparent, and decentralised transactions, which is crucial for maintaining trust among users engaging in commerce, content creation, and data sharing within the Virtual Worlds. The methodology in this study involved designing a scalable architecture capable of handling complex transactions and massive volumes of user data. The proposed model integrates AI to enhance real-time decision-making while utilising Blockchain to manage digital assets, smart contracts, and identity verification. However, the study acknowledges significant limitations, particularly concerning the scalability of Blockchain networks. Current Blockchain systems often struggle with transaction throughput, which could hinder their ability to support the high-frequency transactions required in fully functional Virtual Worlds. Future research is encouraged to explore more efficient consensus algorithms and scalability solutions, such as sharding or layer-2 solutions, to address these bottlenecks. Virtual Worlds publication from the World Academy

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of Science, Engineering, and Technology offers a different perspective by conceptualising the Virtual Worlds as an extension of reality. The authors present the Virtual Worlds not just as a technological innovation but as a sociocultural phenomenon that redefines how people interact, work, and engage in entertainment. This vision aligns with the principles of Web 3.0, where decentralisation empowers users, shifting control from centralised authorities to individuals. The study explores various elements, including Virtual Worlds, digital economies, and decentralised governance models, emphasizing that these components need to be integrated cohesively to create a seamless experience. Using a constructivist methodology, the research examines how decentralised networks can facilitate this vision by enabling peer-to-peer interactions without intermediaries. The authors argue that technologies such as non-fungible tokens (NFTs) and decentralised finance (DeFi) play a pivotal role in giving users ownership over digital assets, which in turn fosters economic incentives for participation. However, the paper lacks empirical data, making it challenging to validate its claims about user behaviour and the adoption of decentralised technologies.

4.1.1 The Social and Ethical Dimensions of the Virtual Worlds

Exploring the implications of the Virtual Worlds as a virtual universe where users can engage in a variety of activities through avatars is critical. Virtual Worlds offer opportunities for social interaction, entertainment, and education, effectively creating a parallel universe that enhances the sense of presence and community, utilising both theoretical and conceptual frameworks, the role of VR and AR in making these experiences more immersive. VR provides users with a fully immersive environment, while AR overlays digital elements onto the real world, allowing for a blend of digital and physical experiences.

Despite the optimistic outlook, still some critical ethical concerns exist. Issues related to privacy, security, and data ownership are a major challenge that could impede the widespread adoption of the Virtual Worlds. For instance, the ability to collect vast amounts of user data in real time could lead to privacy violations if not managed properly. Moreover, the risk of digital addiction, misinformation, and cyberbullying within virtual environments presents ethical dilemmas that need to be addressed proactively. The ethical guidelines, along with robust security protocols, must be implemented to protect users and ensure safe, inclusive Virtual Worlds. Further research is needed to develop comprehensive regulatory frameworks that balance innovation with user protection.

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4.1.2 The Importance of Open and Interoperable Platforms

For the Virtual Worlds to achieve their full potential, they must be built on open standards that allow for seamless communication and data exchange across different platforms. This interoperability is crucial for enabling users to move their digital assets, avatars, and experiences across various Virtual Worlds without facing compatibility issues. The current ecosystem is fragmented, with multiple companies developing their own versions of Virtual Worlds, leading to a lack of cohesion. This fragmentation can limit user engagement and hinder the development of a robust digital economy within the Virtual Worlds. The establishment of global standards and collaborative initiatives that encourage interoperability is proposed in the literature. While the literature provides a broad overview of the challenges and opportunities, it does not explore the specific technological solutions or frameworks that could facilitate interoperability. Future research should focus on developing technical standards and protocols that ensure compatibility across different platforms, fostering a more integrated Virtual Worlds ecosystem.

4.1.3 Integrating Emerging Technologies: The Role of AI, Blockchain, and IoT

The integration of AI, Blockchain, and the Internet of Things (IoT) is a recurring theme across the literature, as these technologies form the backbone of the Virtual Worlds' infrastructure. AI plays a crucial role in creating intelligent, responsive environments that adapt to user behaviour, enhancing engagement through personalised experiences. Machine learning algorithms can analyse user interactions to predict preferences, optimize content delivery, and even create virtual assistants that guide users within the Virtual Worlds. Blockchain, on the other hand, provides the foundation for secure, transparent, and decentralised systems, enabling digital ownership, secure transactions, and trust-less interactions.

The Internet of Things (IoT) further enhances the Virtual Worlds by connecting physical devices to digital environments. This integration allows for the creation of smart spaces where digital and physical objects interact seamlessly. For instance, users can control real-world devices within a virtual world, blurring the line between digital and physical realities. However, the integration of these technologies raises additional challenges, particularly concerning security and data integrity. Ensuring that IoT devices are secure and that Blockchain systems can handle the volume of transactions in real-time is essential for the seamless functioning of the Virtual Worlds. Future research must explore innovative approaches to address these technical challenges, such as enhancing Blockchain scalability and developing more robust security protocols for IoT networks.

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The literature on the Virtual Worlds reveals a complex and multifaceted landscape where emerging technologies converge to create new possibilities for digital interaction. While there is significant optimism around the potential of AI, Blockchain, and decentralised infrastructures to drive the future of the Virtual Worlds, there are also considerable challenges that need to be addressed. Issues related to scalability, interoperability, privacy, and security are critical barriers that could impact the growth and adoption of the Virtual Worlds. Moreover, ethical considerations, such as data privacy, digital addiction, and misinformation, must be taken seriously to ensure that Virtual Worlds are safe, inclusive, and beneficial for all users. Moving forward, research must focus on developing robust technical solutions, regulatory frameworks, and ethical guidelines that support the sustainable growth of the Virtual Worlds. Collaboration among developers, policymakers, and industry leaders will be essential in building a cohesive, interoperable, and user-centric digital ecosystem. By addressing these challenges, the Virtual Worlds can fulfil its promise as a transformative platform that redefines how we interact, work, and play in a digital world.

4.2 ORGANIZATIONS' STRATEGIES AND INVESTMENTS ON VIRTUAL WORLDS TECHNOLOGIES

As Virtual Worlds continue to evolve and become increasingly sophisticated, organizations across various industries are exploring their potential applications. This section examines the strategies and investments that organizations are adopting to capitalize on Virtual Worlds technologies. By analysing quantitative survey results and conducting in-depth interviews with key experts, providers and users of Virtual Worlds, the analysis provides a comprehensive overview of the current landscape.

These sections leverage primary research and in-depth interviews with experts; in particular, the following chapters analyse the results from a quantitative survey with a sample of 800 respondents across Europe and META countries, and insights from qualitative interviews with 19 experts from industry, academia, and policymaking – full details on demographics and questionnaire in appendix.

The sections explore how organizations are leveraging Virtual Worlds for purposes such as training, marketing, product development, and customer engagement. Additionally, it examines the factors driving their investment decisions, including the perceived benefits, challenges, and risks associated with Virtual Worlds adoption.

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4.2.1 Current and Future Adoption Trends

This subsection delves into the current state and projected trajectory of Virtual Worlds adoption across various industries. By analysing recent trends, market forecasts, and expert opinions, we aim to provide insights into the factors driving adoption and the potential challenges organizations may face in the future.

The analysis will explore the rate at which organizations are adopting Virtual Worlds technologies, the industries demonstrating the highest levels of adoption, and the specific use cases that are gaining traction. Additionally, we will discuss the emerging trends and technological advancements that are likely to shape the future of Virtual Worlds. To provide more context and clarity, the analysis of the market sentiment and adoption of Virtual Worlds technologies is divided into foundational technologies – namely, virtual reality, augmented, and mixed reality, digital twins, and brain computing interfaces – and enabling technologies – including 5G, GenAI, Web3, IoT, and Blockchain and the adjacent technologies and applications.

Before double clicking on the individual technologies that are part of the Virtual Worlds ecosystem, the survey also investigated European organizations familiarity with Virtual Worlds solutions more broadly, and their propensity to employ them. Figure 6 provides a snapshot of European organizations sentiment on Virtual Worlds – the survey findings reveal a strong and growing interest in Virtual Worlds solutions among EU organizations. 71% of respondents either currently use or have plans to adopt these technologies within the next two years. This positive sentiment suggests a promising market opportunity for vendors and service providers, as organizations seek to leverage Virtual Worlds for competitive advantages, improved efficiency, enhanced collaboration, and innovative customer experiences. Specifically, 23% of organizations are already utilizing Virtual Worlds, demonstrating early adoption, while 38% plan to implement them in the near future, indicating a positive outlook for market growth. Moreover, only 14% of organizations expressed no interest, highlighting the overall favourable perception towards these emerging spaces. These results suggest that Virtual Worlds are poised to become a significant part of the digital landscape in the EU, driving further advancements in technology and industry-specific applications.

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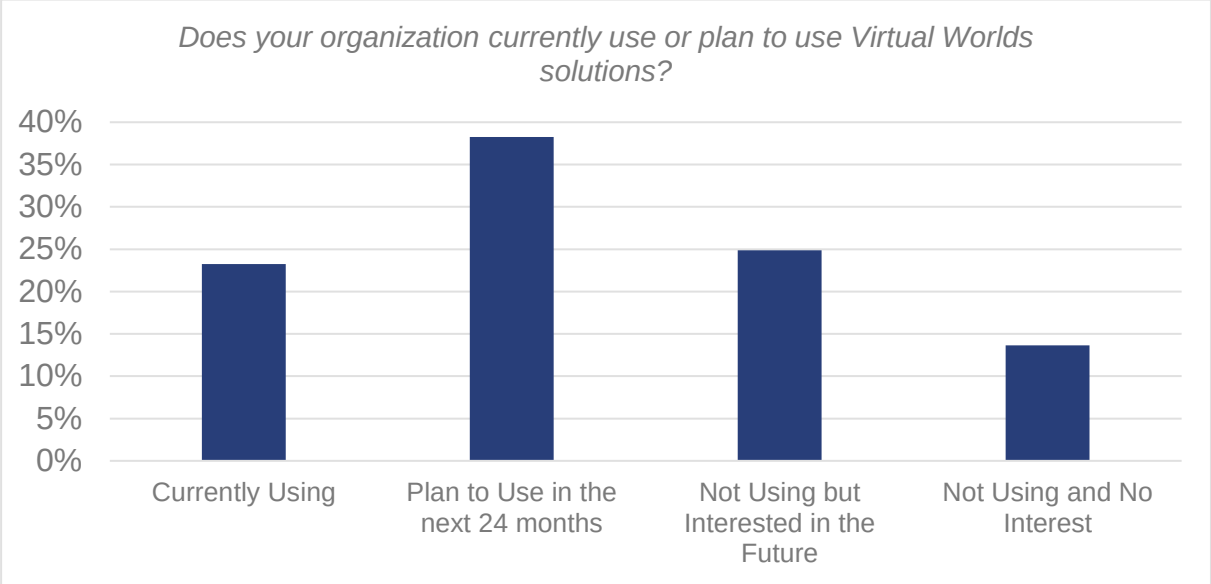
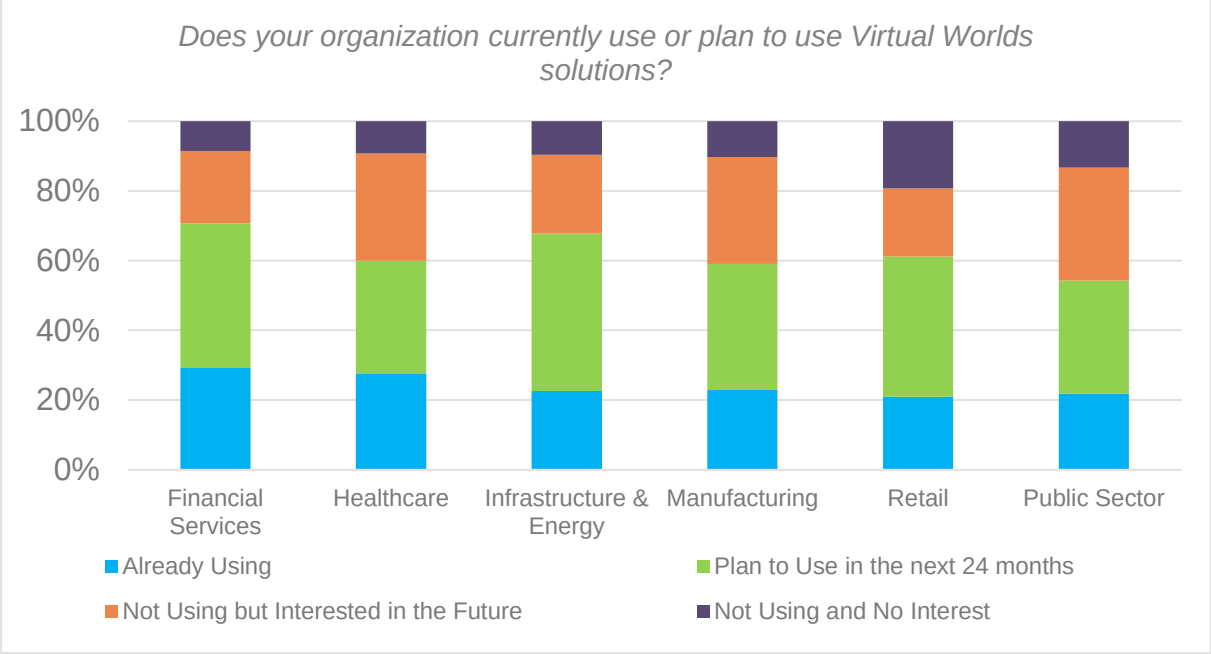
Figure 6 Virtual Worlds Adoption



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 800

After looking at the overall European market, it is interesting to double click on the different industries approach to Virtual Worlds. Figure 7 provides a detailed view of European industry adoption of Virtual Worlds solutions.

Figure 7 Virtual Worlds Adoption by Industry



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 800

Financial services and healthcare providers, already early adopters, exhibit strong plans for further implementation within the next two years. This can be attributed to the potential benefits of Virtual

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Worlds in areas such as remote customer support, digital twinning for asset management, and training simulations. Infrastructure and energy sectors, recognizing the value of Virtual Worlds for design, collaboration, and operational efficiency, have the most ambitious adoption plans. While manufacturing, retail, and the public sector are catching up, their growing interest is likely driven by the need to enhance customer experiences, streamline operations, and explore new revenue opportunities.

Academia plays a pivotal role in bridging the gap between technological development and industry demands, particularly in Virtual Worlds. Researchers highlight that while universities often face limitations due to the availability of market-ready equipment, they remain at the forefront of developing innovative solutions tailored to industry needs. This collaboration between academia and industry is crucial in driving advances, especially in non-formal education, where academic institutions excel in creating cutting-edge applications despite resource constraints.

Educational Institutions like Morehouse College, represented by Dr. Muhsinah Morris, are integrating AR and AI into their curriculum, using these technologies as tools for immersive learning and skill development. They focus on accessibility and practical applications, preparing students for future job markets.
There is an ongoing collaboration between academia and industry to develop curricula and training programs that incorporate AR, as highlighted by various experts. Educational institutions work with companies to provide relevant skills and foster innovation through research and real-world problem-solving scenarios.

Governments are involved as adopters and supporters of AR and AI technologies by partnering with industries and academic institutions. They provide regulatory support, funding, and policy frameworks to drive innovation and set standards for emerging technologies. As the Virtual Worlds and immersive technologies expand, governments are also becoming adopters by establishing governance models, ethical frameworks, and policies for privacy, security, and interoperability, as noted by experts.

Automotive industry and companies like Volvo Cars, as represented by Timmy Girard, are significant adopters, using AR technologies for product design, digital twins, and engineering processes. They integrate immersive technologies for real-time analytics, enhancing their design and decision-making workflows.

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Telecommunication companies like Deutsche Telekom are pioneers in deploying immersive technologies, focusing on multi-user AR/VR environments and developing hardware that supports both indoor and outdoor usage. They collaborate with other tech giants like Amazon and Nvidia to create efficient virtual world solutions.

Media and marketing organizations like Big Rock Creative, led by Athena Demos, leverage AR for virtual events, marketing campaigns, and interactive experiences. They are early adopters in using virtual worlds for community building and innovative projects like virtual reality comic conventions and corporate campaigns (e.g., for T-Mobile).

Enterprises in sectors like construction adopt AR for training programs and simulations, enhancing safety and efficiency. In our inteviews, John Li of XREAL USA highlights the application of AR glasses and AR solutions for enterprise training and productivity improvements.

Innovators in AI, such as Alvin Graylin of HTC, emphasize integrating AI into AR platforms, leading to the development of AI-powered avatars, digital twins, and interactive agents that enhance user engagement and functionality in virtual spaces.

Small and Medium Enterprises (SMEs) especially in the creative, marketing, and tech sectors, are adopting AR and AI tools to remain competitive. They innovate with limited resources, often focusing on niche markets like virtual events, interactive marketing, and immersive storytelling. However, these smaller companies face challenges in competing with larger corporations and often require financial support and partnerships to thrive, as highlighted in discussions on the support needed for these entities.

Individual Developers, Freelancers and Independent Creators are among the early adopters of AR and AI tools, leveraging platforms like Engage, Horizon Worlds, and Infinite Reality for content creation, immersive storytelling, and virtual world building.
Early Adopters and Enthusiasts and Individuals with an interest in emerging technologies and gaming communities are significant adopters, experimenting with AR and AI devices like VR headsets, AR glasses, and AI-driven tools. These enthusiasts help shape market demand and drive early adoption patterns in consumer spaces.

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4.2.2 Adoption and Impact of Foundational and Enabling Virtual Worlds Technologies

Going into more granular details, figure 8 shows European organizations adoption intentions on the foundational Virtual Worlds technologies. The adoption of Virtual Worlds technologies within European organizations is steadily increasing, driven by the perceived benefits and potential applications across various industries. According to the Worldwide Augmented and Virtual Reality Spending Guide published by International Data Corporation (IDC), European augmented reality and virtual reality (AR/VR) spending will reach $4.8 billion in 2024. AR/VR spending will record a 21.9% compound annual growth rate (CAGR) over the next five years to reach $10.2 billion in 2028. Benefitting from the confluence of both AR and VR, and the recent launch of new headsets like the Quest 3 and the Vision Pro, MR headsets are expected to grow faster and lead, representing over 70% of the global volume in 2028. Survey data confirms that VR currently has the highest adoption rate at 26%, with 27% of organizations planning to adopt within the next two years. Augmented reality technologies are also gaining traction, with 13% currently adopted and 34% planning future adoption followed by MR technologies which show relatively lower current adoption rates at 11%, but a significant growing potential with 30% of organizations planning future adoption.

Barriers such as price, fidelity, battery life, thermals, and optics are the key ones for these technologies. The drive to make AR technologies affordable and accessible is a significant current focus, as highlighted by John Li (XREAL) and Athena Demos (Big Rock Creative). Companies like Meta (formerly Facebook) have contributed to this trend by offering affordable headsets, making VR and MR/AR devices more accessible to consumers. Affordability remains a critical factor in hardware adoption. Manufacturers are investing in technology to produce scalable, cost-effective solutions to expand user adoption. The MR implementation of AR on VR headsets allowed for more affordable yet more capable solutions built with state-of-the-art technologies. In this context, the technologist and AR expert, Dulce Baerga highlighted the trend toward AR light headsets and holographic displays, indicating that future adoption will see more sophisticated and lightweight AR/VR devices. Such devices contribute to making AR technologies more wearable and suitable for all-day use, which is essential for widespread adoption and integration into daily activities. The push towards more comfortable, all-day wearable devices will likely continue as the technology evolves. John Li's focus on developing lightweight AR glasses and other consumer-friendly technologies suggests that AR, in particular, will become more ubiquitous, merging seamlessly into daily life.

VR and AR serve different use cases; while VR is well-suited for immersive experiences supporting use cases like consumer and customer engagement or training, AR overlays digital information onto

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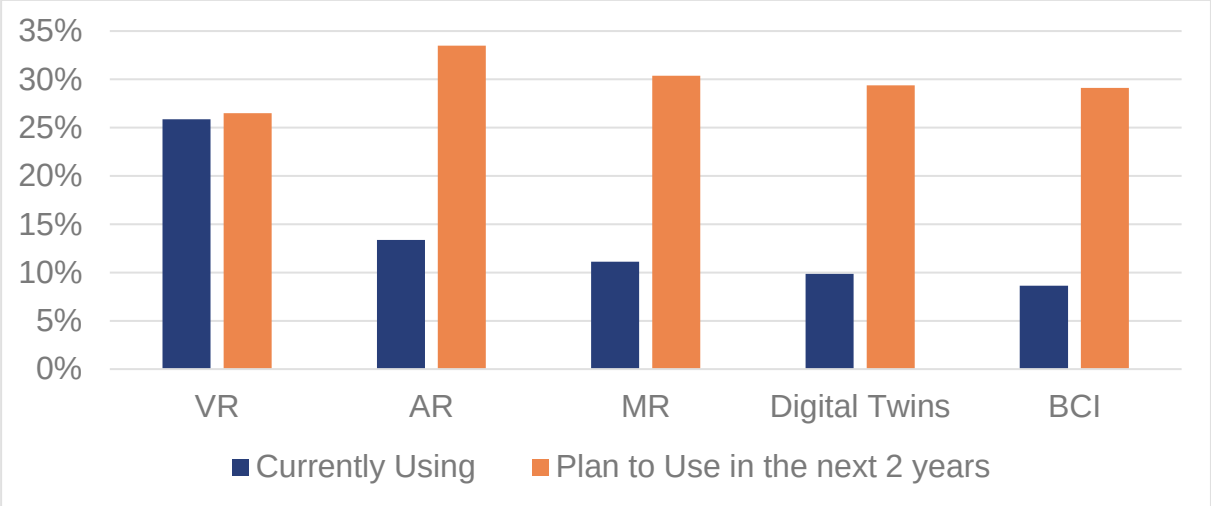
the real world and has been particularly adopted in manufacturing or asset-heavy industries for very specific use cases aiming at driving operational efficiencies. It is however worth noting that, as later investigated in subsection 4.4, despite the delimitations of use cases, AR adopters are quite advanced in establishing initiatives at company level that go beyond the pilot phase. In addition to that, AR technologies can be affected by factors such as lighting conditions, object tracking, and network connectivity, which can limit their effectiveness in certain environments. For example, as mentioned by Ohto Pentikäinen, CEO & Co-Founder at Doublepoint, a European software company provider of immersive computing for augmented reality devices, in order for its market to flourish, AR requires some innovations, in particular on devices. This includes lighter, more comfortable and efficient displays, a more efficient computation of the algorithms needed to run the headsets in a way that does not drain batteries in a short period of time. Having wearables with longer battery life, and being able to run algorithms and displays more efficiently are key in the context of connectivity, and most use cases depend on them.

Further challenges will be investigated in the following chapters. Despite these challenges, VR, AR and MR technologies are expected to experience significant growth in the coming years as technology advances and organizations discover new and innovative applications for these technologies.

Figure 8 Foundational Technologies Market Adoption



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 800

Being more sectorial, digital twins have lower adoption rates at 10%, but showing growth potential as 29% of organizations are planning future adoption. This suggests that these technologies are still emerging but are gaining momentum as their potential applications become more apparent.

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Alessandro Canepa, who has hands-on experience in two very different industries with Piacenza[ix], a company designing and producing textiles for the fashion industry and SizeYou[x], a company providing anthropometric body measurement services, identifies some current applications of Virtual Worlds-related technologies, and pinpoints their potential future evolutions. In particular, in his textile industry experience, he identifies great potential in the transition from physical to virtual fabric samples, which brings benefits both in terms of time-efficiency and environmental impact. Future developments may lead to the complete virtualisation of the design process, from the design of the fabric to the integration of the 3D fabric samples in the clothes design itself, in a sort of Digital Twin.

Brain-computer interfaces (BCI), while still in their early stages, are also showing signs of growth with 9% current adoption and 29% planned adoption. This indicates a growing interest in exploring the potential of BCI for applications such as healthcare, gaming, and human-machine interaction. As mentioned by technologist and AR expert, Dulce Baerga, BCI could enhance human interaction with virtual worlds by integrating biological data and capabilities. BCI can pave the way to new immersive experiences in Virtual Worlds, allowing users to interact with physical-digital worlds with their thoughts rather than physical control, transmitting emotional states but also making Virtual Worlds more accessible to individuals with disabilities creating a more inclusive environment.

As previously mentioned, foundational Virtual Worlds technologies alone are not sufficient to fully develop and deploy immersive solutions. Those require enabling technologies that support and boost their performances in terms of connectivity, bandwidth, infrastructure, intelligent interactions, platforms, tools, and security. Figure 9 provides an overview of market adoption of the main enabling technologies: 5G, GenAI, IoT, Web3, and Blockchain. The analysis delves into the adoption intentions of these technologies, and their underlying functions and infrastructure requirements that enable Virtual Worlds solutions.

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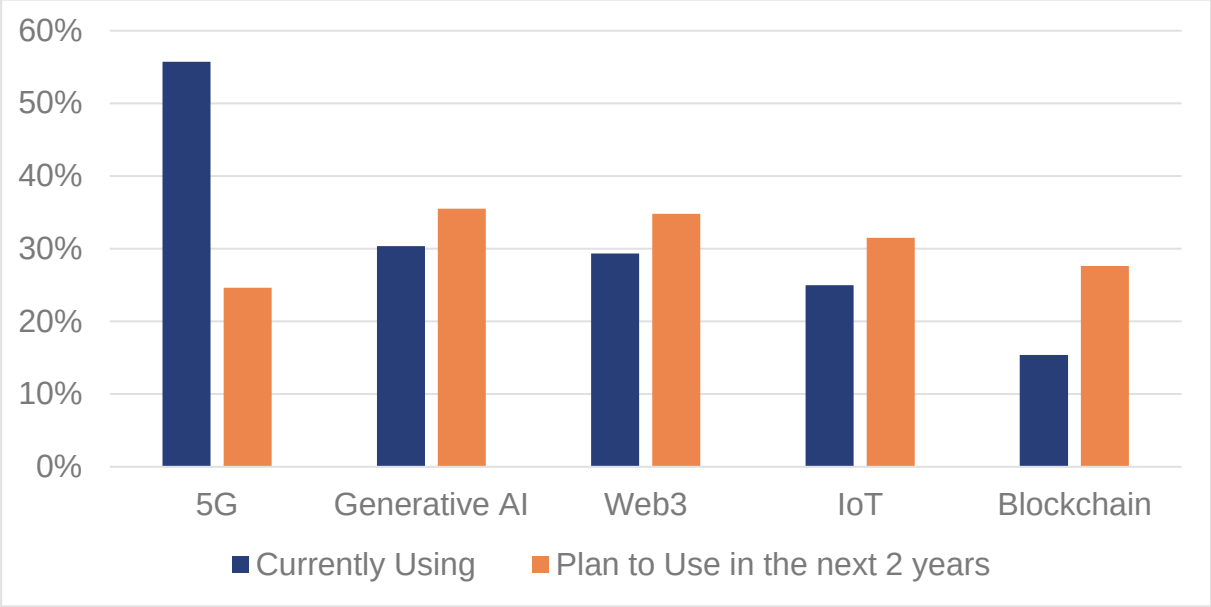
Figure 9 Enabling Technologies Market Adoption



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 800

Immersive technologies rely on connectivity: from ensuring low-latency and reliable communication to enabling devices to offload more to the edge and leverage edge rendering/edge streaming, to access to edge computing with high throughputs and low latency. 5G is a crucial technology for Virtual Worlds. It is not surprising that 5G shows strong current adoption among European organizations – 56% in 2024 – as the technology is becoming quite established and has been rolled out for almost a decade now. Thus, organizations clearly understand the benefits and needs of having strong connectivity infrastructure in order to support demanding technologies. The three main components of the IT infrastructure (the digital core, ecosystem, and edge) have a role to play in Virtual Worlds. The rise of Virtual Worlds will likely increase demand for cloud computing services even further. This is mainly because hosting 3D environments requires much computing and storage resources, and it's a safe bet that few businesses that want to run Virtual Worlds will want to purchase their own hardware to do so. Instead, they will turn to the cloud to host the Virtual Worlds, as they already do for most of other workloads.

Cloud Computing and Edge Computing technologies are essential for delivering real-time, high-performance experiences in Virtual Worlds by offloading processing power and reducing latency. Cloud computing enables the scalability required for large-scale multi-user environments, such as virtual events platforms, as mentioned in various use cases by Terry Schussler, Senior Director at Deutsche Telekom and John Li from XREAL. This technology enhances the responsiveness of Virtual

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Worlds by processing data closer to the user, improving the real-time performance needed for AR applications and collaborative virtual environments.

With millions of people sharing virtual experiences worldwide, bringing the processing closer to users with edge computing solutions can make the entire experience much more fluid. In that context, 5G frequencies reach incredibly high levels, enabling VR experiences (including the sense of touch) and AR experiences, enabling users to converse with AI characters in real-time[xi]. Furthermore, enhanced security is at the core of Virtual Worlds services and 5G will be key in sustaining security and ensuring software and platform interactions. 5G's essential role is to ensure consistent networks to improve users' experiences in Virtual Worlds by enhancing the use of AR/VR devices.

Generative AI, as well as other artificial intelligence systems, are gaining much traction as their applications and potential benefits are expanding and being experimented more widely. Artificial intelligence is crucial to create immersive experience; AI helps gather insights from historical data, learns from previous iterations, and generates unique outputs and insights. Despite becoming mainstream only in the last couple of years, generative AI is already experiencing momentum in terms of adoption: over 30% of European organizations are currently using generative AI solutions, with more than 35% expressing interest in adopting it in the next two years.

As mentioned, the importance of AI systems in deploying Virtual Worlds solutions does not stop at GenAI. As described by a CIO of an Italian furniture manufacturing group, " By merging virtual and real worlds, we can revolutionize traditional business channels. Instead of the multi-step process involved in today's shopping experiences, virtual reality and AI, combined with historical 3D data, allow us to quickly present customers with tailored solutions. By leveraging existing knowledge and designs, we can offer proposals aligned with vendor styles, significantly reducing time-to-market. This approach is both cost-effective and efficient, streamlining the design process and accelerating solution delivery."

The advancement of Artificial Intelligence models could bring further advancements to the sector: the digitalisation of fabric samples into 3D virtual samples will allow for the creation of extensive historical archives, which can in turn be navigated more easily with the assistance of AI but also leveraging the advanced visualisation capabilities of Virtual Words. Additionally, the samples archives can be used as training sets, potentially enabling AI models to generate new fabric samples based on the historical ones which can double as training sets.

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With the help of AI engines, it is also possible to generate avatars that appear more realistic and accurate by analysing 2D images and 3D scans. Using AI and VR solutions, companies are creating entire Virtual Worlds. AI can also be used to create digital humans, which are 3D versions of chatbots that exist in Virtual Worlds. Machine learning, computer vision, natural language processing, and conversational AI are the driving forces in a new race to develop both comprehensive and niche Virtual Worlds solutions. This race for new solutions has led to the creation of new, diverse partner ecosystems around tech giants creating the underlying Virtual Worlds platforms. AI can be used in several ways into Virtual Worlds and Web3 to enhance their potential, from intelligent Blockchain (i.e., Blockchain runtime that uses a machine learning (ML) prediction for transactions to enable a massively scalable consensus protocol) to decentralized apps (the most likely Web3 solutions to rapidly add AI/ML-driven features). Virtual Worlds' aim is to understand users' intentions with the help of AI by releasing natural language processing to different information the way humans can[xi].

Experts like Dr. Muhsinah Morris and Alvin Graylin emphasize the ongoing integration of AI and AR technologies. AI enhances the functionality of AR platforms by enabling intelligent and immersive experiences, such as AI-powered virtual teachers or AI agents guiding users in virtual worlds. The convergence of AI and AR is seen as a major trend, facilitating applications in education, training, and various enterprise settings (e.g., Alvin Graylin's emphasis on the impact of AI avatars).

Multiple experts discuss the evolution of virtual worlds, with predictions that it will become a central part of digital life. As AI integrates more deeply into AR, virtual spaces will evolve to offer richer, more interactive experiences. Athena Demos and Alvin Graylin note the trend toward platforms and events that focus on user-generated content, community building, and collaboration. Future virtual worlds platforms will prioritize inclusivity, accessibility, and multimodal inputs (e.g., voice, eye tracking), as indicated by experts like Deutsche Telekom. This will create more immersive and personalized experiences for users.

Otho Pentikäinen, CEO & Co-Founder at Doublepoint, believes that AI-powered assistance is a key driver for the adoption of AR headsets, particularly in the early stages. While there was initial uncertainty about the practical applications of AR, AI has emerged as a compelling use case. Effective computation of large language models, either through cloud connectivity or local processing, is crucial for realizing this potential.

In this context, spatial computing integrates physical and digital elements, allowing for accurate representation and interaction with 3D environments. Spatial computing is fundamental for AR

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devices, helping overlay digital information onto the physical world, as discussed by John Li from XREAL. This technology supports the creation of AR experiences where users can interact with digital elements in their surroundings. It ensures the smooth integration of hand gestures, voice commands, and eye tracking within virtual environments, which enhances user interaction and immersion.

AI is a critical component in Virtual Worlds, enabling intelligent interactions, immersive storytelling, and personalized experiences. AI is used to create lifelike avatars that interact with users, providing guidance, customer service, or companionship in virtual spaces. These avatars enhance user engagement and make the virtual environment more dynamic and interactive.
AI avatars and virtual agents, mentioned by Alvin Graylin and Athena Demos, are expected to become more sophisticated and emotionally intelligent, influencing user behavior and experiences in AR environments.

Future trends include AI avatars that not only assist in customer service but also act as capable mentors, or educators. The use of AI will likely extend beyond avatars, affecting other aspects like content creation (e.g., AI-generated music and films) and facilitating more immersive storytelling and interactive experiences. As AI assists in generating scripts, music, films, and other content for Virtual Worlds, it automates the creation process and allows for the development of rich, varied environments. AI can monitor user behaviour and adapt virtual environments or avatars to respond accordingly, making experiences more tailored and engaging.

The emerging Quantum Computing technologies, as John Li from XREAL discusses, hold the potential to further accelerate complex computations needed for spatial simulations and AI integration, enhancing the scalability and realism of virtual environments.

Web3 is seen as providing access to Virtual Worlds by leveraging on its decentralized platforms and using decentralized tools such as DAOs (decentralized autonomous organizations) and DApps (decentralized applications). Accordingly, Virtual Worlds themselves can be considered as the most evident Blockchain-enabled use case for Web3. It is a continuously connected virtual place comprising interconnected multiple networks where users can own digital wallets for online shopping, entertainment, and more. Despite experiencing backlash in the last couple of years, Web3 technologies are raising interest as organizations and individuals are evaluating use cases and utility more effectively. Accordingly, Web3 shows solid adoption rates, with almost 30% of European organizations already using it, and 35% planning to use it in the next two years. One of the principles of Web3 is decentralization. Users have complete ownership over content and data, making the role

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of an intermediary for virtual transactions unnecessary. Decentralization ensures cost-efficient and secure transactions between users, since decentralized infrastructures significantly reduce the risks of disruptions and cybersecurity attacks such as data breaches.

Strictly intertwined with Web3 is Blockchain, upon which decentralized data is stored, managed, tracked and monetized. Although the immediate applications of Blockchain were not easily identified from the beginning, the technology is regaining momentum across European organizations, also boosted by European regulations such as the Digital Product Passport. Blockchain lays the foundations for Web3 and Virtual Worlds tools and applications. Being hard to hack and immutable, Blockchain has critical properties for any virtual reality technology to gain broad adoption. Hacks and data breaches are common, but if people are supposed to operate in an entirely online and virtual environment, the underlying platform on which they will be operating must be secure. By eliminating intermediaries, Blockchain connects users through decentralized peer-to-peer networks and provides the fundamentals for secure, easily trackable, and cost-efficient transactions between entities and consumers.

Blockchain is used for decentralization, ensuring secure, transparent, and interoperable transactions and interactions within Virtual Worlds. Blockchain allows users to securely own and trade digital assets (like NFTs) within Virtual Worlds, ensuring transparency and trust in transactions, as discussed by various experts. Blockchain contributes to the creation of interoperable Virtual Worlds, where assets and identities can move across different platforms seamlessly.

As Virtual Worlds continue to evolve and become more immersive, the integration of the Internet of Things (IoT) is playing an increasingly important role in enhancing user experiences. Being a more established technology, IoT adoption rates remain solid, with almost 50% of European organizations either using or planning to use it in their processes. IoT, which involves connecting physical objects to the internet, offers a wealth of data and interactions that can be leveraged to create more dynamic and realistic virtual environments. By providing information about the physical environment, user behaviour, and other factors, IoT can contribute to the development of Virtual Worlds that feel more responsive and engaging. IoT can also help redefine internet accessibility: as the number of IoT devices grows, Virtual Worlds solutions could offer universal connectivity and access to content.

According to Mr Canepa, key areas of future development include the colour calibration for 3D visualisation and the definition of standards for 3D visualisation, with particular reference to representations of the human body. This is deemed particularly important in applications which

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involve the medical sector, in which the accuracy of body representation is key. Mr Canepa also identifies a gap in the development of Virtual Worlds-related technology between Europe and the United States, which is not sufficiently balanced by the availability of funding opportunities to further the industrial development in the sector. According to Mr Canepa, this is also a result of the reluctance of US-based entities to invest in European endeavours in the sector as the regulatory framework appears to be more complete yet more complex to comply with.

It is not surprising that the convergence between IoT, Edge but also Cloud, Connectivity and Computation could be an enabling factor to the adoption of AR and Web 3.0/4.0 technologies as also promoted by other initiatives of the EC[xii].

The convergence of IoT and Virtual Worlds supports the creation of interactive Digital Twins. Digital twins are virtual representations of physical objects, spaces, or systems, and are integral to creating realistic and functional virtual environments. The car industry (as indicated by Timmy Giurau , the head of Simulation and AR at Volvo) highlights the use of digital twins for product evaluation, design, and engineering processes. They provide real-time data and analytics, allowing for immediate decision-making and testing in virtual environments. Digital twins also help in managing and visualizing spatial data for various applications, including real estate, construction, and city planning. The extensive use of digital twins allows for substantial savings in terms of time and money whenever new products and services are developed due to shortening the path from idea to evaluation.

Following the promising adoption rates of virtual world technologies, it is essential to identify the key areas where strategic investments can drive further growth and innovation. This chapter will delve into the most promising avenues for capital allocation, considering factors such as market potential, technological advancements, and emerging trends.

It is foremost important to analyse the investment opportunities starting from a technological perspective. After the assessment of the market adoption of foundational and enabling Virtual Worlds technologies, figure 10 provides an overview of the most critical technologies European end user organizations require in order to better deploy Virtual Worlds solutions.

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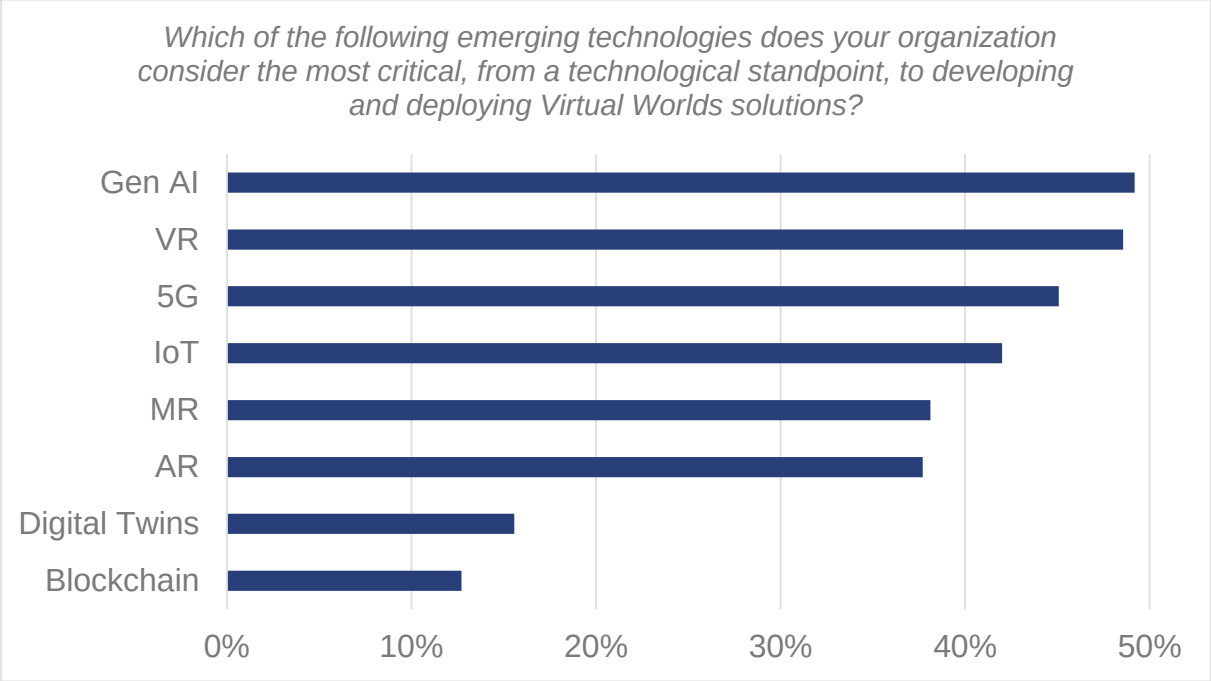
Figure 10 Most Critical Technologies for Virtual Worlds



Source: IDC Emerging Technologies Survey, September 2024, Europe n= 488

Figure 10 interestingly reflects how the technologies with the higher current market adoption are also considered as technologically critical for Virtual Worlds solutions. In the cases of VR, 5G, and IoT it appears more logical as these technologies have been employed by organizations for a few years now and they underpin three essential foundations of Virtual Worlds: immersive experiences, connectivity, and blending digital and physical environments and assets.

A different case can be made for generative AI. GenAI has emerged as a pivotal technology in the development and deployment of Virtual Worlds, as it is ranked as the most critical technology by almost 50% of European organizations. Its capacity to generate vast amounts of realistic content, such as environments, characters, and objects, is instrumental in creating highly immersive and dynamic virtual experiences. By understanding and responding to natural language and gestures, GenAI can facilitate intuitive and human-like interactions within these digital realms. Moreover, GenAI's ability to tailor virtual world experiences to individual users based on their preferences, behaviours, and goals is a game-changer. This personalization enhances engagement and satisfaction, making Virtual Worlds more appealing and relevant to a wider audience. Additionally, GenAI can optimize the performance of Virtual Worlds by dynamically adjusting content and interactions in response to system resources and user behaviour.

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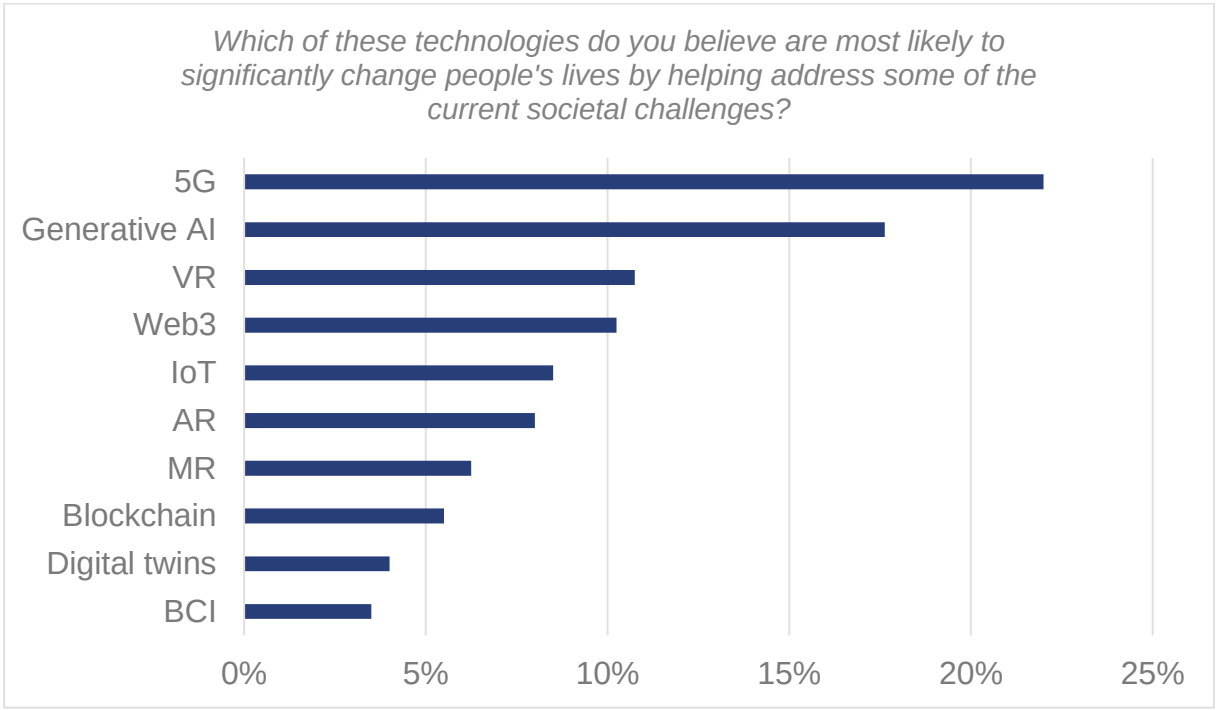
Beyond its direct contributions to the user experience, GenAI also streamlines the development process. By automating tasks like content creation and optimization, it reduces development time and costs, enabling faster iteration and innovation. In essence, GenAI provides the foundation for creating more realistic, engaging, and personalized Virtual Worlds, making it an indispensable technology for driving progress in this field.

It is noteworthy that similar indexes are found when investigating different kinds of impacts of these technologies: 5G is perceived also as the technology that will have the most transformative impact on organizations, as well as being the most strategic one in supporting business goals and delivering the highest return on investment. Similarly, GenAI always ranks second in these three categories, while Web3 and VR are the other two technologies that alternate the third place in these indexes.

Finally, going beyond the pure business impact, it is paramount to consider also the importance of the implications of Virtual Worlds technologies on society and the environment. Figure 11 provides the perspective of European organizations on which technology, amongst the ones investigated, is expected to have the most positive impact on society, supporting in addressing pressing societal and environmental issues.

Figure 11 Social Impact of Virtual Worlds Technologies



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 800

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Based on the chart, respondents overwhelmingly believe that 5G and GenAI have the greatest potential to significantly change people's lives by addressing current societal challenges.

5G, as a foundational technology, can bridge the digital divide by providing high-speed internet access to underserved communities. This enables access to education, healthcare, and economic opportunities, fostering greater social inclusion. Moreover, 5G-enabled smart cities can improve infrastructure, reduce congestion, and enhance sustainability, leading to a better quality of life for urban residents. Additionally, 5G can support real-time communication and data sharing during emergencies, improving response times and saving lives.

GenAI offers promising solutions to address global challenges. In healthcare, it can accelerate drug discovery, improve medical imaging, and personalize treatments. In education, AI-powered personalized learning platforms can enhance educational outcomes and make education more accessible to all. Furthermore, GenAI can be used to develop innovative solutions for climate change, such as optimizing energy consumption and designing sustainable materials.

While 5G and Generative AI are the most prominent, other technologies also hold significant potential for societal impact. Immersive experiences enabled by VR and AR can be used for training, education, and therapy, addressing challenges in various fields. Decentralized technologies like Web3 can empower individuals and communities, promoting transparency, fairness, and inclusivity. Additionally, IoT can improve efficiency, sustainability, and quality of life in various sectors, from healthcare to agriculture.

4.3 KEY DRIVING BUSINESS PRIORITIES

The development of Virtual Worlds technologies is rapidly evolving, driven by advancements in hardware, software, and data management. As technology providers navigate this landscape, they are focused on creating immersive experiences that are both accessible and impactful. In order to assess the main features of Virtual Worlds' providers roadmap, it is useful to investigate the key business goals that are driving organizations adoption of the technologies investigated. Virtual Worlds technologies are becoming increasingly important for European organizations, driven by a desire to improve efficiency, enhance customer experience, and foster innovation. By understanding these key business goals and technology preferences, organizations can make informed decisions about their Virtual Worlds strategies. Figure 12 provides an overview of the key business goals

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European organizations prioritize when planning the adoption of Virtual Worlds technologies. Overall, the chart reflects the following key observations:

- Performance and Cost Efficiency: These two categories consistently rank among the top priorities, indicating that European organizations primarily seek to improve operational efficiency and reduce costs through Virtual Worlds technologies.

- Customer Experience: While not the top priority, enhancing customer experience is a significant driver, suggesting that organizations recognize the potential of Virtual Worlds to create more engaging and personalized interactions.

- Innovation and Growth: These goals are also prominent, demonstrating a desire to stay competitive and explore new business opportunities.

- Regulatory Compliance: Although not a top priority, it's noteworthy that organizations are considering Virtual Worlds as a means to comply with regulations, possibly in areas like training or remote work.

The CIO of an Italian manufacturing company has articulated their primary business goals for integrating Virtual Worlds technologies. Their focus is on enhancing both efficacy and efficiency within their operations. Currently, these technologies are utilized exclusively within the group, which has allowed them to streamline processes and improve productivity. However, the company is now looking to leverage these advancements to introduce a new digital revenue stream. In the market they operate in, there is still a lack of understanding regarding the creation of an ecosystem that benefits all partners involved. Despite this, the CIO sees a significant opportunity in opening up this new revenue stream. By doing so, the company can not only enhance its own business but also share these benefits with other players in the market. This collaborative approach could pave the way for a more integrated and mutually beneficial ecosystem, driving innovation and growth across the industry.

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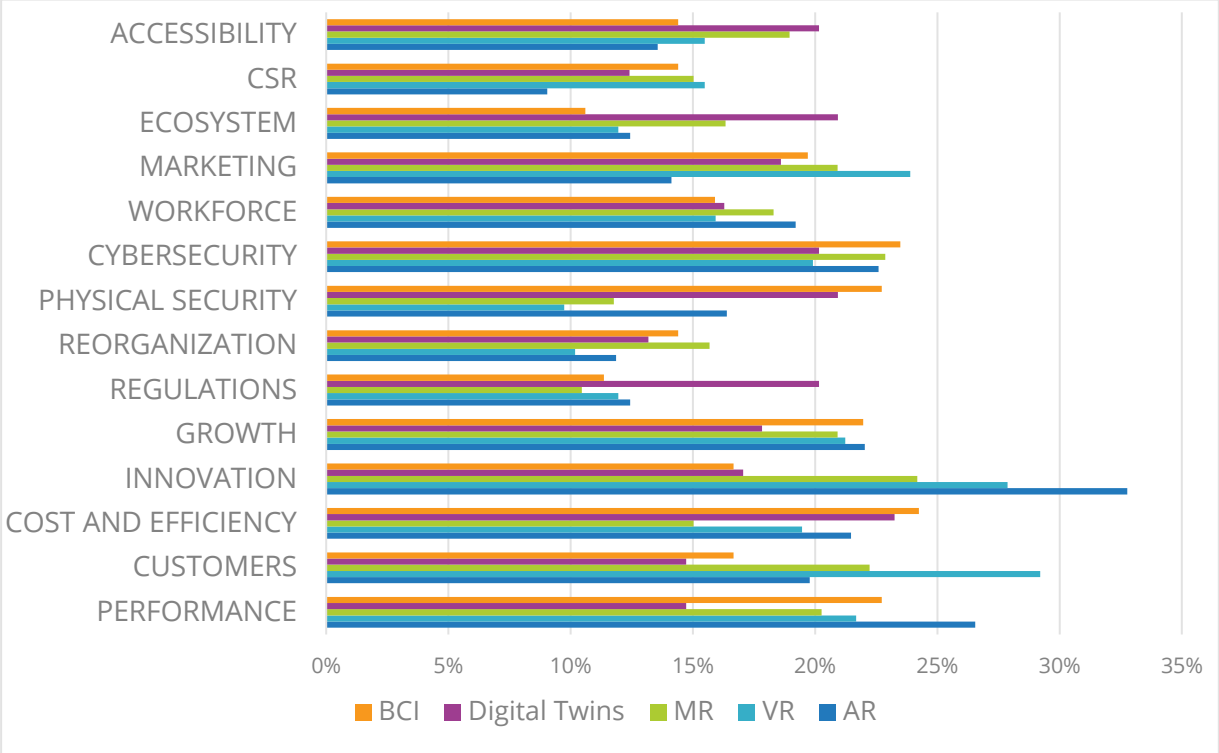
Figure 12 Business Goals Driving Adoption



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 800

While, looking at specific technologies preferences, these are the key insights:

- **BCI:** While less frequently cited than other technologies, BCI's results suggest that some organizations are exploring its potential for more immersive and intuitive experiences.
- **Digital Twins:** The popularity of digital twins indicates a focus on creating virtual representations of physical assets or processes for simulation, optimization, and predictive maintenance.
- **MR:** MR's prominence suggests a preference for blending the physical and digital worlds, potentially for training, collaboration, or product design.
- **VR:** VR's popularity is likely due to its ability to create fully immersive experiences, particularly for training, entertainment, and product visualization.
- **AR:** AR's appeal lies in its ability to overlay digital information onto the real world, making it suitable for tasks like maintenance, navigation, and marketing.

Looking then at the providers perspectives, here are some key insights from the experts interviews performed:

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Greg Roach, CTO at Spinview, and Ohto Pentikäinen, CEO & Co-Founder of Doublepoint, offered valuable insights into the diverse strategies and priorities of technology providers in the development of Virtual Worlds. While both companies share a vision of immersive and interactive experiences, their approaches and areas of focus differ significantly.

Spinview's roadmap emphasizes the convergence of volumetric data and immersive technologies, focusing on data-driven Virtual Worlds and real-world applications. They invest in developing virtual world platforms that can be applied to various industries, such as training and property management.

Doublepoint, on the other hand, prioritizes the development of gesture recognition software to enable more intuitive interactions in Virtual Worlds. They believe that gesture recognition is essential for creating truly immersive experiences and making Virtual Worlds more accessible to a wider audience.

While Doublepoint does not directly invest in AR technologies, they see themselves as an enabler for user experiences in this space. By developing innovative gesture recognition software, they can help to improve the usability and accessibility of Virtual Worlds. Both companies recognize the challenges associated with developing Virtual Worlds, including advancements in display technology, computation, and connectivity. However, their specific areas of focus differ. Spinview focuses on the integration of Virtual Worlds with existing systems and workflows, while Doublepoint highlights the challenges of battery life, industry fluctuations, and the need to identify valuable use cases for AR.

In conclusion, the development roadmaps of technology providers in the Virtual Worlds space vary significantly, reflecting the diverse range of opportunities and challenges presented by this rapidly evolving field. Spinview and Doublepoint offer valuable insights into two distinct approaches to virtual world development, demonstrating the importance of considering both technological advancements and user experience when designing and implementing these solutions.

European organizations are likely to invest in Virtual Worlds technologies, particularly those that offer tangible benefits in terms of efficiency, cost reduction, and customer experience. There will be a growing need for professionals with expertise in Virtual Worlds technologies, such as developers, designers, and content creators. As organizations explore the use of Virtual Worlds for regulatory compliance, it will be important to stay updated on relevant regulations and standards.

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Another notable trend is the role of AI in automating the creation of Virtual Worlds, enabling more efficient generation of realistic environments and avatars. Researchers point to rendering and standardization as significant areas of focus, particularly around avatar realism and the standardization of virtual assets. This aligns with broader industry efforts to make Virtual Worlds more usable for professional applications.

Companies are expanding their strategy by developing their own final products to showcase their assets, aiming to create direct relationships with end-users instead of solely focusing on developers. This strategic shift allows them to control the user experience and better highlight how their technology can enhance, for example, gameplay. Additionally, their investments are branching into forward-thinking technologies like virtual reality (VR) and digital collectibles (previously NFTs), which they view as transformative innovations poised to reshape the future of Virtual Worlds. These cutting-edge technologies are seen as critical to driving engagement and expanding the boundaries of immersive digital experiences.

4.4 KEY USE CASES

The adoption intentions investigated in 4.2.1 are promising and growing for the foundational technologies of Virtual Worlds – it is however useful to look at their rates of application in order to fully assess their maturity and then analyse the most widespread use cases. Figure 13 displays European organizations' maturity in creating concrete applications for Virtual Worlds technologies. The chart provides a comprehensive overview of the current state of Virtual Worlds technologies within organizations. While these technologies are gaining traction, their widespread implementation is still in a more proof of concepts stage, rather than fully scaled initiatives.

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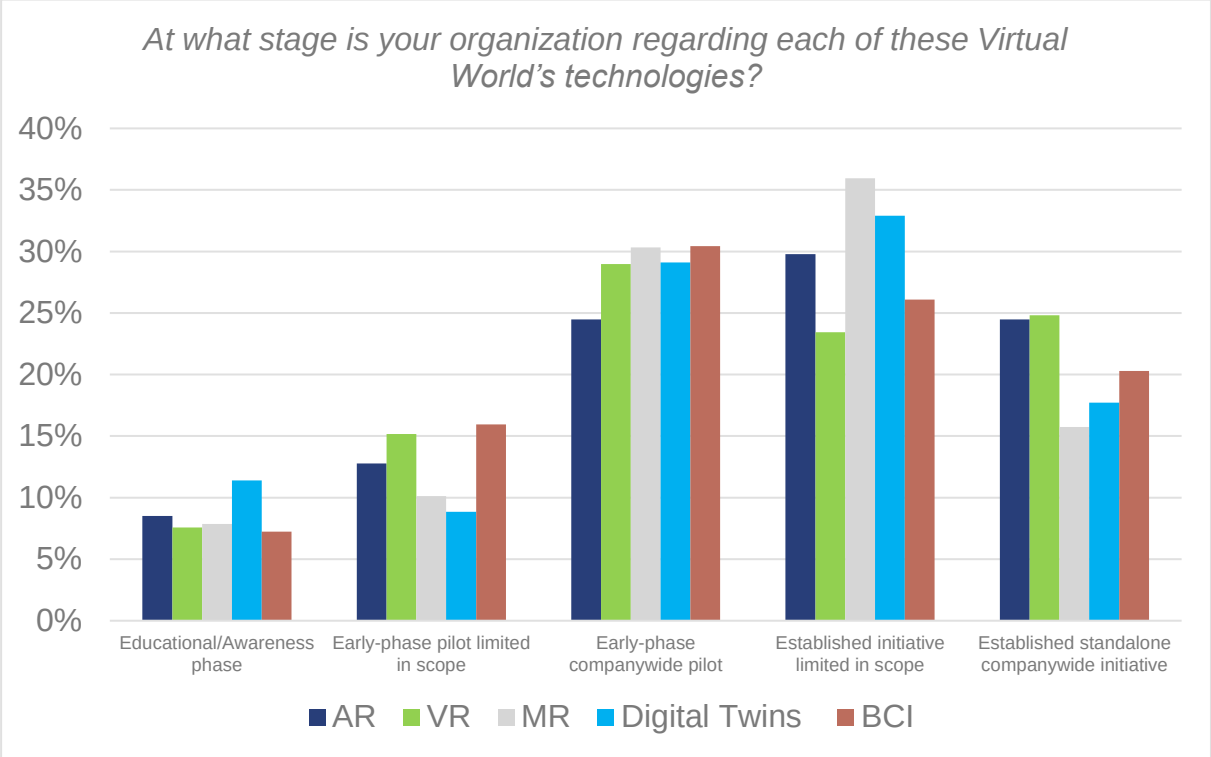
Figure 13 Foundational Technologies Market Applications



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 800

The data indicates that the educational phase is relatively low, while pilot and established initiatives are picking up. This suggests that organizations are becoming more aware of Virtual Worlds technologies and are actively exploring their potential through pilot projects and broader initiatives.

While the number of pilot projects is rising, the limited scope of many of these initiatives suggests that organizations are still approaching Virtual Worlds technologies with caution and are focusing on specific use cases. The emergence of established standalone companywide initiatives indicates that some organizations are beginning to adopt Virtual Worlds technologies more broadly, but this is still a relatively small percentage.

The relatively early stage of adoption offers a chance to be at the forefront of innovation and gain a competitive advantage. On the other hand, it may require organizations to invest in education, training, and experimentation to develop the necessary expertise and infrastructure.

With the increased availability of virtual and immersive experiences, organizations' pace along the Virtual Worlds road map will accelerate. New use cases in the enterprise and consumer segments were born due to employees' behaviour adjustments after the COVID-19 pandemic; these new habits

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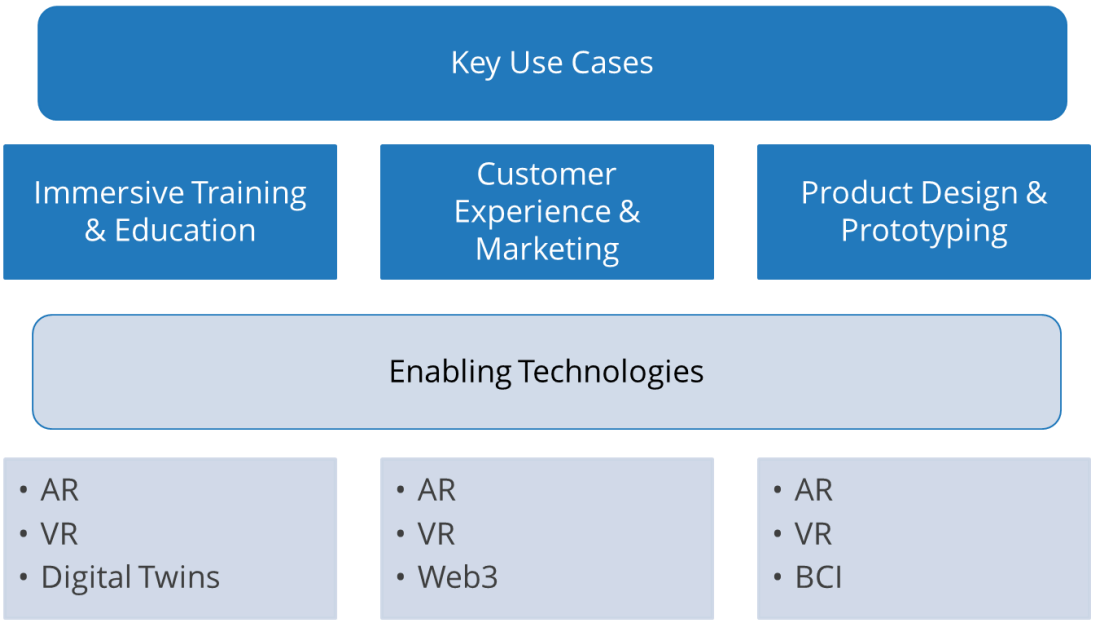
opened new revenue streams and engagement opportunities in the commercial and consumer segments.

Figure 14 looks at the main use cases areas where Virtual Worlds technologies are currently prominently deployed, and the key foundational technologies required for the successful implementations of these initiatives. The three areas in which Virtual Worlds technologies are currently most employed by European organizations include use cases related to immersive training and education, customer experience (CX) and marketing, and product design and prototyping. Researchers point at education and training, as the most promising use case for virtual technologies while they also highlight how the current Virtual Worlds landscape is characterized by a quest for the "killer use case".

Figure 14 Short Term Use Cases for Virtual Worlds



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 488

- **Immersive Training and Education:** Virtual Worlds offer immersive and interactive environments that can significantly enhance learning experiences. These technologies can be used to simulate real-world scenarios, allowing learners to practice skills in a safe and controlled environment. The future will see the rise of holistic and immersive educational programs incorporating AR, as suggested by experts like Dulce Baerga. At the same time, there will be a focus on teaching children and adults alike how to build, manage, and interact

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within virtual environments, preparing the next generation for an AR-integrated world. Virtual Worlds can reduce the costs associated with traditional training methods, such as travel and physical resources. Key technologies deployed here include VR, AR and MR, which are all well-suited for immersive training and education experiences, by creating realistic and interactive environments, where learners can practice skills in a safe and controlled setting. Furthermore, by creating digital replicas of real-world environments or equipment for training simulations, digital twins allow learners to practice in a highly realistic and customizable environment. To provide a practical example, as described by Spinview CTO, Greg Roach, the company developed a VR-based platform used for training initiatives by many of their clients, in particular in the property and building management sector and in the transportation industry. Through their platforms, users leverage 360 imagery for new hires navigation, remote meetings and property management visits, as well as augmented remote maintenance and repair.

- **Customer Experience and Marketing**: Virtual Worlds can create personalized and engaging experiences for customers, fostering stronger brand loyalty. Organizations can showcase products and services in virtual environments, allowing customers to explore and interact with them before making a purchase. Moreover, Virtual Worlds can be used to create unique marketing campaigns that capture attention and drive engagement. In this case, VR, AR, and MR are used to create virtual showrooms and interactive product demonstrations. Additionally, 3D modelling and rendering software are used to create high-quality visuals for marketing campaigns. Finally, Web3 technologies are used to implement decentralized marketplaces or loyalty programs that reward customers with digital assets or tokens for their interactions.

- **Product Design and Prototyping**: Virtual Worlds enable designers to quickly create and iterate on product designs, reducing development time and costs. Teams can collaborate in real-time within virtual environments, improving communication and efficiency. Furthermore, virtual prototypes can be tested and optimized before physical prototypes are created, reducing the risk of costly mistakes. Computer software integrated with AR and VR are used to create and visualize product design in 3D; simulation software can also be used to test and optimize product prototypes before they are physically manufactured. Additionally, BCIs can support to enhance the design process by allowing designers to interact with virtual prototypes using their thoughts, potentially leading to more innovative

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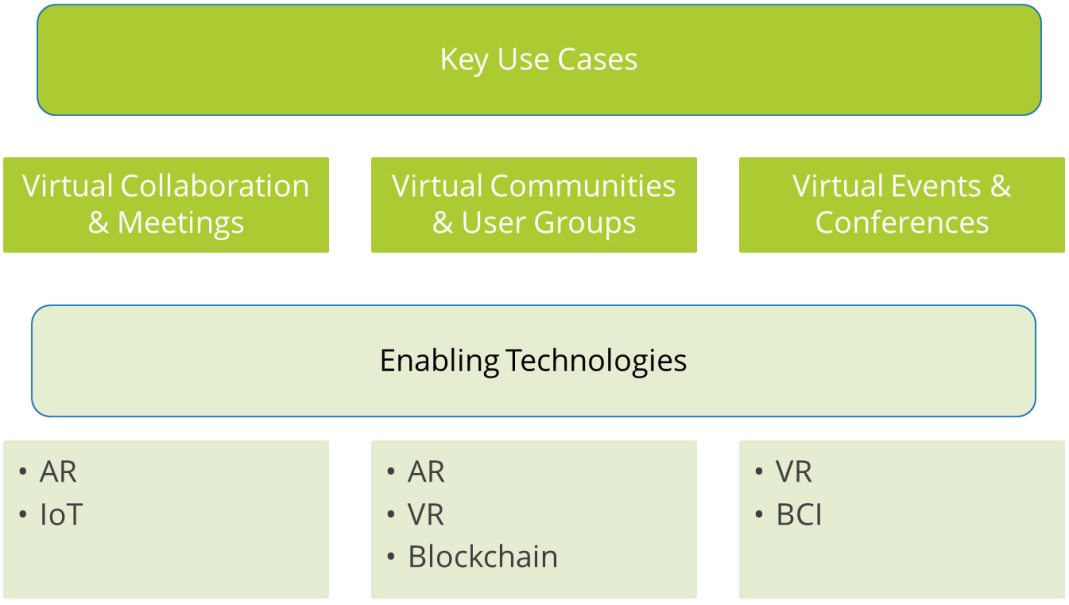
and intuitive designs. A practical example of these use cases was provided by the CIO of an Italian manufacturing company, which employs a product configurator based on augmented and virtual reality, by scanning a QR code to visualize the piece of furniture in your selected space (e.g. office or home). Another practical example provided by Mr Canepa, Virtual Worlds-related technology use cases in the textile industry mainly revolve around prototyping, given the efficiency and environmental advantages that the virtualisation of some of the design phases can bring.

While looking at medium term applications, meaning use cases being developed in the next 2 years, these are more diverted toward virtual communities, events simulations and collaborations. Figure 15 provides insights into these three key medium term use cases areas and the relevant technologies employed.

Figure 15 Medium Use Cases for Virtual Worlds



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 488

- **Virtual Collaboration and Meetings**: Virtual Worlds can create immersive and interactive meeting spaces, allowing participants to feel as if they are physically present. This can be particularly beneficial for teams that are geographically dispersed or for organizations that want to reduce travel costs. VR, AR, and MR can be used to create virtual meeting rooms or conference centres. Digital twins can be used to create replicas of real-world meeting spaces,

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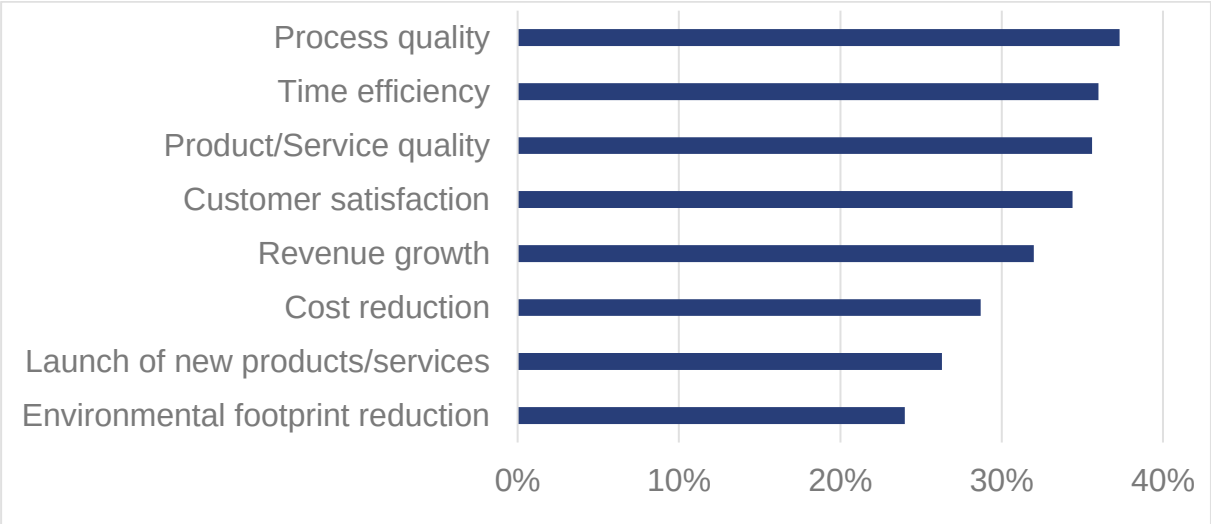
providing a familiar and comfortable environment. IoT devices can be integrated to enable real-time sharing of information and data during meetings.

- **Virtual Communities and User Groups:** Virtual Worlds can create social spaces where users can interact, collaborate, and share experiences. This can be particularly beneficial for niche communities or user groups that are geographically dispersed. VR, AR, and MR can be used to create virtual community spaces. Blockchain technology can be used to create decentralized communities that are not controlled by a single entity. Web3 technologies can enable users to own and control their digital identities and assets within virtual communities.

- **Virtual Events and Conferences**: Virtual Worlds can create immersive and interactive event experiences, allowing attendees to participate in sessions, network with others, and explore virtual exhibits. This can be particularly beneficial for events that are difficult or expensive for attendees to attend in person. VR, AR, and MR can be used to create virtual event spaces. Digital twins can be used to create replicas of real-world conference venues, providing a familiar and realistic environment.

After looking at the key use cases of Virtual Worlds, it is crucial also to investigate the concrete outcomes achieved through the usage of these technologies. Figure 16 shows the key measurable results have been achieved by European organizations thanks to implementing Virtual Worlds technologies.

Figure 16 Key Outcomes from Virtual Worlds Use Cases



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 800

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The survey results show that the top three measurable results achieved by European organizations through Virtual Worlds implementation are:

- **Process Quality**: This indicates that Virtual Worlds have been instrumental in improving operational efficiency and streamlining processes.
- **Time Efficiency:** This aligns with the emphasis on process quality, suggesting that Virtual Worlds have helped organizations save time and increase productivity.
- **Product/Service Quality**: This result highlights the positive impact of Virtual Worlds on product and service development, likely through improved design, testing, and collaboration.

The strong performance in process quality and time efficiency indicates that European organizations are successfully leveraging Virtual Worlds to optimize operations and reduce costs. The focus on product/service quality suggests that Virtual Worlds are being used to create better products and services, potentially through features like virtual prototyping and testing.

These results suggest that Virtual Worlds are having a positive impact on European organizations, enabling them to improve efficiency, enhance product quality, and drive business growth. While not the top 3, the results for customer satisfaction, revenue growth, cost reduction, and launch of new products/services also demonstrate the potential benefits of Virtual Worlds implementation.

Overall, these results suggest that Virtual Worlds are having a positive impact on European organizations, enabling them to improve efficiency, enhance product quality, and drive business growth.

4.5 KEY CHALLENGES

Building upon the previous chapter's exploration of use cases and outcomes, this chapter will examine the challenges that can arise in implementing and utilizing Virtual Worlds technologies. While the previous chapter focused on the potential benefits and successes of Virtual Worlds, it is crucial to acknowledge the obstacles that can hinder their adoption and effectiveness. The challenges faced by the industry in the adoption of Virtual World technologies are multifaceted and range from business-related ones to privacy and sovereignty consideration.

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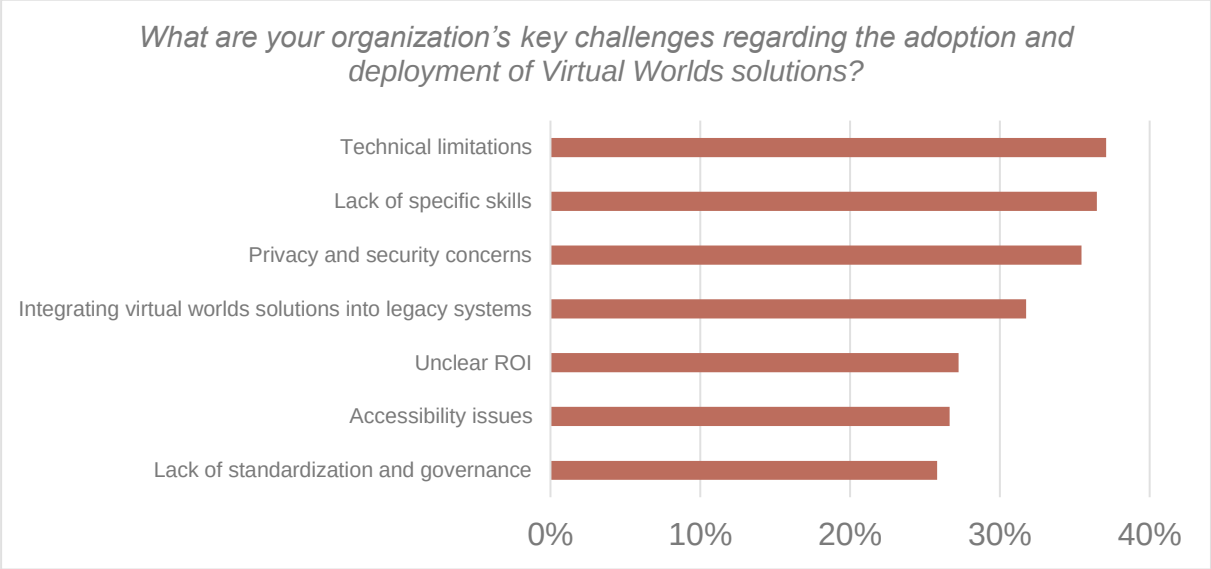
Looking at the overall European end users landscape, figure 17 outlines the key challenges organizations face in adopting and deploying Virtual Worlds technologies. By examining the results, it is possible to identify the key obstacles hindering the widespread adoption of these technologies.

Figure 17 Key Challenges to Virtual Worlds Adoption



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 488

- **Technical Limitations**: This is the most significant challenge, as it directly affects the feasibility and functionality of Virtual Worlds solutions. Furthermore, scaling Virtual Worlds environments to accommodate large numbers of users can be technically demanding and resource-intensive. Finally, lag, latency, and other performance issues can negatively impact the user experience and hinder the effectiveness of Virtual Worlds solutions.

  Taking one example extracted from the expert interviews: according to Mr Canepa, the major challenges while approaching Virtual World Technologies include the need for standardised representations of the human body, along with strong guarantees for intellectual property protection and a good level of reliability of the 3D representation of the human body as compared to the real world. These aspects are particularly relevant from both a wider industrial perspective, and as related to the specialised textile and body representation industries. The latter is a sector in which accuracy and reliability is of pivotal importance as the body measurement services have direct medical applications. Additionally, the need for accurate colour calibration and a lighter user experience are stressed as very important aspects, respectively to guarantee the quality of representation (e.g., in the 3D

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representation of a fabric to be provided to a customer), and to provide a less invasive technological solution to interact with Virtual Worlds in their various implementations.

- **Lack of Specific Skills:** shortage of technical expertise and content creation skills is hindering the development and implementation of effective Virtual Worlds environments. Organizations lack the necessary technical expertise to develop, implement, and maintain Virtual Worlds solutions. Creating high-quality content for Virtual Worlds requires specialized skills and resources.

- **Privacy and Security Concerns**: Data privacy and cybersecurity are critical issues that must be addressed to ensure the trust and safety of users. Organizations must address concerns related to data privacy and security, particularly when dealing with sensitive user information. Furthermore, Virtual Worlds environments can be vulnerable to cyberattacks, requiring robust security measures to protect against threats.

- **Integrating Virtual Worlds Solutions into Legacy Systems**: Organizations face challenges in ensuring compatibility between Virtual Worlds solutions and existing hardware and software infrastructure. Integrating Virtual Worlds solutions with existing legacy systems can be challenging due to differences in technology and standards. The process of integrating Virtual Worlds solutions into legacy systems is technically complex and time-consuming, in particular in the European landscape where a large number of organizations still have outdated legacy systems.

- **Unclear ROI:** Difficulty in quantifying the benefits of Virtual Worlds can make it challenging to justify the initial investment. Quantifying the return on investment of Virtual Worlds solutions can be difficult, as benefits may be intangible or long-term. In volatile economic period, like the current one, short-term returns are the key investments driver.

- **Accessibility Issues**: Ensuring that Virtual Worlds solutions are accessible to all users is essential for promoting inclusivity. Accessibility may be hindered by technical limitations, such as difficulty using controllers or navigating virtual environments.

- **Lack of Standardization and Governance:** The absence of standardized frameworks and guidelines can create challenges in terms of interoperability and compatibility. Clear regulatory frameworks for Virtual Worlds are still emerging, leading to uncertainty and potential legal risks.

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These insights reflect the general perception and challenges from a user perspective. In order to provide a comprehensive picture of the main barriers to Virtual Worlds technologies, it is also crucial to consider the providers perspectives.

According to Spinview CTO, which provides visualization and data capabilities through extended realities and digital twins, the challenges they are facing are several "primarily due to the complexity of developing Virtual Worlds from scratch." Justifying the investments of building inhouse solutions, instead of relying on third-party ones, is also a frequent challenge. This was also partially relevant for Doublepoint CEO, according to whom the main challenge right now is " determining the specific areas where Virtual Worlds can truly provide value before augmented reality becomes more mainstream.". For Doublepoint, identifying those areas where they can make a meaningful impact is the key barrier. "Unfortunately, we haven't fully grasped the everyday challenges that people face where Virtual Worlds could offer solutions."

Skills, or the lack of them, are also a key challenge on the technology providers' side. Developing Virtual Worlds solutions is very labour intensive and difficult to scale, it requires highly specialised operations and expensive equipment – 3D specialists, architects, modelers, developers with capabilities from the gaming industry are crucial.

External factors also impact providers and developers work in producing impactful Virtual Worlds solutions: the recent economic downturn and layoffs in the tech sector have created uncertainty and fluctuations in interest in Virtual Worlds. While AI is currently receiving a lot of hype, it doesn't necessarily benefit Virtual Worlds. At the same time, the Virtual Worlds ecosystem, which will be analysed in depth in chapter 5, also play a pivotal role in the successful advancement of Virtual Worlds. The development of Virtual Worlds often involves multiple companies, many of which are large corporations. These organizations must continually assess and weigh their options, and may need to allocate resources to other priorities. If these companies decide to decrease their investment in Virtual Worlds technologies, it could significantly hinder progress in this field.

Some challenges brought by EU AR startup owners we engaged with, such as: Marcin Polakowski, Creative Director Flat Pixel or Sebastian Tusk, CTO, Breakpoint one relate to significant need for better exposure and better awareness of their business and technologies to potential customers and partners such as large business. Even quite established startups with enough funding such Broken Egg as reported by Ely Santos, Head of Gaming & Partner, raise the issue of strong need for better dissemination, more marketing and engagement. Nevertheless, most EU startups still struggle with

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raising substantial funding as a major issue. The content creators for Virtual Worlds say this impacts both quality and scale of the assets delivered. This also means, many EU players are less competitive on a global stage. The main challenge remain that the USA-based or Asian counterparts have substantially larger funds available to scale solutions and market reach.

Emerging trends in Virtual Worlds technologies focus heavily on addressing user experience (UX) challenges and enhancing human-machine interaction (HMI). A key issue is the ongoing struggle to create immersive virtual environments with high levels of presence, as they continue to suffer from issues of fidelity and interaction. Despite advancements in VR technology, even the most cutting-edge devices are still hampered by problems such as motion sickness and cumbersome, uncomfortable hardware, which undermine the overall experience.

A company focused on interoperable 3D assets identifies standardization as a key challenge in the development of Virtual Worlds. The landscape remains fragmented, with inconsistent use of game engines like Unity and Unreal, and 3D formats such as GLB attempting to maintain visual fidelity across platforms. While these formats represent progress, they are not yet sufficient to address the broader need for consistent standards. This lack of comprehensive standardization still poses a significant barrier to achieving seamless, cross-platform experiences, preventing the virtual space from reaching its full potential.

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5 KEY REQUIREMENTS FOR A SUSTAINABLE EUROPEAN VIRTUAL WORLDS ECOSYSTEM

5.1 PREFERRED PARTNERS AND EXISTING ECOSYSTEMS

This chapter will delve into the critical role of preferred partners and the existing Virtual Worlds ecosystem in driving the successful adoption and implementation of Virtual Worlds technologies. By examining the key partnerships and collaborations within the industry, we will gain insights into the factors that contribute to the growth and development of this emerging field.

Specifically, this chapter will explore:

- **The importance of partnerships**: How collaborations between technology providers, content creators, and end-users can accelerate the adoption of Virtual Worlds.
- **Key partnerships and collaborations:** Examples of successful partnerships and their impact on the Virtual Worlds ecosystem.
- **The role of existing Virtual Worlds platforms:** The influence of established platforms on the industry and their potential to shape future trends.
- **Opportunities for new entrants:** How new players can leverage existing partnerships and ecosystems to establish themselves in the Virtual Worlds market.

By understanding the dynamics of preferred partners and the existing Virtual Worlds ecosystem, organizations can make informed decisions about their strategies for engaging with this rapidly evolving field.

Figure 18 depicts the intricate network of stakeholders involved in the innovation ecosystem for Virtual Worlds technologies. At the centre of the diagram lies the "Virtual Worlds Ecosystem," representing the overarching framework that encompasses all the interconnected elements. Surrounding this central hub are various key players, each contributing to the growth and development of the industry.

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Figure 18 Virtual Worlds Ecosystem

Source: IDC Research, 2024

Digital Natives, Start-ups, and Scale-ups occupy a prominent position in the ecosystem, often driving innovation and experimentation with new Virtual Worlds concepts. Universities and Research Institutions play a vital role by conducting research, developing talent, and fostering academic collaborations. Venture Capital Funds provide essential financial support to promising Virtual Worlds projects, fuelling their growth and development. Governments, through policies, regulations, and investments, can significantly influence the direction and trajectory of the industry. Technology Providers develop and supply the underlying technologies and platforms that enable Virtual Worlds experiences. End User Companies, the ultimate beneficiaries, adopt and utilize these technologies to achieve their business objectives.

Furthermore, the chart highlights the importance of additional stakeholders, such as Industry Associations and Consortiums, Non-Profit Organizations, Media & Influencers. These entities contribute to the ecosystem by setting standards, promoting collaboration, conducting research, raising awareness, and shaping public perception.

This comprehensive representation effectively captures the interconnectedness of the various players within the innovation ecosystem for Virtual Worlds technologies. By understanding the roles and relationships of these stakeholders, organizations can identify potential partners, access funding, and stay informed about industry trends.

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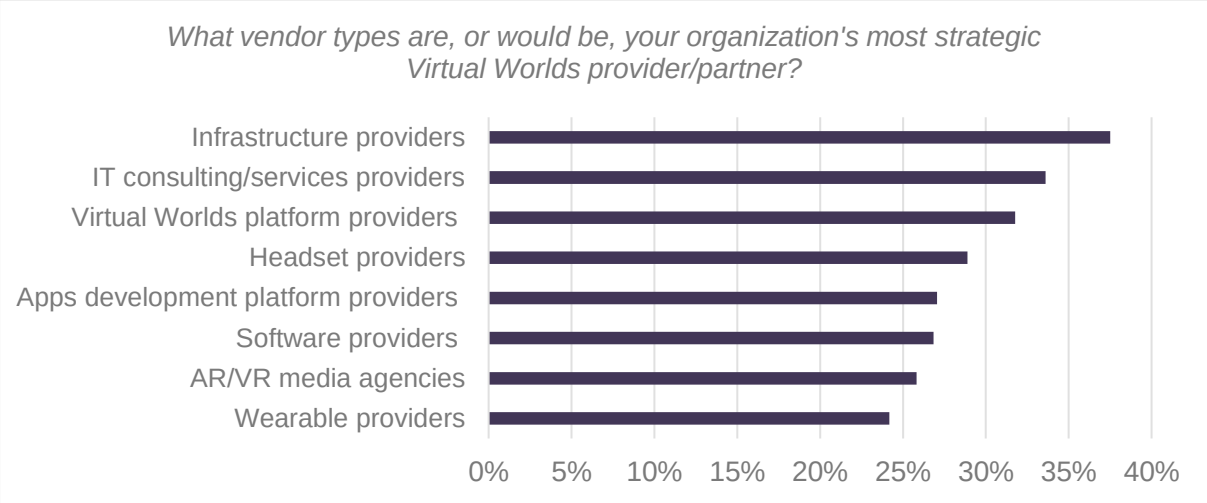
The preceding analysis of the innovation ecosystem for Virtual Worlds technologies provides a valuable foundation for understanding the key stakeholders involved in driving the industry. Building upon this understanding, the following section will delve into the specific partners that European organizations perceive as preferred and strategic for their Virtual Worlds initiatives. By examining the preferences of these organizations, we can gain insights into the factors that influence partner selection and the dynamics of the European Virtual Worlds market.

Figure 19 Strategic Virtual Worlds Partners



Source: IDC Emerging Technologies Survey, September 2024, Europe n = 488

Figure 19 reveals the preferences of European organizations when selecting partners for their Virtual Worlds initiatives. The top three categories of partners are:

1. **Infrastructure Providers:** Companies like AWS, Microsoft, and Google play a crucial role in providing the underlying infrastructure, such as cloud computing and data storage, necessary for Virtual Worlds development and operation. The high percentage of organizations relying on these providers highlights the importance of scalable and reliable infrastructure. Key partners are primarily large companies that invest heavily in various technologies, including Virtual Worlds. While some companies, like Google, may have wavered in their commitment to augmented reality over the years, they still invest significant resources in this area.

2. **IT Consulting/Services Providers:** These firms, including BCG X, Accenture, Cognizant, and TCS, offer valuable expertise and guidance in navigating the complexities of Virtual Worlds technology. Their involvement indicates a need for organizations to seek external support in strategy, implementation, and ongoing management.

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3. **Virtual Worlds Platform Providers:** These companies, such as Roblox, Horizon Worlds, and Decentraland, offer foundational platforms for building and hosting Virtual Worlds experiences. Their prevalence suggests that organizations value the comprehensive solutions and ecosystems provided by these platforms.

Other significant categories of partners include:

- **Apps Development Platform Providers:** Companies like Unity and Unreal Engine provide tools for building and developing Virtual Worlds applications.
- **Wearable Providers:** Manufacturers of wearable devices, such as Manus Prime, Teslasuit, and Solos, offer hardware components essential for immersive Virtual Worlds experiences.
- **Headset Providers:** Companies like Meta, Sony, Microsoft, HTC, and Pico supply the headsets that enable users to interact with Virtual Worlds.
- **AR/VR Media Agencies:** These agencies specialize in creating content and experiences for virtual and augmented reality platforms.
- **Software Providers:** Companies like PTC offer specialized software solutions for various aspects of Virtual Worlds development and implementation.

European organizations are seeking a diverse range of partners to support their Virtual Worlds initiatives. The emphasis on Virtual Worlds platform providers, infrastructure providers, and IT consulting/services providers reflects the complex nature of Virtual Worlds technology and the need for specialized expertise. By carefully selecting partners from these categories, organizations can enhance their chances of success in the Virtual Worlds landscape. However, true success often hinges on effective collaboration among all these partners. To deliver on the business priorities of organizations, it is essential to foster a collaborative environment where each partner contributes their unique strengths and works together towards a common goal.

5.2 ETHICAL AND LEGAL REQUIREMENTS

The Virtual Worlds, as an emerging digital space, presents numerous ethical and legal challenges that need to be addressed to ensure its responsible development and sustainability. These barriers are diverse, ranging from privacy concerns and identity issues to intellectual property rights (IPR) and

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governance standards. The following sections provide an in-depth examination of these challenges, highlighting key studies and proposing directions for future research.

5.2.1.1 Ethical Barriers

1. **Privacy and Data Protection:** As users engage within the Virtual Worlds, vast amounts of personal data are generated and processed, leading to significant privacy concerns. The ability to track, analyse, and predict user behaviour based on their activities within Virtual Worlds necessitates robust data protection measures. Studies on digital privacy emphasize the need for stringent data protection strategies that align with global standards, such as the General Data Protection Regulation (GDPR) in the European Union. Compliance with such regulations ensures that users' data rights are protected, and it promotes trust within the digital ecosystem. However, the challenge lies in adapting these standards to the Virtual Worlds' decentralised and borderless environment, which complicates enforcement and accountability.
2. **Identity and Anonymity:** In the Virtual Worlds, users can create and control digital avatars, enabling them to explore new identities and expressions. While this capability fosters creativity and self-exploration, it also raises questions about authenticity, accountability, and responsibility. Ethical concerns arise over how these digital identities can be manipulated, leading to deception or misuse. Establishing ethical principles that promote both freedom of expression and user protection is essential. Research suggests the development of systems that verify identity without compromising anonymity, ensuring a balance between privacy and security.
3. **Inclusivity and Accessibility:** One of the Virtual Worlds' core ethical considerations is ensuring inclusivity and accessibility. It is crucial that the Virtual Worlds be accessible to all individuals, regardless of physical abilities, economic standing, or geographic location. Creating a digital space that promotes inclusivity involves developing interfaces and systems that accommodate diverse needs and capabilities. Ethical design principles should be integrated from the beginning, ensuring that no group is marginalized. Accessibility features, such as voice controls, screen readers, and affordable entry points, are essential in building an inclusive digital community.
4. **Behavioural Norms and Harassment:** Virtual Worlds can sometimes serve as breeding grounds for harassment, bullying, and toxic behaviour. The anonymity offered by digital avatars can embolden individuals to engage in inappropriate or harmful conduct. Addressing

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these issues requires the establishment of clear behavioural guidelines and the implementation of systems that encourage respectful interaction within online communities. Ethical frameworks must be developed to address such conduct, and platforms should adopt moderation tools that can detect and mitigate harassment effectively. Researchers are exploring strategies to foster positive engagement, including community guidelines and automated moderation using AI.

5. **Transparency, Accountability, and Explainability:** Transparency in the design and operation of Virtual Worlds systems is critical to building trust. Users must clearly understand which tasks are automated (via AI) and which are managed by humans. Systems should also be developed with explainability in mind, allowing users to comprehend how decisions are made, particularly when they are significantly affected by automated processes. Legal and ethical accountability is vital, ensuring that platform providers and developers are responsible for any harm caused by their systems. By fostering transparency, accountability, and explainability, the Virtual Worlds can mitigate risks associated with misuse, bias, and exploitation.
6. **Anti-Discriminatory Design:** Ethical considerations in the Virtual Worlds also involve ensuring equitable treatment of individuals and groups. Platforms must be designed to prevent discrimination based on caste, creed, colour, gender, or other identity markers. Inclusivity extends beyond accessibility, requiring systems that promote fairness and respect for diverse cultures, ideas, and innovations. Platforms should adopt anti-discriminatory design principles that prevent bias in algorithms and ensure that digital spaces are welcoming to all users.

5.2.1.2 Legal Barriers

1. **Intellectual Property Rights (IPR):** Intellectual property concerns are at the forefront of legal discussions surrounding the Virtual Worlds. The creation, sharing, and distribution of digital content in Virtual Worlds lead to complex IPR challenges. A study conducted in 2021 highlights the copyright issues prevalent in these environments, emphasizing the need for clear directives that balance the rights of creators and the freedoms of users. Establishing a framework that recognizes digital ownership and protects creators' rights while allowing for user-generated content is crucial for fostering creativity and innovation. Legal frameworks must also address issues related to the resale and modification of digital assets, which are prevalent in the Virtual Worlds' decentralized economy.

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2. **Jurisdiction and Enforcement:** The global nature of the Virtual Worlds presents significant legal challenges in terms of jurisdiction and law enforcement. Digital environments often operate across borders, making it difficult to apply national laws. A 2020 research on technology regulation points out the complexities of enforcing laws in Virtual Worlds that transcend geographical boundaries. Establishing a unified legal framework or agreements between nations could help address these issues, but achieving consensus on legal standards remains a challenge. Future legal structures must consider the borderless nature of the Virtual Worlds, ensuring that users are protected regardless of where they are located.

3. **Consumer Protection:** Transactions within the Virtual Worlds involve the purchase of virtual goods, services, and experiences. Robust consumer protection rules are essential to safeguard users from fraud, scams, and exploitation. An examination conducted in 2014 explored these issues within the context of virtual economies, proposing legal structures to protect consumer rights in digital marketplaces. Platforms should implement clear guidelines on digital ownership, refunds, and dispute resolution. As the Virtual Worlds' economy grows, there is a need for updated consumer protection laws that address the unique challenges of virtual transactions, including transparency in pricing, terms of service, and data usage policies.
4. **Governance and Standards:** Governance in the Virtual Worlds involves creating frameworks that ensure ethical behaviour and adherence to legal requirements. A 2012 study on multi-stakeholder governance in transnational settings provides a possible model for governing virtual environments. The complexity of the Virtual Worlds necessitates collaboration between various stakeholders, including developers, policymakers, and users, to establish standards that promote ethical conduct. Governance frameworks should be adaptive, accommodating the fast-evolving nature of digital technologies. Establishing a code of conduct, legal standards, and enforcement mechanisms can help maintain order and prevent misuse within the Virtual Worlds.

5.2.1.3 Bridging Ethical and Legal Barriers

The intersection of ethical and legal considerations is critical for the sustainable growth of the Virtual Worlds. Issues such as privacy, data protection, and identity management require both ethical guidelines and legal regulations to ensure that user rights are protected. Transparency, accountability, and inclusivity must be embedded within the legal frameworks that govern virtual

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platforms. Collaborative efforts between technologists, ethicists, and legal experts are necessary to address these complex issues effectively.

Future research should focus on developing comprehensive frameworks that integrate ethical principles with enforceable legal standards. By establishing guidelines that prioritize user rights and safety, the Virtual Worlds can evolve into a digital space that is both innovative and responsible. Policymakers must work closely with industry leaders to draft regulations that are flexible yet robust, ensuring that as the Virtual Worlds expand, it remains a safe, inclusive, and legally compliant environment.

5.3 IPR AND GOVERNANCE MODELS FOR OPEN AND HUMAN-CENTRIC VIRTUAL WORLDS

The Virtual Worlds are developing in their own terms, on the global market, and the main influence that can be perceived in an arena to a great extent dominated by American players active in the gaming and socialising offerings, is the fact the all those which really want to target European customers have to be compliant with the GDPR. It is already a non-negligible success, only seven years after the launch of this EU regulation. More generally, social media and even more than that videogaming historical anchoring of these digital ecosystems shows both innovative and attractive features, and problems and limits.

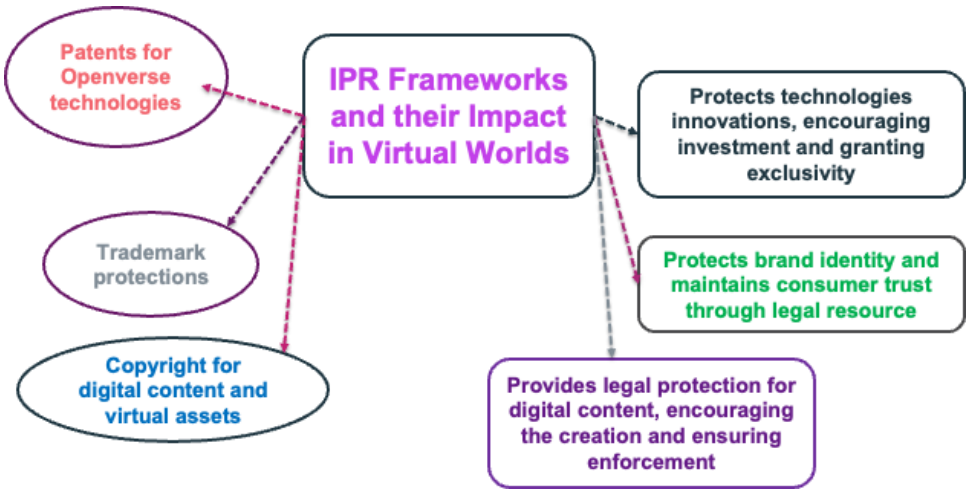

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Figure 19: Analysis of Intellectual Property Rights (IPR) Frameworks and Their Impact in Virtual Environments

Among the positive and promising attributes, in the wake of the videogame industry development, is the impressive drive, in terms of technological and cultural innovations that this trend has generated so far. Now often associated with Blockchain solutions, already existing means of creation and monetized valuation of virtual assets has produced a renewed attractiveness in that market, diversifying away from the strict gaming rationale to socialising, event organisation and participation as well as community-building. Clearly in the lower key of this development, some more instrumental Virtual Worlds have tried to make their way, beyond the internal diversification of the gaming VW towards education or real estate already part of the evolution of that sector, namely with more professional offerings. This strand of the virtual world arena is either tuned towards collaborative support services or/and specific sector needs (construction, security, healthcare, education, smart cities) ,and although they are less developed, compared to the million and billion-making players of the gaming and socialising VWs, they may nevertheless play an important role in the future, away from some of the criticisms and limits of the mainstream VWs, and also likely to make use of European strengths.

This situation, in terms of innovation and IPR, especially for European SMEs and start-ups, is not so obvious to conquer. In the gaming and socialising strand, competition is fierce, and first movers (although some early winning platforms are somehow declining) make (although some early winning platforms are somehow declining), making it difficult for newcomers to emerge. New VWs are appearing all the time, but only a few will most likely still exist in the medium term.

New VW platforms, however, is not the only way innovation can enhance that sector of activity :

- Creative valuation proposals linked to existing VWs and particular form of openness (SDK, virtual marketplace and monetization schemes) is already an interesting track for small innovative players.
- Blockchain specific offerings towards new crypto characteristics or new organisational arrangements, with or without a finance orientation emerges as a strongly innovative support to the VW deployment.
- The design and graphical creativity of the sector is also an area for innovation and at least for IPR engagement.

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- There is also room for technological innovation, even for small players, in the sensorial progression (formats, standard progression, new approaches) for vision, of course, but also sound, haptic and kinetic contributions, as well as holograms, sound-space techniques, olfactive options, robotic supports or forms of collaboration between human and robots, etc., with new protocols, signal processing algorithms and, of course, devices of all kinds, sensors, communication micro-systems (and IOT in general), including ergonomic interfacing solutions.
- The more professional VW may also benefit from all sorts of augmented, mixed and virtual reality developments, customised for specific needs and functions, addressing that demanding market.
- The pervasive emergence of AI, in its various forms, already active in many VWs to enhance their offer, is likely to become a major progression factor for VWs too, and at the moment, although there is a very important imbalance in terms of investment between on the one hand the US and China and on the other hand the rest of the world, including the EU, there is still room for innovative proposals for all sorts of services; many of them fitting the VW enrichment perspective.
- Let's also stress that below that level of innovation, there is the creativity of end-users, which most VWs try to promote and help harness, which has its own need of IPR, as well as in the more professional strand configuring typical B2B2C business models with options for white labels, licences, open source, creative commons and other forms of protecting partnerships.

In that fast-evolving landscape, the number of players likely to contribute to this overall innovation movement, in the case of Europe, is considerable, as a recent JRC study[xiii] has shown (some 27'000 economic players identified, roughly 4% of the EU digital sector as a whole), and they will all have at some level IPR issues to cope with.

The EU, to help this situation and advance its digital strategy, has defined what ought to be the Single Digital Market and promote its advantages, expecting that the member states would converge quickly and even contribute. A number of measures, programmes have been set up to support SMEs and IPR navigation (IPR in the most classical sense, either for copyright, brands, designs or patents) and in order to re-establish some fairness and ethical behaviour (towards an effective human-centricity), such regulatory measures as the Digital Markets Act (DMA), the Digital Services Act (DSA) and AI Act were enacted. Let's stress here this governance level of the problem also involves

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different protecting measures for enterprises, citizens, vulnerable categories of persons and minorities (and not only children, as in the US).

Beyond the traditional IPR approach, the « open » paradigm is also one of the suggested tracks for European players to make their way up, from science-derived innovation and start-ups to the creative sector engagement, open source options (so far very few VWs are open source), open data spaces, but also open innovation approaches are possible channels of motivation and advancements for these players, encouraged by an arsenal of EU and MS programmes and valuing the various forms of European excellence. To the point it is maybe a problem for small players to have a complete picture of what they can access and what they should do. The barriers to the Single market have already been well identified, but as they encompass several distinct types of problems, the possible remedies appear more as a learning and experimentation track than a set of on the shelf solutions.

For the VW arena, there is also the need to identify and build upon communities of interest (sectoral or territorial), conveying a demand-side series of needs which may shape specific market solutions for which Virtual Worlds may bring their contribution. This would be a step apart from the idea that the only way to exist in this sector is trying to compete with or within the mainstream offer (gaming and socialising platforms, mostly American, with a few exceptions).

In order for this field of concern to move in the right direction, for EU players, there is a need not only to work on specific supports, programmes and educational packages, but also turn the different components of this innovation plot into a virtuous circle as in the figure below. This means, for EU economic and policy-level players, to strengthen the existing support measures and programmes and to facilitate innovation strategies either in the classical IPR scenario as well as in all types of alternate tracks to value European forms of excellence, each step, facet or choice being to a certain extent part of a collective learning pathway, to be made visible, known and shared.

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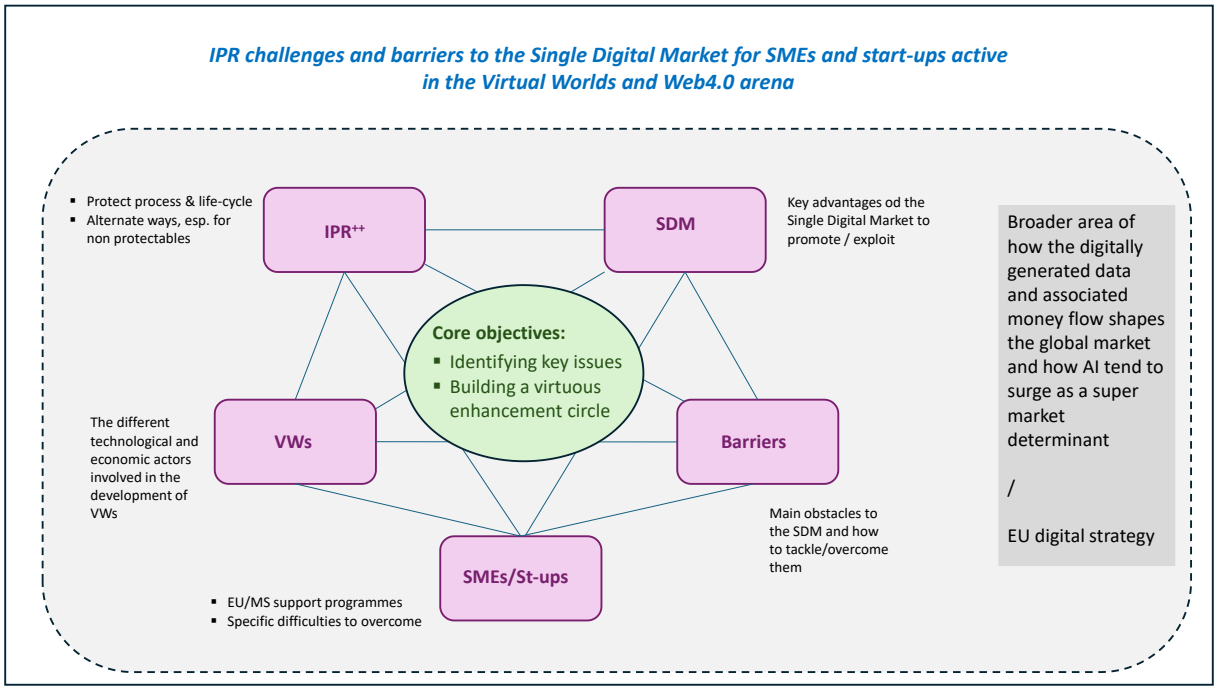
Figure 20 Key Components of the digital ecosystem within an IPR perspective



Source: OPENVERSE, 2024

5.3.1 ESTABLISH AN EU-WIDE IPR FRAMEWORK FOR VIRTUAL WORLDS

Unified IPR Standards: Create consistent EU-wide IPR standards specific to virtual worlds, covering digital assets, user-generated content (UGC), and decentralized ownership. This framework would simplify IPR processes and allow SMEs to confidently protect their creations across EU member states.

IPR Simplification and Support: Implement streamlined IPR registration processes tailored for SMEs, including fast-track IP registration, reduced fees, and simplified application processes. Additionally, provide an IP advisory service or hotline for SMEs navigating complex IPR issues.

Interoperability Standards: Develop and promote open standards for interoperability between virtual platforms, ensuring that SMEs can share, display, and transfer digital assets and content seamlessly across platforms.

Cross-Platform IPR Enforcement: Enable a shared protocol for cross-platform IPR enforcement that recognizes assets and creations across different virtual environments, protecting SME assets even if they move between platforms.

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6 CONCLUSIONS AND NEXT STEPS

6.1 CONCLUSIONS

This deliverable on Report on Virtual Worlds Trends and Benchmarking presented the outcomes of Task 3.1, focusing on the identification of key trends shaping the future of the internet, and cyber-physical systems with particular emphasis on Web3 and Virtual Worlds technologies. Through an extensive research process involving desk research, and semi-structured interviews this deliverable aimed to provide valuable insights into the adoption and growth of virtual world solutions among European organizations.

The deliverable covered the methodology used, including the research approach and data collection techniques. It presented existing definitions of Virtual Worlds, offering clarity on their relationship with the broader concept of the Virtual Worlds. Moreover, it described the key market trends and their analysis, identifying use cases and business priorities driving the development of Virtual Worlds technologies. The report also focused on the key requirements for establishing a sustainable European Virtual Worlds ecosystem, including strategic partnerships, interoperability, and innovation. Finally, it addressed ethical and legal considerations, providing an essential framework for ensuring responsible development and governance of Virtual Worlds technologies in Europe.

6.2 NEXT STEPS

The next steps will build on the findings of this deliverable, contributing to several key ongoing tasks within the OPENVERSE project. The insights gathered contribute to the Road mapping and Policy Recommendations (T2.5), where specific policy recommendations for the future development of the internet and the Virtual Worlds will be formulated. The aim of the recommendations is to help guide European organizations and policymakers in navigating the evolving digital landscape, ensuring that the Virtual Worlds and Web3 developments align with long-term strategic objectives.

In addition, these findings will support the exploratory studies in T3.2 and the demonstration case in T3.3, which is focused on creating industry-specific use cases for Virtual Worlds-enabled robotics. These cases aim to showcase how Virtual Worlds technologies can be applied in real-world scenarios, driving innovation and increasing the adoption of immersive technologies within industries.

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Furthermore, the findings will contribute in the work on ethical and legal requirements (T3.4), helping to address critical issues such as data privacy, digital rights, and user protection within virtual environments. This will also aid in developing appropriate IPR (Intellectual Property Rights) and governance models as part of T3.5, ensuring that the Virtual Worlds evolves as a human-centric, open, and ethically responsible space.

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APPENDIX

Quantitative Survey Demographics:

Full Sample: 800

Table 1 Survey Demographics (Geographies)

EMEA	**Country**	**Belgium**	30
		Czechia	50
		Finland	20
		France	80
		Germany	80
		Ireland	25
		Italy	80
		Netherlands	30
		Poland	50
		Saudi Arabia	50
		South Africa	50
		Spain	80
		Sweden	60
		Turkey	30
		UAE	30
		United Kingdom	55

Table 2 Survey Demographics (Company Sizes and Industries)

Company Size (4)	**Small office: 10–99 employees**	169
	Medium-size business: 100–499 employees	292
	Large business: 500–999 employees	292
	Very large business: 1,000+ employees	547
IDC Sector (6)	**Financial services [banking, insurance, and capital markets]**	152
	Healthcare [healthcare providers, healthcare insurance/payers, and life sciences]	105
	Infrastructure & energy [telecommunications & energy]	105
	Manufacturing & resources [high tech & electronics, durable goods, nondurable goods, and resources]	287

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Retail & services [retail, software & information services, transportation & leisure, and business & personal services]	498
Public sector [education & government]	153

Experts Interviews Details and Questionnaires:

1. Alessandro Canepa, R&D Manager, Piacenza Cashmere
2. Alvin Graylin, Author and Expert, Virtual World Society
3. Anonymous, CIO, Manufacturing Company
4. Athena Demos, Co-Founder and CEO, Big Rock Creative
5. Muhsinah Morris, Ph.D., Senior Assistant Professor, Morehouse College
6. Marcin Polakowski, Creative Director Flat Pixel
7. Dulce Baerga, Technologist and CEO, Dulce DotCom
8. Ely Santos, Head of Gaming & Partner, Broken Egg
9. Fabrizio Lamberti, Professor, Politecnico di Torino
10. Greg Roach, CTO, Spinview
11. Haver Järveoja, Co-Founder and COO, Ready Player Me
12. Jon Li, General Manager, XREAL
13. John Soldatos, INNOV ACTS
14. Karen Alexander, Director, ARconnectED
15. Mariano Luis Alcañiz Raya, Executive Director, Institute for Research on Human-Centred Technology
16. Ohto Pentikäinen, CEO & Co-Founder Doublepoint
17. Sebastian Tusk, CTO, Breakpoint one
18. Terry Schussler, Senior Director Next Generation Device, Deutsche Telekom
19. Timmy Ghiurau, Innovation Lead Virtual Experiences and AR, Volvo Cars

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Questionnaires:

Specific Questions for Virtual World Tech End-user:

Q01. Can you describe your organization's strategy and investments on virtual world technologies in the short, medium and long-term?

Q02. Which of the Virtual Worlds technologies is your organization currently using or planning to use? VR, AR, MR, AI, Blockchain, IoT, and 5G

Q03. Are there any additional technologies or tools critical to your work in Virtual Worlds that were not mentioned?

Q04. How do you see Virtual Worlds technologies impacting your industry specifically?

Q05. Can you describe specific use cases you are exploring for Virtual Worlds in your organizations in the short, medium and long-term?

Q06. Could you provide an example of a successful project or outcome achieved through the use of Virtual Worlds in your organization?

Q07. Which business units/functions within your organization are primarily involved in Virtual Worlds projects/activities?

Q08. Which business units/functions drive investments and adoption of Virtual Worlds technologies within your organization?

Q09. What are the primary goals your organization is trying to achieve when integrating these technologies?

Q10. What are the main challenges that limit or may limit your organization’s adoption of Virtual Worlds technologies?

Q11. What do you expect from technology providers, academia, and European and national policy makers in your Virtual Worlds roadmap?

Q12. What are your competitors doing that you wish you could do?

Q13. Could you please tell me at least five Virtual Worlds that you consider to be the most popular? Platforms/Vendors name.

Specific Questions for Virtual World Tech Academia:

Q01: What emerging trends do you perceive in Virtual Worlds technologies that are currently under research or garnering significant academic interest? Trends in terms of technologies, markets and consumer's expectations.

Q02: Could you elaborate on the specific areas of Virtual Worlds technologies that your academic research focuses on? How do you envision these areas evolving in the foreseeable future?

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Q03: In your academic circles, what discussions or debates are prevalent regarding the potential impacts (both positive and negative, if any) of Virtual Worlds technologies on society, culture, and businesses?

Q04. What are the opportunities you see for these technologies? And what are the key requirements to further expand research and development?

Q05: Are there any recent studies or academic papers in the domain of Virtual Worlds technologies that have captured your attention or influenced your research interests?

Q06: Within your academic institution or research group, what kind of collaborative efforts or interdisciplinary projects are underway to explore Virtual Worlds technologies?

Q07: How do you perceive the role of academia in contributing to the advancement and development of Virtual Worlds technologies?

Q08. In terms of skills requirements related to Virtual Worlds technologies, how do you perceive the evolution of skills in this context and is academia keeping up with or even contributing to these changing requirements?

Q09: From your perspective, what opportunities exist for academia to engage with industry partners, policymakers, and other stakeholders in shaping the discourse and direction of Virtual Worlds technologies research?

Q10: In your academic community, what platforms do you find most valuable for exchanging ideas, sharing research findings, and collaborating with peers on topics related to Virtual Worlds technologies?

Q11. Could you please tell me at least five Virtual Worlds that you consider to be the most popular? Platforms/Vendors name.

Specific Questions for Virtual World Tech Vendors:

Q01: What is your company's current roadmap for the development of Virtual Worlds technologies?,

Q02. What are the key adjacent technologies or specific technological innovation required for efficiently developing and deploying Virtual Worlds solutions?

Q03: As a technology vendor, which specific areas of Virtual Worlds development are you investing in or planning to invest in? How do you prioritize these investments? And Why?

Q04: What are the primary challenges you encounter in the development and implementation of Virtual Worlds technologies, and how do you address these challenges in your roadmap?

Q05: Can you provide examples of successful use cases or projects involving Virtual Worlds technologies that your company has undertaken? How have these experiences informed your development strategy moving forward?

Q06. How do you plan your own research on innovative Virtual Worlds solutions? Who are the key personas/business units involved in the process?

Q07. How do you plan your go-to-market strategy?

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Q08: In your interactions with clients, which industries or sectors show the most interest in adopting Virtual Worlds technologies, and what are their primary use case requirements?

Q09: What specific functionalities or features do clients frequently request in Virtual Worlds technologies, and how do you incorporate these client requirements into your product development roadmap?

Q10: From a technological standpoint, what are the key innovations or advancements you anticipate in the field of Virtual Worlds technologies, and how do you plan to integrate these into your roadmap?

Q11: In your view, what are the most promising opportunities for technology vendors in the Virtual Worlds space, and how do you plan to capitalize on these opportunities in your development roadmap?

Q12. Who are your key partners that contribute to the development of Virtual Worlds solutions? What are the criteria you use to identify them?

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