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Competition in Virtual Worlds

Virtual Worlds applications and market opportunities are currently expanding globally. This is the result of multiple factors including the launch of **new hardware devices** (provided by leading companies such as Meta, Apple, Samsung, Sony, and HTC) that enable increased flexibility of use (both VR and AR modalities through the same device), adapting to the variety of daily tasks, and the **growth of social gaming worlds** (e.g. Roblox, Fortnite by Epic) adding to traditional gaming activities also social events and digital marketing spaces for brands. Following this innovation abundance, both new hardware and software solutions are bringing value to new market sectors thanks to the combined efforts of additional key players such as Microsoft, Google, Sony, Amazon, NVIDIA, and Siemens. The increased availability of content and experiences, however, still presents barriers to wider accessibility and utilisation.

Developing and maintaining Virtual World platforms and services requires advanced and specialized technologies, such as AR/VR hardware and software, cloud computing Edge (5G/6G Network, 3D rendering, artificial intelligence, blockchain, etc. These technologies are often costly, complex, and rapidly changing, which may pose difficulties for **new entrants** or **small players** to compete with established or large companies with more resources and legacy expertise. Moreover, some technologies may be protected by patents or trade secrets, which may limit the access or availability of certain features or functionalities for competitors or users.

Virtual World markets can be subject to various regulations that may differ across jurisdictions and domains. These **regulations and laws** may not be fully adapted or harmonized to the specificities and challenges of Virtual Worlds, which may create uncertainties, inconsistencies, or conflicts for market participants. For example, the ownership, transfer, and use of digital assets, identities or currencies in Virtual Worlds may raise questions about their legal status, taxation, and enforcement, especially as these platforms target a global, cross-border audience. Approaching such a complexity could represent a financial and legal challenge, an unpredictable degree of risk difficult to assess and manage, for new or small stakeholders.

Virtual World may exhibit **strong network effects**, meaning that the value of a platform or service increases with the number and diversity of users and content. This may create a tendency for the market to tip towards one or a few dominant platforms or services, which may

enjoy economies of scale, scope, and data, and create barriers for new entrants or challengers to attract users and content. Moreover, some platforms or services may adopt **proprietary or incompatible standards** or technologies, limiting the interoperability or portability of users, content, or assets across different Virtual Worlds and creating **lock-in effects** that reduce competition and user choice.

Virtual World platforms are still largely driven by entertainment and social purposes, such as gaming, education, art, and communication. However, the potential of Virtual Worlds for **industrial and commercial applications**, such as manufacturing, health care, retail, tourism, etc., is still largely untapped or underdeveloped in the B2C market. This may limit the growth and diversification of the market, and trigger the creation of new **value propositions** and **business models**. Moreover, some industrial and commercial applications may require higher quality standards, security, reliability, and compliance, which may pose additional challenges and costs for market participants.

These entry barriers or obstacles may differ based on the maturity of the various markets, as different markets may have different levels of technological development, regulatory adaptation, market concentration, and industrial integration. For example, more mature markets may have more established and dominant platforms or services, which may make it harder for new entrants or challengers to compete, but also more developed and diversified industrial and commercial applications, which may create more opportunities and incentives for innovation and competition.

The aforementioned diversity of today's Virtual Worlds often risks converting into additional complexity and fragmentation of platforms, services, production processes and knowledge. The key solution to overcome such a landscape lies in promoting the interoperability of digital assets, digital wallets, avatars and identities while clarifying International regulations and promoting awareness and skillsets functional for their use.

Main drives of competition and enabling technologies of Virtual Worlds

Many drivers could enable or disrupt competition for Virtual World platforms, playing at the disadvantage of new European stakeholders.

First of all, **data** represents a valuable asset for Virtual World platforms and services, as it can enable them to improve their performance, functionality, personalization, and innovation. Data can also be used to create or enhance digital assets, such as 3D models, avatars, environments, etc., that can be offered to users or monetized in various ways. However, data access may also raise issues of privacy, security, ownership, and governance, especially when data is collected from users or third parties (and linked/ connected to the physical world and vice versa).

Hardware or infrastructure specifically owned by key Virtual World providers can benefit them by reducing their dependence on external suppliers, increasing their control over quality and compatibility, and creating differentiation and loyalty among users. However, hardware or infrastructure can also entail high costs, complexity, and maintenance, and may face challenges of interoperability or standardization with other platforms or services.

IP rights can be a source of competitive advantage for Virtual World providers, as they can prevent or limit the copying, imitation, or infringement of their innovations, brands, content,

or assets by competitors or users. At the same time, IP rights can pose challenges of enforcement, valuation, or licensing, especially in the context of global and dynamic Virtual World markets where the lines between physical and virtual are starting to blur further.

Control over connectivity can be an additional driver of competition, as it can affect the quality, availability, or affordability of their offerings, and the extent to which they can leverage network effects, interoperability, or portability to attract or retain users. The same aspect can also raise issues of fairness, transparency, or neutrality, especially when dominant or gatekeeping platforms or services may abuse their market power to restrict or discriminate against competitors or users.

Vertical integration can enable Virtual World stakeholders to capture more value, reduce costs, increase efficiency, enhance quality, or offer users bundled or complementary products or services. The same can also have negative effects on competition, such as creating entry barriers, reducing diversity, or creating conflicts of interest, especially when vertically integrated providers may favour their products or services over those of competitors or users. (That's why open source and decentralized alternative solutions and services are so crucial while entering this next generation of the internet, as they provide options.)

Finally, **platform and payment fees** can be a driver of competition, as they can generate revenue, cover costs, incentivize participation, or influence behaviour. Platform and payment fees can also have adverse impacts on competition, as they could create price distortions, reduce incentives, or create rent-seeking, especially when platform or payment providers may exploit their market power to impose excessive or unfair fees on competitors or users.

These drivers of competition may change over time, depending on the evolution of technology, user preferences, industry dynamics, and regulatory interventions in Virtual World markets.

Technology may change the drivers of competition by enabling new or improved capabilities, functionalities, or experiences in Virtual World platforms and services, such as higher resolution, lower latency, more immersion, more interactivity, more realism, and increased smart management of data. Technology may also enable new or alternative forms of hardware, infrastructure, data, IP, connectivity, or payment, such as cloud-based, blockchain-based, or AI-based solutions, that may challenge or disrupt the existing market structures or players.

By nature, XR devices have world-facing **sensor technology** built-in, for example, LiDAR sensing and directional microphones. This sensing is what, in part, drives the Simultaneous Localization and Mapping (SLAM) algorithms that allow XR devices to localize and position themselves within their surrounding (*where they are in the physical world*). These possibilities not just only make it possible to visualize digital assets in the physical world, but they also open new potential risks that go beyond positional tracking and risks of the user itself.

Though XR is already applied within many industries and fields, it's still an emerging technology poised to mark a transition towards mainstream adoption. This transition is driven not only by more accessible and cost-effective hardware such as wearables or head-mounted devices (HMDs) but also by its fragmented infrastructure between services and platforms. How Apple's launch and entry into the industry will play can only be suspected; what we know is that it caught the public's interest, and the so-called public/social attention has rightly shifted toward

the unique security and privacy threats these platforms and output devices may pose. While it has long been known that people reveal information about themselves via their **motion data**, the extent to which this makes an individual globally identifiable within virtual reality has not yet been widely understood.

The research paper “Unique Identification of 50,000+ Virtual Reality Users from Head & Hand Motion Data”¹, published in 2023 proved that a large number of real VR users (N=55,541) can be uniquely and reliably identified across multiple sessions using just their head and hand motion relative to virtual objects. After training a classification model on 5 minutes of data per person, a user can be uniquely identified amongst the entire pool of 50,000+ with 94.33% accuracy from 100 seconds of motion and 73.20% accuracy from just 10 seconds of motion. This research has been the first to truly demonstrate the extent to which biomechanics may serve as a unique identifier within XR, on par with widely used biometrics such as facial or fingerprint recognition.

The currently used state-of-the-art **eye-tracking** technologies utilise cameras to capture the user's gaze points, but a new system uses reflected sound to track where users are looking based on the shape of their eyeballs. Prototype smart glasses can track people's eye movements using a technique similar to sonar, which uses 95 per cent less power than other methods. HMDs like Apple Vision Pro and Meta Quest Pro use cameras pointing towards the wearer's face to track their eye movement. This offers high accuracy, typically estimating the angle of their gaze to within 1 degree, but also consumes a lot of power. These solutions are known to have a high power signature, which results in that they tend to not work well for smart glasses and wearables with a relatively small battery capacity, a promising solution could be the GazeTrak the first acoustic-based eye tracking system on glasses recently published by Cornell University. This novelty system needs only one speaker and four microphones on each side of the wearables or glasses. The acoustic sensors capture the formations of the eyeballs and the surrounding areas by emitting encoded inaudible sound towards the eyeballs and receiving the reflected signals and testing within a user study. These reflected signals are further processed to calculate the echo profiles, which are fed to a customized deep learning pipeline to continuously infer the gaze position as the gaze tracking system was successfully on an MCU with a low-power CNN accelerator (MAX78002). In this configuration, the system runs at up to 83.3 Hz and has a total power signature of 95.4 mW with a 30 Hz FPS.²

The aforementioned research highlights how immersive technologies take companies to a **privileged position** for customer insights processing and behavioural analysis that was not possible so far with traditional consumer devices. In many cases, final sensitive data results from a long and complex data flow that starts from raw information traditionally not included in currently validated risk assessment approaches. This creates potential regulatory loopholes, making it more difficult to evaluate and apply compliance regulations. The complexity required to manage and leverage these aspects also requires financial, technical and knowledge resources,

¹ Nair, V., Guo, W., Mattern, J., Wang, R., O'Brien, J. F., Rosenberg, L., & Song, D. (2023). Unique Identification of 50,000+ Virtual Reality Users from Head & Hand Motion Data. *ArXiv (Cornell University)*. <https://doi.org/10.48550/arxiv.2302.08927>

² *GazeTrak: Exploring Acoustic-based Eye Tracking on a Glass Frame*. (n.d.). <https://arxiv.org/html/2402.14634v2>

that are less likely to be owned by novel companies, putting them at an evident disadvantage as for competition.

In addition to technological factors, **user preferences** may change the drivers of competition by influencing the demand, adoption, or usage of Virtual World platforms and services, as well as the expectations, satisfaction, or loyalty of users. User preferences may vary depending on multiple factors such as age, gender, culture, education, and income, as well as on the purpose, context, or outcome of using Virtual Worlds, such as entertainment, education, work, health, etc. User preferences may also change over time, as users become more familiar, comfortable, or sophisticated with Virtual World technologies, content, or interactions. It should be noted that traditional biological categories of generations are rapidly expanding to culture-driven generational segments of the population, resulting from a widely fragmented experience of social and economic global events. According to foresight studies and future multi-crisis scenarios, the number of events able to break society into even more multiple generational segments and broader divide affects how and why technology will be used, disrupting (potential thread) linear expectations for upcoming user preferences, society and democracy.

Industry dynamics may change the drivers of competition by affecting the supply, innovation, or competition of Virtual World platforms, and services, as well as the relationships, collaborations, or conflicts among different market players. Industry dynamics may be influenced by factors such as market size, growth, maturity, concentration, and diversity, as well as by the strategies, actions, or reactions of existing or new competitors, suppliers, intermediaries, or users in Virtual World markets.

Regulatory interventions may change the drivers of competition by establishing or enforcing rules, standards, or policies that may affect the development, deployment, or operation of Virtual World platforms and services and the rights, obligations, or interests of different market players or stakeholders. Regulatory interventions may be motivated by various objectives, such as promoting innovation, competition, consumer protection, data protection, IP protection, security, safety, ethics, etc., in Virtual World markets. Regulatory Interventions may also vary depending on the level, scope, or approach of regulation, such as local (public or private context), national, regional, global, sector-specific or horizontal, prescriptive or principles-based.

Future Scenarios and Final Considerations for Virtual Worlds

The upcoming developments of Virtual Worlds are a process of **convergence** between traditional XR technologies with Artificial Intelligence (and especially its recent surge due to generative AI and LLMs), new connectivity generations, enhanced cloud computing and infrastructure and the opportunities provided by decentralized digital ledgers. AI is going to enable more new services, from conversational dynamics to virtual assistants and user-generated VR/AR worlds. Several consumer brands like NIKE and L'Oreal are already taking an active role in the sector, requiring from Virtual Worlds platforms an increased focus on innovative monetization and advertisement features able to leverage the specific potential of such a new digital experience and data collection paradigm.

Advertising models are the ones being pursued (e.g. In Roblox), monetizing user attention and data (e.g. behaviour, preferences, social interactions). Returning data ownership to the individuals and making them an active part of the monetization cycle can be a way to promote responsible Virtual Worlds and, at the same time, bundle in consent and privacy action items closer to the citizens.

The main competition issue we expect in the short term is represented by **International big players** coming into the European ecosystem and minimizing with their growth and strategic acquisitions the possibility for new native European players to emerge and develop sustainable solutions. Such a process is expected to be mostly based on proprietary technology, as a result of private investments by individual companies. This also converts into **data flows** mainly managed by extra-European stakeholders, a criticality that could become more complex due to the lack of shared and validated frameworks for the management of complex inferred data, the core of the new data collection paradigms enabled by Virtual Worlds-related technologies.