SHAPING THE METAVERSE:

Policy engagement with immersive technologies in the UK

July 2023

ABSTRACT

The Metaverse refers to a future evolution of the Internet where the physical and cyber domains achieve convergence. It will emerge over the next decade via a set of nascent networking and computing technologies that will **immerse** users in realistic or imagined 3D virtual worlds that are dynamically rendered in real-time. The environments will provide 'presence' i.e. a sense of collective reality brought about by a simulated world that can be viewed and interacted with by multiple users simultaneously.

Proto-metaverse environments such as the massive multiplayer online games Fortnite and Roblox, are bringing forward cultural and social change. To some players, virtual objects have just as much value as physical assets and virtual identities are just as valid as their 'real' selves. **Metaverse is viewed as a massively creative space** that facilitates experimentation and development of ideas in the digital domain that can then transcend into physical goods and services. Music, fashion and the design sectors are likely beneficiaries of an emerging **'builder economy'** in the metaverse. Further work is needed to nurture this new sector via strengthened IP protection, development of ethical guidelines and tools/ registries of creative outputs.

The UK is home to the largest games industry in Europe. Games developers will have significant impact not only on the development of virtual worlds for the Metaverse, but also on more industry focussed mixed-reality applications such as digital twins in the architecture, engineering and construction sectors. Game engines are a prime enabling technology for the Metaverse and **skills development programmes in the games sector** are vitally important to enable the UK to exploit metaverse opportunities in multiple commercial sectors.

British cultural landmarks, institutions and assets should be leveraged to bootstrap a uniquely 'British Metaverse'. Forming a collaborative **triple-helix between government, industry and academia** would provide a Metaverse anchor point for cultural tourism to the UK and a showcase for the wealth of indigenous, creative talent in the music, fashion and design sectors.

The Metaverse products and digital artifacts produced by UK companies needs to be portable between different virtual worlds and the associated platforms that host them. There are **insufficient technical standards** to enable that portability and ensure a level playing field for small enterprises. International standardisation is the critical path towards **interoperability** and the UK should take an active and strategically informed approach to participation in Metaverse standards fora. Schemes that incentivise participants, from UK based SME's and academia, to engage with standards bodies should be considered.

Privacy, data collection and the use of **biometrics** in the Metaverse are pressing concerns. A lack of effective social science investigation into existing social network platforms means that predictions about the long-term effects of Metaverse exposure and its potential for causing harm, are not defensible. EU and US law makers are moving towards **regulated data access for qualified researchers** to very large online platforms. A joint statement following a US-EU Trade and Technology Council meeting held in May 2023 said, "*It is crucially important for independent research teams to be able to investigate, analyze and report on how online platforms operate and how they affect individuals and society*". This approach could open the door to a new era of **'computational social science'**:

> *"Science rarely proceeds beyond what scientists can observe and measure, and sometimes what can be observed proceeds far ahead of scientific understanding. The twenty-first century offers such a moment in the study of human societies. A vastly larger share of behaviours is observed today than would have been imaginable at the close of the twentieth century. Our interpersonal communication, our movements and many of our everyday actions, are all potentially accessible for scientific research." (Lazer et al., 2021)*

A similar legislative program in the UK would provide the means to study Metaverse harms, model their epidemiology, predict their consequences and develop countermeasures for immersive virtual worlds that protects the mental and material wellbeing of our young people into the future.

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EXECUTIVE SUMMARY

This report represents the culmination of nine months of research into the metaverse technology landscape in the UK. The report's evidential base draws on **five 'Shaping the Metaverse' workshops** organised by the project team which were held in Manchester, Dundee, York, Cardiff and Nottingham between February and April 2023. The study concluded with a two-day closed conference held in Queen's University Belfast in May.

Two focus group sessions were held in each workshop (a single session was held in Cardiff) and these sessions were recorded and transcribed. Insights from focus group sessions are quoted throughout this report. They use a simple numbering system. For example, N-1-19 represents a comment made in the Nottingham workshop, focus group 1, comment number 19. D-2-49 refers to the Dundee workshop, focus group 2, comment 49.

At a technical level the Metaverse can be thought of as a comprehensive integration of the physical and cyber domains. This will be achieved via a set of nascent technologies that will allow advanced IT systems to immerse users in realistic or imagined 3D virtual worlds that are dynamically rendered in real-time. The Metaverse is variously described as the **next generation of the Internet**, or the **3D Internet** or a massively scalable, interoperable, persistent network of virtual worlds that gives the impression of presence to limitless numbers of online users. 'Presence' in this context means a sense of collective reality brought about by a simulated world that can be viewed and interacted with by multiple users simultaneously. Much of this report explores metaverse definitions, underpinning technologies and applications in some depth.

Full expression of the **Metaverse is not possible today** and a step change in the enabling networking and computing technologies is required which **may take a decade to complete.** Achieving persistent, interconnected virtual spaces requires high-bandwidth and very low-latency core networks coupled with ubiquitous wireless access networks to support user devices. "A virtual environment will generate an immense number of textured, high-definition 3D objects, as well as their positions, motions, sounds, surroundings, and simulated interactions with other objects and users" (Zhu, 2022). A live online concert staged in the Metaverse would create massive amounts of data to process, integrate and transmit between geographically dispersed participants who are continuously generating dynamic input through their actions and reactions to those around them. These compute platforms will have significant energy requirements.

However, the technical aspects of the Metaverse somewhat miss the point of the **underlying cultural and social change** such platforms are bringing about. For some young adults who regularly use proto-metaverse environments such as the massive multiplayer online games Fortnite and Roblox, a fundamental shift in values is taking place. To them, **virtual objects have just as much value as physical assets** and virtual identities are just as valid and 'real' as their physical selves.

> *N-2-104. Our current understanding of what reality is-of the physical world being more important than the digital world, may just be of our generation.*

Many view the **metaverse as a massively creative space** that facilitates experimentation and the development of ideas in the digital domain that can then transcend into the physical domain.

> *Y-2-70. I think about young people, creating fashion for virtual worlds or musicians, it's a great opportunity, to be able to attract people into their spaces and share their work.*

> *Y-2-84. If we can support people to have spaces to create and have ownership over that content, whatever type of content, that could be quite a positive thing.*

The international panel of independent, academic experts contracted to this study, highlighted the opportunity to **leverage the British cultural landmarks, institutions and assets to bootstrap a uniquely 'British Metaverse'.** This could act both as an anchor for cultural tourism to the UK and a showcase for the wealth of indigenous, creative talent in the music, fashion and design sectors. A collaborative approach to metaverse development, which built a **triple-helix between government, industry and academia**, has proven successful in South Korea. A similar approach in the UK could boost metaverse support, raise public interest and encourage commercial exploration.

Protecting digital intellectual property is a concern and further investigation into the **legal frameworks** surrounding user generated content, the **ethical guidelines** and practices needed to fairly apportion future revenues between independent, disparate content creators is urgently needed. The present-day experiences of games developers and how their revenues are split with distributors and platform owners, is indicative of the issues that will occur within the Metaverse.

> *M-1-20. Creative passports and journaling systems are needed to attribute rights to digital works such as music or engaging content or digital experiences/ spectacles in the MV. The passport detail needs to be attached to the journey map that a digital asset may take through the MV.*

The **UK video games sector is the largest in Europe** and reported £7.05 billion of consumer sales in 2022. Behind this is a strong, indigenous games development sector which is export focussed and has an impressive track record in producing globally successful gaming IP e.g. Grand Theft Auto, RuneScape and the Batman and Lego franchises.

> *"The UK's game development sector generates annual tax revenues of £1.2 billion for the Treasury and contributes £2.9 billion to UK GDP annually". Dr Richard Wilson OBE, CEO of the UK games trade body* TIGA.

Games development is a key sector which will have significant impact not only on the development of virtual worlds for the Metaverse, but also on more industry focussed mixed-reality applications such as digital twins in the architecture, engineering and construction sectors. Game engines are a prime enabling technology for the Metaverse and **skills development programmes in the games sector** are vitally important to enable the UK to exploit metaverse opportunities in multiple commercial sectors.

Interoperability is another topic that the expert panel highlighted for further consideration by UK authorities. A pluralist metaverse, that is not dominated by one or a small group of technology corporations, will foster an environment where many small innovative companies can develop their products and services on a level playing field. The products and digital artifacts that those companies may produce needs to be portable between different virtual worlds and the associated platforms that host them. Consumer protection legislation in the UK may provide some assurance but more fundamentally there are **insufficient technical standards that enable portability of digital objects** and assets to traverse the Metaverse. **International standardisation is the critical path** to portability and interoperability between virtual worlds and the **UK should take an active and strategically informed** approach to participation in Metaverse standards fora. This activity should be driven and resourced by the SME and academic sectors rather than staff drawn from the UK subsidiaries of global corporations. Schemes that incentivise UK participants in Metaverse standards forums should be considered.

The prime commercial drivers for Metaverse development originate in the advertising industry. Google and Meta are personalised/targeted advertising platforms and Amazon receives significant income from advertising (almost $10Bn in their last quarterly results). New metaverse technologies such as head mounted displays are a key tool in validating the effectiveness of advertisements. Eye movement tracking, gaze analysis and eye dilation metrics are clear indicators of the user's level of attention to an object or immersive experience. As Sir Nick Clegg, Meta's President for Global Affairs explained, "... you're not selling eye-tracking data to advertisers, but in order to understand whether people engage with an advertisement or not, you need to be able to use data to know" [Irwin 2022].

> *Y-2-87. The dominant assumption is that we cannot have social media without our data being sold.*

The social metaverse is an increasingly rich territory for such corporations to mine the interests, attractions and aspirations of consumers and monetise that knowledge via advertising. The ability of corporations to witness the first-person perspective of consumers in a dynamic, immersive environment where they control all visual and acoustic cues is "...tantamount to cognitive, mediated and **automated empathy**, this reflecting an interest in the datafication of the first-person perspective and the increasingly diverse ways that algorithmic systems profile, judge and interact with intimate dimensions of human life." (McStay, 2023a).

> *N-1-37. For mass population application of MV technologies, there are huge issues about surveillance, manipulation and political manipulation. Especially from those big tech companies who have access to those kinds of emotional/behavioural data.*

Metaverse advertisements will take many different forms and AI-enabled 3D bots will appear as influencers rather than overt ads:

> *"…as immersive technology develops and becomes more subtle you will be hoodwinked in virtual environments, and they'll know more about you because of all the data they've collected. It will be much more compelling, intimate and much more difficult for us to discern reality." [D-1-28]*

Beyond the extreme cases, we have little insight into the influence these social platforms can have on the population of the UK as a whole. There is insufficient investigation of the social sciences in the Metaverse and little opportunity to predict its eventual impact on society.

> *D-1-24. Ethics and prevention of cybercrime are important, but MV is taking us into another dimension of how we would protect our emotional and psychological selves. This is a whole new area that we know little about.*

However, the regulatory environment is evolving and the data corporations may soon become obliged to provide researchers with access to the data held on their platforms via secure and privacy preserving methods. The **EU Digital Services Act** (DSA) (European Union, 2022) and the US Platform Accountability and Transparency Act (PATA) (Coons, 2023) are examples of legislation which improves access for researchers. The DSA will come into effect across all EU member states by January 2024. DSA mandates 'very large online platforms' (VLOPs) to give researchers access to the "Data necessary to assess risks and possible harms brought about by the platform's systems". This data will be provided in a GDPR compliant fashion i.e. using appropriate privacy enhancing technology. If fully enacted, this movement towards **regulated platform data access,** could open the door on a new era of **'computational social science'.** Fundamental research is needed to determine how people behave in immersive environments and how they can be protected from algorithmic coercion and manipulation.

The top ten actions that arise from the 'Shaping the Metaverse' study are summarised below in priority order:

1. Assess the evolving digital technology-related regulatory environments internationally (especially US, Europe, China) and predict how these may affect metaverse operations with respect to online harms.

2. Undertake a discrete series of study visits to a selection of European countries who are willing to collaborate and share their MV policy elements (academic, industrial and regulatory) with the project team. To include interviews, knowledge exchange events, workshops and pan-European foresight initiatives.

3. Investigate the feasibility of a co-ordination function to organise and support UK representatives to actively participate in metaverse standards fora.

4. Define the strategic objectives for metaverse interoperability and standardisation for the benefit of the UK both socially and economically.

5. Convene a series of focus group sessions on ethical metaverse practices for IP attribution and produce a framework of development practices for an open, sustainable and ethical metaverse by design.

6. Investigate skills for the metaverse to support the emerging Builder Economy and maintain UK strengths in User Generated Content and Virtual World Creation.

7. Carry out a technical assessment of privacy enhancing technologies and determine their potential future role in metaverse operations.

8. Promote digital heritage in the UK by developing interactive experiences that builds on our stunning natural and built environment and the rich history of these islands.

9. Prepare a landscaping paper of global approaches to, and examples of, MV and tourism.

10. Conduct a workshop with the British Fashion Council, Central Saint Martins and other partners on fashion and the future of MV.

The complete list of relevant follow-on actions and investigations that emerged from the study is presented in the 'Recommendations' section along with an implementation time frame and further prioritisation.

HOW TO READ THIS REPORT

This research was supported via UKRI by the DCMS Science and Analysis R&D Programme. It was developed and produced according to UKRI's initial hypotheses and output requests. Any primary research, subsequent findings or recommendations do not represent Government views or policy and are produced according to academic ethics, quality assurance and independence.

This report surveys the technologies associated with development of 'The Metaverse' and maps out the threats and opportunities they pose to UK society and economy over the next decade.

The report is aimed primarily at HMG staff tasked with analysis and policy development in areas incident on metaverse technologies e.g. online harms. The report is structured to aid navigation by such readers and to act as a reference point for their work. Hence the report is presented in several layers of abstraction and much reference material is included.

More generally the report is aimed at UK businesses and academics involved in sectors related to the metaverse such as: the creative industries; games development; cultural heritage; popular music, music performance; fashion design; film and theatre.

If you are a member of the public:

This report presents evidence gathered in five workshops held across GB between February and April 2023. Workshop participants were a mixture of academics, industry representatives, NGOs, and local and central government staff. All participants self-identified as having metaverse interests or professional expertise. Roughly 75% of participants worked in academia.

Focus group discussions held during the workshops were recorded, transcribed and later analysed collectively. The discussion points have been logically grouped into twelve themes that are represented as an interconnected mind-map. Each section of the mind-map is presented in turn in the report i.e. all the content between 'Market Pull?' and 'Metaverse Applications'. By studying the mind-map graphics and reading the high-level introduction provided in each section you will quickly develop an overview of the nature of the discussions.

Short, informative introductions to the underlying technologies are included in section 'Metaverse Technologies'.

Applications of metaverse technologies are discussed in section 'Metaverse Applications' which provides an insight into the potential of the technologies going forward.

If you are a researcher:

A literature review of recent work on metaverse taxonomy and definition is presented initially.

Later sections of the report represent field work carried out during the project and aims to faithfully present the views of the participants who attended the 'Shaping the Metaverse' workshops. We content that taken collectively, the themes that emerged during the focus group sessions form their own taxonomy of the emerging metaverse ecosystem.

Twelve themes are presented and supplemented with additional research and commentary. A full bibliography is provided.

Recommendations are provided at the end of the report which in many instances indicate areas where further study is necessary. These recommendations also coalesce with the views of a panel of independent, international academic experts who worked with the project team.

If you are an HMG analyst or policy maker:

The Metaverse is a nascent area of technology development and this report makes every effort to survey and clarify the various meanings of metaverse. A survey of academic literature is presented followed by a field work survey provided in section 'Market Pull?'.

A taxonomy of the metaverse is developed through an analysis of the focus group sessions and presented in twelve consecutive sections of the report. Each of these sections lists the discussion points and insights gathered via the focus group sessions. These can be directly quoted in any downstream work.

A brief analysis of metaverse policy in selected European countries is included.

The recommendations made point to areas where further investigation and or policy development is needed.

This report intersects several of the DCMS departmental areas of research interest:

1. **The drivers of productivity in Arts, Heritage and Tourism (AHT) sectors and the impact of the sectors on economic growth, productivity, public health and employment**
   How the metaverse affects '*Which AHT sectors are growing, mature or contracting? What are the implications for targeting government interventions?*'.

2. **The role of digital cultural offers and consumption in driving future engagement and business models, domestically and internationally** Metaverse specific issues around '...how can innovative digital content be used to reduce barriers to audience engagement?'. Metaverse specific issues around 'How can digital offers impact income streams, support freelance artists/smaller organisations and retain copyright for producers?'.

3. **The role of AHT sectors in reducing Greenhouse Gases**
   The metaverse as an alternative method of experiencing arts, heritage and tourism assets without the need for travel.

4. **CI R&D, innovation, tech adoption and digital consumption**
   Issues around '*Are digital markets, including digital intermediation services such as platforms, impacting creator remuneration, and if so how?*'. *Metaverse specific issues around 'What are the risks and opportunities to creative business growth posed by new technology, including automation such as the use of AI?*'.

5. **Exports, international supply chains and comparative advantage**
   Commentary on '*Which creative businesses are more likely to export and what are the reasons behind different levels of export propensity?*'

6. **Diversity and inclusion in the creative industries**
   Issues around self-identification in the metaverse and how people may choose not to present their protected characteristics.

7. **The impact of the creative industries**
   Issues around '*barriers to participation' for metaverse content developers based in the UK. How the 'impact of harm caused by online advertising content and its targeted delivery to internet users'* may change in the metaverse and '*How can creative businesses support behaviour change of citizens (and their audiences) to meet net zero targets?*' by leveraging metaverse platforms.

8. **Gambling**
   Issues around metaverse hosted eSports and the '*Development of longitudinal studies to better understand developing patterns of individual/ group harm using rich digital data*' and '*Technical collaboration on data standards and sharing to support research and regulation*' within metaverse platforms.

INTRODUCTION

A multidisciplinary project team from Queen's University Belfast (QUB) was formed to carry out this study. Team members grounded in the creative industries, music technology, games development and virtual production expertise were drawn from the QUB MediaLab unit led by Professor Michael Alcorn. The principal investigator was Dr Jesus Martinez del Rincon from the QUB Centre for Secure Information Technologies (CSIT). Dr Martinez del Rincon and his CSIT colleagues brought deep competence in artificial intelligence, video analytics, networking, security and privacy technologies. The team was further extended and supported by an economic historian from the Queen's Management School and qualitative research expertise from the QUB School of Psychology.

This report represents the culmination of nine months of research by the team into the future of metaverse technologies in the UK. It draws on a workshop held with analysts and policy makers in Whitehall, study visits and attendance at technology conferences, extensive desk research and a phase of field research carried out between February and May 2023. The latter took the form of five 'Shaping the Metaverse' workshops held across the UK (in Manchester, Dundee, York, Cardiff and Nottingham) and concluded in a two-day closed conference held in Queen's University Belfast.

The discussion points and insights gathered in those workshops, forms much of the evidential base created by the project. This report presents a faithful analysis of those insights and uses them as a starting point for further supplementary research and commentary.

Two focus group sessions were held in each workshop (a single session was held in Cardiff) and these sessions were recorded and transcribed. Insights from focus group sessions are quoted throughout this report. They use a simple numbering system. For example, N-1-19 represents a comment made in the Nottingham workshop, focus group 1, comment number 19. D-2-49 refers to the Dundee workshop, focus group 2, comment 49.

'MV' is used as shorthand for 'metaverse' or 'The Metaverse' throughout the report.

The project team reflects a diversity of backgrounds and specialisms and we contend that a Metaverse horizon scanning project can best be approached in a multidisciplinary fashion. This view was echoed by workshop participants:

> *N-1-19. You need to bring in all the voices from all perspectives into conversations like this, and a diverse range of people of different lived experiences to Inform MV progress and development.*

> *D-2-49. Talking in this way, around a table, is rare. The issues are incredibly complex and multifaceted, and no one person will have the full technical or economic, or philosophical understanding of these different components.*

> *D-2-50. Discussions in interdisciplinary scenarios will prove crucial.*

Although the metaverse technology landscape is a complex and evolving area of study, a semantic analysis of the workshop transcripts reveals that all of the discussions were essentially people focused – as shown in Figure 1.

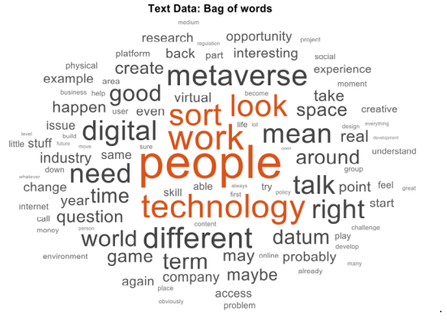


Figure 1 Semantic analysis of workshop transcripts

More than one hundred people contributed to the field research events. They self-identified as having research interests in, or professional experience of, metaverse related technologies or policy areas. Representatives from NGOs, local and central government, industry and academia attended the events which are profiled in Figure 2 and Figure 3.

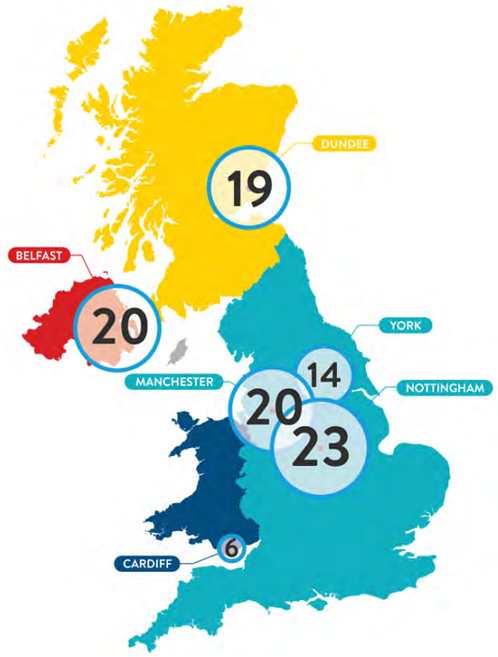


Figure 2 Map of workshop locations and participant numbers

Analysis of all nine focus group sessions reveal twelve recurrent topics of deliberation. We mapped these threads of debate and created the mind-map shown in Figure 4. We contend that this twelve-point analysis is a valid and useful taxonomy of metaverse futures in the UK. More detailed mind-maps of each thematic area are presented in subsequent sections of the report. We expand each theme discussed in the workshops with supplementary research and commentary wherever possible.

Examining evidence from the workshop deliberations, extensive literature searches, meetings and interactions with knowledgeable industry veterans and standards body representatives and close interworking with a panel of four international academic experts who were contracted to the project; we have developed a set of follow-on actions and activities that we believe will help the UK shape a pluralist, inclusive and interoperable metaverse ecosystem which benefits citizens and opens the door to much innovation.

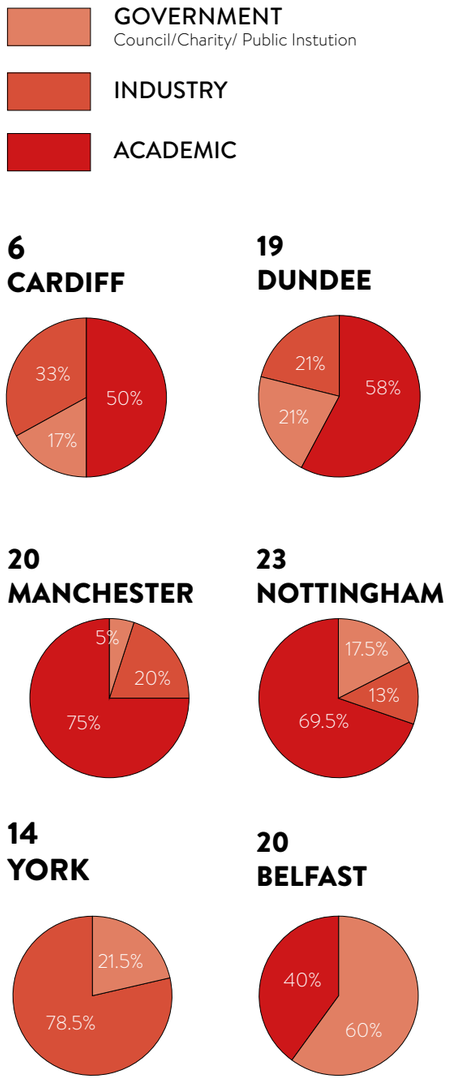


Figure 3 Profile of workshop participants

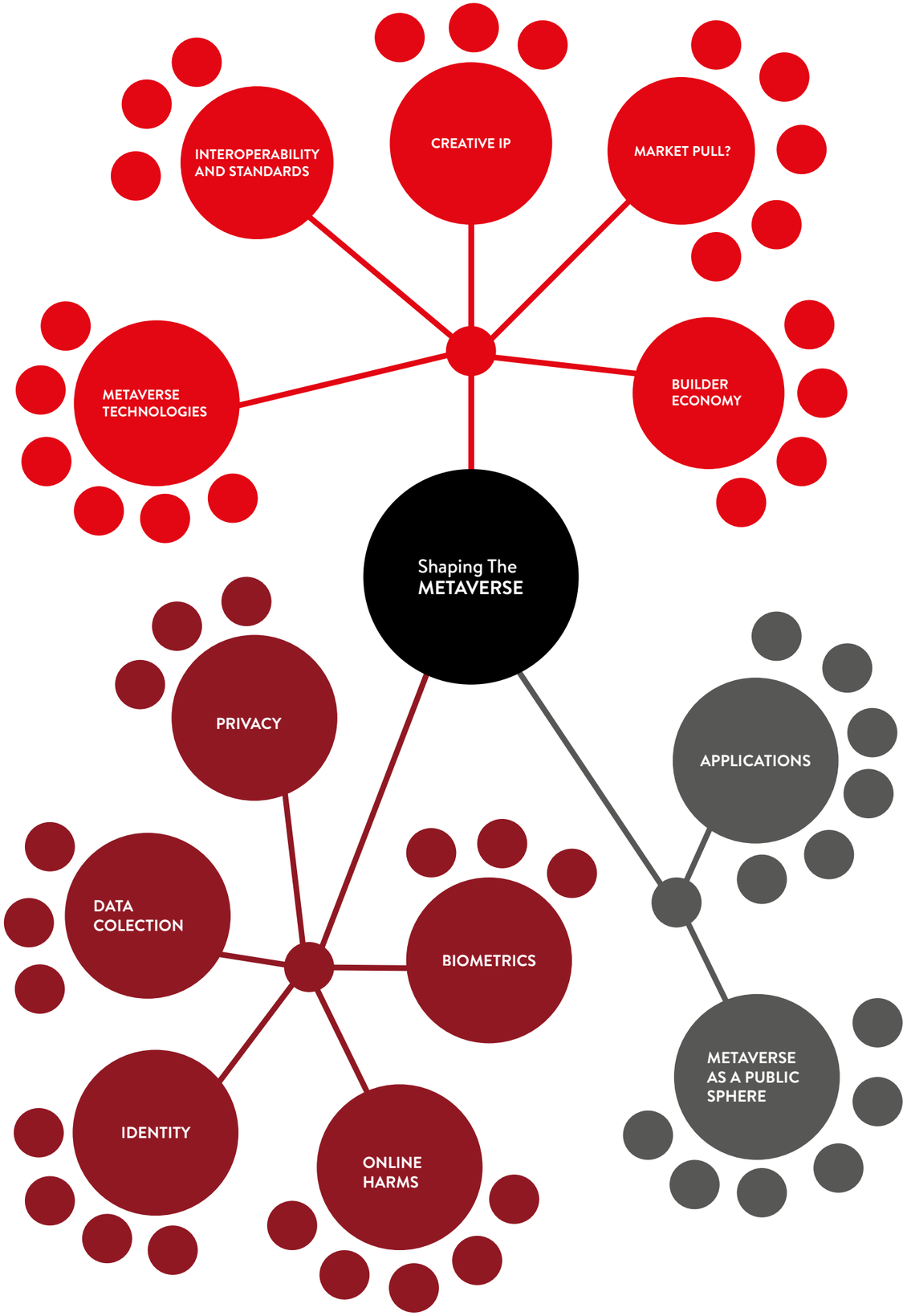


Figure 4 Mind-map of Shaping the Metaverse workshop deliberations

RECENT SCHOLARSHIP ON THE MEANING OF METAVERSE

Literature Review Methodology

Titles, keywords and abstracts from these searches were read for relevance and 2-3 papers per search were selected based on their ability to speak to the framework, or a working definition of the metaverse currently as opposed to papers which dealt with tightly focused areas (see for example: (Kaur et al., 2023; Xu et al., 2022; Yang & Wang, 2023a) The time frame was only purposefully narrowed where searches were voluminous, and to ensure contemporary relevance and accuracy e.g. with our search for metaverse "future" or "challenges". Search results were, in places, augmented with additional academic texts sourced from Google Scholar where more background content was desired. Examination of these broader-scope papers revealed underlying themes, challenges and opportunities analysed in more depth in the main body of this report.

Searches used:

Metaverse	14
Virtual Reality	12
Augmented Reality	8
Artificial Intelligence	4
Avatar	4
Community of Inquiry	4
Metaverse in Education	4
Education	3
Games	3
Graphics	3

Table 1 Top ten ranked subject breakdown of hits for search 1:

1. EBSCOHOST for TITLE: Metaverse
   TITLE: Taxonomy
   Find all search terms. Full text. Peer reviewed.
   Hits after removal of duplicates: 8 These comprised academic journals and conference materials
   Produced the date range 2022-2023 only

2. EBSCOHOST for TITLE: Metaverse
   TITLE: Challenges
   Find all search terms. Full text. Peer reviewed.
   Hits after removal of duplicates: 84
   These comprised academic journals and conference materials Timeframe: Jan 2023 – July 2023

Discussion of Key Literature

Ritterbusch, G. D. and M. R. Teichmann (2023) Defining the Metaverse: A Systematic Literature Review. IEEE Access, vol. 11, pp. 12368-12377. doi: https://ieeexplore.ieee.org/document/10035386

Methods:

Using a Systematic Literature Review approach, (Ritterbusch & Teichmann, 2023) extracted 28 definitions from a focused initial search of 364 texts, weighting definitions in order of time relevance, with lowest relevance to those before 2011 and most relevance (x 3) to those between 2017 and 2022. These texts were extracted from a search of WebofScience, JSTOR, Wiley, and Association for Information Systems eLibrary (AIS). The authors' recommendations below forms part of the research methodology of this report in seeking out definitions of the metaverse/s from multiple perspectives:

> *"[T]here might not be a common consensus between the scientific and the corporate view of the Metaverse, which in turn opens new research questions. For this purpose, researchers could investigate which large companies are currently working on Metaverse projects and how these companies understand the term Metaverse."*

Not only do opinions differ by sector – such as academic versus industry – they also vary by discipline, such as medicine, the arts, or gaming, as this report reveals in its focus group discussions.

Analysis:

Varied and ever evolving definitions of the metaverse over time make it a slippery concept to reach consensus upon; a point raised by Ritterbusch and Teichmann, among other authors (Uddin et al., 2023; Weinberger, 2022). Indeed, Weinberger acknowledges that his own carefully derived definition will, most probably, "be outdated after a while".

This meaning obsolescence is due, in part, to the fact that metaverse definitions are currently "perceived differently by different stakeholders (Ritterbusch & Teichmann, 2023)". Metaverse may in some cases be pluralised (Kumar et al., 2008) or in the singular (Duan et al., 2021), or a mixture of both (Davis et al., 2009). Ritterbusch and Teichmann come down on the side of a move towards a singular vision of the metaverse, at least by definition, stating that its design appears to be "moving more towards inclusivity, i.e., the creation of perhaps a single large Metaverse with a powerful interaction dimension" and that it is essentially "the next generation of the internet", a point echoed by authors including (Koohang et al., 2023a), (Weinberger 2022), and (Uddin et al., 2023). Ritterbusch and Teichmann posit that one defining feature is that it is "walkable". Crespo-Pereira et al have observed that contemporary definitions of metaverse "tend towards a confluence of technologies (e.g. immersive, 3D technologies) in shared virtual worlds." (Crespo-Pereira et al., 2023). These authors concur that a singularised metaverse is the vernacular preference among scholars "without the singular term implying the conception of the metaverse as a single entity."

In a similar vein, Ritterbusch and Teichmann's descriptions of their search methodology reveals the challenges of seeking out a consensus definition via the scholarly literature. The term "metaverse" may encompass many facets, many of which are not uniformly agreed upon, or are considered to relate to a specific part of metaverse infrastructure and not of the whole, "cyberspace" being a key example as reference to the network of information technologies underpinning its myriad virtual worlds. Goldberg and Schär caution that the term "metaverse" has a tendency to be used synonymously with other concepts such as "extended", "virtual" and "augmented reality" when in fact these applications are not exclusive to metaverse platforms. (Goldberg & Schär, 2023). Orthogonal technologies can also muddy the waters when they are lumped in with metaverse, including approaches such as Web3, or the IoT (Internet of Things).

Also tacitly espoused here is the sense that the metaverse cannot be defined with authority because it is too nascent; it has not yet arrived: "From the social viewpoint, it may be necessary to investigate how the underlying social framework should be designed so that a Metaverse *could become feasible*, by making the Metaverse accessible to as many users as possible" (italics added). This point is similarly articulated by *Metaverse* author Matthew Ball and Markus Weinberger, the latter noting in 2022 that metaverse was still considered to be in its "infancy". (Ball, 2022; Weinberger 2022).

For the metaverse to be fully realised, Weinberger and Gross have identified eight core attributes with five maturity levels (ML) required to imply a "complete metaverse". Their core attributes relate to the qualities of Persistence, Synchronicity, Scalability, Physical and Digital Coexistence and Interoperability. (Weinberger & Gross, 2023).

Weinberger, M. (2022).
What Is Metaverse?-A Definition Based on Qualitative Meta-Synthesis.
Future Internet, vol. 14 (no. 11) pp. 310.
https://doi.org/10.3390/fi14110310

Methods:

Weinberger's approach to a review of the literature on metaverse definitions is a logical one given the broad range of categories and voices that fall under the capacious metaverse umbrella. Weinberger's study:

> *"applied an adapted version of the meta-synthesis method to analyse the existing literature and distil a proposal for a Metaverse definition. The adapted method takes the nature of the subject into account by weighing younger publications with many citations over older, less influential documents." It also sought to "to keep the voice of the original text alive rather than just calculating abstract data." (Weinberger, 2022).*

The search produced an initial 47 publications from Web of Science and Google Scholar, 24 of which remained after primary analysis.

Analysis:

Weinberger proposed the following definition based on a synthesis of the analysed texts:

> *"The Metaverse is an interconnected web of ubiquitous virtual worlds partly overlapping with and enhancing the physical world. These virtual worlds enable users represented by avatars to connect and interact with each other, to experience and consume user-generated content in an immersive, scalable, synchronous and persistent environment. An economic system provides incentives for contributing to the Metaverse." (Weinberger, 2022).*

This definition was derived from key, recurrent topic clusters gleaned from the literature search, such as: interoperability; virtual worldbuilding; ubiquity; use of avatars; a sense or realisation of persistence; social connection and interaction; user-generated content; monetary incentives (implying an economic system); user immersion; scalability and real-time synchronicity.

Koohang, A., Nord, J. H., Ooi, K.-B., Tan, G. W.-H., Al-Emran, M., Aw, E. C.-X., Baabdullah, A. M., Buhalis, D., Cham, T.-H., Dennis, C., Dutot, V., Dwivedi, Y. K., Hughes, L., Mogaji, E., Pandey, N., Phau, I., Raman, R., Sharma, A., Sigala, M., … Wong, L.-W. (2023).
Shaping the Metaverse into Reality: A Holistic Multidisciplinary Understanding of Opportunities, Challenges, and Avenues for Future Investigation.
Journal of Computer Information Systems, 63(3), 735–765.
https://doi.org/10.1080/08874417.2023.2165197

Methods:

The authors employed a "multi-perspective approach". Their study offers a very broad, ostensibly global overview of the opportunities, challenges and research agenda for several key industries: marketing, hospitality, tourism, the industrial metaverse, manufacturing operations management, the education sector, retail, banking, healthcare and Human Resources.

Analysis:

(Koohang et al., 2023a) agree with (Duan et al., 2021; Ritterbusch & Teichmann, 2023; Weinberger & Gross, 2023) that the metaverse is the next incarnation of the internet:

"Metaverse is a virtual platform that uses extended reality technologies, i.e. augmented reality, virtual reality, mixed reality, 3D graphics, and other emerging technologies to allow real-time interactions and experiences in ways that are not possible in the physical world."

The overarching opportunity from these authors' perspective is that a fully-functioning metaverse has the potential to offer new business models and be a "disruptive opportunity for brands to engage with customers at a completely new level of interaction—one that is unachievable within current marketing channels and existing platforms." (Koohang et al., 2023a). Pietro De Giovanni cites the "incredible opportunities" for sustainable economic growth within the metaverse, such as within the fashion industry. Allowing online consumers to virtually try on products before they decide to buy provides a testing ground for new prototypes, potentially limiting production waste as it "activates the production systems only when goods are really needed."

(De Giovanni, 2023). De Giovanni caveats this by noting that the metaverse is compute-intensive requiring large amount of storage and power thus leading to increased energy consumption and emissions. Jauhiainen et al agree that an emissions offset needs to occur between the energy savings made possible by the metaverse and the energy output required to implement it, through cooling its servers and sourcing the natural materials for its hardware. They make the recommendation that it might be "more efficient to have a small number of metaverses, instead of thousands of metaverses developed by a very large number of organisations." (Jauhiainen et al., 2022). This does raise its own issues, however, in that it potentially centralises power within those platforms upon which the metaverse is built and facilitated (Goldberg & Schär, 2023).

Metaverse is well placed to offer sustainable opportunities to transform users' lives by shifting everyday activities and interactions into the virtual realm, perhaps the most impactful of these being activities related to travel and tourism, and health. From the point of view of a healthcare metaverse, users "could access medical services based on digital representations of life-signs monitoring to seek guidance, referral, or next stage intervention" (Koohang et al., 2023a). The opportunities for virtual travel and tourism clearly present a positive use case for the metaverse when viewed through the lens of inclusivity and sustainability. Virtual tourism has the potential to offer a viable alternative to conventional travel to people with access issues or on low incomes. It served as a useful market stopgap when the Covid-19 pandemic made conventional travel unfeasible. Authors note that virtual tourism does not need to be a complete replacement but can operate as a complimentary hybrid in concert with in-person travel or events such as weddings or business meetings (Koohang et al., 2023a). Metaverse applications may also be beneficial to users on the neurodiversity spectrum or who struggle with face-to-face social interaction (Hutson, 2022) though more scholarship is needed to fully determine the true benefits or harms. A search conducted for this literature review using the title term "Metaverse" and abstract term "autism" with no other limiters on the EBSCHOST database produced only 3 non-duplicate results (Cerasa et al., 2022; Hutson, 2022; J. Lee et al., 2022). Similarly, a basic keyword search for "metaverse + neurodiversity" produced 25 results, only 7 of which were academic journals.

Lu and Mintz agree that metaverse certainly offers a new frontier of opportunity for consumers, influencers and brands alike, but temper this optimism with caution concerning the metaverse's "potential number of active users, types of engagements offered, and types of new products and industries that may succeed". They suggest that "significant uncertainty" exists around the level of consumer adoption expected as well as concerning development of the metaverse infrastructure, and pace of technological innovation (Lu & Mintz, 2023).

The key challenges Koohang et al and Lu and Mintz both raise centre around issues of trust, data privacy and governance. One key concern is the potential for harm to children. Koohang et al highlight a study conducted by the The Center for Countering Digital Hate (CCDH) in which researchers "spent many hours on Oculus and VR Chat posing as minors and identified that users experienced at least one instance of abusive behaviour every seven minutes." This abuse was not insignificant, including "graphical sexual content, bullying, racism, and threats of violence." (Koohang et al., 2023a). Kou and Gui make the salient point that user-generated virtual worlds (UGVWs) add an extra dimension to problems of online moderation in that they contain more than just static text and images, Roblox being a prominent example: a game "targeted primarily at child players…notorious for harmful user-generated games such as Nazi roleplay games and gambling-like mechanisms. "(Yobu Kou & Xinning Gui, 2023). Microtransactions such as the use of "Loot Boxes" – where players pay a monetary charge to receive a mystery item of uncertain value – encouraged "addictive and reckless spending behaviour" among players, and were referred to by one user in the study as "gambling for children". Kou and Gui argue that in order to protect users from harm, instead of relying on content moderation as Roblox has previously done, a design moderation approach should be employed, defined here as "a set of governance strategies to foster benign UGVW designs while inhibiting harmful design patterns." (Kou & Gui, 2023).

Uddin, M., Manickam, S., Ullah, H., Obaidat, M., and Dandoush, A., Unveiling the Metaverse: Exploring Emerging Trends, Multifaceted Perspectives, and Future Challenges. IEEE Access, https://doi.org/10.1109/ACCESS.2023.3281303

Methods:

The authors conducted a search for relevant secondary texts as per systematic literature review (SLR) and hybrid-narrative literature review techniques. They excluded: "articles that were not pertinent, including those discussing VR hardware or software, prefaces, invitations to submit papers, special issue introductions, and book evaluations." Databases searched included ScienceDirect; ResearchGate and IEEEXplore.

Analysis:

Noting the difficulty of defining the metaverse, these authors provided synthesised interpretations gleaned from their review of the literature (Ananya Babu & Mohan, 2022; David Grider & Matt Maximo, 2021; Nikolaidis, 2007; Ning et al., 2021; Owens et al., 2011; Schroeder et al., 2001). While not as fullsome, these definitions concur with and overlap Weinberger's own synthesised taxonomy; utilising key terms such as "immersive," "avatars", and "virtual world" and an acknowledgment that the metaverse would have its own economy or system or trade. There is this recurrent motif of metaverse as the next generation of the internet (Koohang et al., 2023a; Uddin et al., 2023; Weinberger, 2022) and of it being a "fully-enveloping" digital space in which "in which physical and geographic peculiarities of the physical world are mimicked and modelled" (Schroeder et al., 2001). (Crespo-Pereira et al., 2023) agree that the metaverse can be thought of as a "parallel universe", concurring with Lv et al who argue that the Metaverse "parallels the physical world and is a virtual world exactly like the physical world" but one which can incorporate both online and offline realities. (Lv et al., 2022)

This consensus that the metaverse will be modelled on, and recreate real-world environments and interactions moderates slightly the perception of the metaverse as "a fresh frontier of the internet that provides a unique environment where individuals can interact and create in a completely new and exciting way" (Uddin et al., 2023). Rather than reinventing the wheel in terms of human behaviour and interactions, this impetus to entice the public into the immersive realm may take a more prosaic form. The authors' consideration of Metaverse Seoul's initiative to create "a virtual ecosystem of communication for various municipal administrative fields, including culture, tourism, business, education, and public service," suggests that the metaverse/s may entice users to mass adoption by making it a key access point for pre-extant products and services (Rincon Soto & Sanchez Leon, 2022) (Uddin et al., 2023).

Uddin et al's model for metaverse evolution forecasts an eventual – but still not entirely divorced-departure from real world modelling via 3 steps, developing from an initial baseline of digital twin clones, through to a "digital native" stage where new, exclusively digital ideas are created, and finally a "surreality" stage where the metaverse: "reaches its full potential, evolving into a robust and self-sufficient alternate reality that seamlessly blends with and incorporates elements of the physical world." Yet even here the real world is still integral, and this vision may feel more like an AR overlay as opposed to full 3D immersion via headsets.

Uddin et al have created a theoretical framework for understanding the metaverse and its potential applications based on a three-layer architecture of interlocking realms: the virtual world, the physical world, and the intersection between these. There are branching subcategories: Ecosystem, interaction and Infrastructure, which in turn lead to further tiers. While this model is underexplored in the article, additional case studies are examined based on prototype applications within gaming, social experience, education, and health care.

The authors envision the architecture of the metaverse as underpinned by five key thematic areas: society, the physical world, interlinked virtual spaces, metaverse engine, and inworld data transfer. They view its underlying technologies or enablers as: interconnectivity, digital twins, networking technologies, and blockchain, a vision shared by (Vadlamudi, 2022), but with the inclusion of AI as a metaverse enabler.
Uddin et al view the key challenges to metaverse as:

1. Technical and hardware limitations;
2. Lack of standards and regulations, including concerns around security and privacy such as identity theft;
3. Physical and mental health implications;
4. Concerns around digital currency and payments;
5. Sustainability, and the concept of a "Green Metaverse".

These authors also note several key threats to internet security that are applicable to safeguarding metaverse: Distributed Denial of Service Attacks (DDoS) could make networks or services unavailable. Sybil Attacks could use "stolen or impersonated identities" to block or otherwise impact voting services. As a Single Point of Failure, centralized metaverse architecture reliant on cloud technology is a vulnerability open to attacks and one which "raises trust and transparency challenges in the trust-free exchange of virtual goods, virtual currencies, and digital assets across various virtual worlds in the Metaverse." (Uddin et al., 2023) Other, more pervasive "social engineering" threats were raised; the authors mention:

> *"psychological manipulation techniques to have avatars/users provide and disclose some sensitive information…Threat actors can penetrate the Metaverse to compromise the identities of users, which is very difficult with the lack of legislation for law enforcement to intervene."*
>
> (Uddin et al., 2023)

For more on metaverse cybersecurity risks see (Chow et al., 2022; Gupta et al., 2023; Pooyandeh et al., 2022).

Privacy in the metaverse is key concern centred around the transmission and collection of personal data including user's habits, preferences and location information. Uddin et al here explore these risks through the frame of "data leaks". Potential data leaks can occur when: information is in transit; within the cloud/edge storage; hacked/compromised end devices e.g. wearable sensors or VR glasses; data being processed e.g. data aggregation and collection which occurs as virtual world experiences are loaded for the user; pervasive data collection e.g. for avatar profiling. On this point, Virtual Service Providers (VSP) can provide a point of vulnerability and open-up the potential for user harm. They require real-time access to user's profile/avatar information which may include biometrics and speech patterns as well as movement and location tracking. There is the potential that nefarious VSPs "may engage in unauthorized access to this information through malicious means, such as exploiting buffer overflow vulnerabilities or tampering with access control lists, to monetize the data." (Uddin et al., 2023)

Park, S. M., and Kim, Y. G., (2022)
A Metaverse: Taxonomy, Components, Applications, and Open Challenges,
IEEE Access, vol. 10, pp. 4209-4251,
https://ieeexplore.ieee.org/document/9667507.

Methods:

Park and Kim utilized a systematic literature review (SLR) searching for keywords such as "Metaverse, Avatar, Extended Reality". 260 papers were analysed sourced from databases including Elsevier and Google Scholar. Their multi-layered conceptual model of the metaverse comprises an examination of key concepts which their study explores in detail:

1. Metaverse concepts/keywords: metaverse, avatar, extended reality
2. Metaverse components: hardware, software, contents
3. Metaverse approaches: user interactions, implementations, applications
4. Metaverse case studies: Ready Player One, Roblox, Facebook Research
5. Discussion and Open Challenges: Influences, limitations, open challenges

The study also provides charts offering an overview of literature in these key thematic areas, an extensive bibliography and a comprehensive glossary of technical acronyms.

Analysis:

This broad-ranging and comprehensive paper provides a fascinating overview of the developing metaverse framework, analysing its many building blocks and functions-particularly from a more technical standpoint. It also provides a useful reference for exploring the secondary literature thematically. This study is much broader in scope than others discussed here, and has frequently been used as a reference point for other work (Crespo-Pereira et al., 2023; Far et al., 2023; Roy et al., 2023).

Park and Kim note the barriers and harms posed by the physical effects of using fully-immersive technologies. These can range from more temporary issues such as motion sickness, and poor hygiene from prolonged headset use, to physical fatigue, movement injuries and seizures. Given that Metaverse is based on a "separation from reality but depicts the fact that virtual damage is done to the real world" issues with perception of space and self can lead to accidents

in the metaverse being mirrored in real life (e.g. falling off a chair) and even reliance or addiction on virtual reality experiences to the point where they cause users to lose touch with external responsibilities or realities. While only a hypothetical argument, authors use the example of a character in Ready Player One using money for his rent to pay for an upgraded haptic suit. (S.-M. Park & Kim, 2022)

These sets of physical and behavioural concerns have been highlighted elsewhere including (Tseng et al., 2022)'s study on "The Dark Side of Perceptual Manipulations in Virtual Reality" and (Barreda-Ángeles & Hartmann, 2022) research into virtual reality users' addiction prevalence. (Dwivedi et al., 2023) analysis of negative societal impact of metaverse offers a robust overview of many of the key threats and challenges around: privacy and security; social inclusion, and mental health and wellbeing, sexual harassment; and the threats to children and young people. (See also: (Mystakidis, 2022).

The concluding section of Park and Kim's study is lacking in recommendations or adequate summation, instead, conclusions are dotted throughout. The authors argue that metaverse research has largely focused on "social meaning" at the expensive of exploring its underpinning technologies. Due to its wide scope, what the metaverse needs to fully develop or what it may be capable of, is currently poorly understood. In order to address these gaps, interdisciplinary research and collaboration which incorporates considerations of more technical requirements of the metaverse with input from psychology and the social sciences is recommended (S.-M. Park & Kim, 2022). These recommendations are echoed in part by (Crespo-Pereira et al., 2023) who, while in agreement that there is a "considerable amount of work" to be done by the social sciences and neurosciences point out these fields may be not now be as dominant as Park and Kim suggest, when compared to other STEM fields. As of July 2022, their database search for literature on SCOPUS found the highest number of applicable publications on metaverse were in Computer Science at 264 texts, followed by 115 in Engineering topics, then 88 in Social Sciences. Neuroscience were bottom of the table with only 4 relevant publications. Crespo-Pereira et al note the exponential growth of scholarship on the metaverse from 2022 revealing that "nearly 50% of all of the publications since 1995 have been concentrated in just the first six months of 2022." (Crespo-Pereira et al., 2023).

Conclusion

There currently exists a scholarly consensus that the metaverse (singular or plural) is too complex, emergent and disparate an entity to define neatly. Certain key words and concepts are recurrent within existing definitions of the metaverse, although these are suitably broad and interpretable terms such as "avatar"; "immersion"; "virtual world"; and "interoperability". Authors' optimism centres around the sustainable economic potential and accessibility opportunities the metaverse's virtual worlds might afford. These boons are offset, however, by concerns about governance, data privacy and safeguarding, particularly of children with regards to bullying, sexual harassment and the potential for metaverse applications to promote antisocial, or addictive tendencies.

Researchers examining the current architecture and underpinning technologies of the metaverse frequently use multi-tiered models interlocking technical aspects with social considerations. While these models iterate core attributes such as interoperability and persistence, there is a sense of repetition rather than augmentation. Greater attention could be given to probing their assertions, such as advocating for blockchain as an essential component for a metaverse economy. More literature is required on the means by which the metaverse can reach its full technological potential. Greater interdisciplinary work and knowledge exchange between the broader sciences and humanities is also currently recommended to fully grasp the evolving realities of the metaverse–beyond the hype-and to understand how society will respond and be impacted. One way in which these gaps in understanding might be addressed is in more concerted collaborative efforts to collate and refine disparate, sector-specific attempts at creating metaverse taxonomies. Such an effort could ensure a comprehensive and replicable framework of development which seeks to embed sustainable, and ethical practices within the emerging metaverse, by design and not as an afterthought.

MARKET PULL?

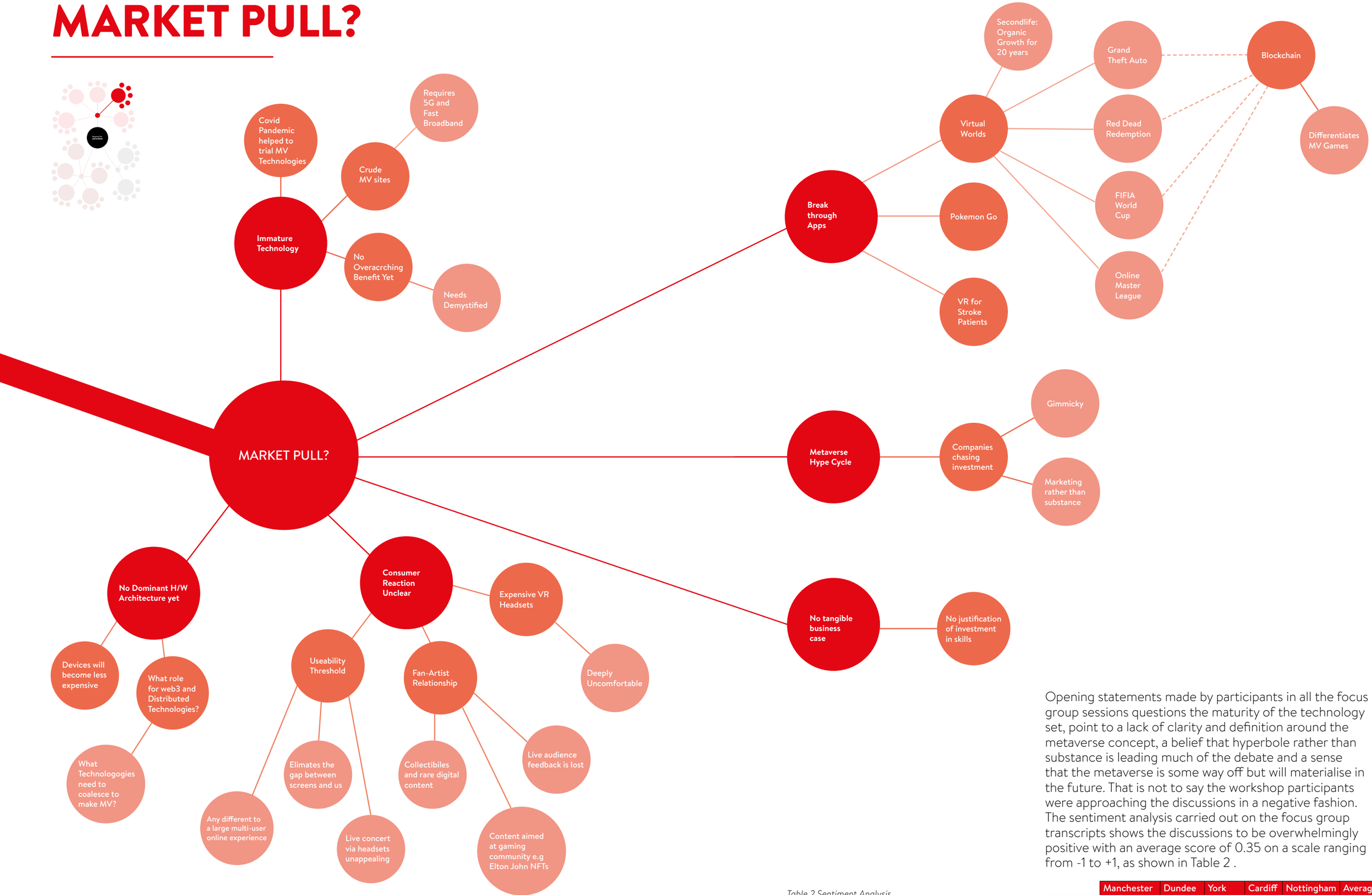


Figure 5 Shaping the Metaverse Mind Map – Market Pull?

Opening statements made by participants in all the focus group sessions questions the maturity of the technology set, point to a lack of clarity and definition around the metaverse concept, a belief that hyperbole rather than substance is leading much of the debate and a sense that the metaverse is some way off but will materialise in the future. That is not to say the workshop participants were approaching the discussions in a negative fashion. The sentiment analysis carried out on the focus group transcripts shows the discussions to be overwhelmingly positive with an average score of 0.35 on a scale ranging from -1 to +1, as shown in Table 2 .

Table 2 Sentiment Analysis of Focus Group Transcripts

	Manchester	Dundee	York	Cardiff	Nottingham	Average
Sentiment	0.354	0.3064	0.3542	0.405	0.304	0.3446

Focus Group Insights

M-1-1. MV is still very theoretical and there is no immediate industry pull for skills such as content editors or story tellers. A sense that it will come, but at the moment there is no tangible business case for organisations to invest in MV skills.

M-1-2. One example offered is a forward-thinking digital team who created a MV interactive fan zone site. Most striking was the crudeness of the experience and a sense that the technology is not there yet. Not at prototype stage yet.

M-1-3. On the other hand, basic, accessible, easy-to-use tool chains will allow early adopters to experiment and get a sense of the potential of MV. Entice people to be part of it.

M-1-4. There is a lot of hype around the MV because there are a lot of companies trying to attract investment and sales. There is a danger that the hype will be taken as reality by some people.

M-1-5. Consumer reaction to MV is not clear yet. VR headsets are high-end products priced at the same level as laptops or tablets. Will consumers and businesses invest in these in the same way that handsets (smart phones) have become essential to daily life?

M-1-11. The Pokémon Go example shows how technology such as AR and maps could reach beyond the gaming community and enter popular culture (for a short time). It is an interesting template for developing retail opportunities. Not sure why it has not taken off.

M-1-12. Games like Grand Theft Auto, and Red Dead Redemption are big open worlds, they are effectively MVs. The FIFA games have an online master league where you can earn cards (NFTs) that allow users to buy bonus packs etc.

M-1-13. Games should be connected to a blockchain – that would differentiate them as MV experiences rather than existing video/AR games that do not use Web3.

M-1-25. User comfort is a big issue both in hardware and software terms. VR headsets are deeply uncomfortable. They are getting incrementally better, but it is slow progress. It feels like some of this technology has not progressed much beyond 3-D glasses at the cinema.

M-1-26. My mum uses an iPad, Netflix and on-demand streaming services but that is because they have been designed for a mass audience and they work really well. There is a big useability threshold for MV to achieve.

M-1-27. Large groups of people in one place all wearing headsets seems like a weird thing to do – like a silent disco.

M-1-28. A concert experience presented live on the MV and attended by people from all over the world wearing headsets is not something that I would refer to do in comparison to going to a concert with your friends and seeing an artist face to face. We are a long way from doing that successfully on MV. Will MV seek to replace or complement that experience? A lot of development activity is about replicating physical experiences and not doing it well enough.

M-1-29. Live concerts will not be replaced as such but consider the gaming community who spend a lot of time in virtual worlds already. Providing content that they can interact with while they are in a virtual world seems like a sensible proposition e.g., Roblox and Elton John promotional material. That material does not need to be fully VR immersive and concert attendance will not go down because of it.

M-2-4. We have not proved that there is any sort of overarching benefit yet.

M-2-5. There is a major question about how a lot of this is going to be used.

M-2-6. The hype can be damaging-people will over expect.

M-2-7. If you scratch under the surface, it is marketing rather than natural substance.

M-2-14. In terms of the direction of broader discussions about the Metaverse, it is gimmicky.

M-2-15. The term is inaccessible – it needs to be demystified.

M-2-27. Just before the pandemic we started a clinical trial with stroke survivors in the local hospital using the VR and we were nervous about taking these VR headsets into the hospitals. They tended to be people of an elderly generation who have had a stroke, not used to using computer tech. We were really surprised how open they were to use this technology. It really shows that they were eager to embrace this technology.

M-2-29. The pandemic was a good opportunity to explore stuff you could never imagine doing through that sort of interface, like live music, although people have watched live streams before. But this is large scale and that helped to push the technology on.

M-2-41. Is the Metaverse fundamentally any different to a large multi-user online experience?

M-2-47. There is a lot of money to be made.

D-1-2. There was a backlash following Facebook's announcement of the Meta brand. Concern that Facebook wants to own the MV for all people and all places. This has led to widespread cynicism.

D-2-1. MV concept is not defined. It means different things to different people. There needs to be a little bit of convergence on that, so we are talking the same language.

D-2-2. We have no idea 10-15 years down the line what MV is going to look like or how it will operate. It depends entirely on the emerging technologies.

D-2-4. The MV will be part-physical, part-digital but tangible.

D-2-5. It is like the term games. You will know a game once you see it, but you cannot really define it any more tightly because it encompasses everything.

D-2-7. The ultimate user experience is not going to be mediated using a screen. So, what will it be?

D-2-11. The MV is vague in nature, but the lack of precise definition helps, because the MV is going to become cross-sectoral. It is not just the creative industries; it is not just the screen. It is going to be ubiquitous.

D-2-37. It is all emerging technology. It requires ubiquitous broadband or 5G. It requires very high-end technology, expensive technology. It is currently controlled by a small number of tech giants.

Y-1-3. No way to force someone into the MV. There is nothing in the MV now that makes people need to use it – or even want to use it. There are compelling use cases and artists are excited about the prospect of reaching new audiences and improving accessibility, but companies do not know how they are going to monetise it.

Y-1-4. The companies building the platforms only see big name artists, concerts, branded content as the way forward but Second Life has been growing organically for 20 years because users were not being told what to do on the platform and they found their own ways to build it and make it relevant. Hence, we should make content that is high quality and users will don their headsets.

C-1-4. MV feels like a product that has been released too early.

C-1-5. It has not actually found its final form yet. It is a collection of "stuff", a coalescing of disparate technologies that will form something that eventually becomes coherent.

C-1-8. Kevin Kennedy says tools are an extension of ourselves and that is what makes the metaverse potentially amazing. It will do in a 3D space what the internet did in a 2D space. It will eliminate the airspace – the gap between us and the screen.

C-1-9. MV will be when we take that space away and there is no gap between the physical and the digital. The walls do not exist. Instead of me going to see something, things should come to me.

C-1-18. We are not sure what the technologies that need to come together will be.

C-1-20. Parts of the technology are not good enough-there are technology leaps that need to happen to progress this.

C-1-21. Someone needs to pull their finger out and get AR to work properly. Magic Leap is brilliant, but then after a while it doesn't work, and after 10 minutes AR gives you a headache.

N-1-43. Will the metaverse make things worse than where we are currently? It will, but are there constraints that can be designed into the system early on that could help?

N-2-82. You bought your train ticket on the Internet. You might find your way around using Google Maps. So, this is the relationship, MV is the thing that sits above or below depending on your perspective theologically. That architecture is a sort of film that sits over reality.

Supplementary Research

Some of the definitions offered by participants are quite insightful:

1. MV is a sort of film that sits over reality;
2. MV will be part-physical, part-digital but tangible;
3. MV will do in a 3D space what the internet did in a 2D space;
4. MV will eliminate the … gap between us and the screen;
5. MV is a collection of "stuff", a coalescing of disparate technologies that will form something that eventually becomes coherent.

They accurately reflect the metaverse definitions given below in a survey of metaverse organisations and commentators.

The metaverse is a nebulous term. It is used and misused resulting in as many loose definitions as there are players trying to deliver their interpretations of the metaverse vision in a competitive landscape.

> *I recently attended a Metaverse/Web 3.0 conference in Santa Clara put on by the Economist Magazine. My comment at the time was if you asked 100 people at the conference to define the Metaverse, you would get 200 answers [not a typo!].*
> Anecdote from Ex-Apple/Magic Leap Employee

The term does not neatly refer to any one specific technology, but rather a speculative paradigm shift in how we interact with technology. It is entirely possible that the term itself will become redundant even as the specific technology it once described becomes commonplace e.g. the information super highway.

To complicate things further, the affordance of the technologies and medium will be different depending on the agency constraints of the sector or technology that players are working within and the metaverse will only be declared "real" when their specific requirements for their vision of the metaverse hold true. For example, those working with Web3 technologies will require decentralisation to be a core feature of the metaverse, fashion brands will insist avatar technologies are critical components, hardware manufactures will require smart phone levels of adoption of headsets etc.

The final challenge in defining the metaverse revolves around the perception of the pace of technology change with many references to the fast-moving nature of the technology during our consultations. However, it could be argued that technology change is somewhat predictable, but it is rather the breadth of the technologies involved in the realisation of the metaverse and the unknown nature around the use cases of the convergence of these technologies that are proving harder to define.

We have been working under the assumption that the 'maximalist paradigm' of the metaverse is:

> *A 3D digital layer of human existence of massively scaled and interoperable network of real-time rendered 3D virtual worlds which can be experienced synchronously and persistently by an effectively unlimited number of users with an individual sense of presence, and with continuity of data, such as identity, history, entitlements, objects, communications, and payments.*

However, given the lack of consensus on the Metaverse and the technical challenges and time horizon to achieve a maximalist vision an alternative realist definition or our preferred definition is:

> *Metaverse is the convergence of spatial computing (VR, XR, MR), digital twins, virtual worlds, Game Engine Technologies, 3D avatars, web3 and other technologies driven by social attitude changes towards decentralised control of identity, social networks and commerce that are attempting to solve problems with the existing Web 2.0 paradigm.*

The definition is less important than the perceived effort to redefine the internet based on our proto-Metaverse experiences where the current state of the art has maximised the benefits of existing technologies, protocols and standards, which has highlighted the need to develop new ones to realise this maximalist viewpoint.

Metaverse Definitions

To support our view on the Metaverse we have gathered some of the definitions from thought leader's, researchers and standards development organisations on the paradigm, which represents a broad range of terms and definitions with significant overlapping consensus.

From Matthew Ball a Framework for the Metaverse:

> *"The Metaverse is a massively scaled and interoperable network of real-time rendered 3D virtual worlds and environments which can be experienced synchronously and persistently by an effectively unlimited number of users with an individual sense of presence, and with continuity of data, such as identity, history, entitlements, objects, communications, and payments."*

From the World Economic Forum-Defining and Building the Metaverse:

> *"The metaverse is a future persistent and interconnected virtual environment where social and economic elements mirror reality. Users can interact with it and each other simultaneously across devices and immersive technologies while engaging with digital assets and property"*

From the Open Metaverse Foundation:

> *The Metaverse is generally considered to be the 3D successor to the Internet. A single and universal immersive experience that can be experienced by any device and anywhere and consists of networked virtual worlds. Many say that VR headsets and AR devices are required to experience the Metaverse but it is most likely that it will be experienced on any 2D or 3D device. There is also an emphasis on social connections and the concept of a new digital virtual metaverse economy. The word Metaverse is often preceded by 'the' and with an 'M' capitalized to denote the one and only Metaverse in-line with Neal Stephenson's original concept and writings.*

From Dr. Louis Rosenberg (Rosenberg, 2022a)

> *Regulation of the Metaverse: A Roadmap: A Metaverse is a persistent and immersive simulated world that is experienced in the first person by large groups of simultaneous users who share a strong sense of mutual presence. It can be a fully virtual environment (i.e. a Virtual Metaverse) or it can exist as layers of virtual content overlaid on the real world with convincing spatial registration (i.e. an Augmented Metaverse) [12].Virtual Reality (VR) is an immersive and interactive simulated environment that is experienced in the first person and provides a strong sense of presence to the user [13]. Augmented Reality (AR) is an immersive and interactive environment in which virtual content is spatially registered to the real world and experienced in the first person, providing a strong sense of presence in a combined real / virtual space*

From the Extended Reality Safety Initiative (XRSI):

> *XRSI defines the Metaverse as "A network of interconnected virtual worlds with the following key characteristics: Presence, Persistence, Immersion and Interoperability. Metaverse is the next iteration of the internet enabled by several converging technologies such as Extended Reality (XR), Artificial Intelligence(AI), Decentralized Ledger Technologies(DLTs), neuro-technologies, optics, bio-sensing technologies, robotics, improved computer graphics, hardware, and network capabilities."*

The four key characteristics are defined as follows,

1. ***Presence*** *refers to the feeling of being present or physically located within a digital environment. By simulating realistic sensory experiences and enabling participants to interact with objects and other participants, it creates a sense of immersion and engagement within the virtual world as if they were in the same physical space.*
2. ***Persistence*** *refers to the ability of virtual objects, environments, and experiences to persist over time, even when participants are not actively interacting with them. Persistence allows participants to make progress, own virtual property, and build ongoing relationships; virtual worlds can provide individuals with a sense of investment and long-term engagement within the digital environment.*
3. ***Immersion*** *refers to the degree to which a participant is fully engaged and absorbed in a virtual environment, to the point where the individual may forget about their physical surroundings. It can be achieved by creating an environment that feels believable and responsive to participant's actions and inputs, through the use of various technological and sensory inputs, such as virtual reality (VR) headsets, haptic feedback devices, and 3D audio.*

4. ***Interoperability*** *refers to the ability of different virtual worlds and systems to communicate and interact with each other seamlessly, allowing individuals to move freely between different digital environments and experiences. In the context of the Metaverse, interoperability is essential for creating a cohesive and interconnected virtual world that allows individuals to seamlessly move between different experiences and platforms.*

From the IEEE Metaverse Standards Committee:

"Demystifying, Defining, Developing, and Deploying the Metaverse" The scope of the Standards Committee is to develop and maintain standards, recommended practices, and guides for metaverse, virtual reality and augmented reality, using an open and accredited process, and to advocate them on a global basis. Its technical scope is intended to be flexible and is ultimately determined by the sum of its approved PARs. Metaverse refers to a kind of experience in which the outside world is perceived by the users (human or non-human) as being a universe that is built upon digital technologies as a different universe ("Virtual Reality"), a digital extension of our current universe ("Augmented Reality"), or a digital counterpart of our current universe ("Digital Twin").

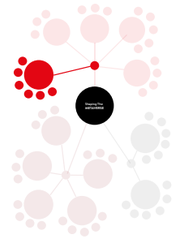
From the Open Geospatial Consortium:

There are many interpretations of what the metaverse may be, but the widest agreement sees the metaverse as the internet in real-time 3D. The metaverse will comprise of many different interconnected 3D 'spaces' (like 3D websites) operated by different entities that together form the much larger metaverse concept. Just as the internet is only successful because Open Standards allow anyone to contribute a webpage, so too the metaverse will require Open Standards if it's to see widespread adoption and proliferation. Without standards the metaverse will remain a series of apps rather than an open platform. Metaverse spaces will include fabricated virtual worlds as well as ones that are modeled after, or augment, the real world. In the fully realized vision of the metaverse, its spaces will be interconnected, with users being able to cross between them–whether it's to visit a friend, play a game, go shopping, manage a construction project, train for a new job, model a new warehouse workflow, or something else entirely. Further to this, metaverse spaces will be used not just by humans, but also by machines: AI/ML applications can use metaverse simulations of real-world locations to, for example, train autonomous vehicle systems with local knowledge. The metaverse spaces that represent the real world are the most obvious place where geospatial technologies, standards, knowledge, and best practices will play a major role. However, every metaverse space will be a massive database of physical and semantic environments designed for efficient streaming.

From the Metaverse Standards Forum:

The metaverse is motivating the novel integration and deployment of diverse technologies for collaborative spatial computing, such as interactive 3D graphics, augmented and virtual reality, photorealistic content authoring, geospatial systems, end-user content tooling, digital twins, real-time collaboration, physical simulation, online economies, multi-user gaming, and more – at new levels of scale and immersiveness.

METAVERSE TECHNOLOGIES



Due to the multidisciplinary nature of the workshops, there was not a deep dive into the technical aspects that will underpin the metaverse as it was felt by participants that it would be outside the scope of the discussions. There was significant interest in how these technologies could be implemented, particularly in relation to the UK. The discussion themes are mapped in Figure 6.

Figure 6 Shaping the Metaverse Mind Map – Metaverse Technologies

Focus Group Insights

Challenges/Concerns

D-1-36. The kind of firewalls used in our institutions that stop spam coming into our inboxes-I don't know how much of that sifting of information and sensing of malfeasance is going to be possible in the Metaverse. Will it be like the banks who gloss over the cybercrime that takes place today and put up a front – everything is fine, business as usual?

D-1-18. I have played with Meta's Horizon Virtual World platform and found it quite lame. I have played in virtual worlds/games since the age of 12 and I assumed that when the headsets came along that I'd spend all my time in there experiencing incredible things. But I cannot be bothered to sit in the virtual reality headset when I get home after work. I wonder will it be a younger generation who will popularise headsets?

M-1-25. User comfort is a big issue both in hardware and software terms. VR headsets are deeply uncomfortable. They are getting incrementally better but it's slow progress. It feels like some of this technology hasn't progressed much beyond 3-D glasses at the cinema.

D-2-16. In many low-income countries, people buy phones just with Facebook on it and that is their internet platform. That is all they see and that is all they have. Facebook went into the market and made their technology and products cheap. Many countries are lucky to have that choice to opt-in or out of Facebook, but most developing countries do not have that option.

N-2-74. You need to democratise content creation and democratise access. Two very difficult things, but it needs to be easier and simpler to create content. With real time engines you need expertise in programming and engineering etc.. To create for the current Internet, you just need to open up Squarespace and click a template and you can make a website.

D-2-37. It is all emerging technology. It requires ubiquitous broadband or 5G. It requires very high-end technology, expensive technology. It is currently controlled by a small number of tech giants.

D-2-45. Platforms like Apple App Store and Google Play Store are adding an additional tax on developers who want to get their thing on that marketplace. If this is to be a space that is not dominated by the big players, if the creators of metaverses must pay the big players to host content on, or play on, their platform then what will that do to the creative industries? Is the ideal model that 80% of the creators' earnings should go to the platform?

Opportunities/Benefits

N-1-23. Creativity: The digital twin concept is a reproduction of the real world that's going to function in exactly the same way and therefore potentially bake in all the existing prejudices and inequalities. What we want from MV is something that gives us the opportunity to do things differently-that might then feed back into the real world.

D-2-40. The most radical intervention would be to develop open-source hardware, which is not really happening on any meaningful scale right now.

D-2-41. A range of open-source technology could lay a foundation that could make a real shift or a fresh approach to how it all might work.

C-1-74. Everything should be place-based. Centres around the UK, the full ecosystems-hardware, software, the full kit-and allowing those to come in and use it and play with this. Fund playgrounds of different spaces around the UK and allow people to engage with those locations and test and use the equipment.

N-1-5. Not sure what terminology to use-MV or Smart City. The UAE smart cities built so far show major benefits in sustainability. We need similar / strong business cases to invest in city wide DT technology.

N-1-6. There are so many variables in the built environment in terms of scale, height, connectivity to workplaces, greenspaces, services, and heritage that the ability of a digital model to estimate the carbon footprints of alternative schemes becomes really important. This is the justification for investment.

N-1-7. BIM tools already exist and give operational carbon footprints for individual buildings but if all buildings in a district had such a model then we could amalgamate them and build a more sophisticated city wide DT.

Y-1-37. The innovation strategy adopted by companies will have an influence on how the technology is received. OpenAI pushed out ChatGPT for use by everyone whereas Meta is more guarded about its MV technology.

N-1-49. MV is going to give you a totally different experience of using the Internet. The interface technologies will change and evolve. At the moment it's the archetypal VR headset, but that's progressing into augmented reality spectacles right through to neuro-reality where you interface through your own brainwaves. That's technology that's being tested. So it's that kind of invisible layer that speaks to an all pervasive environment. It's seamless and it's invisible and yet it's always there.

Y-2-55. Conventionally when we render a 3D space, we do it with polygons and triangles, and we bounce light around. A NeRF cloud is Points of Light in space. You can light it however you want it, it's almost a LIDAR scan of an area, but once you've got a camera pack, you can build that area, light it. It overcomes traditional 3d Scanning.

Y-2-56. NeRF clouds remove challenges of scanning reflective objects, as they are light points in space. However, once we have NeRF cloud data for an area, you can put a camera in absolutely anywhere, at any time of day, in any kind of lighting. Now put performers in that space and you've got something that's completely different to what we're presenting now on devices. That, I think is the future.

N-2-119. So there is a question for UKRI, they are introducing something called the UK Collective Talent Fund which is trying to shape what doctoral training should be across all the councils. These kinds of meetings are quite useful because this area is such a cross disciplinary activity.

N-2-72. I'd love the NHS to have a high-fidelity digital twin of me. Driven by a smart watch with a full stack of health records that can be picked up and looked at by a doctor. But constantly monitored by a bunch of AI going: You're not well, we should talk to you about this, you should do more of that, you haven't done this. I would love for someone to be preventatively observing my health status instead of waiting until I get poorly before something happens.

Metaverse Technologies Primer

This section provides a brief overview of the foundational technologies that we believe will be an essential part of the creation of the metaverse.

Mixed Reality (Augmented and Virtual)

Extended Reality (XR) is an umbrella term used to describe a collection of technologies including VR (Virtual Reality), AR (Augmented Reality), and MR (Mixed Reality). Collectively and individually these technologies should be considered as underpinning the foundation of the Metaverse.

Virtual Reality (VR) offers users a fully immersive experience as if they have entered a world separate from reality.

Augmented Reality (AR), on the other hand, overlays visual information onto real-world objects to provide additional messages or interactions.

Mixed Reality (MR) is similar to Augmented Reality, but instead of simply superimposing visual effects, it emphasizes the interaction between the virtual and real worlds (Figure 7).

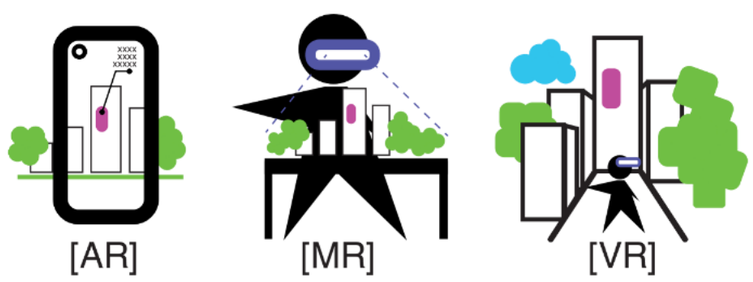


Figure 7 Diagram showing the differences between AR, MR, and VR.

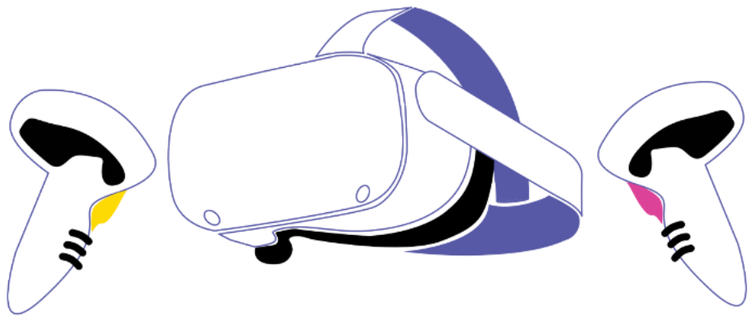


Figure 8 Meta Quest 2 representation. VR headsets typically incorporate a stereoscopic display, which delivers separate images to each eye, along with basic stereo sound and tracking sensors (usually mounted on the head, but some also include eye-tracking), and a pair of controllers for interaction.

Headsets or goggles (like HTC Vive for PCVR or Oculus Quest (Figure 8) as a standalone VR device) have emerged as the primary means of immersing oneself in this world. While holograms offer an alternative solution and AR applications on smartphones also exist, VR headsets currently dominate the market. This trend will likely persist until naked-eye XR technology becomes widely accessible.

The shortcoming of not having crystal clear imagery associated with current VR headsets will eventually be solved with the rapid development of GPUs or use of cloud computing (Nvidia, 2020) to power headsets. Motion tracking will also improve significantly with the assistance of AI, allowing for better movement predictions. However, to achieve a fully immersive experience, other bodily senses besides vision will be required for users to engage and interact more naturally, and this should be the focus of the next XR technological developments.

Key Moments in the Development of XR Technologies Headsets

Since the 1950s, pioneering engineers and technology companies have both inspired and been inspired by renowned science fiction authors to turn this technology into tangible systems. One notable figure is Morton Leonard Heilig, a cinematographer who started developing the Sensorama (patented in 1962)—an arcade-style theatre cabinet from the 1950s that simulated multiple senses using a stereoscopic 3D display, speakers, fans, smell generators, and a vibrating chair. Heilig also invented the Telesphere Mask, the first VR Head-Mounted Display (hereinafter called HMD) (patented in 1960). Another significant contributor is Ivan Sutherland, who, along with his students at Harvard University, created the “Ultimate Display,” the HMD that rendered sequential images based on the viewer’s movements, serving as the foundation for modern virtual reality technologies.

Since then, academic institutions and industry organisations like MIT, NASA, and Nintendo have made notable contributions to the underpinning technologies and user experience of head-mounted displays and conducted experimental trials in this field.

Google achieved a milestone in 2014 by introducing their affordable and accessible solution for entering virtual reality, the Google Cardboard, a cardboard stereoscopic headset for smartphones. This was the same year that Facebook acquired Oculus technology from Palmer Luckey. In 2015, Samsung entered the market with its mobile-connected VR HMD, the Gear VR, becoming a strong competitor. The year 2016 marked a step-change in VR technology with the introduction of well-known VR HMDs such as the HTC Vive, Oculus Rift, and Sony’s PSVR. This trend continued with leading technology manufacturers such as Acer, HP, Asus, and Lenovo developing their own VR HMDs at various price points. After years of collaboration with HTC to co-develop the HTC Vive HMD and implementing the SteamVR hardware and software ecosystem first released in 2015, Valve, the game developer (behind the renowned game distribution service, Steam) also released its first independent proprietary HMD, the Valve Index, in 2019.

While these advancements primarily focused on VR technology, some startup companies like Magic Leap and technology giants like Microsoft sensed the potential of Mixed Reality (hereinafter called MR) in transforming flat-screen surface displays into fully immersive 3D spatial interfaces. Magic Leap garnered attention with the release of their first MR HMD in 2018 but faced financial challenges due to the impact of COVID-19 and high pricing. In 2022, they sought to make a comeback with the release of Magic Leap 2 which has not proved to be successful as of yet.

Microsoft's Kinect camera technology which was initially associated with the Xbox game console, demonstrated the potential of this technology for real-time motion tracking. Recognising the market potential for MR in replacing computer desktop interfaces, Microsoft developed the HoloLens in 2016, targeting industrial manufacturing and professional training applications such as automobile manufacturing, architectural design, and surgical simulations. HoloLens 2 was launched in 2019, although there is no clear plan for the next version yet.

In contrast to Microsoft, Mark Zuckerberg, the founder of Facebook, has retained a strong belief in VR since acquiring Oculus technology back in 2014 and boldly renamed his company Meta in 2021, alluding to the concept of the "metaverse". After achieving significant success building up a social media empire, Meta (formerly Facebook) sought to establish itself as a leader in the VR technology market, both in terms of software and hardware. Through iterations like the Rift, Rift S, and Quest, Meta's Oculus Quest 2 proved to be a commercial success by offering a lower-cost, standalone VR HMD. Meta further expanded its offerings by releasing the Oculus Quest Pro in October 2022, a high-end standalone product aimed at MR applications, boasting high-resolution colour passthrough cameras, infrared depth sensors, and eye tracking. Realising that users prioritise portability over display resolution, leading XR company HTC have diversified their systems by introducing standalone devices alongside PC-VR product. From the Focus to the Flow and XR Elite, HTC have been trying to meet different user preferences.

In terms of video game companies, in 2018, the long-established company Nintendo ventured into the world of VR by releasing the Labo VR kit for its popular Switch game console. The kit included folding cardboard pieces that, when combined with the Switch console display and joy-con controllers, could be transformed into various interactive devices like a fishing rod, piano, or rifle. This allowed players to enjoy a unique VR experience with motion-sensing games.

Sony Interactive Entertainment, as a competitor, also entered the VR market by launching their VR HMD device which can be connected to their widely recognised game console, the PlayStation 4, known as PSVR. Their aim was to provide players with a high-resolution display for an immersive gaming experience. In 2022, Sony introduced the PSVR2, the next iteration of their VR HMD, designed specifically for their PlayStation 5 console and aimed at ensuring Sony remained competitive in the XR space.

Apple unveiled its mixed reality HMD, Vision Pro, at its annual WWDC event on 5th June 2023 and will be soon available in early 2024. This Vision Pro packs 23 million pixels across two displays with its unique dual-chip design (M2&R2) for unparalleled standalone performance and processing input from 12 cameras, five sensors, and six microphones to provide a natural and intuitive input interface by user's eyes, hands, and voice. Although the technology is innovative, only time will tell if the Apple Vision Pro with its price point of $3,499 U.S. has the potential to be a game-changer like the iPhone, propelling XR technologies to new heights.

Game Engine

A game engine is a software framework or toolkit that developers use to create real time virtual content. Game engines enable users to create environments, objects and subjects, through rendered graphics, physics and collision detection, scripting, behaviours and other functions and embed these into software systems. With the help of game engines, developers now can more easily and efficiently build high-quality games without incurring the enormous time commitment and costs necessary to build the underlying game engine from scratch (Jungherr & Schlarb, 2022).

Traditionally these frameworks have been used to develop games, but in the past few years there has been a shift towards their usage in simulation, automotive design software, architecture visualisation, manufacturing process analysis and augmented reality.

There are two main competitors in this space, Epic Games' Unreal Engine and Unity.

Both engines offer developers a wide variety of functionality and can be deployed to Windows, MacOSX, Linux, Android, iOS, PlayStation, Xbox, and Nintendo Switch. Their features are compared in Table 3.

While the use of these engines has lowered the cost of entry to the market, this has not come without a price. Using Unity/Unreal means that developers are "locked-in" to these tools and the practices and technologies they choose to support (Foxman, 2019). If Unity or Unreal decide to no longer support a particular platform (e.g. Smart TV apps) it would require significant expense and effort for a developer using these engines to develop for those platforms. This also means that experiences developed using these technologies tend to follow rules created for video game developers, meaning that it could force experiences to be "game-like" in their design, which may not always be appropriate for applications in architecture and engineering or medical training (Whitson, 2018).

The issue of where revenue from gaming is proportioned is currently a fraught one, with a recent lawsuit from Epic Games (makers of Unreal/Fortnite) vs Apple calling for a reduction in the percentage Apple takes in licencing fees for any purchase made on the iOS store. Currently Apple takes 30% of all transactions on the store, and in 2019 they made a profit of $8.5 billion. More than console manufacturers Sony, Nintendo and Microsoft combined. This was despite Apple not developing any games or dedicated gaming devices. Apple does not allow other payment systems to be used for apps on their devices. Google takes a 15-30% cut on transactions on their Play Store and currently does allow alternative payment systems, but the majority of transactions are still completed using Google Play Services. There have also been disputes between Epic and Valve, owners of the Steam platform (an equivalent of the iTunes store for PC games) over revenue share for developers.

Table 3 Game Engine Comparison

Metric	Unity	Unreal
Entry Threshold	Low, Scripting is done in C# which is an easier language to master	Medium: C++ is used for functionality here, while it is a more complex language it has increased performance and functionality
Graphics	Acceptable, but not top of the line	Capable of photorealistic graphics and lighting
Technological Flexibility	Numerous plugins for prebuilt components available, very large asset store.	Components tend to be first party; asset store is present but not as diverse as Unity
Cost	Free until product earns $100k, pro versions are available with increased functionality for a licencing cost	Free for projects that earn less than $1M, custom licences are available for larger projects.
Mobile Support	High Level of Support	Limited Support
VR/AR	Many features available	Limited built in VR/AR support
Simulation/Non-Gaming Support	Some support, limited use cases	Twinmotion allows for easy AEC visualisation, Unreal has been used for numerous TV/film productions

Digital Twins

A digital twin is a virtual replica of an existing physical object, system, or infrastructure and emerged from work within the so-called “industrial metaverse”. It usually consists of three parts: the physical system, the digital copy, and the communication between the two versions to manage and synchronise the copies. Increasingly, Digital Twins include large arrays of complex sensors which are embedded in the physical objects and mapped to their digital equivalents.

Digital Twins are not merely replicas of existing objects. They can also be used as predictive models to both optimise processes such as transportation or manufacturing, whilst also being used for scenario generation to determine the effects of unlikely or hard to replicate events in a low-cost manner.

Companies can also enable digital twins to interact with each other, allowing for more detailed and rich interaction between the real and virtual worlds (Sharon, 2019). There are a number of efforts to recreate the earth itself in a digital twin, such as Earth-2 by NVIDIA and the Digital Twin for Earth Observations by the US government. Digital twins can also be used to generate synthetic datasets for training AI systems in scenarios that would be too dangerous/rare to trial in the real world. By using digital twins in these ways, companies can increase efficiency and reduce overheads, which is why many experts believe the industrial metaverse will exist before the consumer entertainment focussed version does.

NVIDIA is one significant company who have invested heavily in the industrial metaverse. Traditionally associated with gaming technology, NVIDIA have recently come to the forefront on AI R&D due to the use of their hardware to perform the operations required to train large AI systems.

Nvidia’s Omniverse platform has been developed as a 3D design and collaboration platform, where developers using numerous technologies such as Autodesk, Maya, 3Ds Max, Revit, Blender, Unity and Unreal can all work together on content in a synchronous fashion. This is made possible through NVIDIA’s adoption of the Universal Scene Description (USD), an open-source framework for 3D environments first developed by Pixar for use in their animation department. NVIDIA’s goal from this is to have USD become the HTML of the metaverse, a common standard for scene development that allows for assets created in a variety of applications to be used in others, reducing overheads for content creators. The use of open-source technologies does lend itself to decentralisation of content creation, but further studies are required to assess the impact of a single company becoming the owner of a standard used for all metaverse development.

Web3/Distributed Ledger Technologies

The evolution of the Internet and the World Wide Web can be characterised in three steps from ‘Read Only’, to ‘Read and Write’, to ‘Read, Write & Own’ as depicted in Figure 9.

Web 1.0: Read-Only (1990-2004) Perceived as the foundation protocols for the internet that would become the World Wide Web based upon decentralized protocols that allowed information sharing from anywhere on Earth.

Web 2.0: Read-Write (2004-Present) The evolution of the internet from businesses providing content to users to platforms that shared user-generated content and facilitated user-to-user interactions. This led to the emergence of social media platforms. Through network effects, a handful of companies began to control a disproportionate amount of the traffic and value generated on the web, driven by targeted advertising revenue models. While users could create content, they did not own it or benefit from its monetisation.

Web 3: Read-Write-Own The emergence of a trend, primarily from within the crypto-currency community that the current Web2.0 paradigm required too much trust and that the current technology that people know and use today relies on trusting a handful of private companies to act in the public’s best interests.

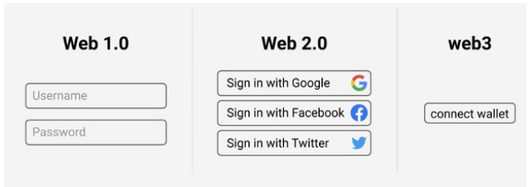


Figure 9 Evolution of the World Wide Web (Image courtesy of Blockworks)

Web3 technologies aim to provide a decentralised and trust-less environment for various applications on the internet. Distributed Ledger Technologies (DLT) provides much of the infrastructure for Web3 and is based on a peer-to-peer network where nodes on the network validate transactions and store data, ensuring that it is immutable and transparent. Many of the applications of DLT’s are crypto-currencies, decentralized storage, smart contracts, Decentralised Autonomous Organisation (DAO) and Non-Fungible Tokens (NFT).

The primary use cases for web3 technologies are in the areas of finance, supply chain management, voting systems, and digital identity. Blockchain-based cryptocurrencies have emerged as an alternative to traditional payment methods, enabling secure and decentralised transactions without the need for intermediaries. Similarly, supply chain management systems can benefit from the transparency and immutability offered by blockchain technology, allowing for provenance checking and the tracking of goods and services from origin to final delivery. Voting systems based on DLT can improve transparency and accountability, while digital identity systems can provide a secure and decentralised way of verifying personal information.

Distributed ledger technologies offer users an immutable and transparent way to store information and proponents champion the technology as an effective solution in building an open Metaverse that exhibits interoperability, transparency and benefits from the economic stability of decentralised operations.

Interoperability, perceived as key feature of the Metaverse (World Economic Forum, 2023) requires a common platform to allow different applications to interact and share data to enhance future internet applications and make it easier for different applications to work together seamlessly and efficiently, improving the overall user experience. Such technologies will enable users to have greater control of their digital identity and enable the creation of private or permissioned networks, which can provide enhanced privacy and data protection for future internet applications that require confidentiality.

The creation of digital tokens to represent assets or other forms of value enables new business models for future internet applications, such as micro-payments or token-based incentives. Currently such tokens are utilised as incentives for participation in the distributed ledger, but it is conceivable that these tokens could be utilised to incentivise participation and behaviour in future Metaverse experiences. NFT gained popularity during the pandemic and are a form of digital deed representing ownership over a unique digital object. These objects commonly include artwork or digital collectibles and are authenticated on the blockchain.

A Decentralised Autonomous Organisation, or DAO, is an organization constructed by rules encoded on a blockchain as a computer program, managed by its members through a decentralised decision-making process controlled by the organisation's members and not influenced by a central governance structure. The rules governing a DAO are enforced by smart contracts which are self-executing contracts with the terms of the agreement between buyer and seller being directly written into lines of code. The smart contracts enable a DAO to operate autonomously without the need for human intervention. The contracts are a self-executing computer programs that automatically enforce the rules and conditions of a transaction or agreement.

It is conceivable that as these technologies, applications and use cases converge with Metaverse technologies, new context-based applications will emerge which have the potential to create unconceivable experiences that will pose vast opportunities and challenging threats. Due to a potential lack of regulation, preparedness and oversight, this could lead to an uptick in fraudulent and illegal activities, such as scams and money laundering.

Privacy Enhancing Technologies

UK Government guidance on adoption of privacy enhancing technologies (PETs) is given in an interactive website (Buckley & Satija, 2021) launched in July 2021 by the Centre for Data Ethics and Innovation (CDEI). CDEI is now part of the Department for Science, Innovation and Technology. The guidance stresses that no silver bullet solution exists, and a blend of approaches is needed to satisfy practical real-world scenarios. PETs can be classified into four groups as shown in Figure 10:

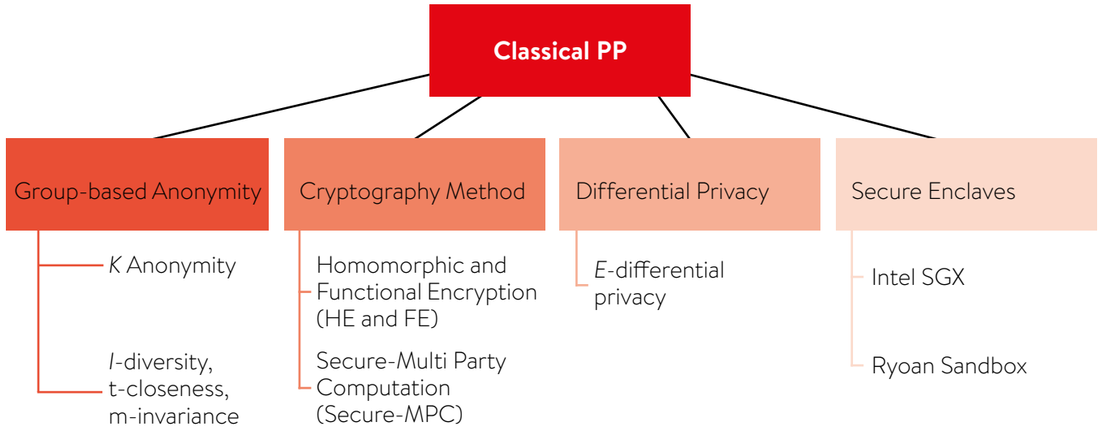


Figure 10 Classical Privacy Preserving (PP) methods Classification (Tanuwidjaja et al., 2020)

Group based anonymity approaches modify datasets to make identification of an individual's data more difficult. Modified data are said to have k-anonymity if the information for any person whose information is in the modified dataset cannot be distinguished from at least k-1 individuals in the modified data. Further refinements address diversity of sensitive attributes i.e., distinct values for each sensitive attribute and maintaining the distribution of sensitive attributes (*t-closeness*).

Physical security of the compute platforms used to process sensitive data can ensure privacy especially if there is an airgap between this secure platform and other internet connected systems. However, the scale and economics of Cloud-based infrastructures mean that air-gapped, standalone compute architectures are increasingly infeasible for data science applications. *Secure Enclaves* or *Trusted Execution Environments* allow 'trusted code' to execute on untrusted (Cloud-based) platforms. Only extremely limited portions of a machine learning workflow could run on a secure enclave with the vast bulk executing on the untrusted platform. *Trusted code* is publicly accessible and allows end users to satisfy themselves that their data will not be stolen.

Differential Privacy
Whereas other PETs address privacy during computation, differential privacy seeks to understand the leakage of confidential information during its disclosure. It is expected that when data is released or queried it should not give away information on any individual. It also assumes that individual information may be leaked over multiple queries and hence a limit to the number of permissible queries must be set.

Cryptographic methods
such as homomorphic encryption, functional encryption, and secure multi-party computation enable computation on encrypted data without revealing the original plaintext.

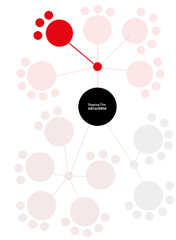
Secure Multi-Party Computation
(MPC) enables a set of participants to compute a common function over their respective confidential data. A protocol is employed which obfuscates which party is processing whose data and collectively they generate a result. In secure MPC, each party incurs almost no computational cost, but it has a huge communication cost as it requires many rounds of communication between the parties and the server, which is non-negligible.

Homomorphic encryption
(HE) allows computation to take place on encrypted data without the need for a secret key. Homomorphic encryption enables complex mathematical operations to be performed on encrypted data without compromising the encryption, but ensuring that the resulting computations, when decrypted, result in an output that is identical to that produced had the operations been performed on unencrypted data. This means that encrypted data can be processed by third parties without having access to the unencrypted data. This is incredibly significant for Cloud-based solutions where traditional methods involve sharing secret keys with the Cloud Service Providers. This results in plaintext data appearing on untrusted platforms during processing.

Royal Society report on Privacy Enhancing Technologies (PETs)
In its 2019 report on *Protecting Privacy in Practice* (Society, 2019), the Royal Society made a series of recommendations promoting the adoption of PETs, which included accelerate the research and development of PETs; driving the development and adoption of PETs; and exploring innovative ways to govern data as enabled by PETs.

Federated Learning
Federated learning is a decentralized and distributed approach to training machine learning models, including deep learning models, via multiple independent clients or nodes, each using its own dataset. Its main advantage being that it does not require an exchange of data from client devices to upstream cloud-based servers. Instead, raw data collected on client devices are used to train the model locally. Clients only share their learned model parameters and collectively these parameters generate an aggregated model which is as effective as if it had been generated by a centralised dataset. This distributed schema approach may also be regarded as a privacy preserving technology, as data can be kept private in each client device. Federated Learning retains all the benefits of an aggregated model approach i.e. traditional centralised machine learning techniques where local datasets are merged into one large training dataset, requiring data to be shared by all clients.

INTEROPERABILITY AND STANDARDS



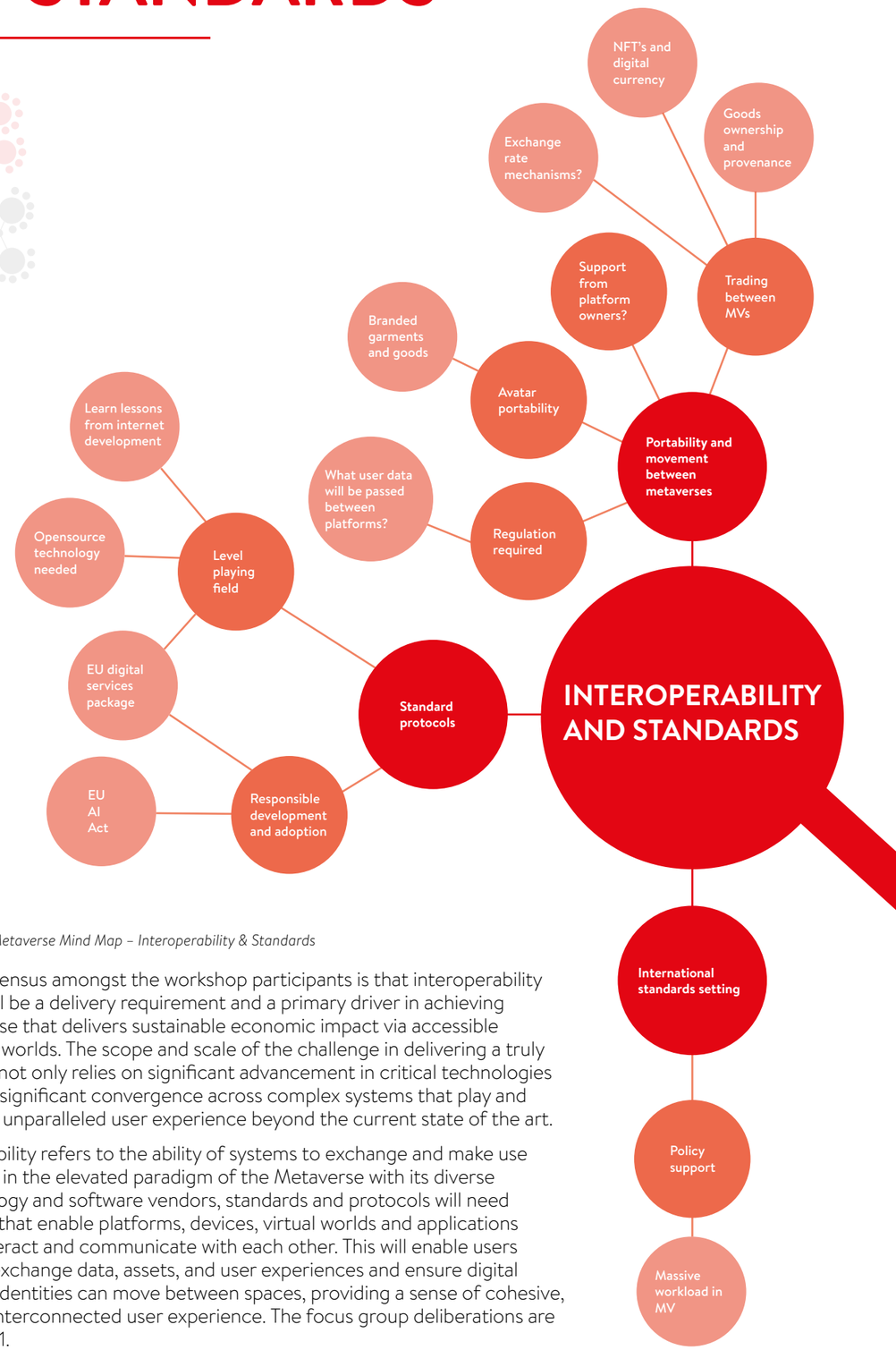


Figure 11 Shaping the Metaverse Mind Map – Interoperability & Standards

A prevailing consensus amongst the workshop participants is that interoperability and standards will be a delivery requirement and a primary driver in achieving an open Metaverse that delivers sustainable economic impact via accessible persistent virtual worlds. The scope and scale of the challenge in delivering a truly open Metaverse not only relies on significant advancement in critical technologies but also requires significant convergence across complex systems that play and integrate with an unparalleled user experience beyond the current state of the art.

While Interoperability refers to the ability of systems to exchange and make use of different data, in the elevated paradigm of the Metaverse with its diverse range of technology and software vendors, standards and protocols will need to be developed that enable platforms, devices, virtual worlds and applications to seamlessly interact and communicate with each other. This will enable users to navigate and exchange data, assets, and user experiences and ensure digital possessions and identities can move between spaces, providing a sense of cohesive, continuous and interconnected user experience. The focus group deliberations are shown in Figure 11.

Focus Group Insights

Y-1-22. A good starting point is what do people want to be interoperable? The big example is avatars – all the platforms impose different constraints – so an interoperability standard that allows people to be as expressive as they wish for their digital identity and enables that to be portable across platforms would be ideal.

C-1-24. One of the biggest challenge areas is interoperability across platforms.

D-1-9. Rather than one MV we see a series of mini-verses where a user must leave one before entering another because they are isolated. You can't take your stuff from one to the other and that's another big blocker. It is hard to see how we will solve that in a ubiquitous way without adding a layer or an open standard that the platforms are willing to implement.

M-1-21. Interoperability challenge: software developers create an app on one platform that doesn't work on other devices. It's a disincentive to them.

M-1-22. It may not always be a disincentive if we consider network effects. The size of the network of potential users that are associated with the device/platform chosen by the app developer will be a critical success factor. You will need dominance in one network.

N-1-11. Businesses tend to be pretty good at picking up new technology e.g. cloud computing was pretty mysterious 10 years but now very few companies want on-premises systems. When technology obviously works and it is interoperable, then businesses catch on. The public sector might be different – there are always other things to invest in in a city.

N-1-50. Are there limits that might be placed on interoperability? For example, a project to model the supply chain of leather goods was challenged because companies along the supply chain would not agree to give up more information than was strictly needed to complete their transactions.

Y-1-13. Digital technologies are complementary– one builds on another e.g. AI is enabled by lots of data that is collected using IoT devices and ubiquitous network connectivity. This is the nature of technology; the general purpose computer has infiltrated every aspect of our lives. Virtual elements and digital objects that are shared amongst people may be a useful definition e.g. a car mechanic who is assisted by AR to disassemble a carburettor, replace a part and then reassemble and test the repair; may also be assisted by a remote colleague or may be demonstrating the procedure to a remote trainee mechanic. Shared participation in the virtual environment is essential to the MV vision.

D-1-6. There will be some applications that will be universally accessible, but there will be quite a lot of separate areas that will not have the level of interoperability that we see in the Internet today. This is because the platforms are very specific about the hardware that they will interact with and the kinds of software interfaces that they offer. So we will get more fragmentation – like people speaking different languages and not intercommunicating.

N-2-25. The wireless connectivity issues that we are going to need to develop for MV to work in chaotic environments, is an infrastructural set of questions that you're beginning to see.

D-2-39. As long as the MV is under Meta's (or any Big-Tech giant's) control, the Interoperability problem will remain.

D-2-40. The most radical intervention would be to develop open-source hardware, which is not really happening on any meaningful scale right now.

D-2-41. A range of open-source technology could lay a foundation that could make a real shift or in approach to how it all might work.

N-2-4. The tech stack required to create the next Internet is wide and complex with so many different areas and as the next Internet will have a lot of different types of experiences, content, games and everything else across it. Are we creating something which is a persistent digital world with avatars in it, or are you just plugging in your IoT doorbell? Both are still in the Metaverse, ones incredibly high fidelity in real time, with thousands of users, the other is one user in a 2D video call and stream, but they're still Metaverse things.

Y-1-38. The WWW was borne out of the scientific community and was explicitly not commercial. It aimed to be open for everyone to access and engage with. Finding an analogous way to do that for MV would be extremely valuable – but would require public investment and international co-operation across governments.

Y-1-19. In the adoption and diffusion of new technologies, standards play a key role. Regulations such as the EU Artificial Intelligence Act will set standards but we will need something similar for MV.

Y-1-20. Guidelines for XR are under development in an EU project with 11 partners. This covers accessibility and interoperability guidelines that may contribute to future standards in this area.

Y-1-21. Rapid pace of technology means that standards bodies find it difficult to keep up. Massive workstream needed to turn guidelines and design objectives into standards and then more work to regulate and find hooks in the platforms to enforce them in the field – most likely via AI.

Y-1-40. Although the advent of the WWW brought us a democratisation of technology and led us to where we are now – I don't know what the broader regulation set needs to be. We can list the problems, but I don't know what the solutions would be. Those regulations (whatever they are) need to be in place from the beginning.

M-1-23. Then how does one medium sized state (the UK) control the emergence of network effects? One approach would be interoperability standards. If the UK mandated their own local standards it would add regulatory burden and impede the market. However, the UK could have a definite policy about supporting and actively engaging the community of interest here towards development of international standards.

M-1-24. The UK was heavily involved in MPEG standards development all the way up to MPEG 21. We're not reinventing the wheel here – the wheel exists!

D-1-11. At the birth of the Internet there was a relatively simple protocol that everyone could subscribe to but the MV has much more complicated engineering. Maybe we have to wait until there's a dominant hardware or technical approach that creates a groundswell to develop standards for the way in which we interact with the Metaverse, or with different platforms on the Metaverse. At that point people will start to manufacture devices that will provide us with proper interoperability. Currently, that's a big barrier to consumers-why am I going to invest in this headset when it limits my usage immediately and it costs a lot of money?

D-2-37. It is all emerging technology. It requires ubiquitous broadband or 5G. It requires very high-end technology, expensive technology. It is currently controlled by a small number of tech giants.

M-2-15. We need a common set of standards and protocols. That's the thing that creates the level playing field along with regulatory frameworks that will be important in terms of ensuring responsible development and adoption.

Y-2-76. Where this has happened before in the audio file format MP3, SONY tried to dominate with a-trac and the community rejected this. SONY struggled on for ages, taking people to court and pushing a-track and it just failed miserably because everyone else just chose a different standard.

M-2-18. We need a much better connection between the regulatory frameworks in Italy and the UK and the rest of European Union in order to try and agree a set of standards and protocols.

Supplementary Research

The Internet Protocol Suite is a relevant, but not the only example of historical precedent for the enablement of convergence in technologies that was only realised through partners across the supply chain with significant contributions from Government, Academia and NGO's involved in professional and technology standards.

> *"TCP/IP is more than some technical rules—it is a complex cultural artefact as well, a system within larger social, technological, and political systems. Given a rudimentary understanding of TCP/IP's functions, one can see the arranged politics (a dumb, trusting middle and smart, anonymous hosts on the edges) maintained by rough consensus and running code"*
>
> (Larsen, 2012)

The decentralized development of theses foundational technologies achieved wide range adoption, but were not the only contenders. In addition, this adoption has afforded a wide range of capabilities and unlocked potential well beyond what was conceivable at the time e.g. social media, e-commerce, streaming etc...

The pervasive interest in the opportunities that are on offer through the convergence of Metaverse technologies has led to a rise in a diverse range of technology players entering the market, which has prompted a range of response from standards development organisations (SDO). A number of existing SDO's have joined forces to create new environments for collaborations, such as 'The Metaverse Standards Forum'. Others have established new initiatives such as the 'IEEE Standards Association Metaverse Strand' as part of its focus on foundational technologies. In addition, in true metaverse fashion, new organisations have emerged that are building on blockchain standards such as 'Lamina1'.

The Metaverse Standards Forum has brought together a range of SDO's predominately involved in 3D graphics such as The Khronos Group, the World Wide Web Consortium, the Open Geospatial Consortium, the Open AR Cloud, the Spatial Web Foundation, and many others.

A number of key working groups have formed covering the recommended topics (MSF, 2023):

1. **3D Asset Interoperability using USD and glTF**, to increase synergy between file formats and reduce duplication of effort, gaps, fragmentation, and industry confusion;
2. **Digital Fashion Wearables for Avatars** to generate insights and interoperability on Digital Fashion including clothing (with a layering system), shoes, hats, and accessories;
3. **Digital Asset Management** to address the transport, exchange, monetization, and access related to 3D digital assets throughout the metaverse stack;
4. **Interoperable Characters/Avatars**, generate recommendations for a standardized avatar format that can be dynamically loaded with consistency in multiple run times environments;
5. **Network Requirements and Capabilities,** to collect use cases and requirements to reduce latency, jitter, throughput and time synchronization;
6. **Privacy, Cybersecurity & Identity** deliver recommendations for responsible innovation that mitigates human and societal harm from objective and subjective privacy risks;
7. **Real/Virtual World Integration,** standards for semantic representations, Unique Real-world Identifiers, OGC GeoPose 1.0, Digital Twins, IoT, WoT, and Sensor ontologies.

IEEE are developing a range of Metaverse related standards and resources through its 'Metaverse Congress' programme which encompasses their VR/AR Advisory Board, Persistent Computing for Metaverse Initiative, Decentralized Metaverse Initiative and Extended Reality Ethics Initiative. Recommended reading from the IEEE includes A Metaverse: Taxonomy, Components, Applications, and Open Challenges (S.-M. Park & Kim, 2022).

Alternative approaches to standards development emerging through organisations such as Lamina1, where an on (block)chain approach is being taken with further reading in the original white paper (Lamina1, 2023) and Metaverse as a Service.

BUILDER ECONOMY

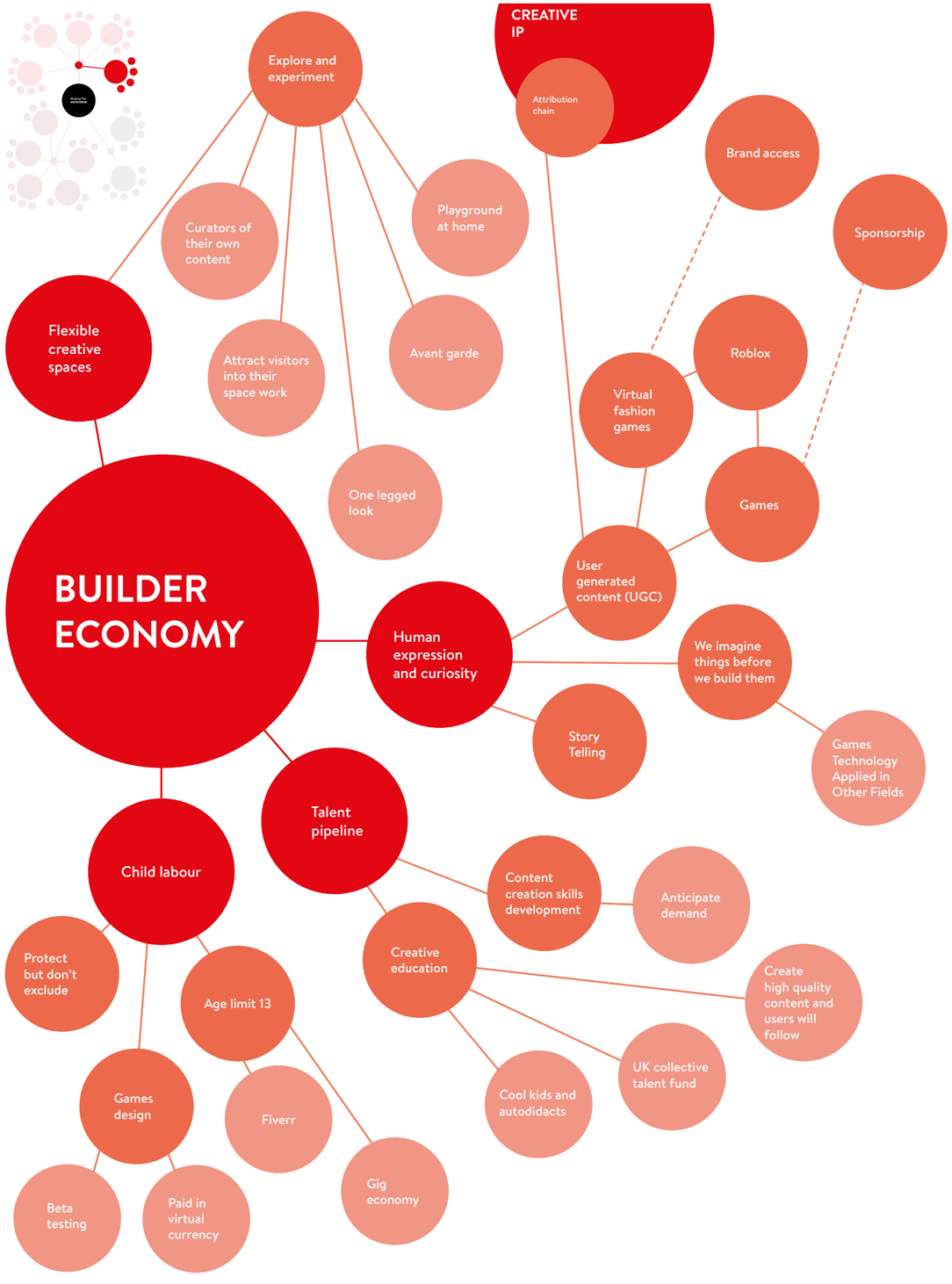


Figure 12 Shaping the Metaverse Mind Map – Builder Economy

The web 2.0 era has been defined by user generated content, persistent connectivity and social participation and has given rise to the creator economy. When talking about "creators" we are typically referring to individuals or small teams of media content producers or influencers who develop engaging media experiences on software platforms, typically in the form of video or text-based content and are generating revenue through brand promotion and engagement. In the Metaverse, it is expected a new builder economy will emerge that will not only engage in brands but will develop new brand identities from within the Metaverse that will transcend into physical brands. For example, the acquisition of Metaverse NFT sneaker brand RTFKT by Nike for $65 Million.

In looking for proto-Metaverse applications, we can begin to draw conclusions about what a mature Metaverse may look like when virtual worlds have User-Generated Content (UGC) as a prominent feature of the experience. Many of these experiences evolved from 'mod communities' where limited development toolsets are handed to the community to enable the co-creation of content to expand the games capabilities through 'modification' of source code and assets. This led to the emergence of sandbox games such as 'The Sims' and 'Minecraft' where the lower cost of social participation gave players more opportunities for self-expression.

The Builder Economy of the Metaverse may be defined by the democratisation of advanced digital creative content tools; the experience economy and decentralised, trust-less architectures. The focus group discussions are depicted in Figure 12.

Focus Group Insights

M-1-3. On the other hand, basic, accessible, easy-to-use tool chains will allow early adopters to experiment and get a sense of the potential of MV. Entice people to be part of it.

M-1-11. The Pokémon Go example shows how technology such as AR and maps could reach beyond the gaming community and enter popular culture (for a short time). It is an interesting template for developing retail opportunities. Not sure why it has not taken off.

M-1-12. Games like Grand Theft Auto, and Red Dead Redemption are big open worlds, they are effectively MVs. The FIFA games have an online master league where you can earn cards (NFTs) that allow users to buy bonus packs etc.

M-1-16. Often the games we get are a replication of environments/activities that we do the physical domain, but they have been gamified in some way. We need some innovation in this area, if the user needs a VR headset to play these games, then it needs to offer something unique. Otherwise, users will resort to more accessible platforms/devices.

M-1-17. There are separate communities related to MV. The Web 2 community generally steers clear of the MV. The Web3 community is keen to pick holes and exploit vulnerabilities in (NFT (non-fungible tokens)) campaigns taking place today. Present day technology could be called Web2.5.

M-1-21. Interoperability challenge: software developers create an app on one platform that does not work on other devices. It is a disincentive to them.

M-1-26. My mum uses an iPad, Netflix and on-demand streaming services but that is because they have been designed for a mass audience and they work really well. There is a big useability threshold for MV to achieve.

M-1-40. There are developers creating games in e.g., Roblox who do not have access to the user data created within their games. The platfform operator can see what is happening but not the creators. Therefore, it is not possible to do a live update to the game because the creator is not aware of problems occurring. This is where regulation should step in.

M-1-45. Storytelling and education: discovery education via immersive AR. Kids do not learn by watching a screen/moving image they learn by interacting with the subject matter so that is why the MV is the future.

M-2-2. There is an emerging separation between believers and nonbelievers.

M-2-11. There is a massive appetite for everyone to engage with it. There are pragmatic applications for this technology that can seem really abstract until you see them in in place. For example, in healthcare, working with a Children's Hospital to gamify the on-boarding experience for children before they go into MRI scanners.

M-2-15. The Star Trek holodeck: no insightful difference between the real world and the virtual world and for all your senses.

M-2-19. Disabled people being able to engage in the physical world in new ways, all sorts of things, the elderly, people with dementia.

M-2-45. People are already having conversations about how to commodify different components of an avatar from clothing, through to cosmetics, through to jewellery. There is a commercial appetite to make it flexible and give people the ability to design whatever they want for their avatars.

D-1-8. The MV is the 3D Internet. It is not another thing adjacent to the Internet – it is the Internet. It is a new medium and a super powerful way of looking at the information we have. The MV is still about information connecting people and things.

D-1-19. There are a lot of people speculating on the value of virtual goods in the MV. Second Life is interesting in that it closed itself. You could not bring things in or out but that created an economy. It would have been destroyed if people like me could have brough in amazing models to sell and extract value from the platform.

D-1-22. Our next generation will approach digital worlds in a very different way than we do. Minecraft and other games require the players to imagine and then build 3D objects and make it all happen through 2D interfaces. They are developing core skills that we would find difficult to perform.

D-2-11. The MV is vague in nature, but the lack of precise definition helps, because the MV is going to become cross-sectoral. It is not just the creative industries; it is not just the screen. It is going to be ubiquitous.

D-2-36. Epic, the company behind Fortnite, is making some very smart moves with an eye on the metaverse. Epic acquired a website called Band Camp, which is the single largest music discovery platform for new independent upcoming artists. So, they now own it. So new artists, new bands, and new upcoming musicians can at some point stream their music into the metaverse. They are three steps ahead.

D-2-46. Games could be a microcosm of what the metaverse may look like. Roblox and Fortnite are not just games, they are online communities which give players tools for creation especially Roblox. And there has been a huge amount of growth for Roblox in the last 12-18 months because kids can build games and make games available. Theoretically they can earn money from that, but realistically 99 plus percent of people are not getting anything. The company is just soaking up everything.

D-2-52. The tools mean that content creation could be in the hands of users. When mobile phones got cameras, we thought that it was the age of citizen journalism and no more police brutality-but that did not happen. And instead, it became the social media and selfie-media culture of influencers. That is a hard lesson and one we could apply to MV. We are now in the age of the influencer that nobody saw that coming. How is the MV, in giving people the means of creation, going to impact society?

D-2-59. Where will those cool kids come from, what schools that are really doing education creatively, and where we will get all those kinds of autodidacts that will create in the future?

Y-1-22. A good starting point is what do people want to be interoperable? The big example is avatars – all the platforms impose different constraints – so an interoperability standard that allows people to be as expressive as they wish for their digital identity and enables that to be portable across platforms would be ideal.

Y-1-32. Human curiosity, creativity and connection. The MV is another domain for human expression. We imagine things before we create them – think of Star Trek gadgets.

Y-1-34. When we are given new tools to be creative with then we will take and use them e.g., tracking people's movement only using Wi-Fi and using it to diagnose metabolic disorders. Blue sky thinking associated with MV can drive through societal good. Traditional gaming technology can be applied to different things, but it is costly and may not make any money.

Y-1-45. Who will have access to build these virtual worlds? Whose world is being simulated? Whose values are being represented? How do we ensure that it is not just the big companies controlling all of this?

Y-2-1. MV is huge and will throw everything on its head because individuals are going to be the creators rather than businesses.

Y-2-3. They have the tools at their disposal that do not really require big businesses to be behind them going "we can push you this way or that way". What they will need is access to brands, access to the people that want to sponsor them.

Y-2-5. The industry moves so fast that you must target these new sectors that is what it is going to be about.

Y-2-7. What is amazing is that people can create their own fashion, what is important is that does not get lost among the platforms.

Y-2-8. People want to express themselves and design their own things and interact with their friends and chat. It is not just a game. It is important that we protect that.

Y-2-9. Young people designing and creating is a valuable thing – and they should be able to have a great career through that.

Y-2-10. One of the most sought after looks in Roblox is a one-legged look where there is a piece of UGC (User Generated Content) that replaces your leg with this tiny little stump thing. That has become a key look in Roblox, and it is not fashionable, it is just about "I was there at that time to get this thing".

Y-2-12. People may have different ways of expressing themselves, and that is often done through visually what you can see.

Y-2-13. It is such a creative space, because people can just explore, experiment, and create bonkers things that they cannot and they would not feel comfortable wearing in the physical world, but they can experiment and create amazing things in the digital world.

Y-2-14. What's fascinating is you have people like Gucci making handbags and stuff. You do not need a handbag in the metaverse. What is the equivalent? What should I have around me? Should it be some sort of particle cloak? These things do not need to be garments as such.

Y-2-16. The Roblox platform has the same problem as the Apple Store-it takes an increasing chunk out of people's revenue. So much is determined by market forces.

Y-2-19. The kids are out there taking the risk doing the avant-garde, doing the weird stuff that we would love to do, but brands would not touch because they want to be safe. These kids are out there going-you know what we can do? Whatever we like. This is my platform. I can do crazy one-legged outfits. I can do a game where you slide down a big ramp in a house and it is wonderful to see that they are doing this because then what that does is allow the brand to look at it and go that is quite good-we can we add that.

Y-2-21. The experiences merge with what kids are doing in the playground and now they have the playground in their own house and how lovely it is to connect.

Y-2-22. Stories are still necessary and the more care you put into a story, the more curation you must do around it and the more valuable the story becomes to it. We have innovative technologies, but you still must build the expertise to tell stories in these new virtual spaces.

Y-2-26. Children being involved in helping to support design, especially of games design, is not new. If you consider beta testing, and alpha testing of new games that are being launched by different companies. Gaming companies involve users.

Y-2-27. Companies are also asking do you have any ideas? Any suggestion on how can we improve the game? Do you know what kind of features we should have? But there is some further private interaction with those individuals who are particularly active on these platforms and developing them. They are being paid in virtual currencies or provided with certain benefits, so they can improve their virtual characters and in-game performance.

Y-2-28. Fiverr is a gig economy creator platform where you can get a logo made or whatever. Fiverr's age limit is thirteen, so a 13-year-old could go on, set up an account and create logos or renders or whatever.

Y-2-30. It is giving someone a route into an industry, and they will not end up with the £30,000 debt because they have been to university. They are going straight into that industry from college.

Y-2-31. Some of the great games and creative ideas are coming from young people.

Y-2-32. We have policy and things in place to protect people, but we must be careful that those policies that are put in place do not exclude those young people.

Y-2-33. How can we allow them to be in that space safely and to create? We want to protect young people, but you have to be careful how you do it, because otherwise the people that are doing some exciting and creative things are then going to be excluded.

Y-2-43. Creating transparency and the value exchange and so on-particularly in Roblox. If they did in the physical world what they do online, under most legislation it would be illegal because you pay people in your own currency that you control, and you have asymmetric exchange values into real currencies. You have a chronic lack of transparency about the creator's share of revenue – it's estimated to be just under 20% in Roblox. That is in stark contrast to Apple.

Y-2-44. The commercial platforms are the real problem. Not just who gets access to this sort of value exchange, but to what degree of transparency can be enforced through policy?

Y-2-51. Suddenly brands are showing interest and it is a constant opportunity where you can present some of these new revenue streams.

Y-2-52. There is a definite a sense of: we've got an existing traditional connection with live performance, there's new technologies coming along and it seems to be a perfect sort of constructive collaboration. We have access to talent; you have access to technology-what's the revenue share opportunity?

Y-2-62. The other thing that we are starting to see now is people approach the metaverse as though it is a real 3D space and therefore it must have a floor and walls and people must be human.

Y-2-63. This pop concert could be in space. You could be able to fly a full 360 degrees around it. They could be 300 meters high. You could redo live aid with 3D models-the camera data exists.

Y-2-64. We need to stop constraining ourselves to what the real world is.

Y-2-82. Young people, creating fashion for virtual worlds or musicians, have an opportunity, to be able to attract people into their spaces and share their work.

Y-2-83. The hierarchies and structures that exist, in the physical world-is there an opportunity to disrupt them?

Y-2-84. If we can support people to have spaces to create and have ownership over that content, whatever type of content, that could be quite a positive thing.

Y-2-102. At the moment, everyone expects it to be a one-way journey from real to virtual. It will be fascinating when you get brands that are completely virtual to start to come out into the real world. So, the outfits that are popular in MV start to be mirrored in the real world and the virtual brands will be exporting things back out again.

Y-2-105. Bringing the arts and humanities, into this space and making these topics quite prominent for the Research Council, I would say that is crucial.

C-1-53. Replicating our environment is very boring, very dull. You must manipulate reality.

C-1-54. You cannot just stream Glastonbury, you have to improve it, add layers, offer more than you would get physically.

N-1-18. These are fantastically empowering tools, how do we take that virtual advantage into the real world and change society in the real world as well? It is an opportunity right now because new technology is very open, everyone can experiment and there is a place for everybody. But the minute it is locked down, commercialised, and made proprietary; all those people are once again locked out.

N-2-24. A project in the School of Education that is building Nottingham in Minecraft and engaging with local schools to not only teach coding skills to kids, but also to help those children and have a cultural relationship with the city through gaming.

N-2-64. During our story trails process no one went out saying-right you lot we are going to digitise you up and get you on a headset. Tell me stories you got that we do not know about, we will get some people who know this tech and put it together. So that it is meaningful and then we will put it someplace near your community. We put it in libraries and the libraries we work with have all been saying-we have never seen this many people come to visit the library and use it as a resource to understand themselves, their communities and how they relate to their own locale.

N-2-73. You need to democratise creation and democratise access. Two very difficult things, but it needs to be easier and simpler to create. Where we are now with real time engines, you need expertise with programming, engineering etc. but to create for the current Internet, you just need to open Squarespace and click a template and you can make website.

N-2-77. People will become curators of their own content. So we all ran off to YouTube and nobody watched it. But it does happen now, everything is entirely on demand.

N-2-94. Think about blockchains powering smart contracts for creators. So the thing I created is on a blockchain and I want 5% every time it is sold. Forever. You can sell it on and on and on and on and on. It is like getting the ultimate PRS-someone will always give you a little cut of the work that you created.

N-2-117. The street finds its uses for stuff, and artists are good at taking stuff that has got one meaning and then suddenly through their curiosity and talent they reform it into something else.

N-2-124. UKRI are introducing something called the UK Collective Talent Fund where they are trying to shape what doctoral training should be-across the councils. They do not really know what that should be at the moment. So these kinds of events are quite useful-in this kind of conversation, because that is such an important cross-disciplinary training question.

Supplementary Research

Metaverse corporations are investing heavily in research and development of immersive technology to enhance the user experience in their platforms. For example, in 2022 Roblox, increased its investment in research and development from $533m to $873m, representing 39% of total expenditure by the company. This is a similar amount of R&D expenditure as Nintendo, the entertainment and software company, spent during the 12 months ended 31 March 2021.

Other examples are Electronic Arts who allocate 54% of their total expenditure on R&D. This level of investment has been sustained over recent years to enable the company to develop new games, studios and their own game engine, Frostbite, with the overall aim of out-pacing their competitors. The cumulative impact of this R&D expenditure has led to an increased adoption of immersive technologies across a range of design and technology sectors including Architecture, Engineering and Construction (AEC), Automotive, Manufacturing, Education, Health, E-Commerce, Media, and in digital twinning applications. Such an emphasis creates new tools and opportunities which results in demand for products and therefore create a virtuous cycle of shared R&D and product innovation. The most recent example of this is the emergence of Virtual Production as a new technique for filmmakers:

> *"The suite of Virtual Production technologies may be the first time that we have introduced a technology in filmmaking that can be funded and invested in by adjacent industries and with* which Media & Entertainment can benefit.*"*

Given the largest investment in R&D on foundational Metaverse technologies has come from the games industry and Visual Effects Sector, the UK have notable strengths in these areas:

> *"The UK's game development sector generates annual tax revenues of £1.2 billion for the Treasury and contributes £2.9 billion to UK GDP annually," said Dr Richard Wilson OBE, the CEO of trade body TIGA*

In addition, it is worth noting that the value of the UK video game consumer market in 2022 was £7.05 billion.

The Games and VFX industry are diverse and broad, working across many platforms, markets and demographics although a comprehensive review is beyond the scope of this report. Given the key strengths of the UK in this sector, it is worth exploring user generated virtual worlds as a distinct area of relevance in developing a Metaverse proposition.

UK Strengths in User Generated Content and Virtual Worlds

FallGuys, Mediatonic & Epic Games

Fall Guys is a free, massive multiplayer battle royale obstacle course game with up to 60 players online battling to be the last one standing. It was launched on the 4 August 2020, and was a huge hit during the Covid-19 pandemic and led to the acquisition of London-based studio Mediatonic by Epic Games in March 2021. After acquisition, Fall Guys changed their business model to 'free to play', with the game achieving 50 million players in just two weeks and featured a Fortnite-themed crossover event during that early period. Fall Guys has now added a creative mode with beginner-friendly game design tools to enable users to create an obstacle course.

Hytale, Hypixel and Riot Games

In April 2020, Hypixel Studios (based in Derry in NI) creators of Hytale, a Minecraft-like sandbox adventure game was acquired by Riot Games. Over 2.5 million people have signed-up for an upcoming beta. The acquisition marks the evolution of an existing partnership between the organisations, with Riot having supported Hypixel as an angel investor when the studio was founded back in 2018. Hytale combines the scope of a sandbox with the depth of a roleplaying game, immersing players in a procedurally generated world. Designed with creative players in mind, Hytale's engine supports everything from block-by-block castle construction to scripting and customization delivered using easy to use and powerful tools.

Star Citizen and Cloud Imperium Games

Star Citizen has surpassed $550 million of crowdfunded support and now has more than 4.4 million registered users, or "citizens", with the average pledge per one citizen is $124.6 In 2021 it was announced that CIG's main development studio in Cheshire would be moving to Manchester's Enterprise City, with a view to expanding operations to 1,000 staff within five years

Suggested Reading

Creator Economy

The Creator Economy: Managing Ecosystem Supply, Revenue Sharing, and Platform Design.
Bhargava, Hemant K. Management Science. 2022, Vol. 68, Issue 7, pages. 19; Institute for Operations Research and the Management Sciences, 2022.

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3858140

Give Everybody a Little Bit More Equity: Content Creator Perspectives and Responses to the Algorithmic Demonetization of Content Associated with Disadvantaged Groups

Kingsley, S.; Sinha, P.; Wang, C.; Eslami, M.; Hong, J.I. Proceedings of the ACM on Human-Computer Interaction, 11 November 2022, 6(CSCW2). Association for Computing Machinery

Democratization / Creative Content Tools

Voodoo software and boundary objects in game development: How developers collaborate and conflict with game engines and art tools.

Whitson, Jennifer R. New Media & Society, July 2018, Vol. 20 Issue 7, p2315-2332, 18p. Publisher: Sage Publications, Ltd.., DOI: 10.1177/1461444817715020

Minecraft and the Building Blocks of Creative Individuality.
Nguyen, Josef. Configurations, Fall 2016, Vol. 24 Issue 4, p471-500, 30p. Publisher: Johns Hopkins University Press

DOI: 10.1353/con.2016.0030

Experience Economy

The Influencers: Van Gogh Immersive Experiences and the Attention-Experience Economy.

Mondloch, Kate. Arts (2076-0752), Oct2022, Vol. 11 Issue 5. Publisher: MDPI., DOI 10.3390/arts11050090

The Experience Economy During Covid-19: Virtual Activations at Comic-Con@Home

Melanie E. S. Kohnen. In: Transformative Works and Cultures, Vol 38 (2022); Organization for Transformative Works, 2022. DOI 10.3983/twc.2022.2325

Electronic sports: A new marketing landscape of the experience economy.
Seo, Yuri. Journal of Marketing Management. Oct2013, Vol. 29 Issue 13-14, p1542-1560. 19p. DOI: 10.1080/0267257X.2013.822906.

Producing place atmospheres digitally: Architecture, digital visualisation practices and the experience economy.

Degen, Monica; Melhuish, Clare; Rose, Gillian. Journal of Consumer Culture. Mar2017, Vol. 17 Issue 1, p3-24. 22p. DOI: 10.1177/1469540515572238.

User Generated Contenty

In the Future Metaverse, What Kind of UGC do Users Need?

Zhang, YanXiang; Hu, WenBin. 2023 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW) VRW Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW), 2023 IEEE Conference on. :901-902 Mar, 2023; IEEE DOI: 10.1109/VRW58643.2023.00293

User-Generated Content and Editors in Video Games: Survey and Vision

Duan, Haihan; Huang, Yiwei; Zhao, Yifan; Huang, Zhen; Cai, Wei. 2022 IEEE Conference on Games (CoG) Games (CoG), 2022 IEEE Conference on. :536-543 Aug, 2022; IEEE.

The influence of user-generated content on video game demand

Brunt, Christopher S.; King, Amanda S.; King, John T. Journal of Cultural Economics: Published in cooperation with The Association for Cultural Economics International. 44(1):35-56; Springer US

CREATIVE IP

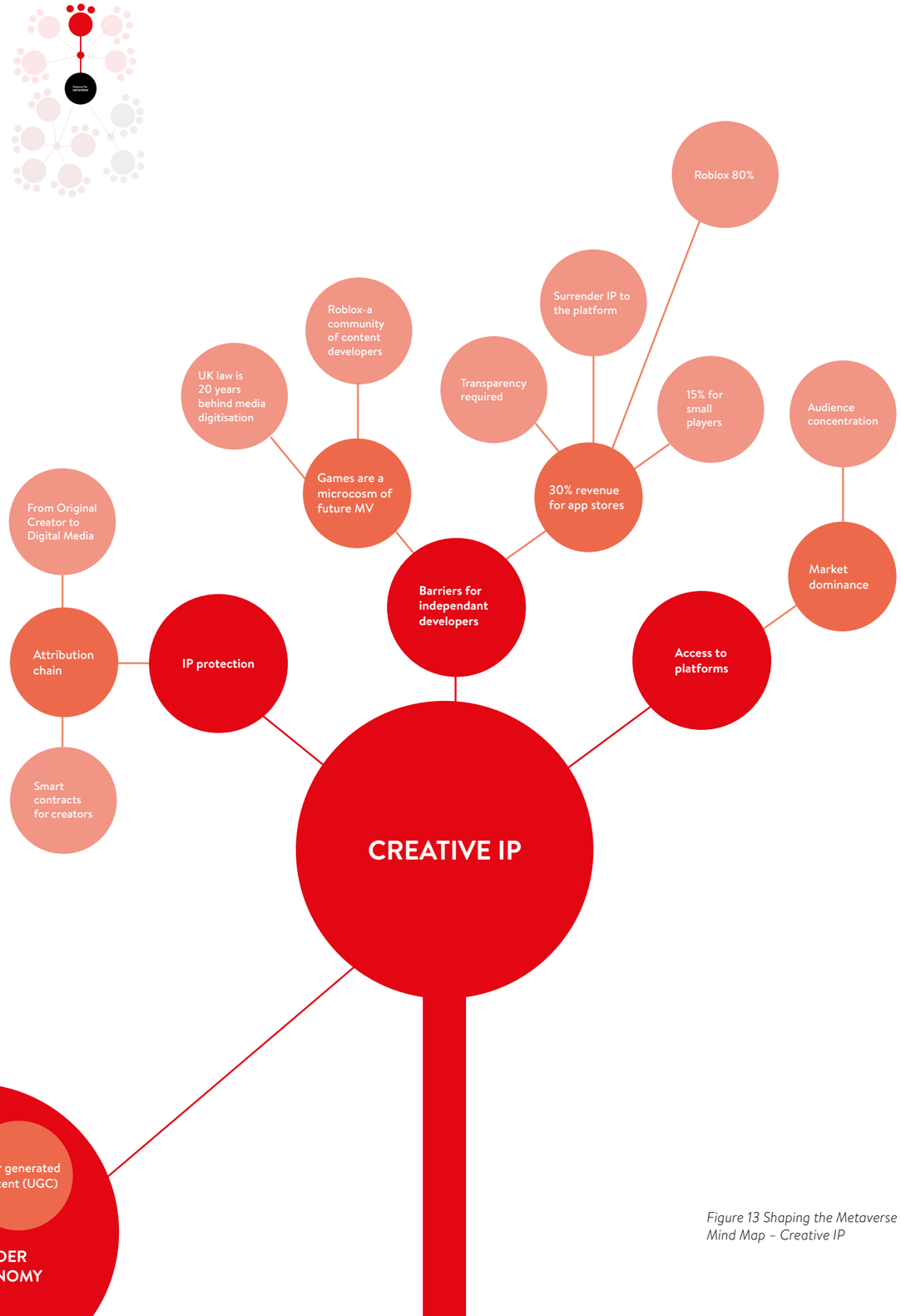


Figure 13 Shaping the Metaverse Mind Map – Creative IP

As the metaverse builder economy emerges, content creators are looking at the lessons from the past and specifically what happened during the Web 2.0 era in the creator economy. Many Web 2.0 gaming platforms offered software delivery and content distribution tools to help monetise the creativity and skills of games developers. New, compelling games and content attracted larger audiences to the platforms. However, content creators have become increasingly aware of the unequal value exchange that this offers them. Nor do they have any control over changes made in the platform's algorithm which do effect creator revenue e.g. the changes introduced by YouTube in 2018. This is the business context which underpins the movement towards decentralised Web3 technologies. These technologies are perceived to give creators greater control over distribution of their creative outputs, audience selection and monetisation routes via existing contractual models and new opportunities via minting of digital assets.

In the current Internet economy, platform fees have become a battle ground for content creators. Games developers are forced to give a 30% revenue split to App Stores a practice established by Apple's iOS app store. This has become a key litigation battle between Epic Games and Apple over the revenue generated by Fortnite-EPIC's proto-metaverse environment.
The rise of Web3 and the Metaverse has raised questions of who manages and exploits intellectual property in the Metaverse. Generating content and experiences for the Metaverse is a sophisticated process that requires interdisciplinary teams to collaborate on a range of technologies and digital asset production methods. Creators are now exploring more balanced approaches to IP attribution and determining their contribution and hence their remuneration share over complex digital assets that may evolve through several generations before they become popular. These themes were discussed in focus group sessions and are mapped in Figure 13.

"These technologies are perceived to give creators greater control over distribution of their creative outputs, audience selection and monetisation routes via existing contractual models and new opportunities via minting of digital assets."

Focus Group Insights

N-2-87. Games have had these challenges in the virtual economy and intellectual property. It's being played out in places like World of Warcraft and EverQuest around who owns things that they created in the world. The end user licenses are suddenly coming into the fore as a thing that people didn't really understand. Well, I made this sword surely. How can you say that it's your sword and that you can monetise in that way.

Y-2-74. I make and sell apps and it's interesting how up until about six months ago I would give 30% to Apple and Google and that seemed quite expensive. But now since I guess the developments around people being able to sell their assets for me and other people earning less than a million we get 15% and that seems OK now I what do I get from the Apple Store? Well they sort my tax out they make sure that I am not breaking the law they put my apps on a server they host and that scales so that's for me that's 15% well spent, 30% wasn't.

N-2-83. There's been a few test cases around the intellectual property question testing what it means to recreate something in the Metaverse and take that from one space to another and that court case has sparked a lot of debate around exactly this issue of content creation.

N-2-84. Brand new content that is created in that space, and then multiple ways in which those are now being shared and given away in a way that is rather interesting and there's physical artefacts that are duplicated into the virtual world by people creating them, what happens when they have created that work, a copy of that work. How much of their agency and the creation of that takes over a bit the ownership of the object.

M-1-37. We're in that transactional relationship where we're effectively getting services digitally for free that we're giving up our data on. That needs to be addressed. Commercial enterprises who control the platforms, user access and content creation are monetizing that whole aspect. So there's no easy solution.

Y-2-6. I think what's so amazing and so fantastic is that people can create their own fashion, what's really important is that doesn't get lost among the platforms and they're not just about accessing creator communities.

MV economies

Y-1-28. How do we do handle bartering and trading of digital assets in the MV? There are NFTs and digital currencies but no clear vision of how MV economics will play out.

D-1-19. There are many people speculating on the value of virtual goods in the MV. Second-Life is interesting in that it closed itself. You couldn't bring things in or out but that created an economy. It would have been destroyed if people like me could have brought in amazing models to sell and extract value from the platform.

M-1-20. Creative passports and journaling systems are needed to attribute rights to digital works such as music or engaging content or digital experiences/spectacles in the MV. The passport detail needs to be attached to the journey map that a digital asset may take through the MV.

D-2-30. In 2022, the global games market was worth $202 billion, and over 54% of that came from mobile. Now on mobile, a lot of content is free to play, and you realize value from your players and another way. Yes, you can have in-app purchases, and yes you can unlock added content, but also product placement and game advertising.

D-2-31. All of these opportunities exist to realize value without necessarily asking the punter to put their hand in their pocket. That is the reality right now. So, in 5-10 years there will be new ways in which every big brand will be pouring money into this.

D-2-35. Buying something in a game is OK if you know what the value is to you, the trade-off, and you know what is going to happen with it. But I think that's where whale hunting in games and the whole free-to-play models are horrendous.

D-2-45. Platforms like Apple App Store and Google Play Store are adding an additional tax on developers who want to get their thing on that marketplace. If this is a space that is not dominated by the big players If the creators of metaverses must pay the big players to host content on, or play on, their platform, what will that do to the creative industries? Is the ideal model that 80% of their money should go and disappear somewhere else already?

D-2-46. Games could be a microcosm of what the metaverse made look like, like Roblox and Fortnite, because they're not just games, they're online communities, which give players tools of creation, especially Roblox. And there's been a huge amount of growth for Roblox in the last 12-18 months because kids can build games and make games available. Theoretically, can earn money from that, but realistically 99 plus percent of people are not getting anything. The company is just soaking up everything.

D-2-47. Dealing with IP is terrible for anyone in the creative industries. There's hardly any protection in place, and even where there is, then the protections are not obvious. The entire system is not set up for the person creating things. It's set up for you protecting holding it to your little copy go who has access to it. So legal and ethical protection as well is a big issue that the government has not kicked off in the last 20 years in digitalization. So, where the entire world has changed, the legislation has not.

Y-2-15. Everything is kind of situation on the Roblox platform which I understand has the same problem as the Apple Store which takes an increasing chunk out people and so like these actions determined so much by like market forces which explains all of the other fashion study.

Y-2-16. To some extent, Arts funded organisations are of insulated from [platform commercial] by virtue of receiving arts council funding so we can take the risk that possibly a young developer on Roblox would not be able to or feel they can. I appreciate that there is people doing [artistic work] in these virtual spaces, but I just find it very hard to separate it from the people backing them.

Y-2-37. Creating transparency and the value exchange and so particularly Roblox, if they did what they do online in the physical world and most legislation would be illegal because you pay people in your own currency that you control, you have asymmetric exchange values into their currencies. You've got a chronic lack of transparency about, the estimates, and again, nobody really knows, but the estimate said is probably a creator share of probably just under 20% in Roblox and that is in stark contrast to, Apple.

N-2-47. Within digital infrastructure, we can say this, these digital things that we own this coat, this Nike trainer whatever it is, and I can go between Metaverse and I can sell them on have and I could sell them on if someone else ever wanted to buy the trainers I had. That idea that when I sell them on you now own them. It says you own them, but so used to own them and that passing on of the data and the infrastructure and the control of who has access to it is the really amazing thing.

N-2-92. If you think about blockchains and powering smart contracts for creators I want 5% of every time it's sold Forever. You can sell it on and on and on and on and on it's like getting the ultimate PRS, like someone will always give you a little cut back of what you created.

N-2-93. I think that that positive spin on the kind of create the creative economy and the Metaverse plus generative AI. Yeah, it's a real coming through. It is coming for us in every single way. And we just need to be prepared because it's going to disrupt us.

N-2-94. So wouldn't that put a premium on the authentic and real so that the hierarchy changes. It's the same reason I pay £10 a pint for a beer brewed by a guy with a big beard covered in tattoos. It is not a better beer but it has a story behind it and why we are making things. You know why we are you switch television on.

M-1-19. We have a challenge in the music business in properly attributing value to the creative works of musicians. Many creatives are struggling to make a living even though digital content that they created decades ago can and frequently is popular today.

Y-1-14. Virtual events and digital twinning of physical venues: No need to travel to venues (reduced carbon emissions & environmental damage), improved accessibility, and artists can reach a larger and more diverse audience. Improving the quality of MV events is key.

Y-1-4. The companies building the platforms only see big name artists, concerts, branded content as the way forward but Second Life has been growing organically for 20 years because users weren't being told what to do on the platform and they found their own ways to build it and make it relevant. Hence, we should make content that is high quality and users will don their headsets.

Y-1-46. Providing an attribution chain from creator(s) to virtual content that would help.

Y-2-71. Like the hierarchies and structures that exist, in the physical world I think we have an opportunity to disrupt them and I think if we can support people to have spaces to create and have ownership over that content, whatever type of content that could be quite a positive thing.

N-2-116. I have seen exploitation of kind of creativity, of more grassroots like group or more individual creativity and there is a big disparity in that relation because there is a huge potential in that sector as well.

Access to platforms

M-2-23. There is a lot of lot of barriers there for an independent developer to create a kind of access through those platforms.

N-2-74. You need to democratize creation and democratize access. Two very difficult things, but it needs to be easier and simpler to create. Where we are now with real time engines, you need expertise with programming, engineering etc.. but to create for the current Internet, you just need to be open up Squarespace and click a template and you can make a website.

Y-1-38. The WWW was borne out of the scientific community and was explicitly not commercial. It aimed to be open for everyone to access and engage with. Finding an analogous way to do that for MV would be extremely valuable – but would require public investment and international co-operation across governments.

D-2-41. A range of open-source technology could lay a foundation that could make a real shift or in approach to how it all might work.

Y-1-3. There's nothing in the MV now that makes people need to use it – or even want to use it. There are compelling use cases and artists are excited about the prospect of reaching new audiences and improving accessibility but companies don't know how they are going to monetise it.

M-1-16. Often the games we get are a replication of environments/activities that we do the physical domain but they have been gamified in some way. We need some innovation in this area, if the user needs a VR headset to play these games then it needs to offer something unique. Otherwise, users will resort to more accessible platforms/devices.

N-1-29. The online activities that we got used to in the pandemic are a quantum leap away from virtual environments in MV. So if you run a music festival in MV there are two practical problems: 1) Making it accessible to any computer-but most computers really struggled with processing / rendering the event; 2) People don't intuitively know how you might move through a virtual environment and that makes interpersonal stuff like listening and talking to people in the crowd very difficult.

Y-1-45. Who will have access to build these virtual worlds? Whose world is being simulated? Whose values are being represented? How do we ensure that it's not just the big companies controlling all of this?

Market Dominance

Y-2-38. The commercial platforms are the real problem. So not just who gets access to this sort of value exchange, but it what degree of transparency can be enforced through policy. I feel really strongly that an area and then somewhat related to that is the realities of Freedom of Information and data ownership.

Y-2-39. These platforms are walled gardens, in some cases you surrender some of the IP and the ownership to the platform. I've made Freedom of Information requests to different platforms, Roblox, Horizon Worlds, Decentraland and they suffer from the problem that you get too much information or the way it's physical IP so you can almost tie behaviours to real people

Y-2-41. The first step is to assert true ownership of the data to the individual users. A company should not have to share all the data of all users, but each individual users as vital starting point for users to enable them to share the data as a collective and derive value from it collectively again. The states of ownership is just simply not there.

Y-2-68. We talk about opportunity; companies like META worry me because they just want full control over spaces. I do not think that is right. The success of game platforms are because they are community driven.

N-2-115. Artists being involved in the process and in relationship in the mix to big tech, where research or creativity is part but there's been points in the experience where whoever has the closest relationships with the tech holds the power in that relations.

Regulation

M-2-41. I think we have an opportunity to control things now-with the Internet it just exploded. So, we have to use all the lessons of what we did wrong regarding the Internet and then seeing which other priorities and see how we handle that.

Y-2-37. Creating transparency and the value exchange and so particularly Roblox, if they did what they do online in the physical world it would be illegal because they pay people in their own currency that you control, you have asymmetric exchange values in their currencies. You've got a chronic lack of transparency about, the estimate said probably a creator share of probably just under 20% in Roblox and that is in stark contrast to, Apple.

Y-2-66. On a policy discussion, real concern that these platforms will be actually massively anti-competitive because they have unique resources the platform owners thinking divorces. Because they are reliant on a lack of interoperability, they drive you further down into one platform. So there's the one case of these technologies can massively increase the concentration in the market and what does that means for the power they hold, it may be financial and but it can be with data and what they're doing and with data in increasing their dominance.

N-2-85. I think there is an awful lot of work that is going to be needed around the intellectual property from physical transferring into digital, but also digital, digital native artworks and their intellectual property.

N-1-20. Going back into history e.g. the industrial revolution, it gave opportunities for some and exploited others. MV will be the same. This is all about taking the opportunity, making sure people can access the technology and adding some protections but there will be exploitation.

N-2-117. We need to disrupt the narrative, there is funding for artists and technologists to work together, they do brilliant things, the technologist goes away and carries on doing that brilliant thing. It has their name on it as they actually were the ones who did most of the technology work and the artist is left with a black box that they don't know how to repeat or how to own.

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Market Dominance

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Payment Rails

Money & Trust in Digital Society -- Bitcoin, Nostr, Stablecoins, Digital Objects and Machine Learning in B2B Telepresent Mixed Reality John Joseph O'Hare, Allen Fairchild, Umran Ali https://arxiv.org/abs/2207.09460

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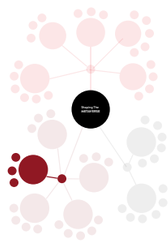
DATA COLLECTION



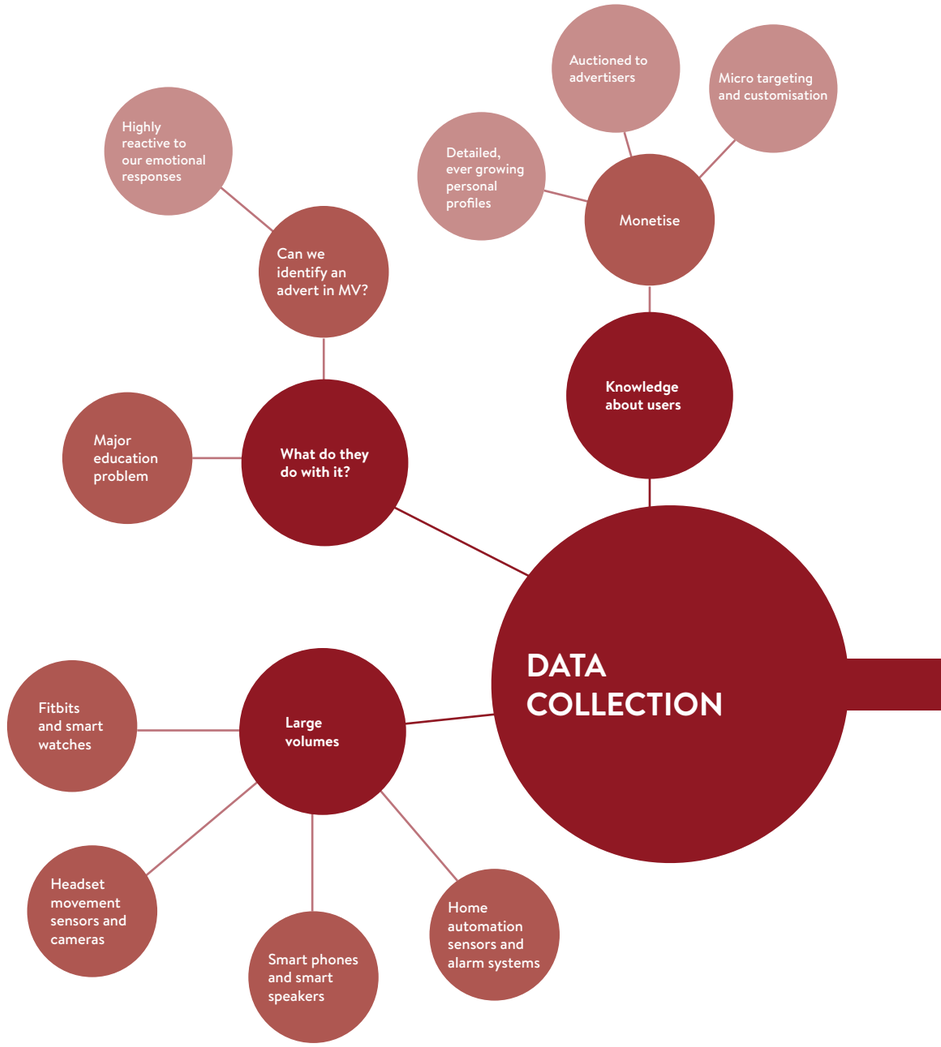


Figure 14 Shaping the Metaverse Mind Map – Data Collection

The scope of data collection facilitated by MV was a significant concern expressed by many of the participants in the focus groups. A primary issue is emergent forms of biometric observation made via VR/AR headsets. These new biometrics can identify individuals with high accuracy in a short period of time (e.g. 10 seconds). Broader discussions around data collection identified advertising as the main reason for collection and the dominant business model of metaverse technology companies. A lack of awareness in the end user population of how their personal data will be used is highlighted along with issues of ownership and agency over personal data. The potential benefits of distributed storage architectures were voiced and more cautionary descriptions of ubiquitous sensor networks that seamlessly span the cyber-physical divide. The mind map derived from the focus group sessions is depicted in Figure 14:

Focus Group Insights

D-1-3. More troubling is the fact that they collect lots of data about us and what they to do with it. Particularly with headsets, people are not cognisant of their ability to capture a broad range of metrics from your motion and your eyes. This will block mass adoption.

D-1-4. There is a major education problem in that people do not understand what can be done with their data.

D-1-32. The sheer volume of data that has been gathered about you while you are wearing a headset or interacting in the metaverse is in a completely different order of magnitude to what you experienced with social media.

Y-1-24. The transfer of personal information across different companies needs to be regulated so that we may control what data is shared across platforms. Who knows what is being reported about your behaviour and interactions across these platforms, so we need transparency and control over that.

Y-1-25. Short clips of headset motion data can be analysed to identify individuals with high precision. Facial recognition will do the same thing. There are no guidelines on how or when these technologies should be used.

Y-1-35. Meta and the big players make their money through advertising. This is the big driving force, and it is up to the rest of us to push forward the societal good. Advertising is the initial use case, but it is about gathering data, knowledge of people, where they are, what they are doing because that is what can be monetised. That is how Meta and other companies make their money–from knowing about us.

Y-1-36. Reactive billboards as we walk past – selling of advertisements is the main commercial application. There are a lot of other applications- healthcare and training in lots of different fields is another but the big bucks and mass adoption is done through advertising and that is a big problem. They need the data collection to enable targeting of advertising and how would we know in any of these virtual environments what is or isn't an advertisement? We need to reconsider what advertising means – it is now an optimisation of what is offered to us.

Y-1-42. Challenge in regulation: If we restrict data collection or deny movement of data/profiles between companies, we do not want to regulate to the point where we cannot do research that is useful or develop new applications that use personal information e.g., analyse motor impairment in patients. How do we design those regulations?

Y-2-49. The first step is to assert true ownership of the data to the individual users. A company should not have to share all the data of all users, but each individual user is a vital starting point for users to enable them to share the data as a collective and derive value from it. The state of data ownership is just simply not there.

Y-2-87. The dominant assumption is that we cannot have social media without our data being sold.

Y-2-110. Control is key-having access to the things I want, and control over what other people can expose to me. So, if I have signed something that says yes you can put adverts in my world for the things I am interested in, then that is my choice. Equally, I should be able to say these are the things I do not want to see.

C-1-39. One of the concerns we have about the headsets is the data collection – but also then technology can be for good, like an apple watch picking up a heart murmur. How do we balance these?

C-1-41. BeatSaber tracks body movements. The day they got bought, Meta changed their T&Cs so that they could keep hold of all that tracking data.

C-1-42. There is a good body of work that suggests that after 10 seconds of watching you move, they can tell who you are. It is more efficient than biometrics.

C-1-43. It also all comes down to how the underlying data is used. Meta's business model is all ad- based. It is all about how they mine you for data. The current prevailing mechanism for making huge amounts of money is the data business.

C-1-44. There needs to be more dynamic models about how data works – now it is either on or off.

C-1-57. In terms of big tech, we all got swindled. In terms of the stack. And the opportunity here is to not let that happen again.

N-1-36. Latest mobile phones can capture your facial expression and will transfer them to your avatar. Leading to more naturalistic experiences in MV. It could also be used to automatically detect your emotions – there is always a tension between the usefulness of the technologies to the individual and the potential misuse of it.

N-1-37. For mass population application of MV technologies, there are huge issues about surveillance, manipulation and political manipulation. Especially from those big tech companies who have access to those kinds of emotion/behavioural data.

N-1-39. Can we put red flags on technologies? So, any technology that captures something about us (facial recognition is an obvious one), need then to go through some kind of evaluation?

N-1-40. It is not necessarily the technologies themselves, but the architecture of the systems involved. What is being collected, who are the people querying that data relating to individuals? Is it preserved and collected by a corporation or a government or whatever. Does that data sit with the individual or have they no agency over it?

N-1-47. Ubiquity is hard to understand in terms of the scale and complexity of the digital environment – regardless of what the systems are meant to represent or captures. Lots of sensors and cameras drawing together different types of data for analysis. What is it being used for? Do we know anything about it?

N-1-48. But we are complicit. People will put a smart speaker in their home and be quite happy for the return of what you get. And everybody anticipates there is some take from it as well.

N-1-51. It is remarkable that companies are so conservative about sharing their data. Whereas we as individual users continuously have to hit the 'Yes, I accept' your privacy policy. We are not offered an alternative either you do accept, or you do not use the service. I mean there are some technological alternatives, but only for people who know how to implement them.

N-2-34. I am thinking about sensors and the role that they are going to play in the realisation of the Metaverse and the way that they come with their good and ill. In terms of how they are being used right now to monitor bodies, survey bodies, discipline bodies or enable the safety of bodies.

N-2-35. This phone, for example, decodes my location and other information from the accelerometer. So, my information is already accessible to for example people who monitor cellular networks or mobile phone data. They can already tell who is sitting in this space around me. Is that the metaverse? Yes, because someone had access to this digital information.

N-2-38. We work with all sorts of sensors, audio, movement tracking, heart rate, health care related sensors and we send it all to our digital twin. Some people think a DT must be a full replica of the whole subject, but it could be as simple as a dashboard. It is a digital twin because the data that we have is coming from the physical world.

N-2-45. Blockchain technologies are incredible, they are a fundamental transformation and evolutionary step forwards for humanity. We have never had any technology which is robust enough to record a fact. For example, whoever wins the next war will wipe the history books clean and say it happened this way.

N-2-48. With blockchain history is locked in as a fact. Not just as an act that can be rewritten by whomever wants to change it. If I try to change it the data will not pass into the blockchain.

N-2-49. With something like Meta and the Horizon World Project, Zuckerberg could turn it off and change everything at a whim because it is not decentralized. It is owned by a company and one person's opinion sits over it all. Whereas a decentralized universe, a decentralized metaverse, means that data and information is protected forever.

N-2-50. When blockchain comes out of the digital realm and back into the physical world, just imagine a car's service record will be absolute and every time something gets fixed the details just get added to the service record. All your medical records would be held and you would control access to those medical records. Every time someone wants to look at them they must ask for your permission.

N-2-69. Amazon has patented technologies that can sense what my tone of voice means about my emotional state and can therefore promote things to me that might work on my depression. How do you regulate and make sure that that data is going to someone that you can trust?

N-2-72. I'd love the NHS to have a high-fidelity digital twin of me. Driven by a smart watch with a full stack of health records that can be picked up and looked at by a doctor. But constantly monitored by a bunch of AI going: You're not well, we should talk to you about this, you should do more of that, you haven't done this. I would love for someone to be preventatively observing my health status instead of waiting until I get poorly before something happens.

"I'd love the NHS to have a high-fidelity digital twin of me. Driven by a smart watch with a full stack of health records that can be picked up and looked at by a doctor."

Supplementary Research

Douglas Edwards' 2011 book *I'm Feeling Lucky* includes an interview with Google's founder Larry Page where he is asked, 'What is Google?'. Page responds, "*If we did have a category, it would be… personal information…The places you've seen. Communications…Sensors are really cheap…Storage is really cheap. Cameras are cheap. People will generate enormous amounts of data…Everything you've ever heard or seen or experienced will become searchable. Your whole life will be searchable.*" (Edwards, 2011). Google intends to record and index our whole lives: everything we have seen or heard or experienced. To achieve this objective, it follows that there can be no distinction between the physical and digital domains; sensing must continue seamlessly across these divides. In 2010, Eric Schmidt the then Google CEO stated, "We don't need you to type at all. We know where you are. We know where you've been. We can more or less know what you're thinking about.". What the Google executives are describing is a metaverse – not the immersive experience aspect but rather the total integration of the cyber and physical domains.

Hal Varian, the economist and academic who later became Google's Chief Economist theorised on computer mediated transactions and how they may affect society going forward (Varian, 2010). Varian identifies four use cases: Data extraction and analysis; Personalisation and customisation; New contractual forms due to better monitoring; and Continuous experimentation. Varian's work provided a roadmap for Google's development. In the early 2000s Google began to build their 'extraction and analysis infrastructure' by providing a series of computer mediated services such as internet search, email, maps etc. each of which produces 'signals' about the behaviour of individuals as a by-product. The company's 'personalisation and customisation' infrastructure is a machine intelligence sub-system which takes those signals, aggregates them and formulates them into profiles of human behaviour. The continuous flow of behavioural data turns this infrastructure into a recursive learning system that improves the accuracy of profiles over time and enables accurate predictions of an individual's future behaviour. Google invented 'targeted advertising' and monetised it via its 'AdWords' service. Eric Schmidt credited Varian for validating Google's business model and said, "All of a sudden we realised we were in the auction business".

Sheryl Sandberg worked in Google between 2001 and 2008, before joining Facebook. Sandberg oversaw the development of Google AdWords and immediately recognised the value of the 'signals' and behavioural excess flowing from Facebook's social directory platform. "*We have better information than anyone else. We know gender, age, location, and its real data as opposed to the stuff other people infer*", she said(Zuboff, 2019). Sandberg was responsible for porting Google's business model onto Facebook's social network platform.

Google and Facebook follow very similar trajectories and share common business practices. The 'data extraction and analysis' prerogative introduced above is a highly intrusive process which reduces end-users of the companies' services and platforms to mere raw materials. The behavioural signals that first appeared as by-products of internet searches were then proactively hunted down across all Internet real estate to widen and diversify Google's and Facebook's extraction architecture. The infrastructure used to gather that raw material is sophisticated, ubiquitous and very powerful. A 2015 study of one million websites found that 90% of them leak data to external domains who track, capture and expropriate data for commercial purposes. Of these, 78% perform data transfers to Google owned domains and a further 34% to Facebook owned domains (Libert, 2015). For the average computer user in the UK, the whole of the Internet has been instrumented to provide Google, Facebook and others with behavioural signals that map out our lives in alarming detail.

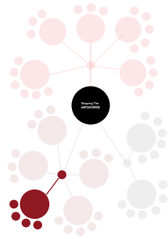
Advertising revenue is the principal revenue stream for Google and Facebook/Meta but other technology corporations use advertising as a secondary income stream. Amazon is principally focused on online marketplaces, retail and logistics operations (cloud computing services is an orthogonal business activity). These rely on mass analysis of the customers' online behaviour in Amazon domains and AI-driven recommendation systems. In this sense the 'data extraction and analysis' prerogative is common to all these corporations. Amazon is also casting its net further afield to capture user data from the physical world with a particular emphasis on speech. 'Alexa' is Amazon's spearhead voice recognition service embedded in its range of hubs and smart speaker products. In 2015 Amazon launched 'Amazon Lex' a service to third party product suppliers. Lex offers the ability to integrate voice controls (i.e.

sophisticated, natural language, conversational interfaces) into household products such as light switches, door bells, thermostats, home security systems and entertainment systems. *"Our goal is to try to create a kind of open, neutral ecosystem for Alexa…and make it as pervasive as we possibly can"*, said Amazon's Dave Limp, Senior Vice President for Alexa. Smart home devices now render conversations in the home and sophisticated semantic analysis produces enhanced predictions which anticipate our needs. It is these insights which are sold to advertisers. In their most recent quarterly financial results, Amazon's advertising business saw revenues jump 23% year-over-year to $9.51bn. Andy Jassy, Amazon CEO said advertisement revenue had benefited from the company's investments in machine learning.

For many years legal scholars have been highlighting the dangers of population level information extraction and processing as a threat to the autonomy of the individual and to liberal democracy itself (Schwartz, 1989; Simitis, 1987). More contemporary work from McStay stresses the importance of the first-person perspectives made available in metaverse architectures, *"A fundamental premise of surveillant physics across the modalities of the Metaverse is a persistent ability to computationally see first-person perspective and that environments may allow for on-the-fly changes to those environments, just as behavioural/programmatic ads change for individuals. This is tantamount to cognitive, mediated and automated empathy, this reflecting an interest in the datafication of the first-person perspective and the increasingly diverse ways that algorithmic systems profile, judge and interact with intimate dimensions of human life."* (McStay, 2023a). This resonates strongly with Varian's fourth use case, 'Continuous experimentation'. The MV is certainly an opportunity for Google, Facebook, Amazon and others to collect more personal information from end-users but crucially it offers additional scope within the virtual environment to nudge, manipulate and control those users also. One focus group participant described this as being 'hoodwinked':

> *"Think of fake news today, there are tell-tale signs that let you know to be sceptical about a story e.g., a breitbart.com URL on your screen. But as immersive technology develops and becomes more subtle you will be hoodwinked in virtual environments, and they'll know more about you because of all the data they've collected. It will be much more compelling, intimate and much more difficult for us to discern reality." [D-1-28]*

IDENTITY



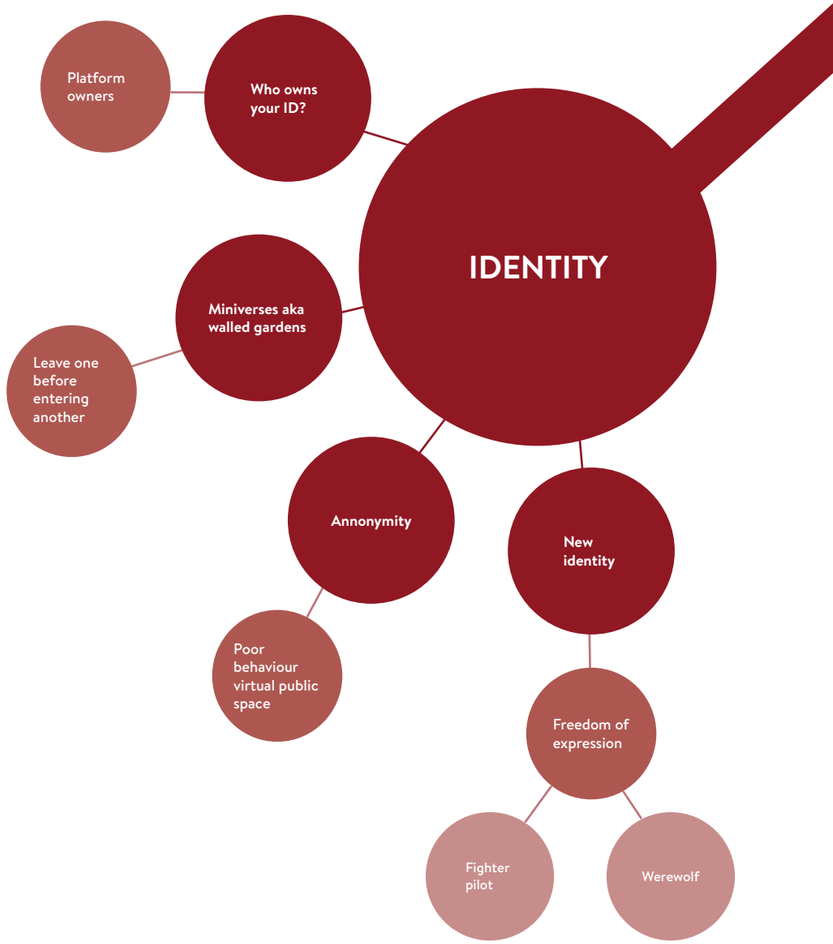


Figure 15 Shaping the Metaverse Mind Map – Identity

Focus group sessions made reference to identity within MV in terms of the governance and technical authority behind identity assignments but also in relation to freedom of expression and the ability of end users to create and explore their identity within virtual worlds. The mind map derived from the focus group sessions is depicted in Figure 15.

Focus Group Insights

M-2-50. The question of digital identity quickly links to questions of economics as well.

M-2-51. Who owns your identity?

D-1-9. Rather than one MV we see a series of mini verses where a user must leave one before entering another because they are isolated. You cannot take your stuff from one to the other and that is another big blocker. It is hard to see how we will solve that in a ubiquitous way without adding a layer or an open standard that the platforms are willing to implement.

D-1-17. Why do people feel entitled to do these things in a virtual public space and not in in the physical world? Mostly because they are anonymous but as soon as you remove anonymity those behaviours may go away. So, it is the digital identity that needs to be resolved.

D-1-35. Identifying that a real person is logged onto the MV i.e., an assurance that you are interacting with a real person would be very helpful. Without that assurance then you should significantly doubt what information you get from them. For the MV to feel like a safe space then that would be very important.

Y-1-22. A good starting point is what do people want to be interoperable? The big example is avatars – all the platforms impose different constraints – so an interoperability standard that allows people to be as expressive as they wish for their digital identity and enables that to be portable across platforms would be ideal.

Y-1-23. There is a lot of information about individual people already out there in the cyber domain and it is quite unsettling that this could be at odds with the avatar or digital identity that you choose to represent yourself with. So as someone enters a new platform/virtual world, which information source will take precedence?

Y-1-43. The key aspect is ownership of data that identifies the individual. Ownership over the data assets that are used to interact with services – that would mitigate any harm.

Y-2-6. On diversity and access, identity is the key. There is an assumption that people want to bring their identity into the Metaverse, but a lot of people don't. They see it as a way of creating a new identity. There are two conflicting schools of thought depending on who you talking to.

Y-2-11. A reason people play games is to escape and to do different things. They want to be a fighter pilot or a werewolf. Do I want to wear my Adidas jacket when I am a fighter pilot, or do I want to be a fighter pilot?

Supplementary Research

Identity is a complex issue because in real life we maintain multiple identities some of which are public facing and others which are held more privately for a variety of reasons. For example, work email addresses, office phone numbers and vehicle registration numbers are generally made available in most contexts. A person may be more reticent about offering their mobile phone number and in some contexts this can be a very sensitive issue e.g. young people, dating and night clubs. A person who volunteers with the Samaritans is probably not going to share that identity widely beyond close friends and family. In other contexts, we may wish to remain anonymous e.g. when responding to a market research questionnaire. Within the context of an emergent metaverse, digital identity systems must replicate the multifaceted nature of our lives and provide the necessary flexibility to express ourselves without compromising privacy. There are different ways to achieve this.

Today most digital platforms offer their own/ proprietary identification methods e.g. Facebook login details, Google account credentials, Online banking credentials, HMRC Government Gateway User ID etc. The platform/bank/corporation owns and assigns an identity to individual end users. That identity serves the business needs of the platform/ bank/corporation only and interworking or interoperability between platforms is not prevalent. Users need to logon to each platform separately using different credentials.

Distributed identity management systems that offer identity services to consumers independently of the incumbent platform/bank/corporation are an evolving technology with a solid basis of regulation in some geographies. eIDAS, the EU Regulation on electronic Identification, Authentication and Trust Services European Parliament, 2014 created one single framework for electronic identification (eID) and trust services, making it more straightforward to deliver services across the European Union. eIDAS promoted interoperability across the 27 EU Member States, ensuring that countries mutually recognised each other's notified electronic identification schemes and provided legal certainty for compliant electronic identities. 'eIDAS 2' extends this work to incorporate an 'EU Digital Identities Wallet' that holds a wide variety of credentials such as driving license, health insurance details, current medication prescriptions, vaccination status, biometric passport etc. All of which will be accepted across the EU trading block. "The new European Digital Identity Wallets will enable all Europeans to access services online without having to use private identification methods or unnecessarily sharing personal data. With this solution they will have full control of the data they share", said the Commission's press release (European Commission, 2021). EUDI Wallets will be GDPR compliant and will enable selective disclosure of attributes (such as age). The user only needs to share the necessary information for a particular transaction. For example, if you use the wallet to prove your age, you do not need to share other personal details such as date of birth, name, or address. Member states are expected to make Wallets available to their citizens by 2024.

Distributed identity management systems are under development within the open-source community also. Self-sovereign identity infrastructure (such as sovrin.org) is built on a 'permissioned blockchain' infrastructure which is scalable and more computationally efficient than BitCoin derived architectures.

If users can assert their own identity within MV to perform a wide variety of activities and transactions e.g. to buy alcohol or hire a car or plan a holiday, then retailers and service providers will benefit from a trusted digital identity that has legal standing and is safe and convenient to use by their customers. This also means that those retailers and service providers can operate independently of the major digital platforms. An interoperable trusted identity platform also creates opportunities for online safeguards and policy interventions such as more effective age-gated access control to specific virtual worlds and experiences.

Anonymity in virtual public space can give rise to antisocial behaviour (see D-1-17). This is a misnomer in the sense that lack of attribution is the root cause of the issue rather than anonymity. A self-sovereign digital identity (akin to the EUID Wallet) can provide a non-descript 'anonymous' ID when the user wishes but all the actions and interactions undertaken by that user are still attributable. This function could help to alleviate antisocial tendencies in MV.

User control over what subset of personal data is made available to each virtual world is also a function of digital identity. The alias (or avatar) we chose to use in a particular metaverse site should also define the personal characteristics and background data we wish to release. Y-1-23 identifies the problem where conflicting or excessive personal information is held internally by the sites/platforms. A lack of transparency is also evident in this scenario.

The maximal distributed identity architecture also includes provision for a 'personal information management system' (PIMS) (Attoresi & Moraes, 2020). PIMS provide end users with a secure and resilient personal data storage system coupled with a policy-based rules engine which mediates with third party sites/platforms/services and determines which personal data may be released. PIMS provides a way for individual users to monetise their personal data. As requested in Y-1-43, this approach provides full end user agency over personal data assets.

BIOMETRICS

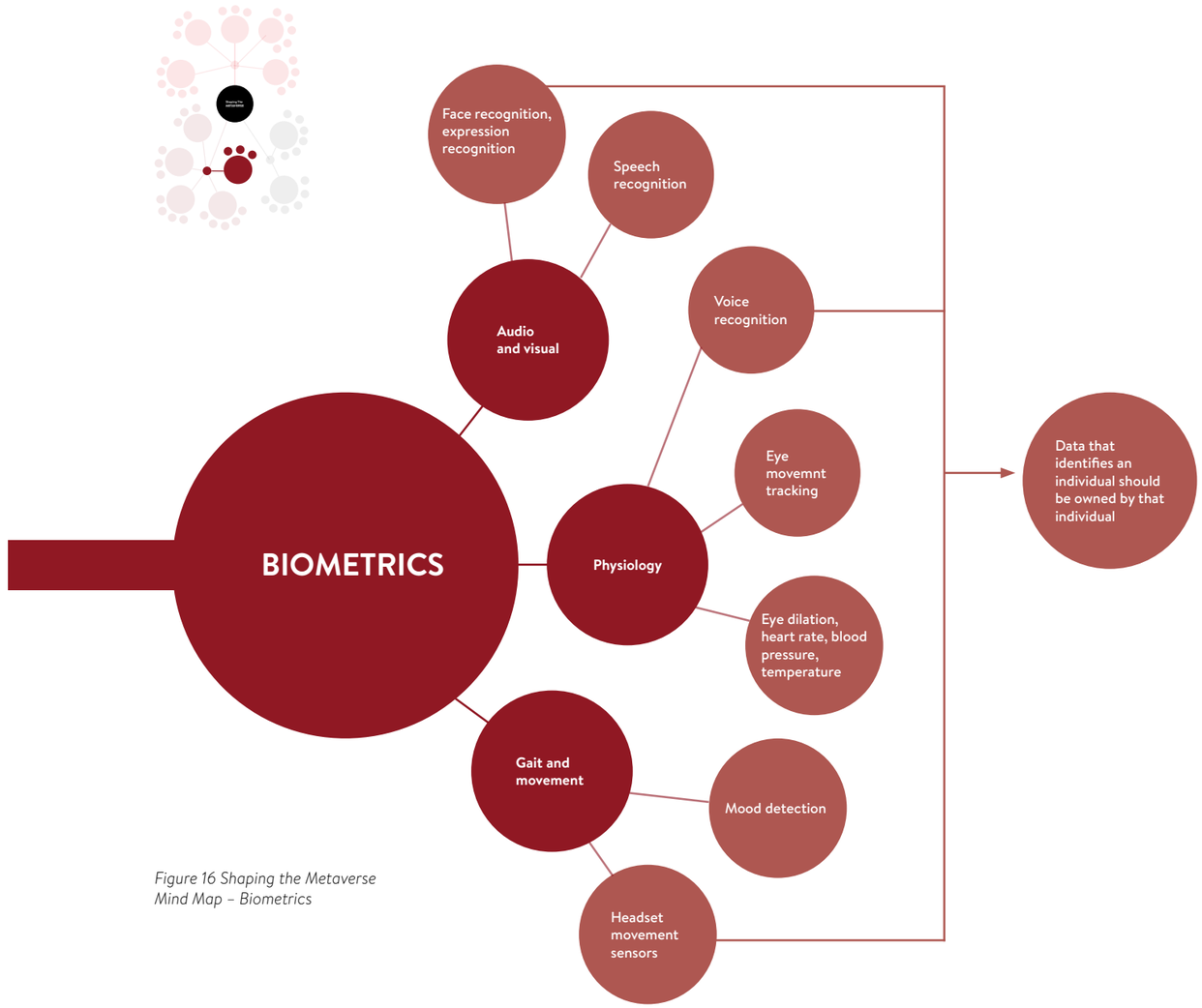


Figure 16 Shaping the Metaverse Mind Map – Biometrics

New metaverse technologies such as head mounted displays are a key tool in validating the effectiveness of advertisements. Eye movement tracking, gaze analysis and eye dilation metrics are clear indicators of the user's level of attention to an object or immersive experience. As Nick Clegg explained, "... you're not selling eye-tracking data to advertisers, but in order to understand whether people engage with an advertisement or not, you need to be able to use data to know" [Irwin 2022]. A series of patents granted in 2022 give insight into Meta's plans for highly realistic virtual reality experiences filled with human-looking avatars whose movements are dictated by tracking the user's real-life facial and body movements through different wearable equipment. In this instance, Meta's business motives appear to be transparent, but the question raised by the focus groups is, are these biometric measurements proportionate? The threads of the discussions are mapped in Figure 16.

Focus Group Insights

D-1-3. More troubling is the fact that they collect lots of data about us and what they to do with it. Particularly with headsets, people are not cognisant of their ability to capture a broad range of metrics from your motion and your eyes. This will block mass adoption.

D-1-32. The sheer volume of data that has been gathered about you while you are wearing a headset or interacting in the metaverse is in a completely different order of magnitude to what you experienced with social media.

D-1-35. Identifying that a real person is logged onto the MV i.e., an assurance that you are interacting with a real person would be very helpful. Without that assurance then you should significantly doubt what information you get from them. For the MV to feel like a safe space then that would be very important.

Y-1-25. Short clips of headset motion data can be analysed to identify individuals with high precision. Facial recognition will do the same thing. There are no guidelines on how or when these technologies should be used.

Y-1-43. The key aspect is ownership of data that identifies the individual. Ownership over the data assets that are used to interact with services – that would mitigate any harm.

C-1-39. One of the concerns we have about the headsets is the data collection – but also then technology can be for good, like an apple watch picking up a heart murmur. How do we balance these?

C-1-41. BeatSaber tracks body movements. The day they got bought, Meta changed their T&Cs so that they could keep hold of all that tracking data.

C-1-42. There is a good body of work that suggests that after 10 seconds of watching you move, they can tell who you are. It is more efficient than biometrics.

N-1-36. Latest mobile phones can capture your facial expression and will transfer them to your avatar. Leading to more naturalistic experiences in MV. It could also be used to automatically detect your emotions – there is always a tension between the usefulness of the technologies to the individual and the potential misuse of it.

N-1-38. It boils down to societal consensus, some people will say (e.g., Facial Recognition) is a great thing. Others would be against it because of human rights concerns. And where is that line? It depends upon where society is at that time and what consensus you are going to build around it. It always comes back to local democracy. That is why we have elected local representatives, who are supposed to talk for their communities and their wards. They will not necessarily represent everyone's views because they are too large and too diverse, but that is the model we have got now. Whether MV can change that or reconfigure it remains to be seen-how many voices do you want to hear because you cannot really appease everybody in terms of their expectations.

N-1-39. Can we put red flags on technologies? So, any technology that captures something about us (facial recognition is an obvious one), need then to go through some kind of evaluation?

N-1-40. It is not necessarily the technologies themselves, but the architecture of the systems involved. What is being collected, who are the people querying that data relating to individuals? Is it preserved and collected by a corporation or a government or whatever? Does that data sit with the individual or have they no agency over it?

N-2-38. We work with all sorts of sensors, audio, movement tracking, heart rate, health care related sensors and we send it all to our digital twin. Some people think a DT must be a full replica of the whole subject, but it could be as simple as a dashboard. It is a digital twin because the data that we have is coming from the physical world.

N-2-69. Amazon has patented technologies that can sense what my tone of voice means about my emotional state and can therefore promote things to me that might work on my depression. How do you regulate and make sure that that data is going to someone that you can trust?

Supplementary Research

The range of biometrics available to MV platform operators is vast and incorporates gait analysis (how we move), facial recognition, emotion recognition, haptics (including how we type on a keyboard), bodily functions such as eye dilation, heart rate, sweat, temperature etc. and even brain patterns. The range of biometric sensors housed in consumer electronics is growing i.e. FitBits, smart watches, embedded GPS location sensors, forward facing infrared cameras in smartphones, embedded cameras in head mounted displays that track eye movement and facial expressions, microphones embedded in household devices, accelerometers embedded in body worn sensors, and the 'magnetic sensor system' worn around the torso which was mentioned in a patent granted to Meta in 2022 (Irwin, 2022)These sensors, operating individually or in combination are capable of uniquely identifying a human subject. In the UK, biometrics are defined in law via the GDPR regulations as:

> *"Personal data resulting from specific technical processing relating to the physical, physiological or behavioural characteristics of a natural person, which allow or confirm the unique identification of that natural person, such as facial images or dactyloscopic data."*(UK Government, 2018)

This definition incorporates measures of the 'rhythm of life' and recurrent behaviours displayed by a natural person as a form of biometric. That is, the pure biological characteristics of a person are not the only form of biometric. Location tracking and the mobility patterns of a natural person are a strong identifier and privacy preservation in location-based systems is an active research area (Calderoni et al., 2021).

Governance of biometric technologies in the UK has been investigated recently (Chang, 2022). The Ada Lovelace Institute's report brings forward the following recommendations:

1. Prepare primary legislation on the use of biometrics;
2. Establish a Citizen's Biometrics Council to enforce that regulation;
3. Introduce independent validation of the accuracy and proportionality of all new biometric systems; and
4. Impose a moratorium on the use of biometrics for one-to-many identification in publicly accessible spaces until comprehensive legislation is passed.

Metaverse environments should be considered 'publicly accessible spaces' in this context.

PRIVACY

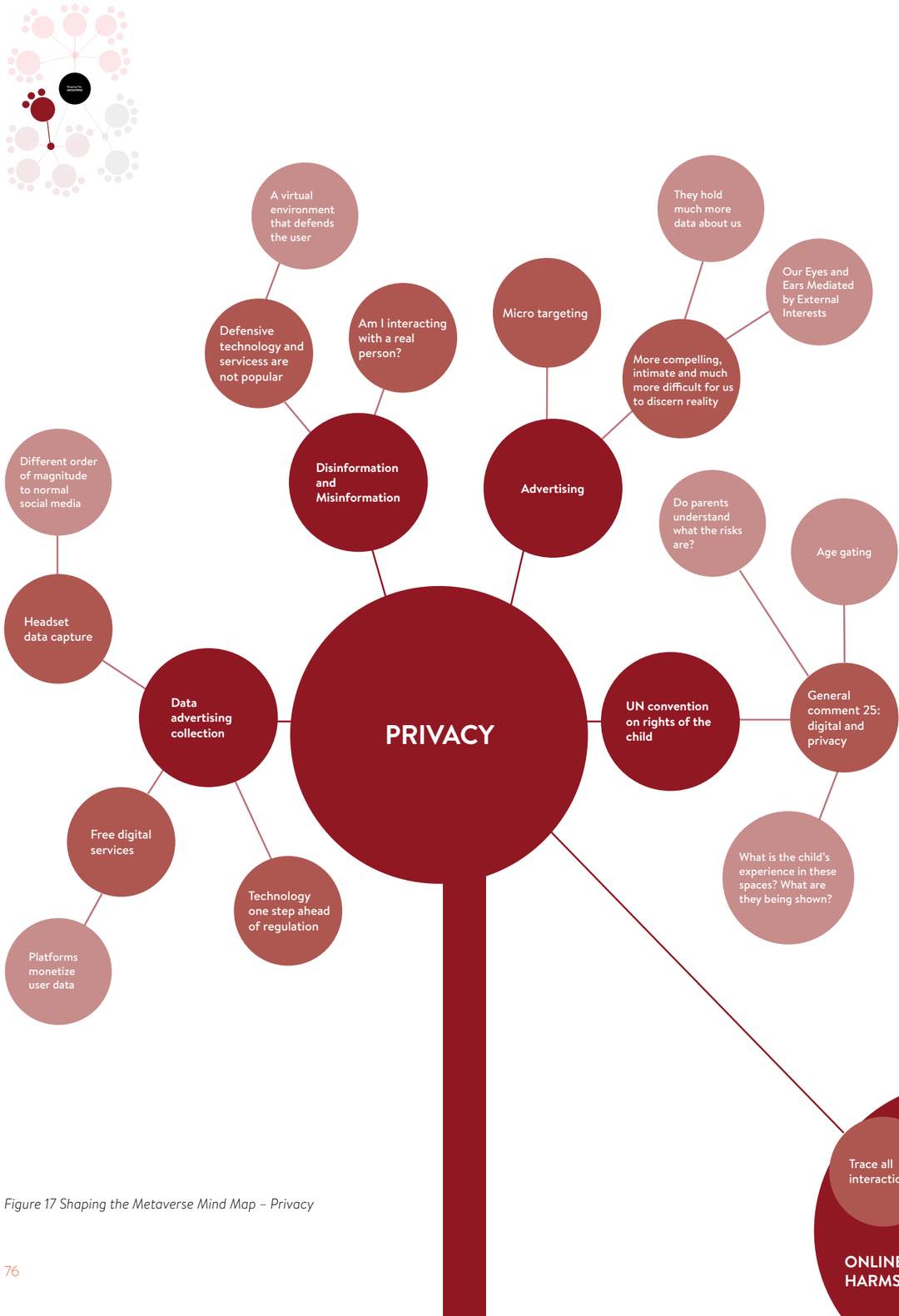


Figure 17 Shaping the Metaverse Mind Map – Privacy

Workshop participants frequently voiced concerns about the volume and/or the intimacy of data collection facilitated by metaverse technologies. They raise questions about effective consent mechanisms and the need to differentiate between separate use case contexts. This also relates to the trade-offs end users make between access to 'free digital services' and releasing their personal information. They highlight the need for regulation based on principles and human rights rather than technology and urge a user-centric approach. They highlight the need for much better education so that citizens (young and old) can be empowered to participate in a metaverse that will be more sophisticated and compelling, but also more difficult to discern reality within. Parents especially need help to assess the risks their children are being exposed to. Participants acknowledge that advertising is the commercial driver for much online activity and the prime motivation / monetisation pathway for digital platform owners to collect and analyse personal data. They express concern around new forms of advertising / influencing that may be facilitated by MV. Finally, they are surprised at the lack of technology aimed at protecting the individual and the lack of virtual worlds that are not predicated on the collection of users' personal data. The focus group discussions around the privacy theme are depicted in Figure 17.

"They highlight the need for much better education so that citizens (young and old) can be empowered to participate in a metaverse that will be more sophisticated and compelling, but also more difficult to discern reality within"

Focus Group Insights

M-1-34. Data privacy is a concern when we consider the amount of information VR headsets will have access to – a million data points in 10 minutes is an estimate. Targeted advertising will come, and with it, targeted disinformation and misinformation.

M-1-35. It is surprising that technology to defend yourself against these harms has not become mainstream i.e., the ability to choose a virtual environment that defends you automatically. A precondition of joining such a forum should be a commitment to not create/spread fear or exploit vulnerability. This should be a condition of a user going online.

M-1-36. There is a real problem with real-time moderation; to deal with ephemeral interactions you need a digital trace of all those interactions. To solve that you can record everything but then you have just raised the privacy bar. How do we balance those aspects?

M-1-37. We are in that transactional relationship where we are effectively getting services digitally for free that we are giving up our data on. That needs to be addressed. Commercial enterprises who control the platforms, user access and content creation are monetising that whole aspect. So, there is no easy solution.

M-2-5. There is a major question about how a lot of this is going to be used?

M-2-31. What happens when these AIs (Artificial Intelligence) are let loose on the web or metaverse, which is again owned more on the economic side?

M-2-37. We have the United Nations Convention on the Rights of the Child (UNCRC). We have the recent updates to the UNCRC on the right to privacy. We have general comment 25 which is the digital update to the UNCRC. UNCRC 25 is trickling down through UK legislation and it is trickling down through other bodies in the US and elsewhere.

M-2-38. It is important to remember that we have a human rights framework in place.

M-2-44. We have an opportunity to control things now-with the Internet it just exploded. So, we have to use all the lessons of what we did wrong regarding the Internet and then seeing what other priorities there are and see how we handle that.

D-1-3. More troubling is the fact that they collect lots of data about us and what they to do with it. Particularly with headsets, people are not cognisant of their ability to capture a broad range of metrics from your motion and your eyes. This will block mass adoption.

D-1-4. There is a major education problem in that people do not understand what can be done with their data.

D-1-28. 'Epistemic Hygiene': Think of fake news today, there are tell-tale signs that let you know to be scep3cal about a story e.g., a breitbart.com URL on your screen. But as immersive technology develops and becomes more subtle you will be hoodwinked in virtual environments, and they will know more about you because of all the data they have collected. It will be much more compelling, intimate and much more difficult for us to discern reality.

D-1-29. We make all our decisions based on the information currently at our disposal. Our best information gathering senses are our eyes and ears and we are about to allow them to be mediated by external interests.

D-1-31. Privacy is a big issue. One of the problems about trying to legislate about privacy is that you have that kind of catch-up game in that the technology is always going to be ahead of the legislation. So, the legislation has got to be principles based, not technology based.

D-1-32. The sheer volume of data that has been gathered about you while you are wearing a headset or interacting in the metaverse is in a completely different order of magnitude to what you experienced with social media.

D-1-33. There are different kind of ways of regulating. It does not have to be legislative. It could be by the market. We saw that happening in 2010 when people reacted badly to Facebook declaring 'privacy is dead'. They had to retract.

D-1-34. The way in which the platforms are designed is important. They can have hidden built-in security and safety features. And again, that might be market driven because people would then get to know which platform provides the safest environment.

D-1-35. Identifying that a real person is logged onto the MV i.e., an assurance that you are interacting with a real person would be very helpful. Without that assurance then you should significantly doubt what information you get from them. For the MV to feel like a safe space then that would be very important.

D-2-6. Currently we are not thinking enough about how the data is driving all those interactions.

D-2-51. What lessons have we learned from the issues with social media, and online harms? How can we take those learnings and apply them here? What do we need to put in place as the MV evolves?

D-2-53. How do we make sure the MV is a safer place to grow up in?

D-2-54. It is going to be crucial to up-skill the younger generation and ensure that their parents understand what the risks are.

D-2-55. What's the child's experience in these spaces? What are they being shown? How are they spending their money?

D-2-56. Not all parents have the background or knowledge or expertise because of their social, economic background and lack of education. That is the issue with women in tech, too. This piece needs to start at an early age, at school to encourage children to feel like they are digital citizens, to empower them.

Y-1-24. The transfer of personal information across different companies needs to be regulated so that we may control what data is shared across platforms. Who knows what is being reported about your behaviour and interactions across these platforms, so we need transparency and control over that.

Y-1-25. Short clips of headset motion data can be analysed to identify individuals with high precision. Facial recognition will do the same thing. There are no guidelines on how or when these technologies should be used.

Y-1-35. Meta and the big players make their money through advertising. This is the big driving force, and it is up to the rest of us to push forward the societal good. Advertising is the initial use case, but it is about gathering data, knowledge of people, where they are, what they are doing because that is what can be monetised. That is how Meta and other companies make their money – from knowing about us.

Y-1-36. Reactive billboards as we walk past – selling of advertisements is the main commercial application. There are a lot of other applications-healthcare and training in lots of different fields is another but the big bucks and mass adoption is done through advertising and that is a big problem. They need the data collection to enable targeting of advertising and how would we know in any of these virtual environments what is or isn't an advertisement? We need to reconsider what advertising means – it is now an optimisation of what is offered to us.

Y-1-42. Challenge in regulation: If we restrict data collection or deny movement of data/profiles between companies, we do not want to regulate to the point where we cannot do research that is useful or develop new applications that use personal information e.g., analyse motor impairment in patients. How do we design those regulations?

Y-2-87. The dominant assumption is that we cannot have social media without our data being sold.

C-1-39. One of the concerns we have about the headsets is the data collection – but also then technology can be for good, like an apple watch picking up a heart murmur. How do we balance these?

C-1-43. It also all comes down to how the underlying data is used. Meta's business model is all ad-based. It is all about how they mine you for data. The current prevailing mechanism for making huge amounts of money is the data business.

N-1-36. Latest mobile phones can capture your facial expression and will transfer them to your avatar. Leading to more naturalistic experiences in MV. It could also be used to automatically detect your emotions – there is always a tension between the usefulness of the technologies to the individual and the potential misuse of it.

N-1-37. For mass population application of MV technologies, there are huge issues about surveillance, manipulation and political manipulation. Especially from those big tech companies who have access to those kinds of emotion/behavioural data.

N-1-38. It boils down to societal consensus, some people will say (e.g., Facial Recognition) is a great thing. Others would be against it because of human rights concerns. And where is that line? It depends upon where society is at that time and what consensus you are going to build around it. It always comes back to local democracy. That is why we have elected local representatives, who are supposed to talk for their communities and their wards. They will not necessarily represent everyone's views because they are too large and

too diverse, but that is the model we have got now. Whether MV can change that or reconfigure it remains to be seen-how many voices do you want to hear because you cannot really appease everybody in terms of their expectations.

N-1-40. It is not necessarily the technologies themselves, but the architecture of the systems involved. What is being collected, who are the people querying that data relating to individuals? Is it preserved and collected by a corporation or a government or whatever? Does that data sit with the individual or have they no agency over it?

N-1-43. It is about education, education about politics, education about British ways to participate in democracy. People must be educated about the processes of political participation. They especially need to understand privacy issues and the complexities of balancing competing rights.

N-1-47. Ubiquity is hard to understand in terms of the scale and complexity of the digital environment – regardless of what the systems are meant to represent or capture. Lots of sensors and cameras drawing together different types of data for analysis: What is it being used for? Do we know anything about it?

N-1-48. But we are complicit. People will put a smart speaker in their home and be quite happy for the return of what you get. And everybody anticipates there is some take from it as well.

N-1-51. It is remarkable that companies are so conservative about sharing their data. Whereas we as individual users continuously have to hit the 'Yes, I accept' your privacy policy. We are not offered an alternative either you do accept, or you do not use the service. I mean there are some technological alternatives, but only for people who know how to implement them.

N-2-34. I am thinking about sensors and the role that they are going to play in the realisation of the Metaverse and the way that they come with their good and ill. In terms of how they are being used right now to monitor bodies, survey bodies, discipline bodies or enable the safety of bodies.

N-2-35. This phone, for example, decodes my location and other information from the accelerometer. So, my information is already accessible to for example people who monitor cellular networks or mobile phone data. They can already tell who is sitting in this space around me. Is that the metaverse? Yes, because someone had access to this digital information.

N-2-67. I was thinking about the issue from the perspective of trust. So, various sectors might all be using sensors and data capture and this might be related to health, or entertainment, or home automation, or engaging with placemaking, or leisure. However, questions about transparency and trust comes into it such as who is using the sensor data that I will happily give over in one context, but it might be used in another context that I do not fully understand. How do we deal with that?

N-2-68. Sensor use cases are very varied. Some sensors are used to detect when some heavy engineering plant is about to develop a fault i.e. preventing them from having a potentially life-threatening accident. At the other end of the spectrum, we have Amazon using sensors in order survey employees and prompting them to work faster and firing them if they are not operating in the right way.

N-2-69. Amazon has patented technologies that can sense what my tone of voice means about my emotional state and can therefore promote things to me that might work on my depression. How do you regulate and make sure that that data is going to someone that you can trust?

N-2-70. We work in the area of edge computing. The idea is that data is captured, processed locally and then thrown away. For example, a camera on a small device which is used to count how many people come through a gate. So instead of sharing images with the cloud, we just share the number of people observed or whatever results/insights are produced by processing the data. There is no need to share personal data. It's the same with health data e.g. your heart rate or other vital signs, detailed data does not need to be shared just the outputs i.e. an alert that you are not well. You might want to keep all the data on that device for your own information.

N-2-71. Using this type of technology, we can do AI on the edge and process the raw data without storing or sharing it. Unless the user wants to share it for specific reasons.

N-2-76. From a human led perspective, a lot of the digital technology that we have from the web has been done to us. With the Metaverse, there is an inward-outward relationship between what I am choosing to consume, and what I am choosing to share and use to influence others. This is what we are seeing in digital culture from an audience perspective. We must design from the human level perspective because the commercial applications will come and they will redefine the data relationship with their customers. Emphasising the benefit of sharing data and safeguarding when it can be anonymised etc.

Supplementary Research

Privacy issues, abusive behaviour and similar concerns about the metaverse are not new, since they currently exist in the present-day digital world. However, they will be amplified by the metaverse and they will make the enforcement of data privacy regulations more challenging.

In the current digital world, it is well understood that if you do not pay for a product or service, then you (or rather your data and your privacy) are the product. Social media platforms are the prime example of this business model. Scott McNealy, CEO of Sun Microsystems prophetically said in 1999, "*Privacy is dead – just get over it*". Mark Zuckerberg (CEO of Meta) sees privacy erosion as a function of new social norms, "*People have really gotten comfortable not only sharing more information and different kinds, but more openly and with more people. That social norm is just something that's evolved over time*". Schmidt is simply dismissive of any need for privacy, "*If you have something that you don't want anyone to know, maybe you shouldn't be doing it in the first place*". If the MV is released as a free-to-use service, it will most likely follow similar data management and privacy management policies as current social media platforms. Workshop participants disagree strongly with the 'Privacy is dead' narrative and are concerned about the harms that will emerge due to the immersive nature of MV technologies.

In addition to the inherited flaws and vulnerabilities from the technologies and systems that the MV is built on, new or expanded security and privacy concerns will emerge: "*A wide range of security breaches and privacy invasions may arise in the metaverse from the management of massive data streams, pervasive user profiling activities, unfair outcomes of AI algorithms, to the safety of physical infrastructures and human bodies*" (Y. Wang et al., 2023) and "*...new threats non-existent in physical and cyber spaces can breed such as virtual stalking and virtual spying* (Leenes, 2008)". Among the new concerns are sexually abusive behaviour towards avatars. To counter this, Meta announced the private boundary function in its metaverse platforms Horizon Venues and Horizon Worlds to provide each avatar a with personal space in the virtual world. This boundary, roughly a 1.5m distance between your avatar and others will remain on by default for non-friends and may be adjusted by the user.

The use of advanced sensors in AR/VR headsets, coupled with multi-sensorial experiences and stimulus in the metaverse will expand the scope of data privacy beyond the existing data points to include multi-modal biometric, physiological, and even emotional data, meaning users, their behaviours, their communications and reactions will be monitored (Di Pietro & Cresci, 2021a; Fernandez & Hui, 2022; ZHAO et al., 2023) at an almost forensic level in real time, "... wearable AR/VR devices with built-in sensors to comprehensively collect brain wave patterns, facial expressions, eye movements, hand movements, speech and biometric features, as well as the surrounding environment"(Y. Wang et al., 2023). It is expected that the personal data involved in the metaverse will be more granular and unprecedentedly ubiquitous (Falchuk et al., 2018a). This will increase the order of magnitude of private datapoints to be protected.

Scientific literature has reported privacy breaches by hackers or third parties and raises issues that needs consideration also. They report how VR glasses can be used to track users' geographical location (Shang et al., 2022) or infer personal data attributes from anthropometrics like height to demographics like age and gender (Nair et al., 2022). Wang presents a taxonomy of privacy related threats in the metaverse and some existing countermeasures as depicted in Figure 18. Similarly, Huang presented a taxonomy of metaverse threats given in Figure 19.

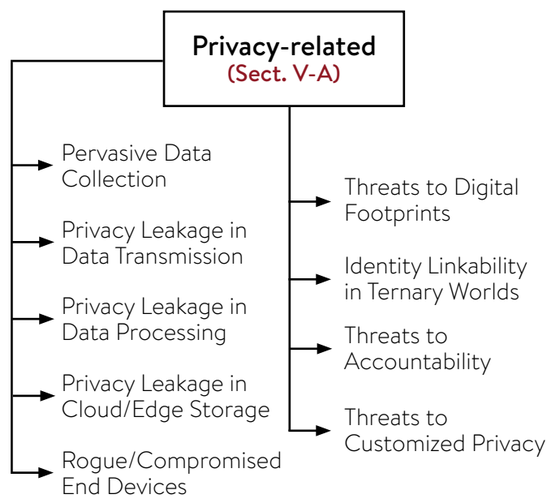


Figure 18 Taxonomy of privacy related threats. Image taken from (Y. Wang et al., 2023)

Characteristic	Security and privacy issue	Solution
Socialization	Injection attacks[22], Man-in-the-middle attacks[24], Cross site scripting[30] Privacy leakage[34,36,57]	End user validation[23], Strong authentication and cryptographic protocols[25,26] Attack detection and monitor [29,31] Deep learning-based detection[32], Secure programming practice K-anonymity[44] L-diversity[45] Differential privacy[46]
Immersive interaction	Insecure deserialization[58–60] Sensory data leakage[61–63] Biometrics leakage[68–70]	Firewall[59], Static scan[60], End-to-end authentication protocol[64], Two-factor[66] or three-factor[67], Authentication, local storage[72]
Real world building	Meta user relations[73–75]	Graph-based framework for privacy preservation [77] Differential privacy[78]
Expandability	Third-party tracking[81], Cross-app tracking[79]	Third-party tracking/cross-app tracking analysis tools and detection algorithms[83], Machine learning based blocking model[84]
Combination	Virtual economy security[85], Data security and privacy in digital twin [90], Data poison[92]	Blockchain[86], NFT[87], Cryptocurrency [88], Federated learning[90,94], Reinforcement learning[93]

Figure 19 Taxonomy of privacy related threats and countermeasures. Image taken from (Huang et al., 2023)

Regarding privacy protection, the use of GDPR as a tool to promote a 'privacy-by-design' approach within the metaverse developer community, has been confirmed by European regulators. GDPR will be enforced in metaverse environments operating in member states. This aims to encourage the adherence to data protection as an integral feature in the metaverse data processing pipeline.

However, the enforcement of data privacy regulations will be incredibly challenging. The intrinsic characteristics of MV may pose a series of challenges for existing privacy provisions (Y. Wang et al., 2023):

1. The real-time fully immersive experience challenges the secure fusion of massive multimodal user-sensitive data for interactions between users and avatars/environments;

2. To avoid a single point of failure and the required scalability, the metaverse should be built on a decentralized architecture (Nguyen, 2016) which raises challenges in reaching unambiguous consensus amongst nodes that may be located in different countries and operating under different privacy regulations;

3. Interoperability across companies, metaverse platforms and integration of ternary worlds poses challenges to ensure fast service authorisation, compliance auditing, trust management and accountability.

Moreover, the existing lack of resources to enforce data privacy laws will only worsen in the metaverse. As a remedy, regulators can improve efficiency by using artificial intelligence to track privacy activity in real time (Fang et al., 2018), while also enforcing the implementation of privacy preserving technologies (C. Chen et al., 2023) within the companies. A brief summary of relevant privacy enhancing technologies is provided in the 'Metaverse Technologies' section.

> *"The GDPR is currently not equipped to protect metaverse users from data misuse. Therefore, amendments taking account of consent, transfers, and technology (particularly artificial intelligence, blockchain, and cybersecurity) are imperative before the metaverse is more widely implemented. Applying the GDPR framework to the metaverse's data practices provides a stress test as to the efficacy of a privacy-conscious programmed platform"* (Martin, 2022)

Some researchers suggest that GDPR, as expanded to the metaverse, may hamper its functionality (Falchuk et al., 2018a). Features such as immersive realism, hyper-spatiotemporality, sustainability, and heterogeneity could be questioned if GDPR was applied strictly. As an example, platforms that estimate the emotional state of the end-user and his/her stress levels could then automatically render, in real-time, avatars that respond to (or take advantage of) that user's emotional state. Therefore, developers should collaborate with government entities to develop the technology with 'privacy by design' at its core.

Finally, scientific literature (Falchuk et al., 2018a; L.-H. Lee et al., 2021) have proposed novel MV-specific privacy preserving solutions. These are based on the combination of three fundamental strategies:

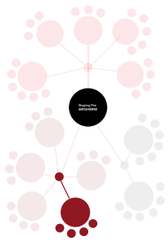
1. *Creating one or multiple clones of the user's avatar to shadow his/her own activities;*

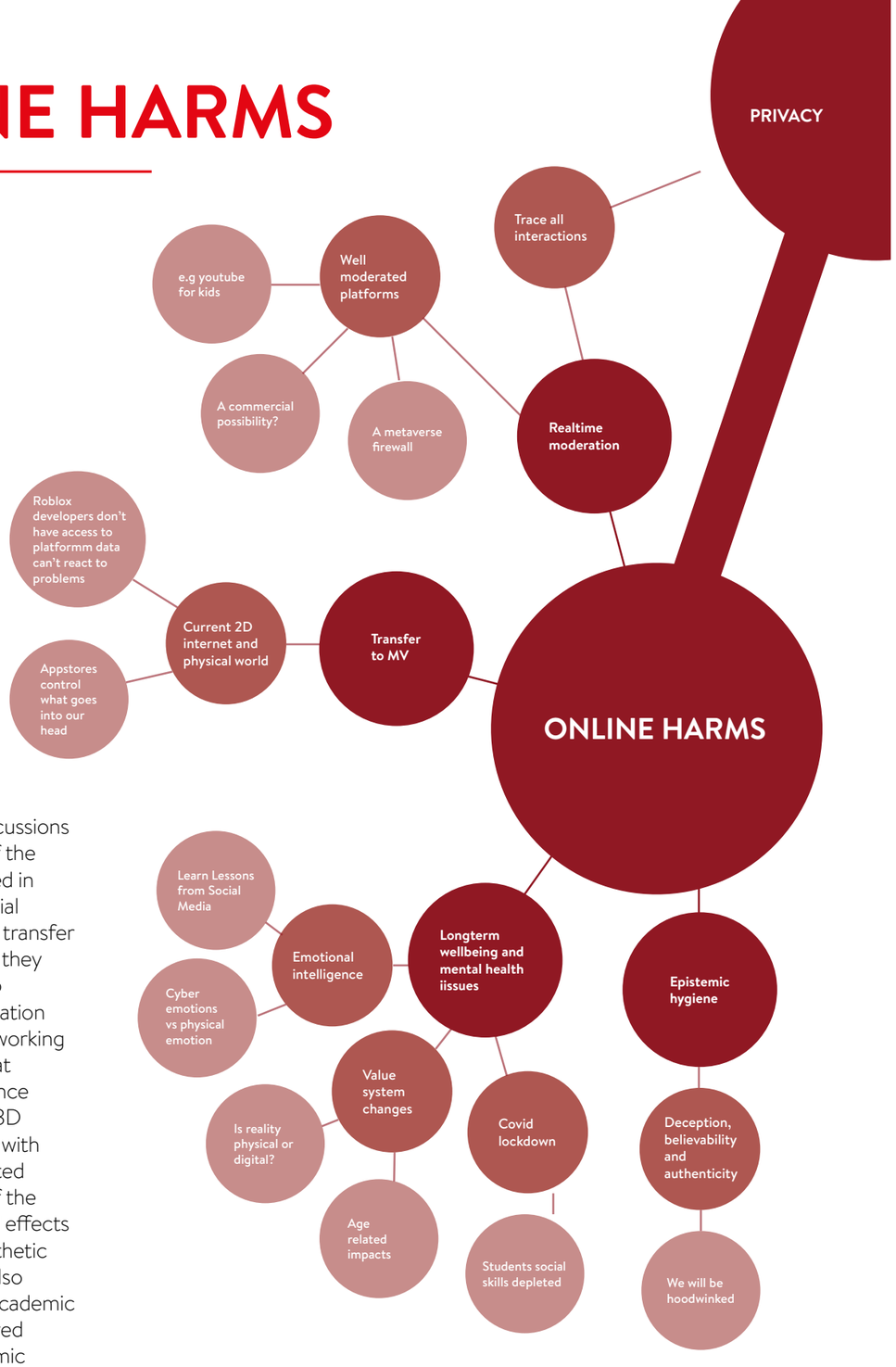
2. *Creating a private copy of a public space for the exclusive use of the user, and/or temporarily locking out other users from a public space; and,*

3. *Allowing user teleportation, invisibility or other forms of disguise.*

(Di Pietro & Cresci, 2021a).

ONLINE HARMS





Focus group session discussions recognised that many of the online harms experienced in current internet and social media environments will transfer to the metaverse where they will proliferate. Failure to provide effective moderation in existing 2D social networking environments means that deception and malfeasance is almost guaranteed in 3D environments especially with the advent of AI generated content. Investigation of the long-term psychological effects of prolonged use of synthetic online environments is also flagged because many academic participants have observed the aftermath of pandemic lockdowns on the social skills of students. The mind map in Figure 20 depicts the main threads of the discussions:

Figure 20 Shaping the Metaverse Mind Map – Online Harms

Focus Group Insights

M-1-18. The one thing that is needed before mass adoption of MV is some form of regulation which will stop the carnage which is happening now.

M-1-33. There are a whole range of harms in the physical world and the 2D world that will translate through into the MV. But we have not really thought about how they translate, what those harms look like and who it affects.

M-1-35. It is surprising that technology to defend yourself against these harms has not become mainstream i.e., the ability to choose a virtual environment that defends you automatically. A precondition of joining such a forum should be a commitment to not create/spread fear or exploit vulnerability. This should be a condition of a user going online.

M-1-36. There is a real problem with real-time moderation; to deal with ephemeral interactions you need a digital trace of all those interactions. To solve that you can record everything but then you have just raised the privacy bar. How do we balance those aspects?

M-1-38. Is there a market for a well moderated virtual space e.g., for kids? Would parents pay for that?

M-1-39. 'YouTube Kids' could be created, but that is basic when we think of the long-term wellbeing, mental health issues and all those kinds of aspects that I think are very difficult to have a blanket license agreement or an online solution that solves those challenges.

M-1-40. There are developers creating games in e.g., Roblox who do not have access to the user data created within their games. The platform operator can see what is happening but not the creators. Therefore, it is not possible to do a live update to the game because the creator is not aware of problems occurring. This is where regulation should step in.

M-1-41. The App Stores and the big tech companies are driving what is happening and literally what is going onto your head. Are the headsets even properly tested before going to market? Toys for children go through a testing regime so should we do something similar for headsets?

M-2-29. The pandemic revealed this tension that we have between our social position and how we maintain it. Many did turn to technologies to overcome the pandemic, but now we have the consequence, where they do not know how to get back out. So, we are seeing, especially with students at the university, they are very much more challenged to approach you, to ask questions. So how are we going to address that?

M-2-30. There are a lot of people considering where we go when we were immersed in a technological setting? What happens to our physical and non-technological emotion? Are they in competition? Once you are in that domain more, what happens to your real life?

M-2-32. Across every single technology situation, age is the continuing factor that we see in terms of differences in attitudes. Age is constantly the massive thing every time, and it is very polarised. But that is quite instrumental from a policy development point of view.

M-2-41. In terms of safety, games are a little different from online chat where you create an online avatar to communicate with others. It is potentially open to deception. There are questions about believability and authenticity.

M-2-44. We have an opportunity to control things now-with the Internet it just exploded. So, we have to use all the lessons of what we did wrong regarding the Internet and then seeing what other priorities there are and see how we handle that.

M-2-47. Influencers and the spread of misinformation is important because we have not really gone into that in terms of Twitter, for example or TikTok. But what are those possibilities for misinformation? W hat could the lack of checks and balances result in?

D-1-24. Ethics and prevention of cybercrime are important, but MV is taking us into another dimension of how we would protect our emotional and psychological selves. This is a whole new area that we know little about.

D-1-25. For example, ‘afterlife’ is an issue-immersive narratives around grieving parents using simulated story telling. We do not know how that impacts on us psychologically yet. It could have positive aspects, but we could be very vulnerable also.

D-1-27. We know very little about how we change when we are in these virtual spaces. Mario Kart players want to wiggle their bums in the real world, and World of Warcraft players want to pick up blue things off the ground (game currency). What other effects will emerge?

D-1-28. ‘Epistemic Hygiene’: Think of fake news today, there are tell-tale signs that let you know to be sceptical about a story e.g., a breitbart.com URL on your screen. But as immersive technology develops and becomes more subtle you will be hoodwinked in virtual environments, and they will know more about you because of all the data they have collected. It will be much more compelling, intimate and much more difficult for us to discern reality.

D-1-29. We make all our decisions based on the information currently at our disposal. Our best information gathering senses are our eyes and ears and we are about to allow them to be mediated by external interests.

D-1-34. The way in which the platforms are designed is important. They can have hidden built-in security and safety features. And again, that might be market driven because people would then get to know which platform provides the safest environment.

D-1-35. Identifying that a real person is logged onto the MV i.e., an assurance that you are interacting with a real person would be very helpful. Without that assurance then you should significantly doubt what information you get from them. For the MV to feel like a safe space then that would be very important.

D-1-36. The kind of firewalls used in our institutions that stop spam coming into our inboxes-I do not know how much of that sifting of information and sensing of malfeasance is going to be possible in the Metaverse. Will it be like the banks who gloss over the cybercrime that takes place today and put up a front – everything is fine, business as usual?

D-2-18. Also, class and economic status-some kids living in tough neighbourhoods are not going outside but staying inside and just spending their life on this platform (Roblox).

D-2-51. What lessons have we learned from the issues with social media, and online harms? How can we take those learnings and apply them here? What do we need to put in place as the MV evolves?

D-2-53. How do we make sure the MV is a safer place to grow up in?

D-2-54. It is going to be crucial to up-skill the younger generation and ensure that their parents understand what the risks are.

D-2-55. What’s the child’s experience in these spaces? What are they being shown? How are they spending their money?

D-2-56. Not all parents have the background or knowledge or expertise because of their social, economic background and lack of education. That is the issue with women in tech, too. This piece needs to start at an early age, at school to encourage children to feel like they are digital citizens, to empower them.

Y-1-18. Internet society seems to have engendered a sense of ‘the truth doesn’t matter’ even though all the information is available on the web. There is a danger that MV will augment that ‘post-Truth’ direction of travel unless we take concrete action to stop it.

Y-1-39. Healthcare applications in MV. Working with kids with autism, we created a VR environment for kids with auditory hypersensitivity – a-controlled gaming framework where they interact with these sounds in a positive enforcement exposure therapy. Applications like these require formal verification via clinical trials and the NHS take time to adopt new therapies. In a free, open and unregulated MV, companies could sell such services directly to users without proper validation/verification. This could be dangerous.

Y-2-31. Some of the great games and creative ideas are coming from young people.

Y-2-32. We have policy and things in place to protect people, but we must be careful that those policies that are put in place do not then exclude those young people.

Y-2-33. How can we allow them to be in that space safely and to create? We want to protect young people, but you have to be careful how you do it, because otherwise the people that are doing some exciting and creative things are then going to be excluded.

Y-2-104. The technology is here are children are spending time in these spaces. It is crucial for humanity to do research and understand longitudinal effects to really get to grips with what is happening and stop it, or at least be prepared.

Y-2-107. These spaces now are designed to be deeply addictive. Where is the protection for the people frequenting them? Are the long-term consequences awful? If you think about how addictive like your phone is, we are imagining fully immersive 3D environment which has subtle advertising or whatever. That feels like it has the potential to be a deeply exploitative environment that I do not want to spend any time in.

C-1-53. Replicating our environment is very boring, very dull. You must manipulate reality.

C-1-64. This technology is fundamentally able to hack our brains. It does something different that no other medium does. Like the internet changed the way we communicate, this is also going to change us.

N-1-16. Social skills in the student cohort have shown a marked decline in real life after the pandemic. Naturally they are more comfortable communicating in digital environments now. If there is an opportunity to avoid sometimes awkward social interactions, then lots of sectors of our communities will do so. Then there is a risk that they withdraw and fail to contribute in the way that they could, or even to get as much out of life as they want to. MV could make this worse.

N-1-36. Latest mobile phones can capture your facial expression and will transfer them to your avatar. Leading to more naturalistic experiences in MV. It could also be used to automatically detect your emotions – there is always a tension between the usefulness of the technologies to the individual and the potential misuse of it.

N-1-37. For mass population application of MV technologies, there are huge issues about surveillance, manipulation and political manipulation. Especially from those big tech companies who have access to those kinds of emotion/behavioural data.

N-1-42. Then we run into the problem that was demonstrated during the pandemic by a surprisingly large amount of the population. They completely overlooked the genuine issues that where there and all the flagging in the world that this was fake news just reinforced their opinion that the government was trying to hide something. You have got to overcome that psychology too.

N-1-44. Will the metaverse make things worse than where we are currently? It will, but are there constraints that can be designed into the system early on that could help?

N-2-23. The social issues that we are facing in the physical realm are replicated in the digital realm, and that is escalating and multiplying at the same cycle of innovation that we are facing.

Supplementary Research

Scientific understanding of online harms, how they propagate through a population of users and how they critically manifest in sub-groups and individuals remains elusive with many open questions. The development of metaverse technologies represents a huge opportunity for multidisciplinary research and investigation into human behaviour as observed by Lazer et al:

> *"Science rarely proceeds beyond what scientists can observe and measure, and sometimes what can be observed proceeds far ahead of scientific understanding. The twenty-first century offers such a moment in the study of human societies. A vastly larger share of behaviours is observed today than would have been imaginable at the close of the twentieth century. Our interpersonal communication, our movements and many of our everyday actions, are all potentially accessible for scientific research; sometimes through purposive instrumentation for scientific objectives (for example, satellite imagery), but far more often these objectives are, literally, an afterthought (for example, Twitter data streams).*"
> (Lazer et al., 2021)

The metaverse offers seamless convergence of sensor technologies in the physical and digital realms and provides detailed insight into population level behaviour. This infrastructure could become a powerful 'telescope' for the social sciences:

> *"...by rendering the unmeasurable measurable, the technological revolution in mobile, Web, and Internet communications has the potential to revolutionize our understanding of ourselves and how we interact. Merton was right: social science still has not found its Kepler. But three hundred years after Alexander Pope argued that the proper study of mankind should lie not in the heavens but in ourselves, we have finally found our telescope.*"
> (Watts, 2011)

The metaverse platforms and corporations gather that raw behavioural data however they are not casual observers and are commercially motivated to manipulate behaviour also:

> *"More generally, internet companies aim to manipulate human behaviour so as to increase engagement on their platforms (for example, Facebook, Twitter and Instagram) or money spent on their products (such as Amazon and Ebay). Those machine-learning-based manipulations are pervasive, and any efforts to develop [social science] measures from platform data need to evaluate the extent to which algorithms will distort both the measures and any downstream analyses. Because of their importance, those algorithms are worthy of closer study.*"

Therefore, social science cannot separate itself from the study of machine behaviour i.e. "*... the scientific study of intelligent machines, not as engineering artefacts, but as a class of actors with particular behavioural patterns and ecology....Animal and human behaviours cannot be fully understood without the study of the contexts in which behaviours occur. Machine behaviour similarly cannot be fully understood without the integrated study of algorithms and the social environments in which algorithms operate.*" (Rahwan et al., 2019)

Close cooperation between independent researchers and the metaverse corporations is needed along with a level of transparency so that researchers can avoid reflexivity issues and the observer effect. Digital technologies have created a new version of the reflexivity problem as illustrated by Google:

"When Google launched the Flu Trends project in 2008, the goal was to use search queries to estimate the prevalence of flu symptoms in the population. In 2013, however, Flu Trends substantially overestimated peak flu levels. One of the reasons was the flawed assumption that search behaviour was driven by external events, such as having flu symptoms. In fact, Google's algorithms were driving those patterns as well: by trying to anticipate the intent of the users through recommended search terms, Google was distorting the information users would have otherwise revealed." (Lazer et al., 2014)

The main stumbling block becomes the motivation of corporations to provide the necessary data access and transparency:

> *"Despite the potential societal benefits of granting independent researchers access to digital platform data, such as promotion of transparency and accountability, online platform companies have few legal obligations to do so and potentially stronger business incentives not to. Without legally binding mechanisms that provide greater clarity on what and how data can be shared with independent researchers in privacy-preserving ways, platforms are unlikely to share the breadth of data necessary for robust scientific inquiry and public oversight.*" (Nonnecke & Carlton, 2022)

The regulatory environment is changing and those data corporations may at some point become obliged to provide data access to researchers. Nonnecke identifies the EU Digital Services Act (DSA) (European Union, 2022) and the US Platform Accountability and Transparency Act (PATA) (Coons, 2023) as examples of legislation which if fully enacted could improve access for researchers. The EU DSA was adopted by the European Parliament in October 2022 and will come into effect across all EU member states by January 2024.

The DSA requires platforms to make three categories of data available through online databases or APIs:

1) Data necessary to assess risks and possible harms brought about by the platform's systems;

2) Data on the accuracy, functioning, and testing of algorithmic systems for content moderation, recommender systems, or advertising systems; or

3) Data on processes and outputs of content moderation or of internal complaint-handling systems.

In response to increased awareness of the risks of targeted advertising, Article 63 explicitly requires very large online platforms (VLOPs) to create a public digital ad repository that must include the ad's content; the entity behind the ad; whether it was targeted and, if it was, the parameters used for targeting; and the total number of recipients.

The DSA initiated further work to determine the 'technical conditions' for GDPR-compliant data sharing. A primary challenge will be to determine how data should be constructed and shared with researchers in ways that are GDPR-compliant while maintaining enough detail to make data useful for research. These technical conditions relate to the application of privacy enhancing technologies (see section 'Metaverse Technologies' for further information).

The Platform Accountability and Transparency Act (PATA) was first proposed in December 2021 and subsequently updated and reintroduced in June 2023 with strong bipartisan support across the US Senate. PATA compels large platform owners to make data available to 'qualified researchers' through a process intermediated by the National Science Foundation (NSF) and the Platform Accountability and Transparency Office (PATO) to be established within the US Federal Trade Commission. In collaboration with the researchers, the NSF determines what platform data and information is necessary to carry out the research. Then the research project is referred to PATO, which brokers data access between the platform and the researcher. PATO is also responsible for establishing privacy and cybersecurity safeguards for platform data and information provided to researchers.

PATA has yet to undergo formal congressional debate and so the fate of the bill is uncertain. However, there is reason for hope as reported in Tech Policy Press: The Biden administration may seek a deal with European regulators to harmonise access for U.S. researchers with provisions in the DSA. A joint statement from the White House and European Commission following a recent US-EU Trade and Technology Council meeting said that "*it is crucially important for independent research teams to be able to investigate, analyze and report on how online platforms operate and how they affect individuals and society.*"

The joint statement goes on to say: "*The United States and the European Union share the view that online platforms should exercise greater responsibility in ensuring that their services contribute to an* ***online environment that protects, empowers and respects children and youth*** *and take responsible actions to address the impact of their services on children and youths' mental health and development*" (US-EU Trade and Technology Council, 2023). There is hope that the means to study online harms, predict their consequences and develop countermeasures for immersive virtual worlds may be granted to researchers in the near future.

METAVERSE AS A PUBLIC SPHERE

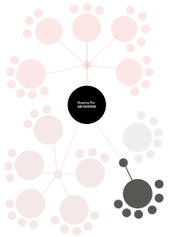


Figure 21 Shaping the Metaverse Mind Map–Public Sphere

A lot of the discussion in the focus groups was centred around the potential benefits and challenges to the development of the Metaverse in relation to society/ public sphere. The interdisciplinary mix of workshop attendees meant the societal challenges were a common ground for discussion as members were comfortable expressing their views in this area. There was an interesting mix of opinions, the prevailing sentiment was one of concern about what an unregulated Metaverse could lead to in relation to public safety and representative democracy, this was tempered by a guarded optimism that the Metaverse could provide a societal leap forward and aid us in removing inherent biases and accessibility issues embedded in society currently. The focus group discussions on this theme are mapped in Figure 21.

Focus Group Insights

Concerns and Challenges

C-1-65. An important question: MV will change how we view ourselves. And our choice of whether that is for good or bad will depend on more forums and work like this conversation. Now – because it is a really scary thing.

N-1-44. Will the metaverse make things worse than where we are currently? It probably will but are there constraints that can be designed into the system early on that could help?

Y-2-68. We talk about opportunity; companies like META worry me because they just want full control over spaces. I do not think that is right. The success of game platforms is because it is community driven.

C-1- 25. Everything in the NHS has to go into the Cloud now. But there is not really functional internet in hospitals. We can't currently stream our VR content into a hospital so being told to put everything into the cloud is a million miles away from the current world. It doesn't mean they are wrong to want this, but right now it is not feasible.

Y-1-45. Who will have access to build these virtual worlds? Who's world is being simulated? Who's values are being represented? How do we ensure that it's not just the big companies controlling all of this?

C-1-8. Kevin Kennedy says, tools are an extension of ourselves and that's what makes the metaverse potentially amazing – it will do in a 3D space what the internet did in a 2D space it will eliminate the airspace–the gap between us and the screen

Y-1-18. Internet society seems to have engendered a sense of 'the truth doesn't matter' even though all the information is available on the web. There's a danger that MV will augment that 'Post-Truth' direction of travel unless we take concrete action to stop it.

N-1-18. These are fantastically empowering tools how do we take that virtual advantage into the real world and change society in the real world as well? It's an opportunity right now because new technology is very open, everyone can experiment and there's a place for everybody. But the minute it's locked down, commercialised, and made proprietary; all of those people are once again locked out.

N-1-14. I think it's an interesting question about the extent to which these experiences are integrated into real life or whether they replace real life. There's real value for some users in escaping or getting out of real life for some period-whether that's for entertainment or wellbeing purposes. However, there are certain groups in society that if they could avoid real life then they will (coronavirus set this in motion). What are the longer-term implications of that withdrawal?

M-2-45. If the metaverse becomes a form of the public sphere, then what kind of access do people have? How is it regulated? Who determines who checks facts?

D-1-16. Issues around content creation should be investigated and solved. Inappropriate content appearing in shared spaces and how it can be prevented is very important. For example, a BBC journalist was reporting on the MV but was sexually assaulted in MV during her investigation.

D-1-17. Why do people feel entitled to do these things in a virtual public space and not in in the physical world? Mostly because they are anonymous but as soon as you remove anonymity those behaviours may go away. So, it's the digital identity that needs to be resolved.

M-1-36. There's a real problem with real-time moderation; to deal with ephemeral interactions you need a digital trace of all those interactions. To solve that you can record everything but then you have just raised the privacy bar. How do we balance those aspects?

D-1-5. We have already seen the fragmentation of the Internet with national firewalls etc. controlling who comes in and out. That infrastructure will persist in the MV. Already, some applications are banned in the USA or China because they don't suit the political agenda in those two countries and that behaviour will be accentuated in the MV.

M-2-32. Regulation is probably the most important thing prior to legislation because legislation you know the problematic actions that have already taken place.

N-2-22. What is the impact on EDI and digital health perspective? What we are hearing from some groups that is, groups that feel underrepresented in the physical world, are actually feeling that those attitudes and perspectives are translating over to the digital realm as well.

N-2-23. The social issues that we're facing in the physical realm are replicated in the digital realm, and that's escalating and multiplying at the same cycle of innovation that we're facing.

D-2-19. The MV will be dominated by big tech unless the government does something to encourage, support, and put money into it for the creative industries. It is not accessible at all.

Y-1-39. Healthcare applications in MV. Working with kids with autism, we created a VR environment for kids with auditory hypersensitivity–a controlled gaming framework where they interact with these sounds in a positive enforcement exposure therapy. Applications like these require formal verification via clinical trials and the NHS take time to adopt new therapies. In a free, open and unregulated MV, companies could sell such services directly to users without proper validation/ verification. This could be dangerous.

Y-2-93. Protection for people in these spaces that are now are designed to be deeply addictive. The long-term consequences are surely awful. If you think about how addictive your phone is and now we're imagining a fully immersive 3D environment which has subtle advertising. That feels like it has the potential to be like a deeply exploitative environment that I don't want to spend any time in.

Solutions and Opportunities

Y-2-41. The first step is to assert true ownership of the data to the individual users. A company should not have to share all the data of all users, but each individual user is as vital starting point for all users to enable them to share the data as a collective and derive value from it collectively again. The state of ownership is just simply not there.

N-2-72. I'd love the NHS to have a high-fidelity digital twin of me. Driven by a smart watch with a full stack of health records that can be picked up and looked at by a doctor. But constantly monitored by a bunch of AI going: You're not well, we should talk to you about this, you should do more of that, you haven't done this. I would love for someone to be preventatively observing my health status instead of waiting until I get poorly before something happens

M-1-45. Storytelling and education: discovery education via immersive AR. Kids don't learn by watching a screen/moving image they learn by interacting with the subject matter so that's why the MV is the future.

C-1-45. Equality, Diversity and Inclusion is everything here– who is in the conversations because we will replicate current inequalities or risk quality design when the design team isn't diverse. Who are we asking these questions to.

Y-2-7. People want to express themselves and design their own things and interact with their friends and chat. It is not just a game. I think it's really important that we protect that.

C-1-62. You can't talk about something properly until you start making it, and then more challenges appear. We need to get people from all different disciplines together to tease out those ethical problems out but also the tech too.

M-2-24. Just before the pandemic, we started a clinical trial with stroke survivors in the local hospital using VR. We were very nervous about taking VR headsets into the hospitals because the patients were elderly and not comfortable with computer technology. We were really surprised how open they were to VR technology. They were really eager to embrace this technology.

C-1-75. From a policy point of view, you have to look further than now, into the future and try to anticipate the issues ahead.

D-1-31. Privacy is a big issue. One of the problems about trying to legislate about privacy is that you have that kind of catch-up game in that the technology is always going to be ahead of the legislation. So, the legislation has got to be principles based, not technology based.

M-2-18. We need a much better connection between the regulatory frameworks in Italy and the UK and the rest of European Union in order to try and agree a set of standards and protocols.

Y-1-41. There is a need for some broad framework of regulation because we can't wait for convergence to occur in specific use cases. A responsible research and innovation approach needs to be adopted.

D-2-23. MV gives the museum the opportunity to reach audiences and tell stories in a way that's focused on them. And so, we can tailor different stories to different audiences whether they can come to the museum or not. A new audience of explorers who are geographically disparate is opening up to us. We want to be able to tell stories to all those audiences, whether they're interested in the traditional museum experience or not.

M-1-35. It's surprising that technology to defend yourself against these harms hasn't become mainstream i.e. the ability to choose a virtual environment that defends you automatically. A precondition of joining such a forum should be a commitment to not create/spread fear or exploit vulnerability. This should be a condition of a user going online.

Y-1-14. Virtual events and digital twinning of physical venues: No need to travel to venues (reduced carbon emissions & environmental damage), improved accessibility, artists can reach a larger and more diverse audience. Improving the quality of MV events is key.

C-1-31. The idea of the metaverse providing people with places they couldn't usually go to and providing them with choice – and a whole new UX.

N-1-1. In terms of built environment, MV has the ability to realistically create alternative realities which will assist planning decisions and could be a huge democratic bonus in strengthening local democracy.

D-1-24. Ethics and prevention of cybercrime are important but MV is taking us into another dimension of how we would protect our emotional and psychological selves. This is a whole new area that we know little about.

C-1-60. There is a huge funding need and potential return on investment, because PTSD , for example, leads to lots of other things that are costly and harmful to society.

C-1-61. Hospitals of Excellence, an approach mooted by NHSX, which make and test and User centric design –is interesting and potentially scalable.

Supplementary Research

It might be considered that the Metaverse provides an opportunity to reshape life on Earth in numerous positive ways. The ability to communicate immersively with people in countries across the world could lead to numerous benefits in communication, collaboration and inclusivity. In addition to the issues mentioned above, there are a number of potential societal concerns discussed in the literature on the Metaverse that will need to be addressed before the vision of maximum benefit becomes a reality. The potential for harassment by malicious users is raised by (Di Pietro & Cresci, 2021b; Falchuk et al., 2018b) They posit that users could be followed by other potentially malicious users while they experience events in the metaverse, which would allow malicious users to observe purchases, activities and areas of interest to them. This is compounded by the possibility of sending unwanted messages in a similar fashion to social media (Dhir et al., 2021; Valenzuela-García et al., 2023). There are potential solutions to these problems, but it remains to be seen if the companies responsible for creation of the metaverse are willing to enact the measures that are necessary to prevent toxic behaviour. User tracking is built into the immersive world's representation of the metaverse, as it is necessary to provide real time interaction between users. AI models could be used to moderate user behaviour, but the concerns about AI bias remain valid here. Open and transparent systems that follow the guidelines laid out in the OECD AI Principles (Organisation for Economic Co-operation and Development, 2019) that make clear what behaviour is considered inappropriate will aid adoption of MV technologies to wider and more diverse communities. While user tracking can be of benefit, particularly in the social metaverse, this technology could be used exploitatively in the industrial metaverse. Companies that encourage their employees to work in the metaverse would now have complete access to their biometric data, allowing for constant surveillance and "productivity scoring" of employees (Hickok & Maslej, 2023). Regulatory frameworks need to be put in place to ensure that an imbalance of power between companies and the workforce does not develop in the industrial metaverse.

The use of biometric tracking is also an issue in relation to user manipulation in the metaverse. MV companies will be able track length of eye gaze, heart rate and other indicators of interest to determine which elements provoke an emotional response. These can then be used to encourage behaviour such as purchasing, social engineering or further data theft (Cooley & Parks-Yancy, 2019). This could be done through artificial intelligence and metahumans that would be indistinguishable from "real" users of the metaverse (Bojic, 2022; McStay, 2023b). The use of social engineering in this fashion could result in the destabilization of governments by corporate entities, leading to a disproportionate influence on society from these groups (Ball, 2022; Marks, 2020). This can be combatted through the use of regulatory frameworks such as those laid out by (Rosenberg, 2022b), where the author urges government agencies to consider rapid and aggressive regulation of metaverse companies before the issues discussed above become entrenched in the metaverse and are viewed as part of the buy in cost of using these technologies, in a similar manner to how inappropriate behaviour such as fake news on social media is viewed as a problem that is baked in to the platforms.

While these concerns are severe, they are not insurmountable. There are many examples in the literature of how the metaverse will be of tremendous benefit to society. An obvious opportunity to the metaverse is that of virtual travel. High fidelity experiences such as National Geographic VR and Wander allows users to visit tourism sites in a sustainable and interactive fashion. While these experiences cannot currently totally replace visiting in the physical world, as technology improves, they can become a valid alternative to visiting heritage and protected sites, reducing the impact of travel on these irreplaceable locations (Rillig et al., 2022). Interactive experiences such as concerts, museum visits and walking tours can also make visiting these experiences possible for those who would not be able to due to accessibility or monetary reasons.

The metaverse also provides exciting opportunities for improvements to health care. Apart from the obvious use in training surgeons/health care professionals (Khor et al., 2016), metaverse technologies also enable new and innovative methods of therapy to neurodivergent people (Ravindran et al., 2019), those who suffer from PTSD (Kothgassner et al., 2019), dementia (Appel et al., 2021) and patients recovering from strokes (Laver et al., 2017). The close ties between the NHS and academia mean that the UK is uniquely poised to take advantage of these opportunities and provide innovative and cost saving treatments to patients, resulting in both improved care and a reduction in visits required by patients to in person facilities.

“The close ties between the NHS and academia mean that the UK is uniquely poised to take advantage of these opportunities and provide innovative and cost saving treatments to patients”

APPLICATIONS

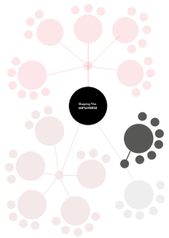


Figure 22 Shaping the Metaverse Mind Map – Applications

Focus group sessions referred to applications of MV in terms of the potential virtual worlds offer to connect people. In terms of specific applications, advertising-which cuts across industries and established within virtual worlds-was heavily discussed, often in terms of its potential negative aspects; and also healthcare. In addition to healthcare, several major areas emerged as a consequence of the interests of our focus group participants; areas in which metaverse-related emerging technologies might viably combine effectively to offer users a useful or popular product or experience in the near future, including live events (namely music), gaming, education, the culture and leisure industries, in particular tourism; and the creative industries, in particular fashion. The mind map derived from the focus group sessions is depicted in Figure 22:

The time constraints on this research piece necessitated an initial focus on only a few of these areas. The majority of conversations across the groups relating to applications were about the heritage sector, fashion industry, and healthcare. These three areas are also correlated as being of strategic importance to the UK economy in terms of national talent, extant demand and future potential growth enabled by emerging technologies.

To achieve a "*a fully realized digital world that exists beyond the analogue one in which we live*" huge advances in the technologies and their ability to interoperate will be required to build a "*persistent network of shared virtual environments where people can interact synchronously through their avatars with other agents and objects*" (Kim, 2021). However, we can already see promising emerging applications in the tourism, fashion, and healthcare sectors, indicating these as possible fertile areas for continuing developments in the metaverse-related space.

Culture, Heritage and Tourism

Our workshops saw participation from a number of academics specialising in fashion; and also from professionals in the cultural sector (e.g. V&A Dundee) and industry specialists, for example Andy Hirst of Modern English Digital, who presented his work on creating an interactive map experience to celebrate Elton John's US tour.

Focus Group Insights

D-2-17. The diversity aspect of the MV is important–it can be open and accessible for people from all different cultures.

D-2-23. MV gives the museum the opportunity to reach new audiences, and tell stories in a way that's focused on them. Different stories can be tailored to different audiences, who can experience them whether they can physically come to the museum or not. We want to be able to tell stories to all those audiences, including those not interested in the traditional museum experience.

D-2-24. There is something in a museum that will fascinate every single person in this country – so how do we get that out there to everyone, and curate it creatively and digitally in a way that people will engage with it, on an online platform that they are already in?

D-2-25. MV could be used to try break down the barriers to culture.

D-2-26. We need to decolonize the Internet-when artifacts (like in the museum) that are owned by our First Nation or an indigenous people, where do those actual owners eventually realize value from that? Is it just they can be digitized and then distributed at profit?

D-2-27. You could get people from all different ages and generations coming to a civic space and then actually finding out what the metaverse is, using headsets for the first time, doing gaming for the first time, all in a safe, welcoming, democratic testing environment.

D-2-48. MV could be amazing for digitalizing museum collections, but realistically there is no funding in the creative industries to help them digitize and get ready for Web 3.0-the money just is not there.

N-1-2. Improved access to suitable equipment and infrastructure would be needed before any democratic benefit would accrue. Libraries and museum sectors could be the catalyst to enable people to learn/be educated via MV technologies.

N-2-6. In terms of culture, physical places, which are incredibly well designed, such as museums or a might only have 100,000 people who could ever go there. In the digital world version 100 million people that could go there, including those would never be able to fly to see it in person-that digital reach is exciting.

N-2-7. During the pandemic, a lot of people who had never been in the digital realm at all were suddenly plunged into it. Theatre operators rapidly found recorded content, or recorded new content, ready to go to a live audience; and suddenly reach brand new communities.

N-2-8. The culture and heritage industries need to continue to access and develop that audience, and maintain that online presence, whilst also continue to do things physically. There is a worry that maintaining the online presence will dilute or deplete the physical stake of a theatre or gallery. What is at risk in investing in that virtual MV world?

N-2-9. What are the future of tourism opportunities? In the MV we potentially can create a borderless visit. What could that look like?

N-2-10. From an artistic perspective, there is a new relationship contract to be defined with audiences in terms of what they want.

N-2-11. Research from the from the hospitality sector shows that majority of visitor spend and audience growth is around experiential customer opportunities, as opposed to more materialistic purchases. There's a potential with MV of how we can think in terms of our placemaking economy. We can think of that hybridized space and that customer experience, of the ability for them to explore themselves. The creative industry will need to evolve with this.

N-2-12. The expectation of what people are looking for something boundary-less, so what does that mean for creation, for the development of art within digital culture? There has to be an iterative process alongside this, because the transition of it all is so quick. It is hard to keep up or to even future proof; but we must develop the appetite for that R&D and testing in this space.

N-2-61. The Heritage Lottery Fund was signalling that they put a big investment into digital skills development, but what they really meant was social media and the back end of digital communications. The pandemics flagged this up – that in the culture and heritage sector, there's potentially a lag. When they're talking about digital skills development, they're actually talking about digital communication, which is different.

N-2-77. From a human-led perspective, a lot of digital that we have from the web now has been done to us. With the MV more agency or choice might come in-an inward outward relationship to it, including what I'm choosing to consume, but also what I'm choosing to share and use that to influence. This is what we are seeing in digital culture from audience perspective. We have to design from the human level perspective.

Y-1-15. There's a strong social case for MV-hosted arts/culture events that expand the audience and provide access to a much wider demographic.

Y-1-16. Hybrid physical/virtual events are difficult, and the technology is not complete. For example, a hybrid choir can sound good but the social interaction between attendees is not equitable. Remote attendees tend to feel more isolated during hybrid events. Further work is needed to enable social interaction between all modes of attendance.

Y-2-48. The ABBA tour has a virtual avatar-holograms-and its been really successful.

Y-2-49. The scope of opportunity is that an existing global tour with an might be 60-100 days. Those arenas only have a finite capacity. Fandoms are much bigger than that, and in the MV far more people can get in access to tickets. What does that particularly look like, what form does it take, what is the digital offer there?

Y-2-50. There is still a market for streamed events, but ultimately more added value will be required, for example access to Q&As, or interactive backstage pieces.

Y-2-62. Not everyone is going to have the same marketing budget behind them. There is a risk a select few artists, or museums, will come to dominate because they can afford digital reach, and that could narrow the sector.

Y-2-64. Arts and culture organisations have to reach a new audiences. Is there an issue with this in terms of an age demographic?

Y-2-65. Despite MV, people will still go to the opera physically. People still like to go to concerts. In the MV, the capital and the energy is going to be put into an increasingly few bankable cases.

Supplementary Research

Visit Britain projects the tourism industry's worth by 2025 at over £257 billion. It is the fastest growing UK sector in terms of employment. In England in 2019, tourism generated £100.8 billion across its 5-6000 attractions(Visit Britain, 2019). In Wales in the same year, £6 billion was spent on tourism trips within Wales (Welsh Government, 2021); and £1 billion within Northern Irish economy (Tourism NI, 2019). Across Scotland in 2016, expenditure by visitors was valued at £9.7 billion (Scottish Government, 2018).

Museums in particular have made nascent use of online platforms to interact with e-visitors, with videos, photographs and hashtags allowing for the most interaction *"high interaction rates were observed in relation to the following three video types: short, pre-recorded video tours of the museum, accompanied by background music only (approx. 2–3 min); live broadcasts of guided tours of the museum lasting approximately 30 min; and 20–30-minute pre-recorded videos of experts explaining a specific artwork or room at the museum"*(Sánchez-Amboage et al., 2023).

Compared to other countries, including in Europe, however, the UK has been slower to embrace emerging technologies at its culture and heritage attractions. While museums have made strides in recent years towards interactivity and inclusivity at being at the heart of user experience, the technologies associated with metaverse (AR, digital twins) have not featured as prominently as they do elsewhere. In France, for example. The French culture and heritage sector has seen a robust uptake of AR-related attractions within some of its most venerated institutions, and also used technology as a stand in for when one of these shut, namely the Notre Dame Virtual Reality Tour developed by Orange and Emissive, which hosts 50 people simultaneously. The Notre Dame cathedral was visited by 11 million people annually before the 2019 fire that closed it. When it reopens, there are plans to use video game technology to allow visitors inside to experience the cathedral's past without having the use a headset. Instead, they will choose their augmented experience via a 'Histopad' which is similar to the controller for a video game. These controls will allow tourists to travel back in time as far as 1160 (Histovery, 2021). The visitor is, through a touch screen, able to interact with 3-D models of statues, replica flooring and stained glass, and listen to the Notre-Dame's organs and bells.

Technological advancements are opening new ways of artistically, dramatically capturing and communicating the past, as well as rendering present-day attractions in novel ways. Galleries have developed AR features, and apps like 'Smartify' use image recognition technology and AI to let users access more information on an object, discovering more about the art. Museums can make use of Smartify in situ and remotely to offer new ways of experiencing art.

How we interact with our past can be mediated through new technologies. At Queen's University, Belfast, Dr Edwar Calderon is using VR to approach the past and explore the possibility of reconciliation within divided societies in Northern Ireland and in Colombia, mediated through people meeting on an VR platform.

In the Netherlands, Brabant Remembers is a mobile AR experience *'that integrates storytelling to emotionally engage tourists on a historic trail evolving around the impact of the Second World War in the Province of Brabant'* telling 75 people's stories in 75 locations and inviting users to make predictions of the choices that will be made in the story (Bijsterveld et al., 2019).

The development of new technologies might also enable the preservation of culture by allowing it to be shared with a wider audience, improving its cultural sustainability, for example in the digitalization strategy for Miao silver in China (M. Wang & Lau, 2023).

Time Machine Europe uses AR/VR applications to simulate hypothetical spatiotemporal 4D worlds (i.e. a 3D world that moves through time), such as the Roman Forum, with the aim of *"mapping the European social, cultural and geographical evolution across times"*.

As well as the past, new technologies are enabling access to remote or protected places, where physical visits are difficult (e.g. Everest VR) or prohibited. Unreal of Rural Australia used photogrammetry-based content to reconstruct a remote outback (Weber Sabil & Han, 2021) Saudi Arabia's ancient and remote city of Hegra was announced in November 2022 as the *"inaugural UNESCO monument to appear within the virtual realm and will be open to discovery and exploration by visitors from across the globe"* and now includes the option to fly over Hegra in Decentraland in a hot air balloon. Places where tourism is historically low or undeveloped may also benefit from new technologies, particularly where experiences are co-created using local knowledge. In Amiais, a very small village (population 15) in Portugal, researchers worked closely with residents to replicate the village in Second Life, to share their home with visitors around the world, transforming Amais' reach *"from the local to the international scale so that there is an enhancement of cultural heritage and intangible environments as well as promotion of tourism in rural areas"* (Martins et al., 2022).

Virtual Tourism is also popular among well-visited places and sites. In South Korea, ZEPETO World (which has 15-20 million active monthly users) is a smartphone app enabling e-tourists to design a personalised avatar who then travels around the country. One feature alone (an intricate map of Han River Park) receives 257,000 visitors daily. Post-pandemic, virtual tourism presents "an innovative way to remain resilient in the face of change and crisis and secure the future of the industry" (Lekgau et al., 2021), which could prove a useful diversification strategy within low- and middle-income countries where their economy is heavily reliant on tourism, e.g. Egypt.

The widespread use of technologies among the younger population might indicate an openness to these being applied across the tourism industries, with a recent study suggesting that *"Gen Z specifically is constantly searching for more authentic and unofficial interactions with local resources. Cultural heritage sites which have been neglected and suffer from lack of visitation have a chance to increase visitation flows through MR technology by making visitation exciting through innovation and cocreation"* (Buhalis & Karatay, 2022). Tourism Australia found that around a quarter of consumers were open to using VR to decide on a future holiday destination, and that 20% had already done so. Visit Wales offers potential visitors the chance to watch 360° VR videos of some of its premier attractions. Rise NY, which opened in Manhattan in 2022, is a partnership of several cultural institutions (Rock & Roll Hall of Fame, Museum of American Finance, Museum of Broadcast Communications & Radio Hall of Fame, Museum at FIT, Skyscraper Museum, Tribeca Festival, and David Bushman, former head curator at The Paley Center) offering an AR flight over New York City. It might well be that, while physical travel will remain intact and not be substituted by virtual trips, the metaverse will *"modify the ways in which consumers consume hospitality and tourism products and services"* (Gursoy et al., 2022).

Koo et al surmise that the core technologies of metaverse tourism take four stages, with the first being new immersive experiences, followed by tourists using the technologies to plan their trip. Third might be the fact that tourists might express multiple identities, enabled by online worlds. Finally, they predict the emergence of a new business model of a creative economy, where *"metaverse tourists can reinforce a physical visit to a destination by actualizing their fantasies and imagination"* (C. Koo et al., 2022). Yang et al similarly see a four stage process, with their taxonomic model of metaverse tourism taking the following route: (1) imitation '*a mirrored counterpart of the real world*' (2) 'intensification', blending virtual ingredients into physical surroundings, (3) 'interaction' *"a fusion of novel digital experiences and real-world experiences starts to prevail, the metaverse paradigm undergoes a major transformation with a higher degree of exchange"* and (4) integration, which *"enables rich and imaginative tourist experiences with the sensory appeal, making what is impossible in the physical world possible in the metaverse"* (Yang & Wang, 2023b).

Virtual worlds have the potential to significantly improve the accessibility of culture and heritage, in terms of removing barriers to access, including physical barriers and financial barriers, while ameliorating the tourism or museum experience for disabled people through interactive and assistive technologies. Virtual heritage worlds might enable new and existing cultural and heritage sites to decolonise their interpretations, offering deeper, more multi-layered ways of engaging with collections than the traditional physical set-up of written descriptors on a wall. They would also allow for more objects to be shown than are able to be on display physically, opening far more points

of cultural connection for people. Virtual Worlds in museums could offer non-traditional spaces where the public can represent themselves and their heritage. For example, the world's first LGBT+ VR Museum, which aims to disrupt *"historical gatekeeping and erasure of marginalised voices"* has curated its collection *"directly from the queer community" across the world, "contributed dozens of personal items scanned into 3D and 2D artworks, that contextualise their lived experiences".* All of this is on display using VR and won the New Voices award (Immersive category) at the 2022 Tribeca Film Festival.

Whatever path tourism and the metaverse takes, is heavily determined by technology readiness and the resources available to the tourism industry. However, it likely also depends on the uptake and the user experience. Koohang et al identify this as a "significant knowledge gap, because the users' behaviour, usage, and adoption of the metaverse technology will significantly determine its success". They outline specific research questions to address, in order to accelerate the use of quality metaverse-related technologies across the sector:

1. *How the metaverse can influence the customers' (e.g., tourists') perceptions, decision-making process, and willingness to travel to a destination before their trip?*

2. *What data security issues do metaverse users identify and how does the latter influence their metaverse adoption?*

3. *How do metaverse marketing and advertising influence the customers' (e.g., tourists) decision-making process and outcomes?*

4. *What is the profile of customers (e.g., tourists) that have adopted the metaverse, and what is their metaverse usage profile?*

5. *How can the metaverse enrich and augment the customers (e.g., tourists) experience at a destination? How decentralized finances (e.g., non-fungible tokens) can influence the customers' (e.g., tourists) experience in the metaverse?*

(Koohang et al., 2023b).

Creative Industries: Fashion

Focus Group Insights

D-1-2. I hope the MV helps society with ecology, sustainability and the environment. Working in fashion, we are moving away from fast fashion and towards virtual representation of clothing; and products that don't have to be made and then thrown away. The MV can have a positive influence on how we produce and consume fashion, and a more blended way of living between the physical and digital domains will reduce waste.

M-2-42. Conversations are happening about how to commodify different components of how you build an avatar, from the clothing through to cosmetics through to jewellery-that's a reality that has to be considered. There is a commercial appetite to make it, to design in flexibility and allow people to have that ability to design whatever they want.

Y-2-13. What's fascinating is that Gucci, who make handbags, are active in the MV. Why would you need a handbag in the MV? To hold what? What is the digital equivalent? What should I have around me? Should it be some sort of particle cloak? MV apparel does not necessarily need to be garments in the traditional sense.

Y-2-79. think fashion is a huge opportunity. In the pandemic, buyers couldn't go and see collections, they could not see the visible garments. To be able to meet in a virtual space and still see a product and buy it was great as an interim. But people want to go back to be able to see products in person, or at least to see a realistic version, which they can feel, because it's not just how it looks, it's also the touch of the materials that haptics aspect of it.

Y-2-80. For the fashion industry, there are lots of opportunities that cross between digital and physical fashion. You can be sat on the front row of a fashion show in the MV and see the garments walking past and have that interaction with the fabric and materials.

Y-2-81. We need better realistic rendering of fashion in the MV. Programmes like Clothe 3D, which do great things in terms of how garments look and drape, need improvements in terms of rendering clothing realistically, so it can be fully represented in the virtual space.

Y-2-82. There's that tactile aspect. Haptic gloves exist but the quality isn't right yet. But that area of haptics and its relation to fashion is a huge opportunity.

Y-2-83. Full sensory experience of a fabric, of the garment, includes colour. The colour that you see in virtual space should be representative of what you would see in the physical world.

Y-2-84. Sometimes you don't want realism-you want stylisation.

Y-2-85. Gucci handbags have been sold in the MV. A lot of fashion brands want to be a part of it. They want to get earning some money from being involved in that space. Sometimes they are not successful because what they attempt is just a gimmick. They do not always understand why people are in that space, what people want from that space.

Y-2-86. It should be a creator economy. There's a lot of exploration and freedom at the moment, a lot of creative risk. The big brands in the fashion industry do not move in that way.

Y-2-87. What's fascinating is that now it looks like it's a one-way journey from real to virtual. But we will see brands that were completely virtual start to come out into the real world. Outfits popular in the MV could start to be mirrored in the real world.

Y-2-88. We're already seeing that through iridescent fabrics. Digitally, you can generate these otherworldly fabrics. We are then seeing these in WGSN reports-trend reports. That is why colour is such a rich potential R&D area. What colours are people using in the MV? What are the trends in virtual worlds and how that might translate into the physical fashion industry?

Supplementary Research

The fashion industry contributed almost £35 billion of direct value to the UK economy in 2021 (British Fashion Council Annual Report 2021-22); however inflation, rising costs and lower consumer spend means the industry could be in for a stormy few years (McKinsey State of Fashion 2022). However, uptake of digital technologies by the fashion industry could cut their costs and widen their customer base.

A growing number of establishment luxury fashion brands have forayed into the MV space, usually in the form of *"releasing NFT brand assets, engaging customers with branded virtual worlds via games and virtual worlds, and creating unique brand experiences using immersive technologies"* (Joy et al., 2022). High-profile recent examples of these strategies have been achieved through the collaboration approach. For example, Louis Vuitton are selling NFTs of their collaboration with the Japanese artist Yayoi Kusama (Feb 2023) as well as selling NFTs of their iconic trunks, the physical version of which retails for €39,000 each (April 2023). The French luxury fashion house Balmain, owned by Mayhoola, the investment company of the Emir of Qatar, collaborated in March 2023 with the NFT specialist Spacerunners to offer an NFT collectible pair of trainers. Customers who bought a digital pair of 'Unicorn' trainers were also able to claim a physical pair.

That same month, Gucci collaborated with Yuga Labs, creating MV fashion including an NFT collection. A March launch allows for items to be showcased at the annual Metaverse Fashion Week, which has been held annually since 2022.

Gucci also made its debut into Roblox, the proto-metaverse gaming platform, with 'Gucci Garden Archetypes', a short term (two week only) immersive virtual space, which Gucci says was visited by over 20 million users. They have also established a more permanent presence, Gucci Town, which sells clothing for avatars but also has communal spaces to socialise in. Similarly, Vans, the lifestyle and streetwear company, has opened a Vans World within the Roblox platform, offering skateparks, beaches, and the ability to design shoes and skateboards for your avatars use. Tommy Hilfiger, which partnered with the Animal Crossing game in 2020, creating a 'Tommy Hilfiger Island' has also partnered with Roblox (Dec 2021), allowing the platform's community creators to re-design some of its most famous pieces, culminating in a collection of 30 digital wearables for their avatars.

Where collaboration has not happened, fashion companies have fallen victim to copyright infringement via digital designs and NFTs. In a recent high-profile case Hermès, the luxury fashion house, sued artist Mason Rothschild in the U.S.A. for *"trademark infringement and dilution, misappropriation of its BIRKIN trademark, cybersquatting, false designation of origin and description, and injury to business reputation", following Rothschild's "creation and sale…of one hundred NFTs linking to a depiction of a digital Hermès BIRKIN bag…Rothschild also registered and used the domain name www.metabirkin.com and social media handles such as @metabirkins to promote the sale of the "MetaBirkin" NFTs. By early January 2022, Rothschild had sold in excess of $1 million in MetaBirkin NFTs".*

There are emerging case studies of the fashion industry making use of the MV beyond sales and marketing, deploying immersive and MV-enabling technologies in novel ways. Coty (est 1904) has become one of the first beauty companies to enter the MV, partnering with Web3 company Spatial to build an internal metaverse campus, servicing 11,000 employees around the world, and offering a *"a physical reward system, based on item collection, location exploration, and quest fulfilment"*. Digital twin technologies were used to make a digital twin of 1990s supermodel Eva Herzigova, which can *"wear clothes, but also hairstyles and make-up, created digitally, and will even be able to adopt specific poses for advertising campaigns, digital fashion shows or, more simply, the modelling of digital clothes"*. Smart Mirror technology, which use AI-driven measurements, such as the MySizeID FirstLook Smart Mirror could become a staple of the physical and digital dressing room. A recent report concluded that, while the MV would not wholly replace the 'real-life' in-person shopping experience, it is likely to heavily influence and shape the online retail arena (Breiter & Siegfried, 2022). This is significant when online shopping is rapidly becoming a consumer's preferred choice (H. Park & Lim, 2023).

The fashion and textile industry is the joint third highest emitter of greenhouse gases globally, accounting for around 5% of global emissions, using 98 million tonnes of non-renewable resources and 93 billion cubic metres of water annually (The Circular Fashion Ecosystem: A Blueprint for the Future 2021; Fixing fashion: clothing consumption and sustainability, 2019). Digital technologies could revolutionise the design and manufacture of clothing. The pattern cutting process is *"one of the most labour-intensive and least efficient processes in terms of waste generation"*(Ramkalaon & Sayem, 2021). By digitising the design and prototyping process, including pattern-making, virtual samples can be ready within hours instead of weeks (Casciani et al., 2022).

3D technologies and digital transformation are being used by established fashion companies for collaborations with digital businesses, and to acquire and/or incubate digitally start-ups. SMEs in this space include agencies that support digital retail experiences, digitise collections, or provide specialised digitalisation services, as well as using the online space to retail direct to consumers. Further technological developments to improve the MV visual experience (e.g. haptic and sonic technologies in VR) would likely greatly increase trade and traffic this area and *"recover the loss of tangibility of garments"* (Casciani et al., 2022).

MV opens opportunities to enable personalisation of garments, allow on-demand design, and offer immediate gratification for consumers (Tupikovskaja-Omovie & Tyler, 2022). It may also enable the democritisation of the fashion business, allowing emerging designers to create and sell designs without industry barriers or overheads. MV is also a possible pathway for *"enhancing brand equity in the fashion industry"* (H. Park & Lim, 2023).

There are clear indicators that emerging digital trends in the fashion industry are seen as worth investing in: Syky (pronounced like 'psyche'), a digital fashion incubator, marketplace and community hub in one, operates using blockchain-enabled technology. It attracted a £95 million investment in January 2023 from Seven Seven Six, the venture fund of Reddit cofounder Alexis Ohanian. Similarly, academic research in the UK is taking note, with Ulster University recently (April 2023) offering a funded PhD in Addressing the Digital: The role of the Metaverse in re-thinking the sustainability of the fashion industry from concept-to-customer. Viewing future industry developments here through the R&I lens, the most fertile areas are likely the greening of the industry via digital technologies, and also the developments

Healthcare

Using metaverse technology to support the health care of elderly

Metaverse technologies, such as virtual reality (VR) and augmented reality (AR), hold significant potential in the field of diagnosing and treating Mild Cognitive Impairment (MCI) and serving as tools for exposure therapy. These applications are particularly crucial for the elderly population. Early detection of MCI is of utmost importance as it enables timely intervention and improved outcomes. Metaverse technologies offer exceptional opportunities for evaluating cognitive function through interactive and captivating assessments. By utilizing cognitive assessments based on virtual reality, memory, attention, and executive functions can be assessed within a controlled and standardized environment. This technology immerses individuals in virtual scenarios that replicate real-world situations, enabling a more ecologically valid assessment of cognitive abilities and facilitating the early detexion of MCI. Additionally, metaverse technologies play a pivotal role in exposure therapy, which is an effective treatment for anxiety disorders commonly experienced by the elderly. By employing virtual reality in exposure therapy, therapists can create realistic and customizable environments that gradually expose patients to feared situations. Virtual exposure therapy proves beneficial for elderly individuals with limited physical mobility or restricted access to real-world environments. VR simulations provide a secure and controlled setting for progressively confronting anxiety-provoking scenarios, resulting in reduced symptoms and enhanced overall well-being. Furthermore, metaverse technologies can contribute also to the cognitive rehabilitation of elderly patients with MCI. VR-based cognitive training programs offer personalized and engaging exercises tailored to specific cognitive domains. These technologies provide interactive and adaptive tasks within metaverse environments, thereby improving attention, memory, and problem-solving abilities in elderly individuals with MCI. Consequently, this may potentially slow down cognitive decline.

Figure 23 Insights on health care technology provided by Prof Jan-Niklas Voight Antons, June 2023

Focus Group Insights

C-1-25. Everything in the NHS has to go into the Cloud now, but there is no adequately functional internet in real terms within hospitals. Currently, they cannot properly stream VR content into a hospital, and being told to put everything into the cloud is a million miles away from the current world. It doesn't mean the NHS are wrong to want this, far from it, just that right now it is not feasible.

C-1-37. There is work in the VR and the mental health space that is powerful – around empathy – it offers us something that we haven't had before in terms of treating mental health. That might be one key emerging and lasting affordance of this medium.

C-1-38. Working the VR and health space, we are trying to make people better. We want to give people power and to enable them to understand themselves better. That's the world we want to try and create.

C-1-39. One of the concerns we have about the headsets is the data collection – but also then technology can be for good, like the way apple watches have picked up heart defects. How do we balance these two polarities of data mining vs data for healthspan?

C-1-40. There are really good people working in this health and VR/MV space-there are people in NYU [New York University] for example who are completely inspiring here, world-leading.

C-1-58. In the USA, the Veterans Society is like a micocosm NHS– actually, its about the same size as the NHS. Veterans get access to healthcare, but they also essentially sign up to be guinea pigs within it.

C-1-59. And that [the military and veterans society] is where this space is being trialled, played out, and tested.

C-1-60. There is a huge NHS funding need but also a huge potential return on the investment here. PTSD [Post Traumatic Stress Disorder] for example, leads to lots of other things that are costly and harmful to society.

C-1-61. Hospitals of Excellence, an approach mooted by NHSX, which make and test and User centric design, is interesting and potentially scalable.

C-1-62. You can't talk about something properly until you start making it, and then as you make it more challenges appear. We need to get people from all different disciplines together to tease out those ethical problems out but also the tech too, to design and prototype MV for health.

C-1-63. Human-Centered AI design at Swansea is an excellent example of good future directions here– they demand their students think ethically and bring an ethical opinion to bear on the technology in the health space.

C-1-64. This technology is fundamentally able to hack our brains. It does something different that no other medium does. Like the internet changed the way we communicate, this is also going to change us, at a neurological level.

C-1-65. MV will change how we view ourselves. And our choice of whether that is for good or bad will depend on more forums and work like this conversation.

M-1-39 What are the long-term wellbeing and mental health issues from the se online platforms, especially for children?

M-2-9 There's a massive appetite for everyone to engage with MV. There are pragmatic applications for this technology that can seem really abstract until you see them in in place. For example, in healthcare, working with a Children's Hospital to gamify the on-boarding experience for children before they go into MRI scanners.

N-2-22. What is the impact on EDI and digital health perspective? that feel underrepresented in the physical world are feeling that those attitudes and respective are translating over to the digital realm.

N-2-72. I'd love the NHS to have a high-fidelity digital twin of me. Driven by a smart watch with a full stack of health records that can be picked up and looked at by a doctor. But constantly monitored by a bunch of AI going: You're not well, we should talk to you about this, you should do more of that, you haven't done this. I would love for someone to be preventatively observing my health status instead of waiting until I get poorly before something happens.

N-2-38. We work with all sorts of sensors, whether it is audio, somebody's movement tracking, heart rate, health care related sensors and spend all our time digital. Some people think it has to be full replica of the whole thing. Again, it could be as simple as dashboard. That is a digital twin because the data that we have in from the physical world.

N-2-71. We work on edge computing, what we call tiny machine. The idea is that that data is captured and thrown away. For example, I have a camera on a little device and then I take these frames, the camera frames count how many people come through the frames. So instead of sharing images with the cloud, we just share that the number of people or the insights from this data processing. There's no need to share personal data. It is the same with health, your heart rate or other kind of information about your body and your health does not need to be shared.

Y-1-12 What isn't in the MV? Are we talking about all emerging technologies? This becomes very hard to unpick as more and more technologies converge. For example, healthcare and network technologies converge to enable a surgeon to operate remotely on a virtual representation of someone's heart.

Y-1-33 Meta may realise that creating a 'new real' through VR may not be what society wants or where they will make their money. However, this has opened the door to new applications and industries who realise the potential, like healthcare.

Y-1-39 Healthcare applications in MV could be huge. Working with kids with autism, we created a VR environment for kids with auditory hypersensitivity – a controlled gaming framework where they interact with these sounds in a positive enforcement exposure therapy. Applications like these require formal verification via clinical trials and the NHS take time to adopt new therapies. In a free, open and unregulated MV, companies could sell such services directly to users without proper validation/verification. This could be dangerous.

Y-1-42 Challenge in regulation: If we restrict data collection or deny movement of data/profiles between companies, we don't want to regulate to the point where we can't do research that's useful or develop new applications that use personal information e.g. analyse motor impairment in patients. How do we design those regulations?

Supplementary Material

There is much written about the incoming-or already here–'Health 4.0', which integrates technology with healthcare (Al-Jaroodi et al., 2020). This integration will likely most impact clinical practice and health administration, as well as the research across public health and biomedical R&D. What this all means for a medical MV is being debated by clinicians and technologists, with ideas circulating about an increased telepresence, the creation of virtual hospitals and digital twins of patients, novel treatments enabled by VR and other new technologies, and the NHS interaction with all this (Liu et al., 2022). We could see NHS nurses in avatar form (Schuelke et al., 2019), while physical nurses might have been effectively trained in MV environments (F.-Q. Chen et al., 2020), guaranteeing standardised training and offering the opportunity for quality education of nurses in remote environments (Petrigna & Musumeci, 2022). Surgeons have also been trained in the MV, for example 200 lung cancer surgeons in Seoul National University's Bundang hospital (H. Koo, 2021).

Developments in big data and machine learning systems that could help the NHS to innovate (Kostick-Quenet et al., 2022), including MV-base technology adopted with success for diagnosing and treating a broad spectrum of conditions, including strokes, cancer, neurodegenerative disorders and a number of mental health illnesses (Yeung et al., 2021). Remote, highly accurate monitoring could reduce the number of appointments as well as detect illnesses earlier, leading to better health outcomes and reduced costs and burden on the health service. An immersive patient experience might include platforms for receiving consultations, treatment, surgery, and counselling / therapy, with patient data sent to explainable artificial intelligence (XAI) models, before the XAI sends their analysis to clinicians for verification and action (Ali et al., 2023). (G. Wang et al., 2022) have named the infrastructure of a healthcare MV 'MeTAI', which they see as being brought to fruition by collective attempts now to advance the XR-based healthcare experience, to demonstrate new MV applications are feasible, and by developing MeTAI to be "*cost-effective, user friendly, high performance, reliable, safe, equitable and ethical, while moderating 'metaverse hype' with expectations that are both measured and measurable*".

Collecting precise, useful, non-biased and diverse information for use in machine learning (ML) will engender more precise and equitable AI applications for healthcare. This, alongside improved AI decision making in the medical domain, and VR for health education and for patient-clinician interactions, could feasibly transform the way we care for our population. In the arena of spine care, researchers assert that this triad (ML, AI and VR) will merge into a greater all-encompassing digital entity, which can in turn be applied to niche applications such as spine health (Chapman et al., 2022).

Research has shown that VR might have a transformative effect on the knowledge and treatment of mental health problems, if "*...the best immersive VR technology is combined with targeted translational interventions. The capability of VR to simulate reality could greatly increase access to psychological therapies, while treatment outcomes could be enhanced by the technology's ability to create new realities. VR may merit the level of attention given to neuroimaging*" (Freeman et al., 2017).

Nascent forays into a Health MV have already occurred, notably in the area of remote surgeries, such as the 2022 operation to separate conjoined twins in Brazil, with the surgery directed from London, following an extensive trial of techniques making use of CT and MRI scans of the twins to create accurate VR projections (Conjoined Twins Separated using VR).

Imaging AI technologies show considerable promise in helping trained radiologists to quantify medical imaging (Peng & Wang, 2021). AI-based methods for detecting and 'reading' digitised imagery, also known as digital pathology, has been shown in some studies to have an efficacy level equivalent to pathologists (Ehteshami Bejnordi et al., 2017) but is most effectively and impactfully deployed when combined i.e. digital pathology plus human pathologists both assessing the data. (Bera et al., 2019).

In Africa, countries with dense telecommunications networks and cell phone uptake (like Nigeria, Ghana, South Africa, and Kenya), are seeing telemedicine deployed to treat a range of conditions, including mental health problems via Chatbots over the Telegram channel. "Since the outset of the pandemic, telehealth service providers have rapidly scaled offerings and are seeing 50 to 175 times the patients via telehealth" (Adepoju, 2020).

Much of the move to online healthcare has been catalysed by the pandemic, which saw a 38-fold growth in telemedicine. After telehealth, the second biggest new healthcare trend to emerge from the pandemic was an increase in the adoption of electronic informed consent.

In the EU, pre-pandemic, the three major causes of death were circulatory diseases (35% of mortality) and cancer (26% of mortality), and respiratory diseases (8%). Considering this, in addition to treatments for Covid19 and Long Covid, there would be a significant benefit across Europe for developing high-quality MV interventions in the prevention, diagnostic and treatment arenas for ischaemic heart diseases, cerebrovascular diseases, and cancer (notably lung, colorectal and breast cancers, the three main causes of death from cancer in the EU in 2019), and Chronic obstructive pulmonary disease (COPD) (OECD, 2022). With 24.4% (14.5 million) in England and Wales aged 60 years and over, MV innovations in dementia, which affects the 60+ age group disproportionately would also be impactful. The current limits of the metaverse must be addressed in order to accelerate health-related applications. These limitations include data management, privacy, cybersecurity, infrastructure including connectivity (Petrigna & Musumeci, 2022) and the exclusion of patients with impaired vision (Tan et al., 2022). Developing the technologies needed to power the Health MV, and making them interoperable, remains a primary challenge, and rapid collaborative work on these, in tandem with end users, would enable a future MV where patients and doctors can fully avail of VR, AI and ML to transform the way people are diagnosed and treated (Patel et al., 2019).

Collecting precise, useful, non-biased and diverse information for use in machine learning (ML) will engender more precise and equitable AI applications for healthcare."

EUROPEAN PERSPECTIVES

The European Union is especially active in the MV space, with two public consultations released in 2023:

1. Virtual Worlds-metaverses-a vision for openness, safety and respect which aims for an *"open, interoperable and innovative virtual worlds that can be used safely and with confidence by the public and businesses"*; and

2. The future of the electronic communications sector and its infrastructure which aims to *"gather views on the changing technological and market landscape and how it may affect the sector for electronic communications (and explore) the types of infrastructure and amount of investments that Europe needs to lead the digital transformation in the coming years"*.

There is also an 'own-initiative' procedure launched in January 2023 on Virtual worlds: opportunities, risks and policy implications for the Single Market with reporters from political parties in France (Anne-Sophie Pelletier, Laurence Farreng) and Portugal (Francisco Guerreiro and Maria-Manuel Leitão-Marques).

Several countries in Europe were identified by the authors as having a concentration of MV activity, and a willingness to participate in, or collaborate on, research in this area. A small team undertook some initial research into the European MV landscape, including meeting with six 'Science and Innovation Network' leads. This work is emerging, but below is a snapshot of some of the initial conversations undertaken with collaborators across Europe.

Denmark

Invest Denmark & Industry

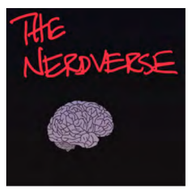
Denmark's national investment department, part of the Ministry of Foreign Affairs, has specific resource dedicated to MV technologies. Denmark led the 2021 Digital Economy and Society Index (DESI) 2021, which looked at the confidence with and adaptation to tech (e.g. online banking, shopping online) among populations across 28 European countries. Current examples of Danish companies deploying AR and other MV technologies include Grundfos (VR for training staff and a MV version of water utilities). Mærsk (VR for safety training for ship mooring) and DTU Space (VR-enabled mental health system for astronauts). Lego has also partnered with Epic Games (Fortnite) to co-develop a MV.

The SDU Metaverse Lab
This interdisciplinary research lab, at the University of Southern Denmark, (Odense) is headed up by Professor Anders Drachen. It combines academics with industry working across gaming, health, robotics and more, and focusses on creating tech-enabled experiences that will allow people to *"shape and engage with the future"*, and on tech transfer.

TRANSMIXR
TRANSMIXR is a €9m Horizon Europe project to build MV tools for the media and arts sectors, with around 20 project partners across Europe, including Khora APS in Denmark, a VR and AR production studio based in Copenhagen.

Copenhagen Institute of Futures Studies
The Copenhagen Institute of Futures Studies (CIFS) is an arms-length body of the Danish state, with world-leading expertise on foresight. They recently undertook a Delphi Study on 'The Free Metaverse', which discussed four plausible future scenarios for MV:

The Free Metaverse: MV as an "evolution (and progressive replacement) of the World Wide Web, a new way of accessing applications, contents and services, decentralized and interoperable, capable of merging the physical world with a shared virtual universe using various XR technologies".



The Nerdverse: MV as "*an evolution of the World Wide Web, but the initial interest tends to wane once the curiosity of the first period has passed. In this case, the metaverse doesn't offer anything that most users feel they really need, the technologies around the metaverse haven't really proven their worth, and the big brands that initially invested heavily to get into the metaverse haven't actually succeeded to integrate the new Web3 logics in their own solutions, thus failing to take advantage of the new technologies or to understand the new needs of the consumers*".

Betaverses disunited: "*A dozen Big Tech companies come forward each with their own product that they say is the Metaverse. All they have in common is the use of virtual 3D meta-spaces that can be accessed with XR technology as well as more conventional interfaces.*"

One metaverse to rule them all: "*Many Big Tech companies rush to build their own versions of the metaverse, however one of them quickly becomes much more popular than the others, both for better functionality and for better conditions reserved for content creators and for best marketing ability, or just being a successful first mover. This popularity becomes self-reinforcing as the resulting increase in revenue streams allows for the continuous improvement and extension of their metaverse's functionality and user experience to a level that competitors cannot match.*"

CIF surmises that governments will probably want 'Betaverses Disunited' and 'One metaverse to rule them all', "more or less a copy of existing situation, when it comes to search and social, are probably what most authorities will want." Dataethics recent white paper describes the zeitgeist of 'One metaverse to rule them all' as follows:

> *"The open-source community has fallen on hard times because authorities demand governance and certification that the decentralised open-source organisations find it difficult to live up to, such as checking all content against copyright and trademark violations and policing forums against hate speech and fake news. Most successful open-source systems have been de-facto acquired by commercial interests that can afford to handle the complex and extensive regulations."*
>
> (Dataethics, 2022)

Finland

VTT

The VTT Technical Research Institute of Finland launched its first human-driven MV project in October 2022, aimed at the industrial MV. A number of industrial companies are partnering on this large piece of R&D-Valmet Automotive, KONE, Finavia, YIT, Granlund, Telia, ZOAN, Sulava, Dazzle, Augment and Nordkapp.

> *"The objective of the project is to identify work tasks in which the use of a metaverse would benefit both employees and the organisation. The use cases identified should contribute to the productivity of work, employee well-being, the attractiveness of work, and the achievement of Sustainable Development Goals by, for example, increasing the number of place-independent work tasks"*
> Karoliina Salminen, MV project lead, VTT.

During spring 2023, the project will create novel and innovative initiatives to provide tech companies with scalable solutions, for the Finnish and the international market.

VTT is also examining the infrastructure needs of a future MV, looking at the ICT requirements, particularly 6G, in accordance with the Finnish Strategic Research and Innovation Agenda, which has prioritised a national 6G Bridge in Finland. This EUR 130 million 6G Bridge innovation programme runs January 2023 to December 2026, with the goal of helping Finalnd "maintain leadership in future connectivity and provide growth opportunities for Finnish companies".

Finland National Metaverse Strategy

In April 2023, Finland launched an initiative to create a national MV strategy led by Jani Vallirinne at the University of Oulu, and overseen by the Ministry of Economic Affairs and Employment.

France

Metaverse Report

In February 2022 the French government announced an exploratory mission on the development of metaverse, and in October 2022, a report was delivered jointly to the French Minister of Culture, and the Deputy Minister for Digital Transition and Telecommunications (Basdevant et al., 2022). The authors of the report were Adrien Basdevant, a lawyer who works at the intersection of technology and society; Camille François, an academic based at Harvard who specialises in digital harms; and Rémi Ronfard, research director at Inria, the French national Institute for digital science and technology, who researches computational models of visual storytelling.

The report made a series of recommendations to the French Government, including seizing the opportunity of MV to regain leadership positions in global digital services; to adapt current legislation to ensure it regulates / applies to MV; to analyse MV value chains to bolster tech sovereignty; to invest in a standards body and to participate in international discussions on interoperability; to invest in interdisciplinary research and establish an institute based on the 'Institut de Recherche et Coordination Acoustique/Musique' (Ircam) model; to measure the environmental impact of MV; to create hybrid funding arrangements between French technological structures and cultural institutions; to roll out MV technologies in the public facing sector; and to use MV technologies during the 2024 Olympic Games.

Laval

The annual Laval Virtual International Conference is a major European XR conference held in France, with over 10,000 attendees, which in recent years has increasingly incorporated MV specific topics on its agenda.

TRANSMIXR

Immersion (a VR innovation company, is one of the project partners on the large, pan-European MV research project TRANSMIXR.

Germany

Privacy and Security

Germany has been a frontrunner in raising privacy concerns resulting from data harvested from MV adjacent technologies, a topic regularly debated in the German parliamentary structures as well as in the judicial system; and also on the regulation of competitive markets. One notable case is the one brought against Oculus, which resulted in Meta removing their headsets from the German market (2020). Meta assured authorities the headsets could be used without needing a Facebook account (November 2022).

The implementation of the EU Audiovisual Media Services Directive (AVMSD), in Germany resulted in new regulations for online services, specifically Germany's Interstate Media Treaty, which introduced regulations for media platforms and user interfaces. Media here covers broadcasting, so where there is any broadcasting occurring or journalistic content within a platform, it is considered under German law to be a media platform. Where this applies to MV platforms, for example ones allowing viewers to stream or watch content, they will be subject to these regulations. Germany's 2017 Network Enforcement Act (Netzwerkdurchsetzungsgesetz, NetzDG, or NetzDG) , which applied to social media platforms with over 2 million users, initiated the imposition of fines of up to 50 million euro for noncompliance with existing laws and regulations, including those legislating against hate speech. Content that is judged to be illegal must be removed by the provider within 24 hours. On June 28, 2021, NetzDG was amended regarding social media platforms' transparency reports, to improve the usability of reporting channels for content, to introduce an appeals process for the companies, and (subject to the EU Audiovisual Media Services Directive) to include video-sharing platform services under the scope of the Act. Conventional games currently remain out of the scope of the Act.

Academic Research

Germany's Fraunhofer Institute for Systems and Innovation Research has a specialism in MV technologies.

Hamm Lipstadt University of Applied Sciences is an interdisciplinary centre, which in part looks at immersive media and human computer interaction. The Computer Graphics and Virtual Reality Research Lab (CGVR) at University of Bremen researches VR.

TU Berlin Institution for Architecture has established 'Does It Meta?', a student-based channel about the metaverse.

Digital twins

The German Federal Agency for Cartography and Geodesy (BKG, based in Frankfurt) is in the process of creating a digital twin of Germany, which will be rolled out to simulate future scenarios, including land use, extreme weather events, and change in energy demands.

Siemens are building Siemensstadt Square, using a digital twin of a 73-hectare area of Spandau in Berlin, designing a carbon neutral, mixed-use area of the city, where future tech is developed as well as tested.

TU Berlin are working on a large scale digital twin of a water pumping plant, led by Professor Paul Uwe Thamsen.

TRANSMIXR

Germany is the 2nd largest VR/AR Ecosystem in Europe. Intel Germany is one of the project partners in TRANSMIXR.

Italy

Meta Study

Meta commissioned a study (Dec 2022) on the risks and opportunities the MV poses for Italy, including an assessment of value chains, to be carried out by Guiliano Noci and Lucio Lamberti at Politecnico di Milano.

Politecnico di Milano

The School of Management at Politecnico di Milano has begun a MV Marketing Lab, directed by Manuella Balli, to analyse best practice and consumer behaviour towards, and interaction with, marketing in the MV.

Parthenope University of Naples

Mariapino Trunfio, at the Department of Management and Quantitative Studies, works on the design of future MV research streams, including technologies, applications, marketing, and consumer behaviour and sustainability.

Istituto Marangoni

Italy's fashion institute has a MV called 'The Talent District' which uses Web 3.0 technology, immersive technologies, and digital language to create an educational and design platform.

Aldo Moro University

The University has a project, led by Professor Giosue Prezioso, that uses MV technologies, including NFTs, to create a digital library of Italian culture.

Fiat

The car manufacturer has partnered with Microsoft in 2022 to create the first MV-powered car dealership, offering personalised service to design, test and buy Fiats online.

XR Salento

A large international conference on eXtended Reality run in Salento annually in September. XR Salento 2024 will focus on digital twins, IoT, AI and data mining to create digital representations, to gather and store data, and to simulate the future state.

Blockchain funding

In 2022 the Italian government announced 45 million euro of funding to develop blockchain and AI technologies as applied to (1) industry and manufacturing, (2) the education system, (3) agri-business, (4) health, (5) environment and infrastructure, (6) culture and tourism, (7) logistics and mobility, (8) security and information technology, and (9) aerospace.

Chat GPT

Italy banned Chat GPT in March 2023 due to its perceived non-compliance with privacy laws. One expert on this is Luca Bolognini, President of the Italian Institute for Privacy and Data Valorisation.

The Netherlands

Immersive Tech Week

An international conference and showcase held annually in Rotterdam (November 2023) concentrating on eXtended Reality.

TRANSMIXR

Centrum Wiskunde & Informatica (the national research institute for mathematics and computer science in the Netherlands, based in Amsterdam) are a partner on the European TRANSMIXR project.

AI and Ethics

The Netherlands is a world leader in research on responsible and ethical AI, which has relevance to future MV spaces.

The Research Priority Area Human(e) AI at the University of Amsterdam researches the legal, ethical and social consequences of AI and automated decision-making. At the same institute, 'AI technology for People', focuses on the development and application of responsible AI.

In June 2023, Erasmus University (Rotterdam) and TU Delft announced the opening of the world's first ethics lab for artificial intelligence (AI) in healthcare.

The Eurocities' Digital Forum Lab developed the Algorithmic Transparency Standard, co-designed with Amsterdam, Barcelona, Brussels, Eindhoven, Mannheim, Rotterdam, and Sofia, and modelled on best practices already implemented in Amsterdam and Helsinki, as well as the Dutch Standard for Algorithmic Transparency.

Portugal

Hardware

Portugal has well-established and world leading capabilities in novel material innovation for the hardware that will be needed to power any future MV, for example the CENIMAT (https://www.cenimat.fct.unl.pt/) at Nova School of Science and Technology (Lisbon) headed by Elvira Fortunato, the Portuguese Minister for Science and Technology.

Web Summit

This annual event (November) in Lisbon is attended by 70,000 people. In 2024 the summit will look at MV technologies.

Altice

The largest Portuguese telecommunications company, Altice (8,800 staff and a turnover of $3.3 billion), launched a metaverse experience in November 2022 for its mobile subsidiary, 'Meo'. Users can create their own 3D avatars and shop in an online rendering of Lisbon's central business district.

Spain

España Digital 2026

Spain's national digital strategy is a roadmap for the country's digital development, including eight plans:

1. The Digital Infrastructures and Connectivity Plan for society, economy and territories
2. Strategy for the promotion of 5G Technology
3. ENIA, National Artificial Intelligence Strategy
4. National Plan for Digital Skills
5. SME Digitalization Plan
6. Public Administration Digitalization Plan
7. Spain Audiovisual Hub of Europe
8. National Cybersecurity Plan

España Digital 2026 also outlines plans for a novel regulatory environment for new technologies, such as a 'Create and Grow Law', a 'Start-Up Law', a new 'Telecommunications Law', a '5G Cybersecurity Law', and a new 'Audiovisual Communication Law'. All these new regulations will be steered by a 'Charter of Digital Rights', which will aim to align the digital sphere with Spain's constitutional values and laws.

Event Lab

The University of Barcelona's Event Lab is led by Mel Slater. Its research specialism is virtual environments for healthcare and for technologies.

CONCLUSIONS

Our study endeavoured to gather a broad range of views on the metaverse from professionals and academics working in various related areas. Given the inherent fluidity of what the metaverse might mean, a broadly based approach was deemed the least risky option. The cross disciplinary platform established during the project has been fascinating and highly informative. We have witnessed palpable excitement from representatives of the museum sector, the fashion sector, and music and performance professionals:

> *D-2-23. MV gives the museum the opportunity to reach audiences and tell stories in a way that's focused on them. And so, we can tailor different stories to different audiences whether they can come to the museum or not. A new audience of explorers who are geographically dispersed is opening up to us. We want to be able to tell stories to all those audiences, whether they're interested in the traditional museum experience or not.*

> *D-2-24. There is something in a museum that will fascinate every single person in this country-how do we get that out there to them and get it into a way that they will engage with on a platform that they are already in?*

> *Y-2-95. For the fashion industry, there are lots of opportunities that crossover between digital and physical fashion. If you can be sat on the front row of a fashion show and see the garments walking past and have that interaction with the fabric and materials.*

Many view the metaverse as a massively creative space that facilitates experimentation and the development of ideas in the digital domain that can then transcend into the physical domain:

> *Y-2-13. It is such a creative space, because people can just explore, experiment, and create bonkers things that they cannot and they would not feel comfortable wearing in the physical world, but they can experiment and create amazing things in the digital world.*

> *Y-2-64. We need to stop constraining ourselves to what the real world is.*

> *M-2-47. There is a lot of money to be made.*

We must encourage the development of metaverse applications and demonstrators which highlight and harness the creative talent across the UK. Cross-cutting benefits will accrue from many metaverse applications. For example, metaverse based collaborative design and market testing of fashion garments can significantly decrease environmental damage, improve the sustainability of the industry and get products to the market quickly. Projects in tourism, heritage and live entertainment provide similar opportunities. Virtual production technologies underpin all the above and a hub and spoke model which supports, co-ordinates and integrates a range of sectoral projects could provide a metaverse showcase for the UK.

Of course, there are concerns about data collection, privacy, accessibility, and the emotional or psychological consequences of prolonged metaverse exposure on children and young adults:

> *Y-2-87. The dominant assumption is that we cannot have social media without our data being sold.*

> *D-2-21. We have to take the person who has the least capacity to access the products and services with us.*

> *D-1-24. Ethics and prevention of cybercrime are important, but MV is taking us into another dimension of how we would protect our emotional and psychological selves. This is a whole new area that we know little about.*

> Y-2-104. The technology is here and children are spending time in these spaces. It is crucial for humanity to do research and understand the longitudinal effects, to really get to grips with what is happening and stop it, or at least be prepared.

The changing regulatory environment surrounding social metaverse platforms e.g. the EU Digital Services Act and the proposed US Platform Accountability and Transparency Act (PATA), could provide extensive platform level data access to researchers.

This would fuel multidisciplinary 'computational social science' research and immediately transform the study of online harms and cyber-psychology. Ultimately, this work could sustain the UK's international reputation as a safe place to do business online.

The metaverse will mature technically over the next decade and hence we have an opportunity to shape and mould its development towards UK beneficiaries. Many of the metaverse's underpinning technologies are prominent UK industries e.g. the games sector. Industrial metaverse applications in closed domains will gain traction before mass movement towards a social metaverse. Digital twins will form a beach head for metaverse adoption. We must take a leadership role in defining the technical standards that will lay the foundations of a mature metaverse. Interoperability between virtual worlds is a way to ensure that UK enterprises can operate on a level playing field. Co-ordinated activity in metaverse standards fora, at a national level, is required.

Maintaining public confidence in metaverse environments will be a challenge given that much of the current development and hyperbole has come from technology corporations wedded to advertising revenue. Privacy enhancing technologies will have strategic importance in metaverse rollout and successful adoption. AI technology such as 'Federated Learning' and advanced cryptographic schemes such as 'Multi-Party Computation' and 'Homomorphic Encryption' may prove transformative in a range of metaverse use-cases. If these enabling technologies mature to the point of practicality, then policy makers will need to understand the implications and opportunities for radical change and innovation.

Figure 24 Shaping the Metaverse Mind Map – Future Recommendations

RECOMMENDATIONS

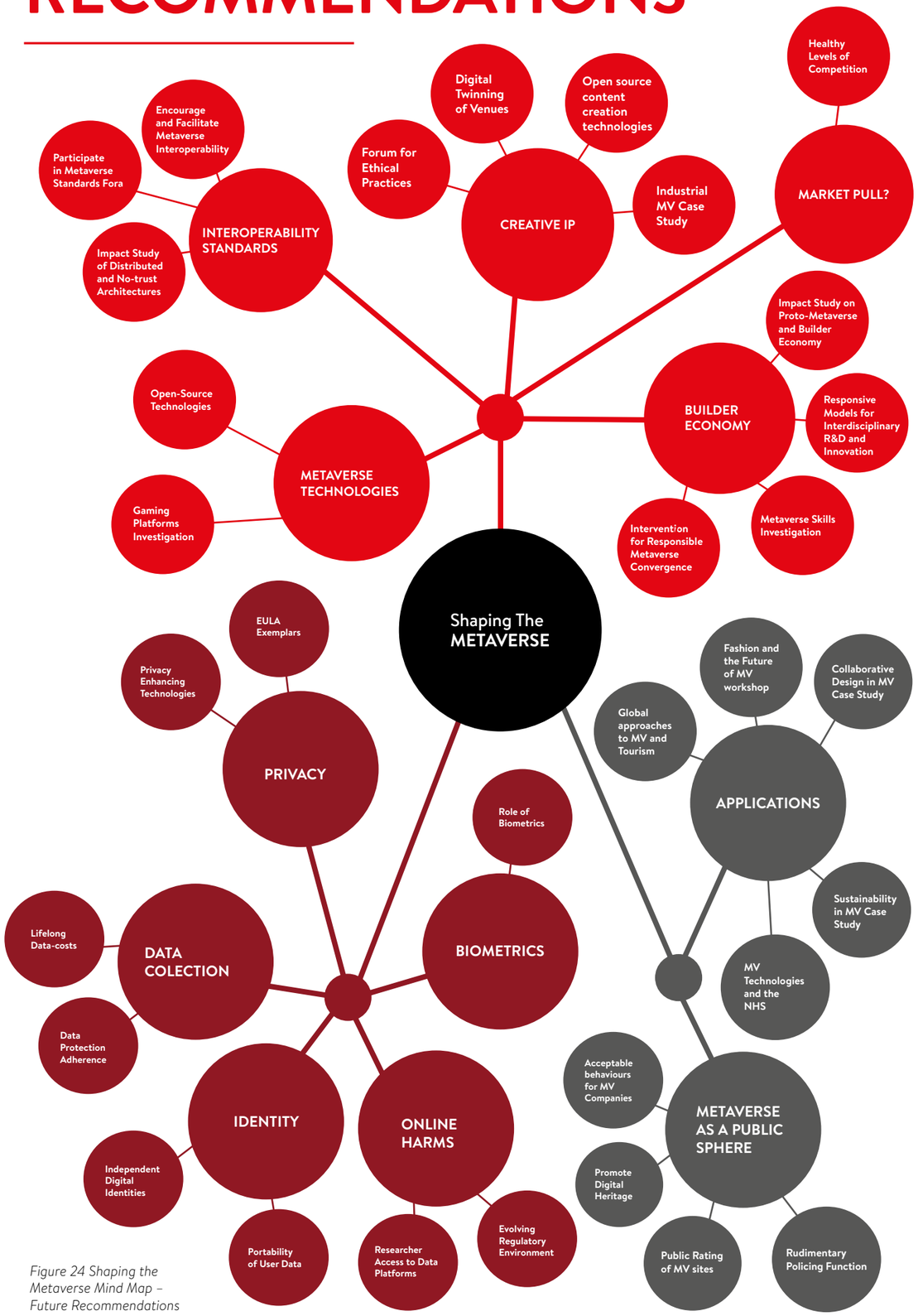


Figure 24 Shaping the Metaverse Mind Map – Future Recommendations

Expert Panel Recommendations

We asked the international, independent panel of academics, who were contracted to the project, to recommend a way forward for UK metaverse development and future exploitation. Their suggestions are given below and are remarkably consistent. These are provided for information only and the recommended follow-on activities and investigations are given in the next section.

E-1. Invest in the work on **standardisation** and **international collaborations** with a focus on interoperability from the technological perspective and **user experience** from the end-user perspective (including accessibility and inclusiveness).

E-2. **Invest in standards**. The Internet was primarily standardised by the US. The UK needs a strong presence in standardisation bodies such as the **Open Metaverse Forum** such that British interests can be reflected in government efforts. In order to achieve this, the British government needs to **incentivise participation** of both industrials and academics. Currently, standardisation work carries little weight in academic promotion cases or industrial reviews. There needs to be a concerted effort to change this.

E-3. Establish the leadership role in **developing the metaverse by setting some standards** that can be recognised by European or even global industry players. For example, **the metaverse now is not aligned on the same horizon,** and every industry player, or even academic researcher, attempts to define their metaverse and the related standards. For example, an HCI researcher may call for a user-centric metaverse focusing on interaction techniques (input/output) but neglect the importance of edge/cloud computing for delivering content or a privacy-preserving approach to ensure the user's trust in the metaverse (and hence, the long-term operations of the metaverse). Such an approach may not give a holistic view of the national development of the metaverse. Thus, it is essential to **consider every building block in the policy.**

E-4. **Leverage world-renowned British cultural landmarks to bootstrap.** The BBC, the Royal Family, British Television (Doctor Who, etc.) as well as music companies carry significant clout abroad and are a portal to Britain and **British culture.** Leveraging those cultural pillars to bootstrap a uniquely British Metaverse has the potential to see significant adoption. Think about a BBC metaverse, a Harry Potter or Buckingham Palace metaverse. More generally, creating strong **partnerships between media/art companies and technology experts** that leverage uniquely British culture is key.

E-5. It is crucial to leverage the **cultural heritage of the UK** and the related historical stories behind the scenes. As the UK owns numerous tourist attractions and national trusts, the digital overlays (AR) on the top of the attraction can **improve the tourist experience.** Also, the use of VR can **attract potential tourists** during the planning stage. For instance, the Giant's Causeway in Northern Ireland provides a trip related to Game of Thrones… XR can strengthen the user experience, make the tour like a game, or create activities based on the tour. The tourism industry may not have the resources to kickstart such a technology project. It relies on some consortium or alliance (as suggested below) to make meaningful use cases and boost the national economy of the UK.

E-6. In S. Korea, the government forms an **alliance with some technology companies and universities** to build practical AR/VR applications. Meanwhile, the government will take the lead in using the outputs from those alliances, leading to a **sound ecosystem**. For example, South Korea has a strong initiative in K-pop culture, and thus the government leverages the metaverse to disseminate K-pop culture and its content (Hyundai, Blackpink, etc.) to the rest of the world. The UK government can consider that transmedia, supported by AR/VR, can serve as **a lens to spread the content to the global market.**

E-7. Create and fund a research initiative focusing on **basic research-related questions** (define Metaverse and related technologies) but also on **applied skills development** (for Metaverse creation and usage).

E-8. The Metaverse will become a 3D space, and text-based interaction is one of many options. Of course, the text corpus provides a rich dataset for analysing user behaviour. Moreover, we should **develop new techniques to capture non-verbal/non-textual cues** to understand users in the Metaverse.

E-9. When we move our **social networks** to the Metaverse, the virtual spaces **collect countless user interactions.** With the vigorous promotion of mobile headsets among Apple, Meta, and Microsoft, the number of active users and, thus, user interactions in such virtual spaces will undoubtedly increase. Nonetheless, such virtual worlds and **platform owners currently do not provide methods or channels (e.g., APIs) that allow researchers to conduct studies**, e.g., We can get the user post and engagements on Twitter but not Meta. Nowadays, the research can only happen when the platform owner signs a collaborative research agreement with a particular lab. So, it is critical to have **government intervention** in opening such data and building such a research domain.

E-10. Invest in **analysis activities** (research and running operations) to scan for potential unethical and criminal behaviour e.g., **application of ethical principles**. Here a focus should be the **dependencies with artificial intelligence.**

E-11. **Avoid grouping complementary but orthogonal technologies together.** The metaverse is often grouped with Web3, blockchain and DAOs. This is not necessary and obscures conversations. These technologies are completely orthogonal (there is no inherent need for a blockchain in the metaverse) and discussing them in conjunction muddles the conversation. The metaverse is about spatial technology; Web3 about decentralisation. These technologies may of course be complementary and identifying synergies between them will drive innovation.

Using these suggestions in combination with the 'Shaping the Metaverse' taxonomy presented in this report, we developed a more detailed set of initial, small-step, policy actions and follow-on investigations which aim to build community across all the relevant sectors and specialisms in the UK and develop momentum towards a pluralist, inclusive and interoperable metaverse ecosystem which benefits citizens and opens the door to much innovation.

Follow-on Actions & Investigations

Market Pull?

1. Investigate ways of maintaining healthy levels of competition in social metaverse platforms and virtual worlds.

Metaverse Technologies

2. Investigate the impact of gaming platforms as the standard tools for metaverse creation with reference to creative content homogenisation and unfair commercial terms.

3. Encourage the use of open-source technologies in all funding calls related to metaverse applications & experiences including digital twins.

Interoperability and Standards

4. Investigate the feasibility of a co-ordination function to organise and support UK representatives to actively participate in metaverse standards fora.

5. Define the strategic objectives for metaverse interoperability and standardisation for the benefit of the UK both socially and economically.

6. Convene a series of focus group sessions on the impact of distributed and no-trust architectures.

Builder Economy

7. Identify a case study on Proto-metaverse and builder economy to support better understanding of a potential metaverse through assessment of games and creator impact on culture and society.

8. Investigate skills for the metaverse to support the emerging Builder Economy and maintain UK strengths in User Generated Content and Virtual World Creation.

9. Develop research & innovation approaches to support regulation for responsible technology convergence around specific use cases relevant to UK capabilities and priorities.

10. Develop funding requirements for Metaverse responsive models for R&D&I that supports convergence use cases in digital content creation, the builder economy and the industrial Metaverse to unlock productivity potential.

Creative IP

11. Convene a series of focus group sessions on ethical metaverse practices for IP attribution produce a framework of development practices for an open, sustainable and ethical metaverse by design.

12. Demonstrate virtual events and digital twinning infrastructure for physical venues.

13. Demonstrate open source and accessible metaverse content creation technologies.

14. Identify a case study in emerging social and industrial metaverse technology practices.

Data Collection

15. Investigate from an end-user's perspective, the methods and metrics necessary to assess the true 'data costs' of releasing personal information to MV platform operators. Assess the likely risks, lifelong costs and benefits to an individual user of 'free' social metaverse applications.

16. Investigate classification schemes that rate publicly accessible metaverse sites on their adherence levels to data protection principles.

Identity

17. Investigate how users might independently define their digital identity and be given the freedom to move the data, entitlements, digital assets and property associated with their identity, between virtual worlds.

18. Assess the prospects for interoperability and portability of consumers' identity and associated data between similar virtual world classes.

Biometrics

19. Carry out a comprehensive assessment of the role biometrics will play in the metaverse going forward. Assess the impact of current UK biometrics regulations and any proposed legislative changes (nationally and internationally) that may materially affect metaverse operations.

Privacy

20. Review End User License Agreements (EULA) associated with 'free' metaverse services and prepare more proportionate exemplar licenses that reflect a privacy-by-design approach.

21. Carry out a technical assessment of privacy enhancing technologies and determine their potential future role in metaverse operations.

Online Harms

22. Assess the evolving digital technology-related regulatory environments internationally (especially US, Europe, China) and predict how these may affect metaverse operations with respect to online harms.

23. Investigate the potential to grant academic researchers access to data relating to UK subjects that is held on MV platforms and develop workable co-operation frameworks and protocols between MV platform operators and the research community.

Metaverse as a Public Sphere

24. Assess how the UK can be a leading standard bearer in determining acceptable behaviour for metaverse companies and user protection.

25. Promote digital heritage in the UK by developing interactive experiences that builds on our stunning natural and built environment and the rich history of these islands.

26. Investigate citizen science led approaches to rating the quality of publicly accessible metaverse experiences and applications.

27. Investigate the feasibility of a rudimentary policing function that crawls metaverse sites and assesses functions that play on the cognitive biases of consumers.

Metaverse Applications

28. Prepare a landscaping paper of global approaches to, and examples of, MV and tourism.

29. Conduct a workshop with the British Fashion Council, Central Saint Martins and other partners on fashion and the future of MV.

30. Prepare a case study on MV technologies and collaborative design practices.

31. Prepare a case study on MV and sustainability.

32. Convene a series of focus groups sessions to discuss MV Technologies and the NHS.

European Perspectives

33. Undertake a discrete series of study visits to a selection of European countries who are willing to collaborate and share their MV policy elements (academic, industrial and regulatory) with the project team. To include interviews, knowledge exchange events, workshops and pan-European foresight initiatives.

Table 5 Prioritisation and Implementation horizon:

Priority	Immediate Action	Action within 3 years	Action within 5 years
High	22, 33, 4, 5, 11, 8, 21, 25, 28, 29	7, 12, 23, 19, 14, 13, 6, 2	1
Medium	3, 30, 31, 32,	18, 15, 9,	16, 24,
Low		17, 20, 10	26, 27

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2. **Dr Christina Harrington**, Carnegie Mellon University, Human-Computer Interaction Institute

3. **Dr Lik Hang Lee**, Hong Kong Polytechnic University, Dept of Industrial and Systems Engineering

4. **Dr Natacha Crooks**, UC Berkeley, Department of Electrical Engineering and Computer Science, Distributed Systems & Security Dept

The expert panel were not asked to endorse the conclusions or recommendations in this report, but rather provided expertise on the technical content. They acted in a personal and not a representative capacity.

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