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Additional information and material related to this Executive Briefing are available at: www.itu.int/metaverse. If you would like to provide any additional information, please contact Cristina Bueti (ITU) at: tsbfgmv@itu.int.

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List of abbreviations

AI	Artificial Intelligence
AR	Augmented Reality
COVID-19	Coronavirus disease 2019
FG-MV	ITU Focus Group on metaverse
IoT	Internet of Things
ITU	International Telecommunication Union
UNWTO	World Tourism Organization
VR	Virtual Reality
SDGs	Sustainable Development Goals

1 Accelerating digital transformation through the metaverse

Achieving universal and meaningful digital connectivity, the opportunity for all people to enjoy a safe, satisfying, enriching, productive and affordable online experience, is key for enabling digital transformation and meeting the Sustainable Development Goals (SDGs). The investment and positive momentum generated by the promise of the metaverse offers a unique opportunity to build a better online experience for people around the world and accelerate the digital transformation required to achieve the SDGs. However, the metaverse also poses many policy and technical challenges that could undermine its potential.

Figure 1: The metaverse and SDGs

2 What is the metaverse

The metaverse has become one disruptive area of innovation with great potential to change our economy and society, and the way we live and communicate. While there is currently no internationally agreed definition of the metaverse, it is expected to draw on a number of technologies such as AI, immersive technology, digital twin, cloud computing, IoT, and distributed ledger technology in new and innovative ways.

The metaverse commonly refers to a future persistent and interconnected virtual environment in which social and economic elements mirror reality. Users are expected to have the ability to interact with one another in the metaverse simultaneously across devices and immersive technologies, while engaging with digital assets and property.[1] Using virtual reality (VR) and augmented reality (AR), immersive experiences are created where users can create virtual avatars to represent them in any desired shape or form. Another technological aspect is the bandwidth and equipment requirements such as devices and hardware needed to access the metaverse. The quality of the metaverse experience thus will depend on the type of equipment and Internet connection to which a user has access.[2]

3 A disruptive area of innovation

In the metaverse, users can expect to interact not only with one another, but also with digital assets and property in digital copies of real environments and in newly imagined virtual spaces.

Today, there is a diverse ecosystem of infrastructure and applications, as well as key players and stakeholders that are developing nascent metaverse experiences.[3] These stakeholders are expected to play an important role in building the more ubiquitous metaverse of the future. An overview of this ecosystem is provided in Figure 2.[4]

Figure 2: Metaverse ecosystem diagram: 2022, Newzoo

This ecosystem is already transforming many aspects of our digital lives in the consumer sector, industry, government or in cities. The metaverse use cases, whether single or multiple, promise to accelerate this transition, creating new opportunities and value models.

3.1 Industrial metaverse

The industrial metaverse is a world in which real machines and factories, buildings, grids, health care, education, transportation and tourism are reflected in the digital environment. As an early adopter of the digital twin technology, the manufacturing industry is well placed to benefit greatly from the metaverse.[5] For example, Mercedes-Benz announced in January 2023 that it is using the NVIDIA Omniverse platform to digitalize its production process further. With Omniverse, Mercedes-Benz planners can access the digital twin of the factory to review and optimize the plant, and synchronize plant locations anywhere in the world.[6] New online and immersive experiences can transform various industries, and create new business models and opportunities. The tourism industry can create virtual experiences for travellers, allowing them to visit destinations without physically travelling.

In addition, virtual healthcare services, medical training and mental health support provided through the metaverse have the potential to revolutionize the healthcare industry. The use of metaverse in health care can provide patients with a safe and immersive environment to undergo procedures, manage pain or overcome phobias. Medical professionals can also benefit from virtual training simulations to improve surgical techniques. Additionally, the metaverse can provide a platform for remote health support, making it more accessible and more readily available.[7]

Figure 3: Industrial metaverse – Healthcare sector

Figure 4: Industrial metaverse – Education sector

The metaverse also has the potential to revolutionize the education sector by creating new immersive and interactive learning experiences. Using various immersive experiences, students can be transported to a wide range of simulated environments. Immersive learning allows for a more engaging and interactive approach to learning, which can enhance retention of knowledge and increase student engagement. Another possibility is more accessible remote learning and collaboration. As shown during the COVID-19 pandemic, remote learning has great potential, particularly for those without physical access to learning facilities. Metaverse classrooms could allow students and teachers to engage in real time and from any location.[8]

3.2 Metaverse in cities

Together with technologies such as IoT and digital twin, the metaverse has the potential to revolutionize the way cities and communities function, interact and manage their resources, in becoming more sustainable, carbon neutral, efficient and inclusive.[9] In so called "citiverses", a community can create a virtual replica of its physical infrastructure and systems, to build what is known as a "local digital twin". By monitoring the physical environment in real time through its digital twin, city planners can make an infinite number of data-driven decisions such as optimizing energy usage, reducing traffic congestion, or improving public services. Furthermore, the metaverse can provide a platform for citizens to interact with their city government and participate in city planning processes, and social and economic activities, in a virtual environment, thereby potentially increasing citizen participation.

Seoul, the capital city of the Republic of Korea, has launched a five-year plan to build Metaverse Seoul. The plan involves seven areas: economy, education, tourism, communication, city, administration, and infrastructure.[10] The first service phase of its virtual municipal world Metaverse Seoul has been launched in January 2023, to test various administrative services in the metaverse such as economy, education and tax affairs.[11]

Figure 5: Metaverse Seoul

Another example is Barbados. The country plans to legally declare digital real estate as sovereign territory by establishing a metaverse embassy.[12] The Barbadian Ministry of Foreign Affairs and Foreign Trade signed an agreement with Decentraland, which provides a fully digital world, to establish this metaverse embassy. With opening of the embassy, Barbados will become the first coutry in the world to recognize digital sovereign land.

3.3 Consumer metaverse

The metaverse is expected to change the way consumers interact with products and services significantly.[13] For example, consumers could purchase virtual real estate and other assets in the metaverse, creating new forms of digital investment and economic development. Consumers can also use the metaverse to interact with brands and products in a virtual environment so providing new marketing and advertising opportunities. The metaverse can also provide a platform for virtual events such as concerts and sporting competitions so offering consumers new forms of entertainment.

Figure 6: Consumer metaverse

The gaming industry has often been at the forefront of interactive digital technologies, and is likewise an early adopter and beneficiary of the metaverse. Combining virtual and physical worlds will create complex and sophisticated game worlds, allowing players to interact in ways that were previously impossible. The transformative possibility of the metaverse is to create persistent, shared virtual worlds that can be accessed by players from anywhere in the world. This new development enabled by the metaverse is expected to create new economic, social and collaboration opportunities.[14]

4 Underlying technologies

While various models have been proposed by numerous organizations and individuals to organize the metaverse components, they differ on emphasis and granularity. Examples are Deloitte's metaverse ecosystem,[15] WEF's five layers of value creation model,[16] Jon Radoff's seven-layer model,[17] and McKinsey's ten-layer model.[18] This document introduces a model that breaks the metaverse components down into five core building elements: infrastructure, human augmentation, digital identity, economic enablers, and ecosystem.

Based on connectivity and computing infrastructure, consumers can access the metaverse and explore the virtual and physical worlds seamlessly with the support of human interfaces and various software and hardware platforms. Enabled by digital identity and decentralized finance technologies, the metaverse can provide various immersive experiences, creating profound impacts on economy and on society by gradually fostering a new digital ecosystem. The five building elements of the metaverse consist of the following concepts and technologies:

1) **Infrastructure**: Networks/connectivity, computing power, graphic processing units, storage capacity, sensing/perception, cloud/edge infrastructure, semiconductor (chips/processors).
2) Human augmentation:
    a. Mobile devices: headsets (VR), smart glasses (AR), other wearables, haptics, holographic, brain-machine interface.

b. Creation platform: interaction platform, content moderation platform, 3D design/ modelling, game engines, AI/ML services, creator tools, search/visual search.

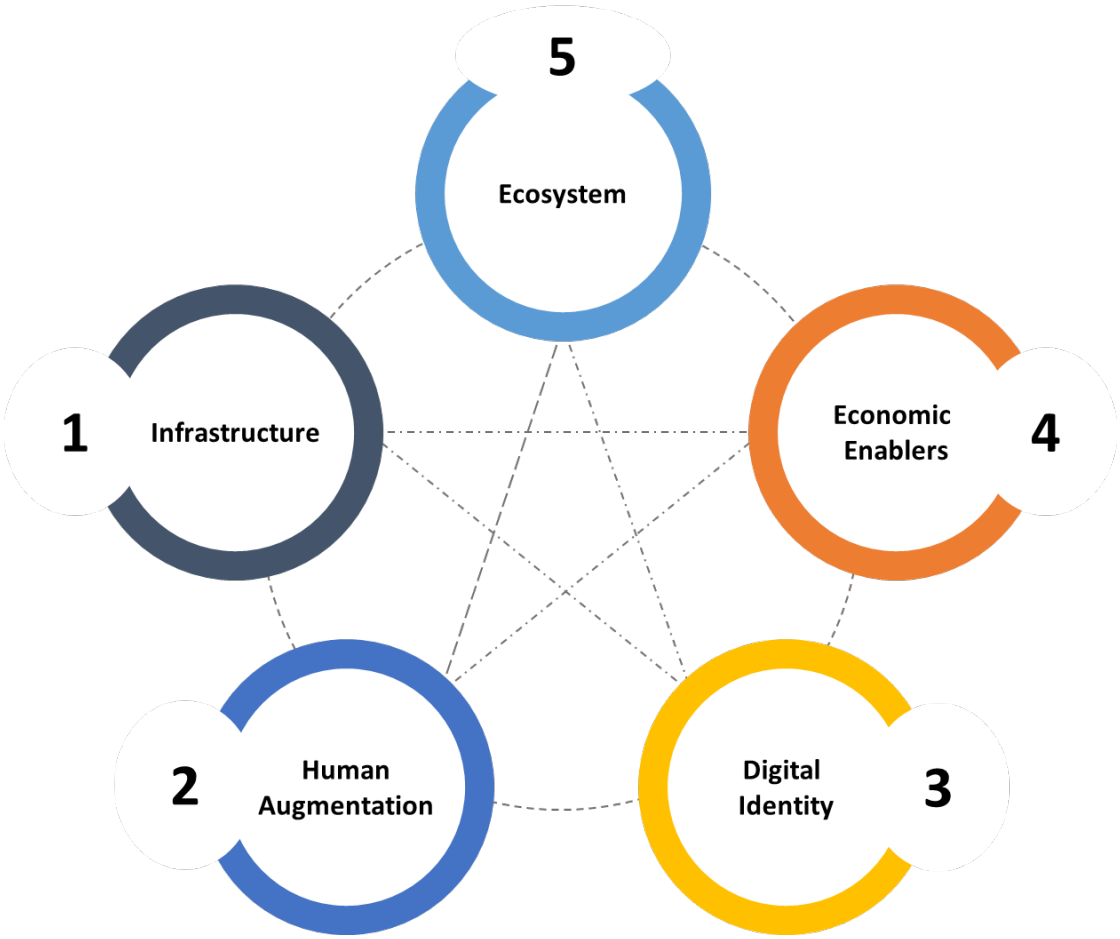
c. Asset: 3-D Interoperable assets, asset market.

1) **Digital identity**: avatar, agent, multiuser and multitasking, social graphs, rating, social curation, security, privacy.

2) **Economic enablers**: decentralized, blockchain, cryptocurrency, NFT, commerce, advertising, payment, transactions.

3) **Ecosystem**: entertainment, shopping, education, games, e-sports, industrial applications, regulation, governance, ethics.

Figure 7: Five elements model of the metaverse



5 Policy and regulatory challenges

One of the main challenges of the metaverse is ensuring that it is a safe and secure place for people to interact and transact. This requires addressing issues such as access and inclusion, data privacy, intellectual property, and online harassment.[19]

5.1 Accessibility and inclusion

The metaverse must be accessible and inclusive for everyone, regardless of their technology capabilities or socio-economic status.[20]

5.2 Access

Access to the metaverse depends on the availability of ICT infrastructure. For the metaverse to reach its full potential, everyone everywhere will need to be able to access it. To do this will require closing the connectivity gap and bridging the digital divide.

5.3 Competition

For the metaverse to flourish it needs to be built on a foundation that enables market competition of ideas and avoids dominance by a few companies.[21].

5.4 Data protection and privacy

With so much personal information being generated and stored in virtual spaces, it is important to ensure that people's privacy rights are protected. This includes issues such as who owns the data generated in the metaverse, and how it can be used and shared.[22]

5.5 Intellectual property

The metaverse has the potential to create new forms of intellectual property such as virtual goods, digital assets, NFTs, and experiences. It is important to ensure that these new forms of intellectual property are protected, and that their owners can profit from them.

5.6 Interoperability

Different metaverse platforms will have to interact with one another to offer a seamless experience to all users. The metaverse should be accessible regardless of the underlying topologies and technologies. Therefore, pivotal points or common agents will have to be standardized to enable interoperable workflows between several platforms, enabling minimum but sufficient interoperability mechanisms.

5.7 Cybersecurity

With vast amounts of sensitive data required to operate the metaverse it can be expected to attract cybercriminals. Comprehensive security guidelines and regulations will need to be in place to protect metaverse users from scams, ransomware and other cyberthreats.[23]

5.8 Online harassment

Users of the metaverse will not be immune from online harassment, and it is important to ensure that people are protected from abusive behavior in virtual spaces.[24]

5.9 Sustainability

Other important factors that would impact the evolution and growth of the metaverse are the impact it would have on sustainability, and the role it could play in adapting and mitigating climate change. In addition, it is important to examine and assess the impact of the metaverse on greenhouse gas emissions early enough in order to adopt suitable standards and regulations.

Figure 8: Challenges in the metaverse

6 The importance of interoperability

One of the key factors that will determine the success of the metaverse is the development of international interoperable technical standards.[25] Interoperability and standardization will be critical for facilitating seamless cross-platform experiences, promoting innovation and competition, and encouraging global adoption in developing and developed markets.

These international standards will ensure that virtual spaces and experiences are consistent and compatible across different platforms and devices. This will allow people to move seamlessly between virtual worlds, without encountering technical barriers or compatibility issues. It will also help to ensure that virtual goods and experiences are portable and can be transferred between platforms.

Most importantly, open, international standards help to create a level playing field for developing countries to maximize the benefits offered by new technologies. The metaverse can serve as a catalyst for accelerating digital transformation and adoption of the metaverse-enabling technologies. Pivotal points or common agents will have to be standardized to enable interoperable workflows between different metaverse platforms, enabling minimum but sufficient interoperability mechanisms.

Figure 9: Open and interoperable metaverse

7 The role of ITU

ITU provides a unique collaborative platform to bring together experts from 193 Member States, as well as more than 900 companies, research institutes and international organizations. ITU works with its members around the world to support them with capacity building, opportunities for dialogue, as well as through leadership and policy and standards guidance.

As the UN specialized agency for digital technologies, ITU – with its unique membership of governments, industry and academia – is mobilizing the digital community to bring all voices to the table, as we start to explore the role of open and inclusive standards in creating a better metaverse experience for all.

In December 2022, the ITU membership unanimously established a new Focus Group on metaverse (FG-MV) that offers an international platform to start laying the groundwork for international standards that can help create an underlying technology and business ecosystem that encourages market entry, innovation, and cost efficiency in a sector expected by some industry analysts to grow to a value of nearly USD 800 billion by 2024, according to Bloomberg Intelligence.[26]

Some other standards development organizations and industry forums have also started work to consider the impact and opportunities of the metaverse. The ITU-T Focus Group on metaverse is already collaborating closely with the European Commission, Metaverse Standards Forum and the World Metaverse Council, among others, thus contributing to the development of the highest quality interoperable international metaverse standards.

ITU-T Focus Group on metaverse (FG-MV)

The Focus Group on metaverse has been established under the ITU-T Telecommunication Standardization Advisory Group (TSAG) in December 2022.

FG-MV provides an international collaboration platform for dialogue and aims to develop a roadmap for setting technical standards to make metaverse services and applications interoperable, enable a high-quality user experience, ensure security, and protect personal data.

FG-MV analyses the technical requirements of the metaverse in order to identify fundamental enabling technologies in areas from multimedia and network optimization to digital currencies, the Internet of Things, digital twins, and environmental sustainability.

To facilitate the discussion and collaboration, eight working groups have been established under the focus group:

- Task Group – Collaboration
- Working Group 1 – General
- Working Group 2 – Applications & Services
- Working Group 3 – Architecture & Infrastructure
- Working Group 4 – Virtual/Real World Integration
- Working Group 5 – Interoperability
- Working Group 6 – Security, Data & Personally Identifiable Information (PII) Protection
- Working Group 7 – Economic, Regulatory & Competition Aspects
- Working Group 8 – Sustainability, Accessibility & Inclusion

The focus group is coordinating with governments, industry and academia, and collaborating with other standards development organizations, as well the UN family, to establish an agreed foundation for open, inclusive and interoperable metaverse standards, which will ensure that the metaverse contributes to sustainable digital transformation for the benefit of all users.[27]

8 Conclusion

The future metaverse will be built from the existing ecosystems of infrastructure and applications, as well as from key players and stakeholders that are already transforming many aspects of our digital lives, whether in the consumer sector, industry, or smart cities. Interoperability and standardization will be critical for facilitating seamless metaverse cross-platform experiences, promoting innovation and competition, and encouraging global adoption in developing and developed markets alike.

To ensure that the future metaverse can be enjoyed by everyone, it needs input from governments, industry, academia and civil society. The metaverse offers a unique opportunity to accelerate digital transformation and achievement of the SDGs; however, this can only be accomplished by everyone working collaboratively in order to create a better metaverse for all.

Annex

List of definitions[28]

Artificial Intelligence (AI): An interdisciplinary field, usually regarded as a branch of computer science, dealing with models and systems for the performance of functions generally associated with human intelligence, such as reasoning and learning. [Source: ISO/IEC 2382-28]

Augmented Reality (AR): An environment containing both real and virtual sensory components. The augmented reality continuum runs from virtual content that is clearly overlaid on a real environment (assisted reality) to virtual content that is seamlessly integrated and interacts with a real environment (mixed reality). [Source: ITU-T P.1320]

Digital twin: A digital representation of an object of interest. [Source: ITU-T Y.4600]

Internet of things (IoT): A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies. [Source: ITU-T Y.4000]

Interoperability: The ability of two or more systems or applications to exchange information and to mutually use the information that has been exchanged. [Source: ITU-T Y.101]

Mixed Reality (MR): An environment containing both real and virtual components that are seamlessly integrated and interact with each other in a natural way (one end of the augmented reality continuum). [Source: ITU-T P.1320]

Virtual Reality (VR): An environment that is fully generated by digital means. To qualify as virtual reality, the virtual environment should differ from the local environment. [Source: ITU-T P.1320]

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