In collaboration with Accenture

WORLD ECONOMIC FORUM

Interoperability in the Metaverse

BRIEFING PAPER

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Foreword

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The next era of the internet is coming, with the convergence of technologies forging "the metaverse" – an immersive, interoperable and synchronous digital world. Though a standard definition for the metaverse is still under development, experts agree that this new age of the internet will likely disrupt and transform current social and economic structures. From more immersive, empathetic social experiences to increased universal access to services and education, the metaverse presents momentous opportunity but also brings about new challenges.

It is within this context that, in May 2022, the World Economic Forum launched the Defining and Building the Metaverse initiative. The goal of the initiative is to advance consensus among major metaverse stakeholders and contribute to a future metaverse that is economically viable, interoperable, safe, equitable and inclusive. The initiative does so via two tracks: governance and economic and social value creation.

The value creation track looks at the opportunities in consumer, industrial and enterprise metaverses and researches the considerations for access, inclusion, sustainability and well-being that will come with its development.

Meanwhile, the governance track focuses on governance frameworks that may empower stakeholders to lead responsibly within the metaverse while mitigating potential socioeconomic harms. Through consultation with experts from academia, civil society, government and business, the Forum began exploring themes relating to "interoperability", "privacy, security and safety" and "identity".

This first briefing paper, written by the World Economic Forum in collaboration with Accenture, aims to explain interoperability, which is founded on the ability of data to circulate via interoperable infrastructures, of participants to be able to move themselves, their assets and their creations across platforms and experiences, and of experiences being safeguarded through collaboration and guardrails such as content moderation. For the metaverse to operate seamlessly, it will require varying degrees of interoperability for users to move, create, transact and participate across different platforms and localities.

Overall, the Defining and Building the Metaverse initiative has brought together a global, multi-sector working group of more than 100 experts in academia, civil society, government, technology and business. All insights, frameworks and guidance published in the frame of this initiative are being co-designed and guided by this working group. Multistakeholder discussions on the metaverse play a critical role in catalysing the cross-sector global cooperation that is necessary to design and build a human-first metaverse.

This publication aims to illuminate this topic but does not claim to provide a comprehensive view of the metaverse. However, it gives a glimpse into the complex issues that can arise when the cyber and physical worlds come together, as well as the role of multistakeholder collaboration in building the metaverse to its true potential.

Executive summary

Matthew Ball's vision of the metaverse is "a massively scaled and interoperable network of real-time rendered 3D virtual worlds that 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."[1] These real-time rendered worlds are expected to be accessed through devices like extended reality (XR) technologies, desktops, tablets and smartphones.

In this analysis, interoperability in the metaverse can present enormous opportunities and value for frictionless experiences, development and economies.

- **Frictionless experiences** enable users to move across and between the physical and digital world with relevant data, digital assets and identity(s). This could facilitate greater consumer engagement but also provide efficiencies in enterprise, as well as industrial applications.

- The standardization of tools and both the formation and adoption of uniform development practices resulting from interoperability could allow stakeholders to benefit from **frictionless development** – or network effects that provide efficiencies and cost savings across consumer, enterprise and industrial interaction paradigms.

- **Frictionless economies** allow for greater access, marketplace engagement through healthy competition, transactional efficiencies and trust if interoperability balances privacy, security and safety. Such new market opportunities will be able to make use of existing economies of scale while providing new potential revenue streams, access to new audiences and possible points of connection for enterprise partnerships and industrial logistics.

To achieve this frictionless state, good system-wide interoperability of the metaverse should consider interests such as privacy, security and safety. Given the borderless nature of the metaverse, multistakeholder and multilateral collaboration will be required to reach consensus on design choices, best practices, standards and management activities.

To enable responsible metaverse interoperability, stakeholders must consider technical, usage and jurisdictional aspects.

- **Technical interoperability** design addresses topics such as network constraints, asset ownership, intellectual property protections, payments, identity, data privacy and security concerns at both hardware and software levels.

- Meanwhile, **usage interoperability** keeps users at the centre of design, creating the metaverse globally, inclusively and across demographics to ensure equitable experiences.

- Finally, **jurisdictional interoperability** must include best practices and standards for the entire data supply chain and across localities, industries and nations.

The findings in this briefing paper serve as a baseline for further research that will inform a future governance white paper. The white paper will make recommendations, including those for interoperability, in tandem with those from future privacy, security and safety, and identity briefing papers.

Introduction

Defining interoperability, its relevance to the metaverse and its relationship to themes of identity, privacy, security and safety.

Bloomberg estimates metaverse commerce to be $800 billion by 2024.[2,3] Just like the internet today, much of the metaverse's potential depends on some forms of interoperability. This briefing paper intends to demystify by highlighting interoperability case studies, identifying key challenges and proposing opportunities so executives, governments and stakeholders across society may be empowered to collaborate and make human-first design choices.

FIGURE 1 **Key concepts**

Metaverse

A massively scaled and interoperable network of real-time rendered 3D virtual worlds that 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 (Matthew Ball).

Metaverse stakeholders

Providers, creators, participants and other individuals from academia, government, business and civil society.

Human-first metaverse

A metaverse that prioritizes the human needs of the individual and consequently integrates supportive design choices, tools and interactions to respect the persons behind the data. This transcends decisions – from architecture and security to privacy, identity and safety choices.

Interoperability

The ability to interact, exchange and make use of data and resulting information to enable movement, transactions and participation across systems, platforms, environments and technologies.

Web3

web3 describes an emerging portfolio of decentralized technologies, protocols and standards that help to establish provenance, veracity and value of data.

Web 3.0

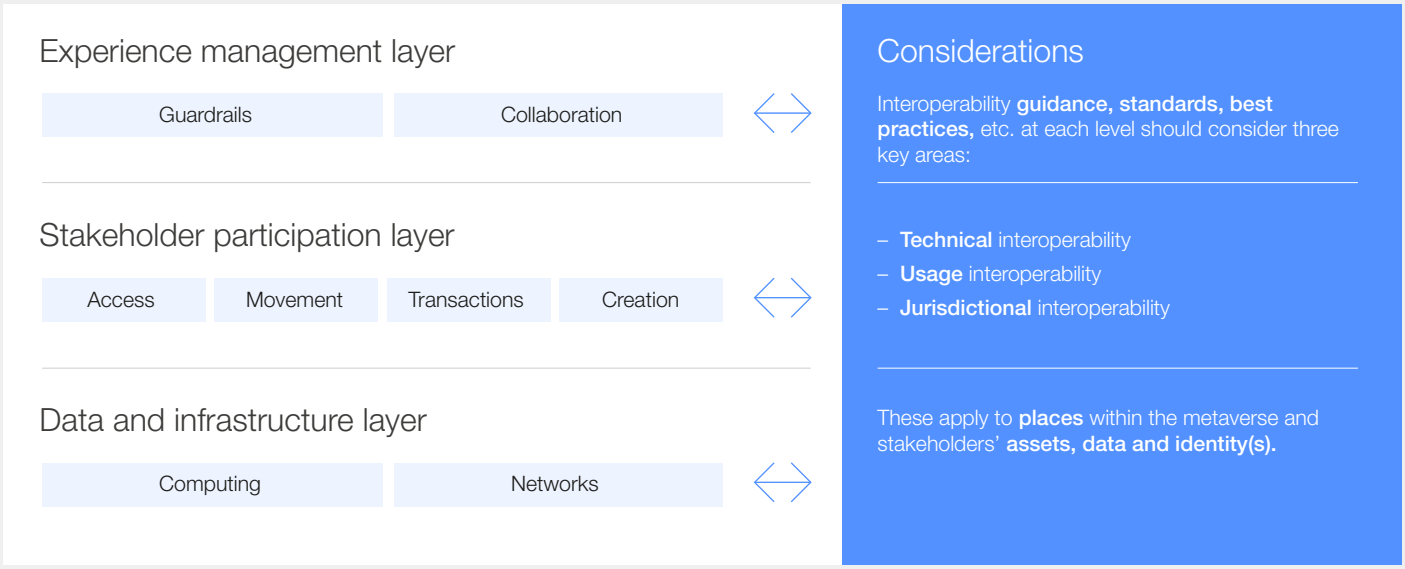
Web 3.0 describes the third stage of the World Wide Web's development. It is an evolution focused on distributing systems to create a more secure, transparent and open internet experience that enables direct interactions between users and their peers without intermediaries.

Extended reality (XR)

XR is an umbrella term that includes immersive technologies such as augmented reality (AR), virtual reality (VR), and mixed reality (MR).

The metaverse creates immersive experiences that are enabled by a range of technologies—including, but not limited to, extended reality (XR),[4] artificial intelligence (AI),[5] internet of things,[6] and digital twins.[7] Many experts agree that the metaverse is the natural evolution of digital platforms[8] and will likely transform existing social experiences and digital economies, presenting both meaningful opportunities and critical challenges for web3 technologies and Web 3.0. Interoperability in the metaverse will play a key role in how those social experiences and digital economies are transformed.

FIGURE 2 | **Layers of interoperability and considerations**



While interoperability may initially seem like a topic only to be considered from a technical perspective, it is much broader and requires consideration across usage and jurisdictional domains as well.

Each of these key areas will affect management decisions, participation abilities, data and infrastructure design.

Foundationally, interoperability depends on data interchange across infrastructures to enable participants' ability to access, move, transact and create within and across digital (and physical) worlds. It is with the utmost importance that guardrails and collaboration take place at the management layer to ensure that the sub-layers – participation, and data and infrastructure – of the metaverse be safe, inclusive, equitable and economically viable.

Interoperability is a tool – or value lever – that stakeholders may employ to:

- Improve access to participate, work and play in digital experiences and digital marketplaces
- Activate social, privacy, security and financial network effects
- Extend (real-life) experiences in novel ways to provide value to end-users.

BOX 1 **Standards**

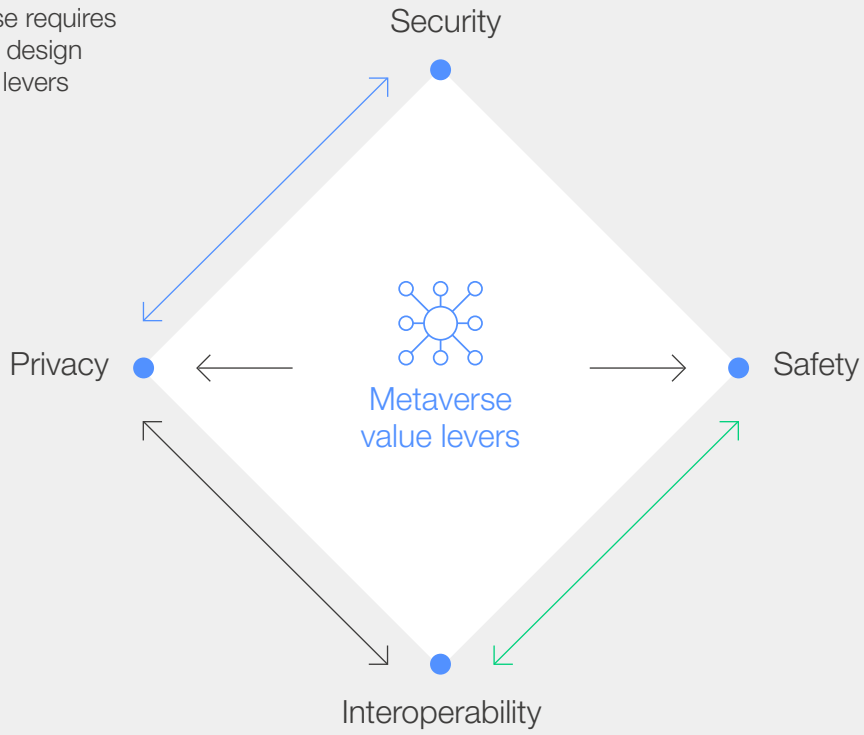
Standards are multidimensional tools – used by practitioners – to provide guidance and specifications to products and services.

Standards for interoperability would provide guidance for how, when and where interoperability would, could and should, or should not, be used.

A lack of standards for interoperability may result in fragmented systems.

FIGURE 3 | **Metaverse value levers**

Building the metaverse requires a delicate interplay of design choices across value levers



Interoperability design choices must be balanced to create flexible systems that also consider privacy, security, safety, and identity needs. Interoperability may not always be the desired state. While not inherently at odds, an action that only maximizes a single value – such as interoperability – may do so at the expense of achieving other goals. For example, over-indexing on interoperability without balancing safety as a value may expose children to unwanted content creating an imbalance between the desired levels of safety and privacy.

Given the delicate interplay of design choices and value levers to pull – standards, guidance, best practices, and other means should be timely and not be created independently. It is integral that stakeholders – providers, creators, civil society and participants alike – both formally and informally collaborate to co-develop human-first interoperability best practices and standards to maximize the potential of the metaverse at scale.

FIGURE 4 | **Metaverse stakeholders**

Providers

The technology, platform and service providers that build the infrastructure and devices for the metaverse.

Participants

Individuals also known as end-users of the metaverse; they participate in the experiences made by creators that are hosted by providers.

Creators

Makers of content and experiences; they create content for participants on the platforms that providers make available.

Society

Society is the manifestation of communities that creators, participants and providers live in and engage with in real life. It is inclusive of individuals from academia, government, private and public businesses, and citizens at large.

1 Highlighting interoperability and its opportunities

Interoperability has the potential to transform experiences, development and economies to give providers, creators, civil society and participants value.

While the below outlines potential end-state opportunities, it is essential to reflect that these target states will require levels of interoperability and technical execution beyond those demonstrated in Web 2.0. Overcoming present challenges, harmonizing with existing governance and collaborating on net-new industry practices requires careful architecting to address the 2.5D and 3D requirements of the metaverse. By collaboratively addressing these interoperability design choices, stakeholders can capitalize on the market value provided by interoperability.

A Towards frictionless experiences

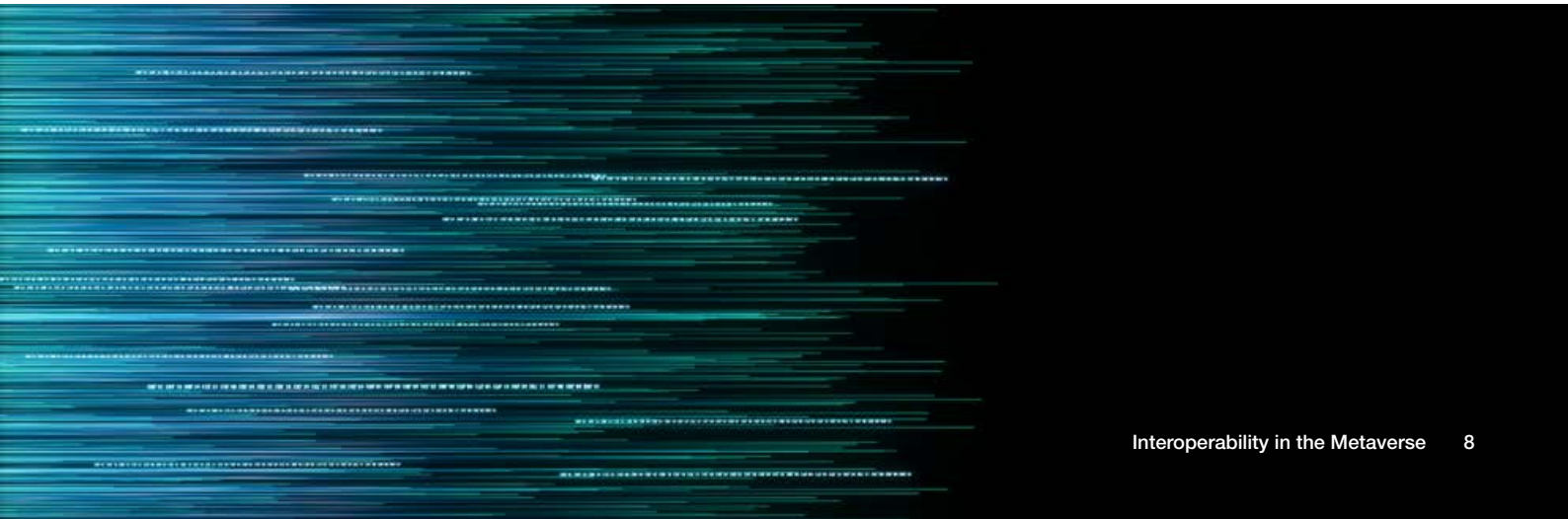
The metaverse allows participants to blend technology and reality through ease of access across XR technologies – augmented reality (AR),[9] mixed reality (MR)[10] and virtual reality (VR)[11] – and other access points such as computers, tablets and phones.

Interoperability contributes to the metaverse experience by providing improved continuity and a sense of presence irrespective of where an individual may be – or may be going – in the physical or digital world. Interoperability enables all users, from consumers to enterprise organizations and industrial applications, and their individual or collective assets, to move across and between the physical and digital world with their relevant data. Examples might include interoperability of:

1. **Assets:** Participants are enabled to bring and use assets from one space into other spaces, both digital and physical – e.g. a buyer wishes to bring their digital wallet into a virtual world hosted by another provider. They use (existing) payment rails to pay with fiat or other digital currencies to purchase both a physical and digital concert t-shirt that can be worn by an avatar across interoperable environments or worn by the individual in real life.

2. **Authentication:** Participants are enabled to set their preferences for data sharing – providing only the most essential or required data when accessing experiences. By choosing either a trusted third-party intermediary or self-management with decentralized data stores, a user can create a single interoperable token that provides authentication into multiple different independent services, devices, platforms and systems. This shares only relevant information required to continue engaging with an experience. This could be used across experiences like unlocking an AR headset, keying into a point of sale (PoS) system, completing a transaction online or badging into a building.

Frictionless experiences can persist beyond just importing assets into a new virtual world – they can create near-seamless onboarding experiences to new spaces, enable efficient transactions, create streamlined data management and improve the flexibility of technologies. Case study 1 showcases the opportunities for interoperability.



CASE STUDY 1

Healthcare in the metaverse

A surgical team is conducting real-time surgery with some physicians present through mixed reality headsets and smartphone AR. The team can see the same situation at the same time with imperceptible latency across different devices and platforms. AI-assisted language localization is accessible across experiences to allow for multi-lingual preferences.

The patient's electronic health records are easily accessible as an overlay for each physician, and they can take notes or make highlights on the records so that the others can see as it happens. To verify that the records are indeed those of that specific patient, their biometric data is analysed before the surgery and scanned by the physician who is physically with them and relayed across the team. The telerobotic surgical tools are accessible to physicians with preapproved access so each can virtually use a physical machine at the site of the surgery from any location if needed. The on-site physician can also adjust the machines and scan the new configuration, so they are visible to everyone.

Once the patient is in recovery, although unable to have visitors, they are able to interact with family while in a headset as parents and siblings see them in augmented reality. Families can reach out and hold hands, which is picked up by sensors on the phone and felt by the patient through haptic gloves.

B Towards frictionless development

Opportunities for interoperability to improve metaverse interactions go beyond participant experiences. Interoperability creates a channel where providers and creators may benefit from uniform standards and tooling, resulting in network effects,[12] which provides time efficiencies and cost savings.

When communities standardize, make use of uniform tooling and adopt common practices, creators and developers benefit. For example, when communities cooperate, stakeholders may benefit from improvements in the following:

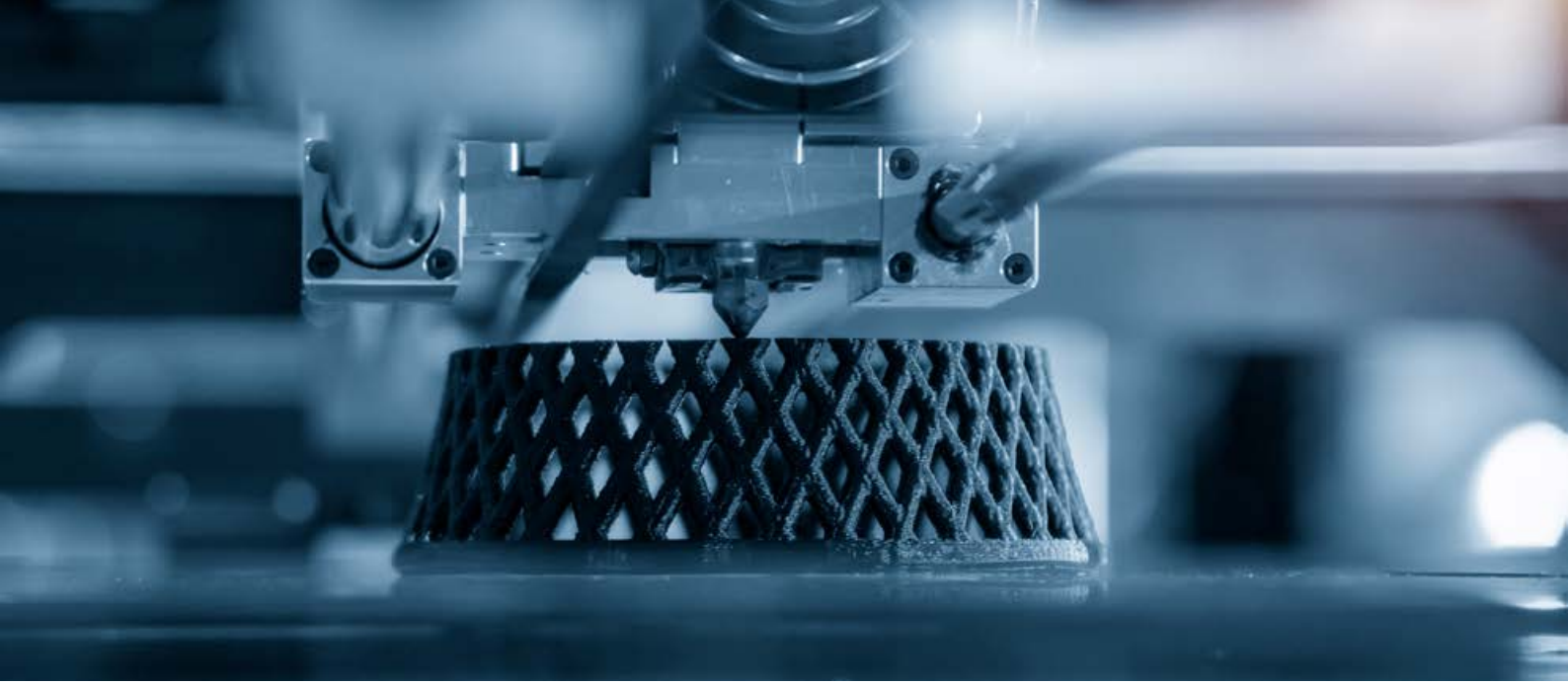
1. **Development network effects:** Stakeholders may reduce time spent on curating multiple file formats, access protocols, asset definitions and/or communication protocols for a single digital asset. For example, users will want the avatars they design to be consistent across experiences and platforms. Interoperability standards and design best practices will allow for the individuality of avatars and consistent design styles in different experiences, but with consistency in users' representative features. This provides developers with an increased ability to capitalize on efficiencies and produce valuable content.

2. **Social network effects:** Stakeholders may reduce time spent on enabling content compatibility to be backwards-compatible and cross-platform to provide content to a wider audience – e.g. a developer that creates an immersive experience for VR can more easily enable the same experience to be presented on desktop, mobile and other devices while maintaining expectations of low latency and persistence. This provides communities increased access and ability to socialize, engage and use a single platform and/or experiences across more devices – thus, creating more egalitarian opportunities to create, engage, and consume content.

3. **Financial network effects:** Stakeholders may produce digital assets or services that provide value and gain visibility to a wider market across multiple platforms. For example, a brand selling digital assets benefits when that asset is transported – or informally marketed – across metaverse experiences. When it is seen and then purchased by other potential customers the brand benefits financially.

4. **Privacy and security network effects:** Stakeholders may reduce time spent on developing unique privacy and security elements, e.g. by participating in a community where all users have agreed to common enforcement mechanisms and policies, end-users experience continuity of safety. Simultaneously, stakeholders may potentially reduce resourcing needed to support individual privacy and security efforts and mitigate against harms as the entire community contributes to the collective.

While not exhaustive, these examples highlight how network effects can multiply if interoperability is adopted across geographic regions and technical access points. However, it is cautioned that each metaverse stakeholder sets their own strategy to take advantage of these market opportunities; missteps may lead to negative repercussions such as brand confusion, revenue leakage and IP concerns. It is only with careful investment, multistakeholder coordination and thoughtful efforts that developmental, social, financial, security and privacy benefits may be reaped. Case study 2 highlights such benefits.



CASE STUDY 2

Advanced manufacturing in the metaverse

An advanced manufacturing vendor 3D prints spacecraft parts on-demand for international space tourism maintenance clients:

A maintenance engineer from a client in South America needs to refurbish a recently returned spacecraft before its next launch. They use AR that is interoperable with an interactive maintenance checklist to inspect the spacecraft and identify parts that need to be replaced.

Logging into a virtual storefront, the engineer and sales manager use a digital twin of the clients' spacecraft that is interoperable with a back-end parts catalogue to identify the parts that need to be replaced.

The vendor is enabled to cross-reference the part via an application programming interface (API) with the International Standards Organization (ISO) database to confirm specifications and manufacturing schematics. The ISO specification allows the engineer to be confident that the 3D-printed parts will be compatible with their spacecraft and pass inspection.

The vendor allows the customer to purchase an on-demand licence to receive certified 3D printing schematics to print it themselves to their own printer. By using industrial 3D printers that are interoperable with standard file formats, materials and compliance certificates, it promotes accessibility for buyers to access the platform as needed irrespective of device or location.

C Towards frictionless economies

While benefits thus far have focused on outlining positive externalities for providers, creators and participants, interoperability also benefits society.

By standardizing development tools and processes, while also creating standards regarding how to move, transact, access and create, society has effectively created, augmented and expanded a new digital marketplace. For example, interoperability is a value lever that can enable the following:

1. **Increased access:** By standardizing hardware compatibility and interoperable data interchange, the market creates access parity and equity for marginalized groups. This enables a wider audience to participate in the digital economy and enterprise functions. For example, individuals within a marketplace that have issues obtaining VR headsets due to high-tax import fees may instead access metaverse experiences from more accessible hardware – like smartphones.

2. **Increased engagement:** By reaching a broader marketplace, participants and creators can develop and engage with a broader set of assets and experiences. This expands global, dynamic marketplaces where new economic opportunities flourish. For example, a movie producer on a European streaming service can casually access an Australian audience, given that audiences no longer have to intentionally use tools like virtual private networks (VPNs) to gain access to systems that were previously region locked.

3. **Increased efficiencies:** By standardizing transaction processes via nimble cross-border payments,[13] exchanges,[14] and atomic settling processes,[15,16] time savings occur. For example, a bank may potentially avoid the need to settle transactions through an exchange house and instead can settle directly with a given consumer.

4. **Increased trust:** By using blockchain technology – or a value exchange supported by universal data provenance[17] and data lineage[18] – consumers and sellers can possess greater trust in transactions. For example, a seller of a non-fungible token (NFT) can prove authenticity to a buyer as the asset's history was enabled to move with it across platforms.

While not comprehensive, the above showcase new market opportunities. Again, like in frictionless experiences and development, a frictionless economy must navigate market challenges, competition concerns, IP law, as well as technical, usage and jurisdictional challenges. When executed strategically, benefits, as demonstrated in case study 3, may be obtained.

CASE STUDY 3

Consumer experience in the metaverse

A luxury car maker from Asia has developed a virtual showroom for a new line of built-to-order automobiles; this maximizes customization and minimizes inventory.

A customer is enabled to access a 3D virtual showroom on their device. Here, they are able to tailor all aspects of the build. Once customization is complete, the customer has the option to virtually test-drive the new car on various digital tracks, including snowy mountains in the Nordics, sandy roads in the Middle East or smooth interstates in Australia. Given the selected track and present driving conditions, the customized car will react accordingly to provide an authentic experience. Whether using a console, phone, laptop, headset or an advanced simulator, the consumer can use available controls to drive the car.

This dealer offers multiple options for purchasing, such as buying the physical car, purchasing an NFT digital replica, or both. Should the consumer wish to purchase an NFT of the car, they may save the car to their digital wallet and transport the object into relevant games. Should they wish to purchase the physical car, they are able to purchase the car directly from the online design experience, through a kiosk at a dealership or with a sales agent using fiat or cryptocurrencies.

All parts of the experience and transaction are dynamically linked to the customer's identity; upon ordering a physical car, the car is built and delivered. Should the customer ever wish to sell either their NFT or physical car, the asset comes with certificates proving its authenticity and ownership.

2 Actions to enable interoperability

Interoperability offers a wealth of possibilities, but there are also risks to be mitigated.

While interoperability promises lucrative opportunities in certain scenarios, stakeholders must consider technical, usage and jurisdictional mechanisms to mitigate risks.[19,20] Granting some interoperability challenges are the same as Web 2.0, the below acknowledges existing barriers, identifies new concerns and provides ways for stakeholders to champion interoperability.

BOX 2 **Technical interoperability**

The ability to build seamless connections across different technologies or closed networks.

A Technical interoperability

Technical interoperability[21] in the metaverse requires a strong network infrastructure foundation that allows for data interchange across varying hardware and software to deliver (near) realistic experiences.

> Technical interoperability design should consider how to address topics such as network constraints, asset ownership, IP protections, payments, identity, data privacy and security concerns.

Just like webpages require transmission control protocol (TCP)/IP to exchange data and HTML for presenting information in 2D, the metaverse will require a similar degree of standardization to enable communication and interoperability. Among others, this includes reviewing: 1) the scope of data needing to move across devices and networks, 2) the timeliness of the data exchange, 3) the file formats and data schemas, 4) the artistic and stylistic interpretation of assets, and 5) the computing power required to process transmitted data. Standards groups, like the Metaverse Standards Forum,[22] the Open Metaverse Alliance for Web3 (OMA3),[23] and stalwarts like the Institute of Electrical and Electronics Engineers (IEEE)[24] and the World Wide Web Consortium (W3C)[25] have started – and should continue – to consider these technical interchange needs.

Beyond the technical structure, given that data is at the heart of all participation and management activities in the metaverse, technical interoperability design should consider how to address topics such as network constraints, asset ownership, IP protections, payments, identity, data privacy and security concerns at both hardware and software levels to cultivate a human-first metaverse.

1. **Infrastructure requirements:** Accessibility and inclusivity are essential to building a human-first metaverse. From a technical approach, designers should examine how localization, latency and bandwidth can be addressed to extend a similar sense of persistence and presence across metaverse experiences. Given the differences in the availability of hardware, stakeholders should examine how data interchange can be designed to support inclusive access irrespective of device. This could be achieved through backward compatibility standards, minimum bandwidth requirements or the production of scaled experiences for global accessibility. For example, a sports tournament could be completely immersive in a headset, be semi-immersive with AR/MR or desktop browser, or passively streamed to a mobile device. The production of technical standards such as glTF[26] and/or universal scene description (USD)[27] will support data interchange interoperability across the infrastructure. Future best practices should cover functional usage and technical data interchange.

2. **Data privacy and security:** Metaverse hardware technologies – such as AR glasses, VR goggles, brain-computer interfaces (BCIs)[28] and other sensors – will produce and process a myriad of data. These data types may include (perceived) field of view (FoV),[29] voice analysis, biometric data[30] such as heart-rate monitoring, iris scans, pupil dilation,[31] and inferred data[32] like gait detection. It is critical that stakeholders consider the gravity of these data types and position privacy and security at the centre of competitive, interoperability standards. Standards bodies should make use of existing privacy, security, and child safety frameworks and enterprise risk management tools[33] when:

> While addressing interoperability challenges and employing human-centric design processes, it is essential to include individuals across cultures to achieve inclusive design[38] that respects cultures, norms and practices.

- Setting standards for data collection, sharing, classification, labels, retention, ownership, rights, agency, storage locations and encryption methods.
- Advising on how much data and what type of information must be exchanged to support persistence and presence, and enable users to move across worlds.
- Setting standards for how and when data or persons should be authenticated to provide expected degrees of anonymity.

3. **Identity and onboarding:** Web 2.0 asked users to accept terms of service and cookies and occasionally verify age before accessing webpages – which has shown to be limited and easily bypassed. Similarly, traversing immersive spaces will require users to opt-in to new experiences. In 3D environments, however, beyond accepting notice and consent structures, opting in may include creating a new avatar and agreeing to net-new codes of conduct or community standards. This lengthy and tedious process can be reimagined and supported through technical interoperability design. Stakeholders should consider how individuals and associated identities, or attributes, assets and preferences may follow users across experiences to reduce recreating identities and improve the onboarding experiences while keeping users' privacy and security rights in mind. It is worth considering, however, that users may wish to have multiple identities and expectations in different environments. Digital intermediaries,[34,35] or trusted third parties, could facilitate actions such as identity clearing, asset management and compliance checking, among others.

4. **Asset ownership:** The economy of the metaverse will be supported by the creation, buying, selling and trading of digital assets. Owners of digital assets are likely to want to keep them in a digital wallet available across platforms and experiences. This functionality creates technical requirements around: 1) how items should be associated with, collectively managed by and interoperate across users, 2) how assets should translate and be rendered across interoperable worlds, and 3) how data should be attached to portable objects to provide provenance. Moreover, as digital objects can easily be copied, requirements must also protect intellectual property to prevent copyright infringement. Stakeholders should review how standards and common structures – like APIs and regulations from the 2D world – may translate and be enforced in immersive spaces and 3D objects. While not exhaustive, some solutions may include web3 technologies like distributed ledgers, digital wallets and smart contracts.

5. **Payments:** The metaverse economy will require technical interoperability to extend to transactions and currencies, but like the existing banking system, it will be complex and differentiated, with standardization existing as appropriate. With the rise of digital currencies, providers should consider what cross-settlement[36] should look like and the role of digital exchanges. For example, if a participant from China wishes to use the digital yuan (e-CNY), stakeholders should address what this data and currency interchange looks like across users, borders and the physical-digital paradigm more broadly. Select opportunities may lend themselves to using financial institutions' know-your-customer (KYC) frameworks in the metaverse. Questions about data interchange support and compliance also need to be addressed, as well as critical issues regarding taxation in each of the relevant jurisdictions.

Solutions across these categories are highly varied but will rely on guidance from standards bodies.

BOX 3 **Usage interoperability**

The ability for different demographic groups to participate in the metaverse and to participate across different geographies at low cost, leading to inclusion without any discrimination.

B Usage interoperability

Usage interoperability[37] is a core component of the metaverse and is required to deliver value-add, human-first experiences. Consideration of the following components may assist in developing and implementing meaningful decisions across interoperability layers in a way that prioritizes human needs and consequently integrates supportive design choices, tools and interactions. By conscientiously building with usage interoperability in mind, metaverse stakeholders will collectively enjoy the benefits the metaverse offers. However, this is not without its challenges.

1. **Designing and collaborating globally:** While addressing interoperability challenges and employing human-centric design processes, it is essential to include individuals across cultures to achieve inclusive design[38] that respects cultures, norms and practices.

2. **Designing across demographics:** Stakeholders should not assume that all users are created equal. For example, a minor has

different needs than an adult, and a young first-time user should not be treated like a seasoned cybersecurity professional; each has a different digital literacy level and tolerance for being exposed to sensitive content and other users. Information, content and experiences should be appropriate for different levels, from novice to professional. As such, design considerations should be equitable and inclusive to protect the end-user's interests. These choices include items such as: 1) age-appropriate design,[39] 2) how and when participants can traverse, enter and engage with worlds,[40] 3) which assets are portable across experiences, 4) how and to what degree content and conduct are moderated, 5) what data is captured,[41] and 6) how interoperability is integrated to protect the interests of children.

3. **Designing for inclusivity and accessibility:** Stakeholders should thoughtfully ensure that designing for accessibility does not result in a lesser experience. Stakeholders should collaborate to curate and expand developer guides[42,43,44] for accessibility needs, including but not limited to the following use cases:

    a. An individual using VR who is blind or has low vision should not be relegated to using a lesser alternative; creators should design an immersive headset that is rendered for users with limited or reduced vision or something with functional equivalence.

    b. An individual using a standard AR tool to translate street signs in real-time should be enabled to select a default language that translates the text into the user's native language instead of needing to rely on defaults – such as English.

    c. An individual that cannot access VR hardware due to external barriers should not be excluded from accessing a metaverse event or experience.

4. **Designs that are fit for use:** Stakeholders must identify the underlying needs or problems that metaverse experiences are solving for and design the experience and community guidelines accordingly. For example:

    a. An individual's awareness of cultural norms across virtual borders may affect user experience and preferences.

    b. An individual may choose to obscure facial expressions from other avatars in entertainment experiences; however, in a therapy or telehealth session, it may be a requirement to enable sharing.

By considering the above, stakeholders empower individuals and enable access to potentially life-altering technology. Implementation of solutions across these categories are varied but will rely heavily on human-first design and literacy campaigns that educate and involve participants, creators, providers and society on how to make inclusive choices on:

1. Setting expectations for terms of service.[45]

2. Creating standardized community guidelines and codes of conduct – inclusive of content and conduct moderation mechanisms and portability of assets.

3. Defining the limits of what should be interoperable to protect privacy, uphold security and ensure end-user safety.

BOX 4 **Jurisdictional interoperability**

The ability to operate within a jurisdiction or across different jurisdictions governed by differing regulatory requirements to ensure that metaverse activities are conducted in a lawful manner.

C Jurisdictional interoperability

Jurisdictional interoperability, also known as regulatory interoperability,[46] centres the conversation on how to collectively curate interoperable metaverse experiences while considering stakeholders' varied locations, regulations, and regional and cultural expectations. The boundless metaverse exposes challenges, including:

1. **Data compliance:** Regional localities maintain regulatory guidelines and mandates for managing the data supply chain. This scope includes acquiring, storing, disclosing, aggregating, analysing, manipulating, using, sharing, selling and disposing of data. With a boundless metaverse built within the constructs of a physical-centric legal system, the metaverse must address data flows resulting from geographic constraints. For example, a German citizen lives abroad in the United States but is currently in Peru while accessing a metaverse world hosted in Australia. Which data laws apply to this citizen and the experiences they have? From a compliance perspective, what laws must the platform(s), data exchange(s) and other stakeholders prioritize? With increasing amounts of critical, sensitive data, the ramifications of data use in the metaverse expand beyond those of Web 2.0.

2. **Transacting and creating:** The expanse of the metaverse leaves questions open to how the international community should address participants' ability to transact and create within

new 3D spaces. This brings into question topics of ownership, intellectual property, copyright, trademark and licensing laws, along with contract, security, tax and employment law. Their relation to digital currencies, assets and virtual places opens more areas to explore for metaverse law.

3. **Accountability:** As in Web 2.0, users will experience harms, such as identity fraud, transaction fraud or other social harms. Metaverse stakeholders must create accountability models that enable recourse and redress for social and economic harms. Additionally, these must be multilateral to allow participants, creators and providers to benefit irrespective of geography. Moreover, while transgressions and cybercrimes may be occurring in VR, the physical world must indicate how the international community should address digital services to create safe digital spaces.

4. **Identity frameworks:** Digital identity is the nexus to an interoperable metaverse. It enables accountability and the capacity to traverse worlds with minimal friction. Identity is also highly contextual. For example, a punk rocker may want to disassociate from their musical persona during their workday as an attorney. Where possible, interoperability should honour the human-first need for selective anonymity and pseudonymity to protect user privacy while respecting the tension between self-expression and creating safe environments.

Solutions across these categories are varied but include:

1. Establishing inclusive channels across localities, industries and nations to facilitate open dialogues where competitive standards can be co-developed to address concerns, such as:

   – How stakeholders can mitigate risks and ensure privacy and security compliance throughout the entirety of the data supply chain.

   – What best practices and solutions may encourage commerce while protecting stakeholders across the transaction and creation life cycle.

   – What the necessary components of identity frameworks are that enable appropriate mechanisms to enforce accountability and seek recourse and redress.

2. Reviewing existing regulatory frameworks created in Web 2.0 and analysing how existing laws around relevant topics – like online safety and content moderation – may be applied in metaverse spaces before crafting new regulation.

3. Formalizing research and development between private-public sector bodies via regulatory sandboxes, academic investment, trade organization creation and/or non-profit engagement.

3 Towards a governance framework

The Forum is collaborating to identify a governance framework that considers privacy, security, identity, safety and interoperability.

The following items will be helpful to consider when composing a future governance framework:

1. **The interoperable metaverse must be human-first to prioritize the well-being of all stakeholders:** Creating a human-first metaverse depends on interoperability considerations across design processes – extending to data interchange practices, participation considerations, agency and management decisions.

2. **Interoperability design must consider existing privacy, security and child-safety frameworks to strike the necessary balance:** Stakeholders should seek to make inclusive design choices that do not marginalize or unnecessarily exclude populations based on privacy, security or safety preferences.

3. **Metaverse literacy is indispensable for enabling safe, interoperable experiences:** Metaverse stakeholders not informed of digital processes cannot knowledgeably interact across the metaverse. Informed consent is necessary to engage in digital spaces. Multistakeholder approaches must invest in digital literacy as a component of building the metaverse.

4. **Interoperability design choices should be meaningful and timely:** Standards, best practices and other forms of guidance are only productive if they provide value by solving for identified, established concerns. Incomplete and hurried interventions and/or regulation may incur significant tradeoffs that can stifle market innovations. Late regulation, on the other hand, can also result in complications to technical standards compliance. Additionally, certain cases require earlier intervention or regulation, particularly in child safety and medical use cases.

5. **Technical data interchange, participant engagement and management across experiences are dependent on multi-stakeholder collaboration:** Well-designed interoperability should involve diverse stakeholders – including providers, creators, civil society and metaverse participants – to assist in establishing a common language, necessary standards, industry best practices and policies where appropriate.

6. **Social contracts and participant expectations vary across experiences:** Decisions in an interoperable metaverse must be made in context. Context should be included when considering conduct moderation, content moderation, identification requirements and the degree of interoperability permissible for a given platform and/or experience.

7. **Interoperability is nuanced, multi-dimensional and is a spectrum that should be respected:** Interoperability is a market choice that providers may implement to create openness and differentiated services across platforms, virtual worlds and experiences. Not all facets of the metaverse should be interoperable and metaverse stakeholders should carefully consider decisions mandating as such.

The above findings will be used in conjunction with outcomes from other briefing papers to inform a white paper on metaverse governance.

Although harmonizing existing regulations and building new policy may prove necessary to adapt to new and unforeseen challenges, continued collaboration between metaverse stakeholders – inclusive of providers, creators, civil society and participants – and further research into policy, standards and other forms of guidance are a key first step towards progress in building a metaverse that is human-first. Businesses, governments, academia and civil society should collaborate to build appropriate standards that support metaverse interoperability, encourage innovation and take a human-first approach. More work is to be done, but understanding the foundation that will drive interoperability, and the potential it can unlock, is an important first step.

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This paper is a combined effort based on numerous interviews, discussions, workshops and research. The opinions expressed herein do not necessarily reflect the views of the individuals or organizations involved in the project or listed below. Sincere thanks are extended to those who contributed their insights via interviews and workshops, including those not captured below.

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