In collaboration with the University of Cambridge

Exploring the Industrial Metaverse: A Roadmap to the Future

BRIEFING PAPER

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Foreword

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The industrial metaverse is likely to impact industry and shape its future. The path for the evolution and conceptualization of the industrial metaverse remains uncertain, especially regarding its short-, mid- and long-term developments within industry.

To help industry gain a better understanding, the World Economic Forum and the Cyber-Human Lab at the University of Cambridge have worked together with leading industry partners and organisations to shed some light on the complex dynamics of the industrial metaverse, its technology, use cases and market.

This paper is another milestone in understanding the potential behind the metaverse as part of the Defining and Building the Metaverse initiative, where investigations have started regarding *Demystifying the Consumer Metaverse*, the social implications of its development, and the considerations for interoperability and privacy and safety in its construction.

In this briefing paper, a technology roadmap outlines the potential development paths of the industrial metaverse and provides action and discussion points to industry leaders and governments to keep abreast of its latest developments.

We would like to thank all contributors and invite readers to explore the current state, future vision and key developments of the industrial metaverse in this briefing paper.

Executive summary

The industrial metaverse is in its early stages, which makes it difficult to predict and manage for industry leaders. Building on extensive fieldwork, this briefing paper addresses this challenge by outlining a roadmap for the industrial metaverse. The roadmap focuses on four key dimensions: market, use cases, technologies and resources.

- The roadmap shows that on the market side, it is important for industry players to assess the economic, social and environmental value of the industrial metaverse.
- At a use cases level, they should start experimenting with the first proofs-of-concept, which may be integrated into a wider industrial metaverse platform.
- In terms of technologies, companies should consider building infrastructure that ensures interoperability.
- On the resources side, they should educate, upskill and reskill employees around a shared vision and promote cross-disciplinary collaboration.

The industrial metaverse is likely to scale up in the coming years, and it is important for industry leaders to understand its complex, multi-dimensional impact to be ready to use its potential for their organizations and society overall.

Introduction

This briefing paper aims at stimulating discussions and helping industry leaders to understand what the industrial metaverse is and its potential over the short-, mid- and long-term horizons.

The industrial metaverse is a new concept that has recently attracted considerable public attention. However, industry leaders are still grappling to understand what the industrial metaverse actually is, what its current state is, where it is going and how to get there.

The intent of this publication is to address those questions by providing a preliminary definition, shedding light on the current state and outlining a vision for the industrial metaverse as it emerged through consultations with leading industrial companies. Building on this foundation, different dimensions of an industrial metaverse with market, use cases, technologies and resources have been mapped out to explain potential future developments. Finally, the roadmap will conclude with points of action and discussion. It is acknowledged throughout this briefing paper that an industrial metaverse and its developments are uncertain. The roadmap should be seen as a document facilitating further, more in-depth communication and discussion. In doing so, a balance is sought between a positive vision for an industrial metaverse and critical aspects and decision points.

1 Industrial metaverse: definition, where it stands today and a vision for the future

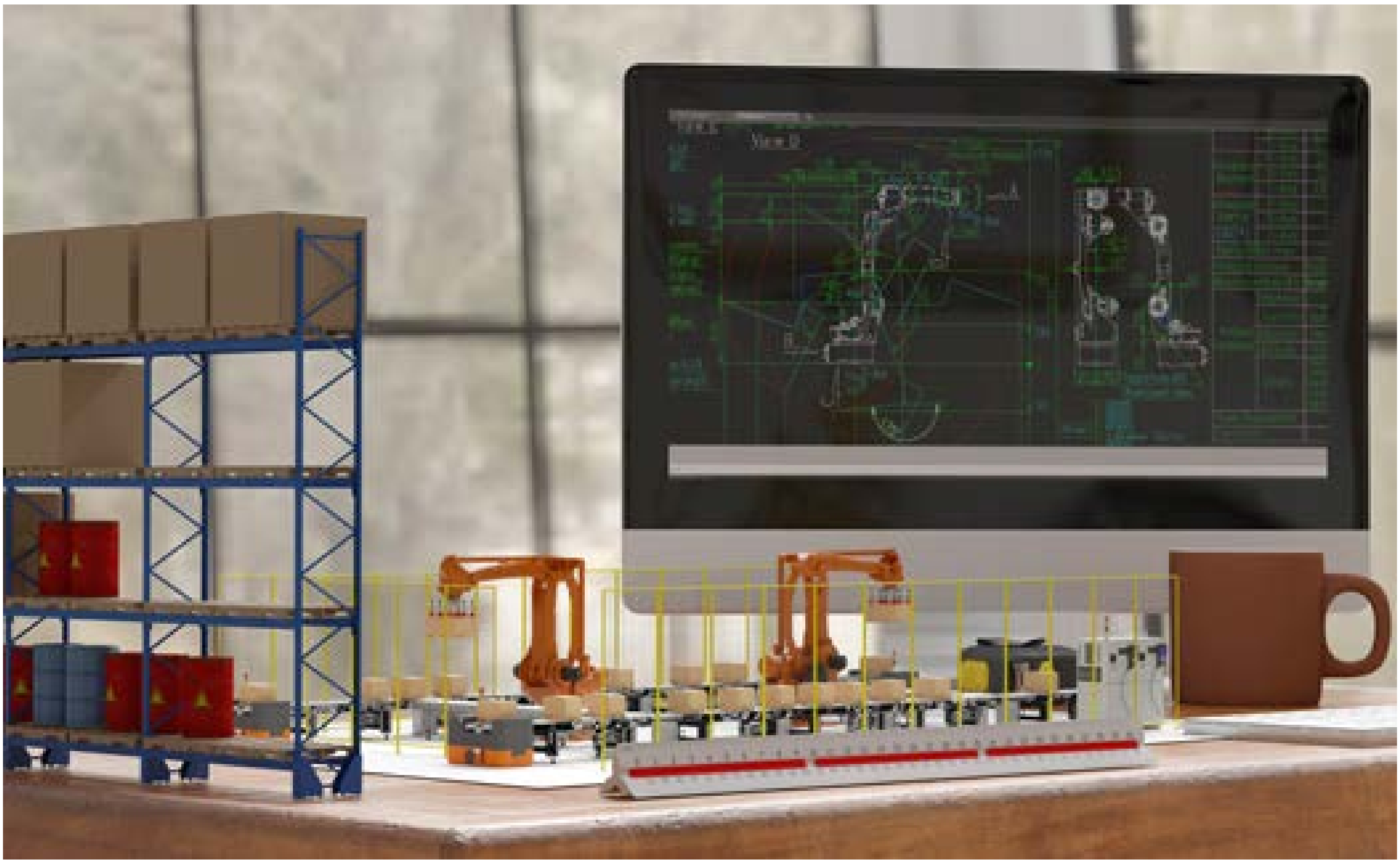
While first use cases are currently being explored, the industrial metaverse is envisioned as an open ecosystem platform in the long term.

1.1 What is the industrial metaverse?

The "industrial metaverse" is a term commonly applied to the set of metaverse applications designed for industrial users.[1]

As the next evolutionary step of digital twinning, the industrial metaverse extends beyond a digital replica of a machinery or a manufacturing plant. In fact, it can be defined as a persistent 3D platform that is implemented across an organization, value chain and product life cycle, serving as a digital reflection of an entire organization in its operational environment. In its combinatory nature, it integrates processes, materials, machines and people in a bi-directional flow between real and virtual worlds.

It builds on enabling technologies, including extended reality (XR), robotics, sensors and actuators as part of the internet of things (IoT), artificial intelligence (AI), development tools, blockchain, computing and connectivity.



1.2 Current state of the industrial metaverse

To date, there are significant differences across industries when it comes to the adoption of the industrial metaverse, with some companies leading the space, particularly in the automotive, aerospace, energy and pharmaceutical sectors. Despite the different levels of advancement in these industries, the opportunities and challenges encountered by companies in its adoption are similar.

More specifically, industrial companies are experimenting with initial proofs-of-concept such as virtual reality (VR) safety training and mixed reality (MR) showrooms. The use of 3D modelling and simulation software is becoming more common for development and testing. However, these pilot projects often lack integration into existing software infrastructure or an industrial metaverse platform.

To implement more advanced use cases, many companies face challenges such as insufficient high-speed, low-latency connections to the factory and a lack of structured data from sensors within existing machines and other devices. Additionally, while almost all companies collect data, they struggle with interpreting them due to incompatible formats. Creating new 3D content through technologies like 3D scanning devices or AI-generated content is promising, but the associated costs are still considered to be high.

Aside from these hurdles, many companies are overwhelmed by the complexity and speed of innovation in the industrial metaverse. As of today, a clear vision, strategy and governance processes for the whole industrial metaverse concept are missing.

1.3 Vision for the industrial metaverse

Industry experts foresee AI as a significant enabler of the industrial metaverse, with its potential to elevate other enabling technologies to new heights.

Building on different industry perspectives, the industrial metaverse is mainly envisioned as an open ecosystem platform built on defined and shared standards. It should be embedded in a fair, ethical and internationally coordinated legal system where it provides economic, social and environmental value to many players.[2]

According to companies, in a few years, use cases will have evolved from unconnected proof of concepts into an integrated platform enabling multiple and increasingly complex applications, including virtual design, testing, production planning, operations and monitoring and maintenance. On this integrated platform, use cases should be accessed immersively and intuitively.

In this context, connectivity and computing infrastructure are expected to be widely set up to realize this interoperable, open platform. Additionally, industry experts foresee AI as a significant enabler of the industrial metaverse, with its potential to elevate other enabling technologies to new heights.

Internally, industry experts will have established a shared, company-specific vision, strategy and flexible governance mechanisms that ensure the responsible and sustainable implementation of the technology.

2 Foundations and applications of the industrial metaverse

Four dimensions are key to ensuring a valuable, responsible and collaborative industrial metaverse.

Building on a shared community understanding of what the industrial metaverse is and how it could be broadly envisioned, the aim is to map out a possible implementation path. In general, roadmapping is a powerful technique used to structure and visualize complex systems in dynamic environments.[3,4] The approach is applied using four key dimensions: 1) market drivers, 2) underlying technologies, 3) resources required, and 4) potential use cases, describing each underlying dimension with sub-categories and visions.

1 Key market influences for establishing the industrial metaverse

For the industrial metaverse to scale in a responsible way and benefit all stakeholders of society, there are five key market drivers that need to be taken into account: economic, social, environmental, political and legal. Their complexity is likely to increase as the industrial metaverse market spans international borders with different political and legal systems.

FIGURE 1 **The market drivers of an industrial metaverse**

Market

Economic
An open industrial metaverse ecosystem should create economic value for all companies across industries.

Environmental
The net environmental benefits should outweigh environmental costs throughout the whole industrial metaverse life cycle.

Legal
Fair, ethical and internationally coordinated legal frameworks should regulate an industrial metaverse.

Social
An industrial metaverse should be designed to make work more enjoyable, productive, inclusive and healthy for everyone.

Political
National and international politics should equally consider social, economic and environmental interests for the industrial metaverse.

2 Underlying technologies of the industrial metaverse

The industrial metaverse is enabled by multiple technologies that can be conceptualized in a five-layer technology stack. The hardware infrastructure includes connectivity and computing. One layer above, the software infrastructure layer includes AI, development tools and distributed ledger technologies (e.g. blockchain) that are dependent on the underlying hardware. Building on the software infrastructure, the industrial systems may consist of robotics, various sensors and actuators (IoT). All these technologies build the foundation of an industrial metaverse platform. On top of all these, the interaction layer with input/output (XR) devices represents the interface to the users.

FIGURE 2 **The technology stack of an industrial metaverse**

Technologies

Interaction

Input/output (I/O) devices

Comfortable, industrially suitable (mobile) devices and wearables with a high resolution and long battery duration, which allow for seamless and precise interaction with an industrial metaverse platform, can be realised through XR and MR, (or brain computer) interfaces.

Industrial metaverse platform

Industrial metaverse platform

An interoperable and open platform that combines underlaying technologies and integrates different use cases. It should be intuitively operable by humans.

Industrial systems

Robotics

Flexible and reliable robotic systems that are capable of autonomous decision-making. Robotics should also enable intuitive human-robot collaboration.

Sensors and actuators/IoT

Industrial objects collect data in standardized formats and can be remotely manipulated.

Software infrastructure

Artificial intelligence

AI enables better scaling, autonomous decision-making and more intuitive interaction. It enhances many other underlying technologies of an industrial metaverse.

Development tools

These tools help developers to build an industrial metaverse and will enable precise and cost-effective virtual replication of industrial environments and easier creation and modification of virtual content and assets.

Distributed ledger technology (DLT)

DLT might be integrated into other technologies where it could increase security, interoperability and audibility in an industrial metaverse.

Hardware infrastructure

Connectivity

Secure and reliable, high-bandwidth, low-latency connection between industrial metaverse objects and systems.

Computing

Flexible, ubiquitous computing in the cloud, edge and on-site.

3 Required resources for an industrial metaverse

The resources dimension refers to fundamental, organizational and human assets that companies need to put in place to successfully implement the industrial metaverse and achieve impact at scale.

Its fundamental resources include financial resources, safety, privacy and security; organisational resources include organisational structures, governance and culture; and human resources span across management and employees.

FIGURE 3 **Resources required for an industrial metaverse**

Resources

Human

Management
Management should establish a clear, shared company vision and strategy for an industrial metaverse.

Employees
Knowledge about an industrial metaverse and its implementation should be continuously built.

Organizational

Organizational structure
The organizational structure should be flexible and enable interdisciplinary, cross-functional teams and dedicated industrial metaverse roles.

Governance
Governance structures should enable a responsible implementation of the industrial metaverse use cases and a commitment to open standards and interoperability.

Culture
Open, responsible tech-embracing, supportive culture can promote collaboration and co-creation within and across companies.

Fundamental

Safety
Safety of humans and physical and virtual assets must be ensured at all times.

Privacy
The privacy of employees, customers and other stakeholders must be ensured within and across the organization.

Security
Security of systems must be constantly ensured across the whole industrial metaverse.

Financial resources
Financial investments into an industrial metaverse must be continuous and sufficient with a positive return on investment.

4 Identified use case applications in the industrial metaverse

Through the industry community consultations, it has been possible to come up with a list of potential industrial metaverse-related use case applications. In fact, potential applications can be clustered along the product life cycle into pre-production, production and post-production. Pre-production includes training, development as well as testing and procurement. Production spans across operational planning, process optimization, monitoring, operations and assembly, business intelligence, quality control and maintenance. Post-production includes marketing and sales, customer support and product recycling. All these use cases represent a concrete way for the industrial metaverse to generate impact and value for companies both in terms of operations and business models, supporting the shared community belief that industry is among the most relevant fields of impact of the metaverse.

FIGURE 4 **Use cases in an industrial metaverse**

Use cases

Pre-production

Training
Remote, immersive learning in a realistic and interactive virtual environment.

Development and testing
Collaborative virtual product and factory prototyping and simulation.

Procurement
Virtual simulation and testing of supplies before purchase. AI supported supply and inventory predictions. Supply chain optimization, simulation and increased transparency.

Production

Operational planning
Automated planning of operations in integrated systems in industrial metaverse applications.

Process optimization
AI-enhanced optimization of entire production systems.

Monitoring, operations and assembly
Real-time (remote) monitoring and operations with control of physical production systems and XR-assisted assembly.

Business intelligence
Aggregated information and visual analytics for forecasting and decision-making in a single integrated system.

Quality control
Automated, AI-supported quality control at each production step.

Maintenance
Remote support, predictive maintenance and XR instructions.

Post-production

Marketing and sales
Immersive virtual product demonstration and showrooms.

Customer support
Remote, XR-enhanced support and maintenance for customers.

Product recycling
Enabling tracking of materials and information on up-, re- and downcycling.

3 The future of the industrial metaverse: a roadmap

Different potential developments outline the short-, mid- and long-term of the market, technologies, resources and use case dimension.

The four dimensions (market, technologies, resources and use cases) build the roadmap framework from which the potential implementation of an industrial metaverse between the current state and a future vision could evolve.

Building on the four dimensions, developments are mapped out along a time axis with short-, mid- and long-term horizons.

The content of the roadmap is the result of interviews with leading stakeholders from industry, including software and hardware providers as well as consultancies and other relevant organizations. This roadmap does not claim to give a fixed picture of the future but outlines a credible path, based on community insights, towards achieving the envisioned state of the industrial metaverse over the next fifteen years.

In Figure 5, only key sub-dimensions are included, with the goal of providing a high-level overview and facilitating initial discussions among industry experts.

FIGURE 5 | A potential roadmap towards realizing an industrial metaverse

<table>
<tr><th></th><th>Short-term
(now-5 years)</th><th>Mid-term
(5-10 years)</th><th>Long-term
(10-15 years)</th></tr>
<tr><th colspan="4">Market</th></tr>
<tr><td>Economic</td><td>The economic value of an industrial metaverse is still uncertain, a key driver for its adoption is a shrinking workforce and need for automation.</td><td>Industry has recognized the economic potential of an industrial metaverse and invest in underlying technical infrastructure. Return on investment is still uncertain for many use cases.</td><td>The industrial metaverse ecosystem becomes an economic enabler for many industries.</td></tr>
<tr><td>Social</td><td>Enthusiasm towards an industrial metaverse but also scepticism and fear of labour replacement.</td><td colspan="2">The industrial metaverse is designed in an inclusive and safe way, less tech-enthusiastic employees are supported and upskilled to prevent a “digital divide”.</td></tr>
<tr><td>Environmental</td><td>Assessment of environmental opportunities such as efficiency gains and reduction of resources and waste as well as challenges such as an increasing need for hardware and energy.</td><td colspan="2">Increasing importance of environmental considerations and regulations in the industrial metaverse when scaling use cases and their potential negative environmental effects.</td></tr>
<tr><th colspan="4">Technologies</th></tr>
<tr><td>Input/output devices (XR)</td><td>Personal computers and tablets remain the most common device for most use cases. Companies experiment with XR headsets but face problems with limited user experience, cost of content creation and ruggedness for an industrial environment.</td><td colspan="2">Technology improvements in battery life and optics allow MR application in industrial environments.</td></tr>
<tr><td>Industrial metaverse platform</td><td>Technology companies start building platform ecosystems for industrial companies, which integrate different use cases within the company into a single platform. Missing standards and lack of interoperability make this difficult.</td><td colspan="2">Establishment of few platform providers; integration of multiple use cases within a company and across the value chain on these industrial metaverse platforms, high pressure for integration for small- and medium-sized companies.</td></tr>
<tr><td>Robotics</td><td>Robotic systems come equipped with advanced sensors, actuators and 3D models and can therefore quickly be integrated into an industrial metaverse.</td><td>Increasing importance and use of robotic systems for industrial companies, focus on human-robot collaboration systems.</td><td>Increasingly fully-automated production lines.</td></tr>
<tr><td>Sensors and actuators (IoT)</td><td>A lot of sensor data is not being analysed, companies face problems upgrading sensors to legacy (brownfield) systems.</td><td colspan="2">Increasing coverage of sensors and actuators enable complete control of industrial environments and processes.</td></tr>
<tr><td>Artificial intelligence</td><td>AI is being implemented in many underlying technologies. Companies invest heavily into new developments and are assessing opportunities and risks.</td><td colspan="2">AI models are becoming increasingly sophisticated and become an enabling technology that supports scaling up use cases.</td></tr>
<tr><td>Connectivity</td><td>Connectivity to the factory is a bottleneck for use cases that require real-time interaction or high bandwidth.</td><td colspan="2">High investments into new network infrastructure to and within the factory enables more complex use cases.</td></tr>
</table>

FIGURE 5 | A potential roadmap towards realizing an industrial metaverse (continued)

	Short-term (now-5 years)	Mid-term (5-10 years)	Long-term (10-15 years)
Resources			
Management	Lack of knowledge about possibilities of the industrial metaverse by top and middle management.	Establishment of a company-wide industrial metaverse vision and strategy.	
Employees	Technical and interdisciplinary knowledge become more important.	Continuous learning and upskilling for all employees to implement and make use of the potential of the industrial metaverse.	
Governance	Established processes and governance structures already enable cross-functional and interdisciplinary collaboration to implement first industrial metaverse pilot use cases.	Creation of external governance structures encourage more collaboration between companies on an industrial metaverse platform.	
Culture	Culture is a crucial factor and can encourage or hinder the adoption of the industrial metaverse use cases.	Increasingly open, collaborative, tech-embracing culture spanning organizational functions promotes innovation.	
Use cases			
Training	In-person training, video content and text are the prevailing methods for teaching and training. XR pilot use cases trial training in predefined virtual learning scenarios.	Increasing effectiveness of (remote) training in realistic, immersive, highly manipulative, virtual environments. Multi-user interaction and automated supervision becomes possible.	
Development and testing	Products and factories are planned digitally in 3D and accessed with 2D monitors, simulation and tests with few parameters are possible.	Increasingly complex products and factories can be simulated and tested, minimizing the need for physical prototyping and testing. AI-supported asset generation and (remote) real-time collaboration with customers and suppliers becomes possible.	
Monitoring, operations and assembly	Real-time digital operation and monitoring of production systems.	Increasing automation and digital twinning of production systems with AR assisted assembly.	Increasingly autonomous production systems enable remote monitoring and control, are assisted by AI and can be intuitively visualized in XR.
Business intelligence	Data are analysed in an aggregated manner in different systems, AI is explored for decision support.	Enhancement of visual analytics with AI and internal and external data, voice input.	
Marketing and sales	Industry mainly uses physical product demonstrations in-person or through videos, pictures and text. Cost for immersive content creation is still high.	Increasingly immersive 3D presentations of products or factories in 3D showrooms that are accessible with XR and created in no-code development tools.	
Customer support	In-person or remote expert assistance via audio or video are predominant in industry.	Increasing use of remote customer support for physical maintenance with a shared perception of space through XR or holographic instructions.	

The scepticism and fear originating from a potential labour replacement could be balanced by the possibility of upskilling and reskilling the workforce in the mid and long term.

1 Market

On the economic side, the value of the industrial metaverse is still unclear. Still, according to the community, it should become more recognizable in the mid-term, thus leading to increased investments. In fact, industrial companies and metaverse platform providers have a common interest in establishing an interoperable, open industrial metaverse platform and look committed to working for it.

On the social side, the scepticism and fear originating from a potential labour replacement could be balanced by the possibility of upskilling and reskilling the workforce in the mid and long term, which should prevent a digital divide. Further, environmental considerations around energy, resources and waste are likely to become increasingly important as use cases scale and more technical infrastructure is required.

2 Technologies

Industrial companies are experimenting with XR devices in industrial environments for specific use cases such as training and product design. As technology matures, it will become clearer how XR can add value to the 2D screens currently in use.

Beyond XR, some technology companies are working to implement industrial metaverse platforms that integrate different use cases. Moreover, the importance of robotics, sensors and actuators is expected to increase in the mid and long term as industrial environments become more virtually controlled and automated. Robotic simulations are seen as the first stepping stone for the realization of the industrial metaverse. Automation is foreseen to be significantly enabled through AI. Particularly in the scaling phase of the industrial metaverse in the mid-term, AI is expected to make use of all other underlying technologies.

In the present, a strong limiting factor for the implementation of the industrial metaverse is the existing public network infrastructure. With a shift towards cloud computing and real-time virtual interaction, higher bandwidth and lower latency are required. It is important for industry players to continue developing open standards. This can ensure interoperability between technologies and platform solutions, enabling faster and more cost-effective development and implementation.

3 Resources

Besides changes in the underlying technologies, the implementation of an industrial metaverse will also require changes in existing organizational resources, including governance and culture. Governance structures need to be adapted to guide collaboration within and across organizations. An open, technology-embracing and supportive culture can help to facilitate the necessary change.

Human resources are also needed for industrial metaverse implementation. Managers need to gain a clearer understanding of how the industrial metaverse can support organizational goals and develop a coherent industrial metaverse vision and strategy. Ongoing learning – both soft and hard skills – for employees is an important factor in building up technical knowledge and promoting interdisciplinary work.

4 Use cases

Currently, first proof-of-concept use cases are being explored by companies but are often limited due to a lack of integration of underlying technologies, such as advanced head-mounted displays (HMDs), connectivity infrastructure and limited content to populate virtual environments. Further, use cases often still generate 2D data as an output, are not real-time and have no collaborative features. The most prominent use cases currently deployed are training, and marketing and sales due to their often less resource-intensive implementation.

In the mid- and long-term, use cases are expected to be implemented more widely on an interoperable platform. They are also envisioned to have a stronger collaborative focus, possibilities for real-time manipulation, features for customization and more consistently offer 3D output capabilities. Use cases could be enhanced with AI features, increasingly being employed for decision assistance and decision-making. Use cases such as training, development and testing monitoring, operations and assembly, business intelligence, marketing and sales, and customer support are likely to be explored in the mid- and long-term, given their high dependency on underlying technologies.

4 Actions for companies and governments

Companies and governments should discuss the role of humans, extended reality, level of openness and granularity.

Building on our roadmap for an industrial metaverse, what are points of action and discussion industry leaders and governments should consider today to keep abreast of developments?

Market

Industry players should get a better understanding of the economic, social and environmental value of the industrial metaverse, which is derived from its problem-solving potential. Further, they should collaborate with other industry representatives and governments on legal protection for sharing virtual assets and knowledge across companies. Openness to sharing information is seen as a big lever for value creation in the industrial metaverse.

Technologies

The underlying infrastructure of an industrial metaverse should be enhanced. Aside from infrastructure, companies should develop and establish common standards in industry associations to ensure interoperability of the technologies and use cases.

Resources

The development of a shared vision and strategy, as well as upskilling and reskilling of employees, is key. Moreover, industry players should promote cross-disciplinary collaboration within the firm, as implementing an industrial metaverse in a holistic way requires diverse people. Overall, industrial players need to consider all four dimensions when implementing and scaling an industrial metaverse.

Use cases

Industry leaders are advised to strategically consider whether to build virtual assets in-house or externally while considering the current high costs for content creation. Options that reduce the cost of virtual assets should be constantly assessed as they hinder widespread implementation. In addition, industry players should prepare for combining and scaling use cases across the organization.

Abstracting from short-term actions, there are several points of discussion that need to be negotiated and agreed on by all parties involved in an industrial metaverse ecosystem. Currently, one point of discussion arises around the role of humans in the implementation of the industrial metaverse. Aside from the design choice of humans in-the-loop or out-of-the-loop, industry players should discuss the role of XR and how open, collaborative and interoperable the industrial metaverse ecosystem should be. Moreover, the level of granularity of the real world that is replicated (e.g. the resolution of the virtual environment) should be discussed.

To successfully consider the above points, sound and meaningful stakeholder collaboration is required. Through its Defining and Building the Metaverse initiative, the Forum is bringing together leading voices from the private sector, civil society, academia and policy to define the parameters of an economically viable, interoperable, safe and inclusive metaverse, with the industrial metaverse becoming an increasingly relevant area of work.

FIGURE 6 **Points of action**

Points of action

Market

Value
Assess the economic, social and environmental value of the industrial metaverse.

Sharing
Advocate for better legal protection to share virtual assets across companies.

Technologies

Infrastructure
Build the underlying infrastructure for the industrial metaverse.

Interoperability
Develop and establish common standards and ensure interoperability.

Resources

Management and employee skills
Train management and employees, create a shared vision and strategy.

Cross-functional collaboration
Foster cross-disciplinary collaboration within the firm with dedicated roles.

Use cases

Virtual assets
Reduce the cost of content creation.

Use case connection
Combine and scale use cases on an industrial metaverse platform.

Points of discussion

Humans
With an increasing use of robotics in manufacturing, what is the role of humans? Will the industrial metaverse still be human-centric in the future?

Extended reality
What value does XR add for humans in the industrial metaverse?

Openness
How interoperable, collaborative and open should the industrial metaverse be? How can we prevent lock-in effects by those companies?

Granularity
To what level of accuracy should physical industrial environments be replicated? What value does photorealism and 3D add?

Conclusion

The industrial metaverse is part of an ongoing development towards digital first in industry. It has gained much attention primarily due to rapid advancements in commercial XR technology, AI and 3D modelling/simulation. With these technical capabilities, many industry players are currently testing how to best realize the economic, social and environmental value of the industrial metaverse by experimenting with first pilot use cases with limited complexity. Industry players are thinking about strategies and governance mechanisms that support the implementation of the industrial metaverse on a broader scale within and across companies. Therefore, discussion and alignment are particularly needed on common standards to ensure interoperability and the creation of an open platform ecosystem. For industry players, much potential exists in scaling and combining different use cases in one industrial metaverse in the next 5-10 years.

In summary, this roadmap aims to shed some light on the complex dynamics of the industrial metaverse. It provides a framework for discussion on key steps towards an ecosystem that can provide value for different stakeholders. It will be down to industry, governments, academia and civil society to build the industrial metaverse in a responsible way. The World Economic Forum represents a space for all stakeholders of society to collaborate on building an inclusive and sustainable metaverse that can support a responsible transition of the industry.

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Endnotes

1. Any assumption/consideration on the vision included in this paper refers to the industry players/communities that are engaged with the World Economic Forum and took part to the consultations at the basis of the paper.
2. Betti, Francisco, Thomas Bohné and Cathy Li, “The industrial metaverse and its future paths”, *World Economic Forum*, 19 January 2023.
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