451 Research
Discovery Report

October 2024

Industrial Metaverse Research Study

Business Perspective

Commissioned by

SIEMENS

S&P Global
Market Intelligence

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Executive summary

This is one of two reports analyzing the results of the custom Industrial Metaverse Research Study. These reports examine the characteristics and best practices of industrial metaverse Leaders while contrasting these with the approaches of Challengers and Explorers. This report focuses on the business perspective of the industrial metaverse, while an accompanying report focuses on technology trends.

The Industrial Metaverse Research Study provides a comprehensive analysis of the industrial metaverse landscape. The study aggregates insights from 907 decision-makers involved in the industrial metaverse, encompassing business and technical perspectives, use-case adoption, technical characteristics and impact, major external forces, internal challenges to adoption, perceptions of metaverse vendors and strategic recommendations.

Introduction

The industrial metaverse is captivating organizations globally, as awe-inspiring demos in digital worlds are quickly transforming into initial practical use cases in the physical world. Not all elements of the industrial metaverse concept are fully in place, technically evolved and adopted, but the linking of physical objects and their digital twins with synchronous and real-time data sharing is rapidly progressing. The power to digitally monitor, manage, optimize and predict physical products and processes is a significant value creator for industrial organizations adopting metaverse technologies.

Definition

Industrial metaverse: A shared, immersive, persistent, physics-based digital space where humans and machines interact with one another, and with data, enhancing the physical world as much as replacing it.

While the industrial metaverse as a fully realized concept is still emerging, many metaverse technologies and use cases are already demonstrating several of its key characteristics. The technologies enabling it are highly developed and still improving. Metaverse use cases are currently deployed in production environments, and organizations rely on them for critical industrial operations and processes — even if they may not always be referred to as industrial metaverse.

At the core is the digital twin, which facilitates digital and physical interactions among people, machines, data and information. A digital twin is a comprehensive virtual representation of a physical asset, product, process or space. It allows for the simulation of design alterations, "what if" usage scenarios and changes in environmental conditions as a means to test potential modifications without the costly trial and error of uninformed physical interventions.

> **"The company's digitalization strategy prioritizes the development of a digital twin, which brings the most value in terms of planning efficiency, quality, troubleshooting and proactive maintenance."**
>
> **VP of IT workplace, automotive**
> 50,000+ employees, Europe

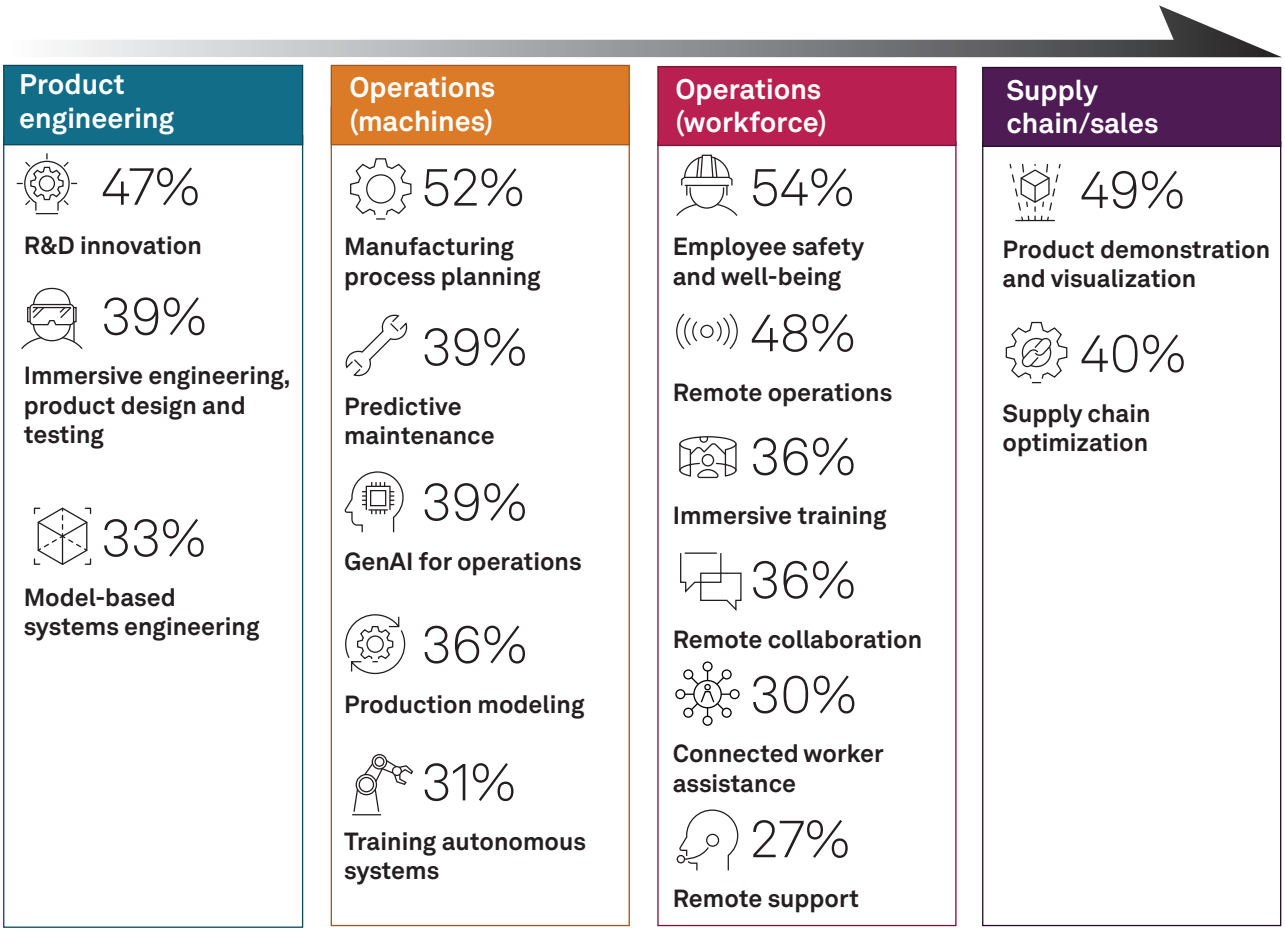
The industrial metaverse provides a space to collaborate, experience and interact with a comprehensive digital twin. While immersive technologies such as extended reality (augmented and virtual reality) enhance this experience, traditional desktop and mobile devices also facilitate many interactions. Furthermore, the industrial metaverse is being enabled and shaped by foundational technologies such as industrial IoT, cloud and edge computing, blockchain and AI/ML (including generative AI).

The business case for industrial metaverse

With long-standing and emerging technologies in place and maturing, the business case for industrial metaverse is gaining momentum with use cases driving significant impact in production environments today. Initial high-impact industrial metaverse use cases include manufacturing process planning to reduce material costs and cycle times, as well as R&D innovation to improve time to market and new product introduction and development rates. These applications are already driving measurable financial impact on the top and bottom line for early adopters.

> "We look for successful use cases in other industries to argue for the adoption of new technologies and make the implementation process more cost-efficient. Our successful use cases have resulted in improved maintenance efficiency, upskilling of staff and higher employee satisfaction, especially among younger colleagues."
>
> **Head of digitalization**
> Utilities/electricity distribution
> 5,000-9,000 employees, Europe

Figure 1: Industrial metaverse use cases across the industrial value chain



Q. What is the current stage for the following industrial metaverse use cases at your organization?
Base: Actively using in multiple projects/locations or in a single project/location. (n=907).
Source: S&P Global Market Intelligence 451 Research custom metaverse survey, 2024.

The number and variety of industrial metaverse use cases are quickly expanding, driven by the significant impact and technical considerations they entail. This research study benchmarks and analyzes the top 16 industrial metaverse use cases identified by survey respondents (see Figure 1), focusing on their adoption, impact and technology.

Metaverse adoption is rapidly segmenting markets

The recognition of significant financial gains and business outcomes from industrial metaverse applications is not universal as adoption is quickly expanding past initial schisms of "haves" versus "have-nots" and into multifaceted market segmentation. Overall, more than four in five respondents (81%) are using, piloting or planning to adopt industrial metaverse technologies, while the remaining 19% either have no plans or plans that are more than three years out.

Among adopters, nearly one-fifth are identified as industrial metaverse Leaders. These organizations are actively rolling out use cases at scale within a matured digital transformation strategy that is delivering significant financial and business impact.

Leaders

Nearly one-fifth (19%) of metaverse adopters are Leaders; they have deployed several use cases at scale and achieved enterprise-wide digital maturity.

Two additional groupings — Challengers and Explorers — sit close behind but have not yet achieved integrated, enterprise-wide digitalization. Their efforts are often uncoordinated and departmental, lacking a cohesive strategy across the organization. However, shortcuts to bypass common hurdles to metaverse adoption are opening through technology innovation and vendor maturity. These developments present a "second-mover advantage," providing a path to avoid excess expenditure of capital, time and other resources that first movers may have succumbed to.

Rounding out the market segmentation is a large swath identified as Observers — those that are still operating exclusively in pilots, proofs of concept or not at all. Yet many are on the cusp of initiating a transformation that could significantly impact their organization and gain self-perpetuating momentum, as has happened with other adopters.

The Industrial Metaverse Research Study delves into these shifting market maturities, showing how an organization's position influences its perceptions and actions. The study offers insights for both business- and technology-minded stakeholders, along with actionable strategic recommendations that can be applied to their own organizations' metaverse strategies.

Industrial metaverse segmentation

The survey data revealed noticeable variances regarding the number and scale of deployed metaverse use cases, as well as the maturity of organizations' digital transformation. These differences underpin the four metaverse adoption categories, which are analyzed throughout the paper and described in Figure 2.

Figure 2: Maturity characteristics

	Leaders	Challengers	Explorers	Observers
Sample size (n)	171 (19% of total)	300 (33%)	101 (11%)	335 (37%)
Number of metaverse use cases active in single and/or multiple sites/projects	10+	8-9	1-7	0
Digital transformation maturity	Enterprise-wide: **100%**	Enterprise-wide: **17%** Departmental: **72%** Piloting/proofs of concept : **10%**	Enterprise-wide: **40%** Departmental: **48%** Piloting/proofs of concept: **13%**	Enterprise-wide: **26%** Departmental: **37%** Piloting/proofs of concept: **23%** Consideration: **12%** No strategy: **2%**

Source: S&P Global Market Intelligence 451 Research custom metaverse survey, 2024.

Organizations with a centralized, enterprise-wide digital transformation strategy achieve far greater success than those operating in a decentralized and departmental manner. These organizations benefit from ongoing and structured support from C-level executives, management board and steering committees. These metaverse Leaders have incubated a culture that embraces new technologies and democratizes best practices for adoption. Their initiatives are managed and optimized by formal digital teams, and they have successfully deployed and scaled several metaverse use cases.

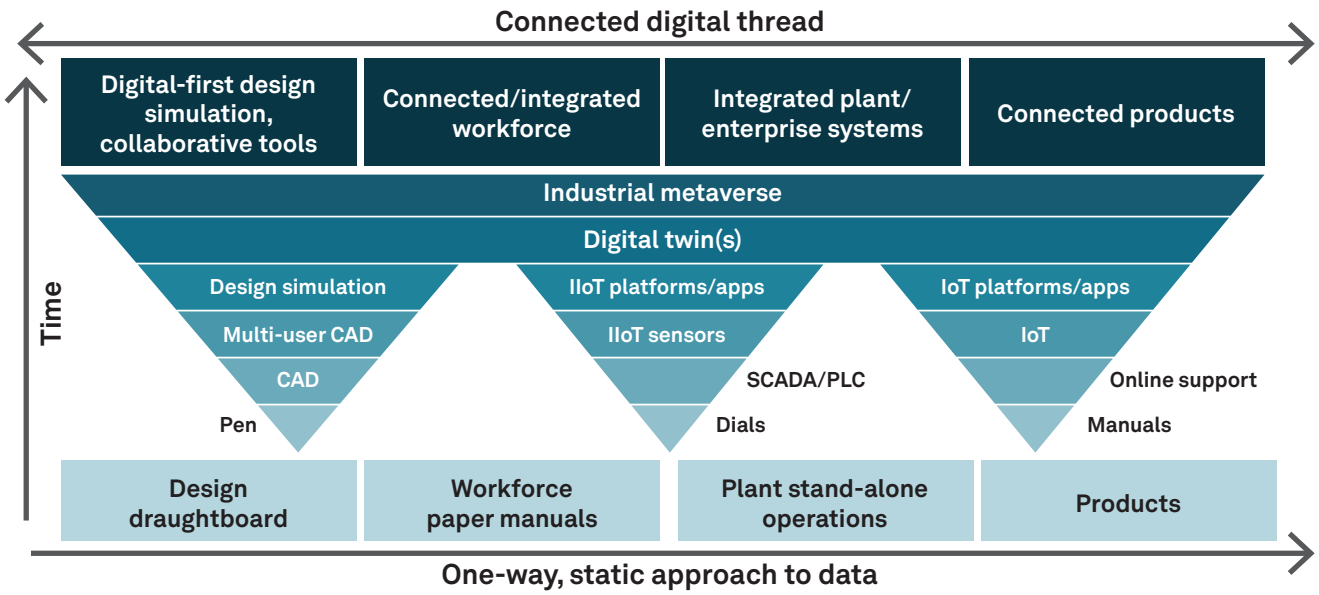
The large pack of Challengers is not far behind the Leaders in terms of the number of metaverse use cases deployed. However, the maturity of Challengers' digital transformation is far more nascent and often even trails that of companies with fewer metaverse use cases (Explorers, Observers). As with other digital projects in industrial settings, many organizations have highly siloed efforts, where each department, region or site may pursue its own efforts, forming a fragmented installed base of digital projects.

However, metaverse maturity doesn't equal digital maturity; organizations with more established digital programs may not have implemented industrial metaverse at scale, or vice versa. In fact, a relatively high share of Explorers and Observers show a level of enterprise-wide and departmental digital transformation comparable to many Leaders. These segments also report usage of key technologies critical to digital transformation — i.e., AI/ML, IIoT, cloud, etc. — at similar rates to those of Leaders.

The evolution: From IIoT to digital twin to industrial metaverse

The industrial metaverse should be viewed as an evolution of the digital transformation of industrial systems. It represents the potential to integrate data and the workforce into a unified, real-time digital system. The digital twin is a key building block that provides a reliable source of "engineering truth" to multiple use cases and applications, accurately reflecting, for instance, the state of plants and processes and the features of new designs and products.

Figure 3: Evolution to industrial metaverse



Source: S&P Global Market Intelligence 451 Research custom metaverse survey, 2024.

Industrial applications have constantly adopted new technology, in many cases integrating the new alongside legacy systems. In the past decade, industrial IoT has transformed isolated physical plants and factories into digitally connected webs of assets. This development has occurred alongside the digital transformation of product design and products themselves. These elements combine in a digital thread through industrial metaverse applications, providing access to a single engineering source of truth, rather than a segmented picture in which each stage — design, manufacturing and shipped product — represents a one-way handover from silo to silo.

Historically, industrial software and systems such as CAD, IIoT, applications and connected products were point solutions for sets of sensors and processes, often leading to disparate digital silos replacing physical ones. This digital patchwork is evolving into a more integrated setup, combining richer unified data and digital twins. These, in turn, become part of a larger, system-wide digital twin and a digital-first life cycle. The workforce interacts in real time with these digital twins and one another.

This integration is at the core of the industrial metaverse, where engineering precision is linked to the physical reality of the plant, leading to a more unified system for greater efficiency. In time, this will form the basis for a "system of systems" — or an "internet of twins" — as supply chain integration and cross-company collaboration increases. Industrial metaverse Leaders — organizations that have implemented enterprise-wide digital transformation and deployed 10 or more metaverse use cases — embody this ongoing shift toward a system-of-systems view.

Digital twin integration:

"It was the idea when the use case was implemented, to standardize that globally, because until today, we would have not hundreds, would have thousands of different digital twins. And with this centralization and standardization, we want to reach, roughly, for each and every different division, five to six digital twins, not more — this is currently our aim. I know that we can't tackle everything there, but at least we get the majority of 90% and be covered. This will be already helpful, and this is our goal for 2028."

VP of IT workplace
Global automotive supplier
10,000+ employees, Europe

Key findings: Business trends

1. **Leading entails both advantages and challenges:** While metaverse Leaders reported significant impact across financial and business outcomes from running several metaverse projects at scale, they face on average more critical barriers and major challenges (5.5) than Challengers (4.7), Explorers (4.9) and Observers (5). Although moving quickly has benefited Leaders with a first-mover advantage, many must overcome growing pains after the resource-intensive effort to implement multiple high-value metaverse use cases.

2. **The market is primed for a "second-mover advantage":** Nearly half (44%) of organizations (Explorers and Challengers) are well-positioned to catch up with Leaders. As mentioned, these organizations cited fewer significant challenges while enjoying significant impact from their use cases. They may also be less bogged down by over-investment in non-interoperable technologies, legacy infrastructure and other technical debt. Moreover, Challengers and Explorers expect to narrow the spending gap on industrial metaverse projects in 2024.

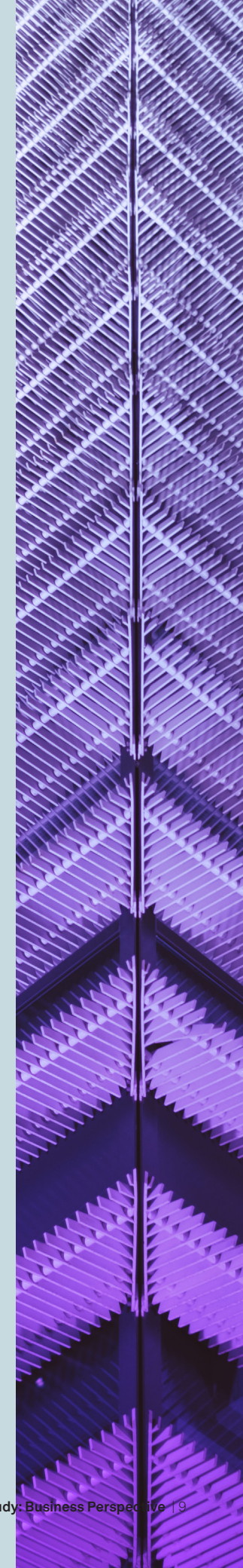
3. **Industrial metaverse spending to rapidly accelerate in 2024:** Despite its nascency, 62% of organizations are increasing industrial metaverse spending from 2023 to 2024. Medium-sized organizations (1,000-5,000 employees) were more likely to report plans for increased spending (68%) compared to their smaller (58%) and larger (58%) counterparts.

4. **Widely adopted use cases are driving high impact:** The most frequently adopted use cases are driving significant impact on critical financial and business outcomes. These include product demonstration and visualization, manufacturing process planning, and employee safety and well-being. While these use cases are spread across the industrial value chain, they quickly drive significant impact on both the top and bottom line. They alleviate business pain points and require relatively fewer resources for implementation.

5. **Digital maturity, a stepping stone to metaverse maturity:** Industrial metaverse Challengers, Explorers and Observers all reported relatively mature digital transformation programs, yet lagged Leaders in industrial metaverse adoption. Organizations with successful industrial metaverse programs, then, must have distinct structures, strategies, best practices and other criteria that are independent of, yet aligned with, their digital transformation strategy.

6. **Partner ecosystems are a metaverse must:** The development of multiple metaverse use cases requires a partnership ecosystem to manage the scale of these complex projects; Leaders preferred partnership strategies to work with multiple systems integrators (32%) and metaverse technology providers (30%).

7. **An inflated perception of digital maturity exists:** Nearly three-quarters (71%) of respondents who have no digital twin integration — which has traditionally been considered a necessity for industrial metaverse applications — think of themselves as somewhat or substantially more digitally mature than their peers.



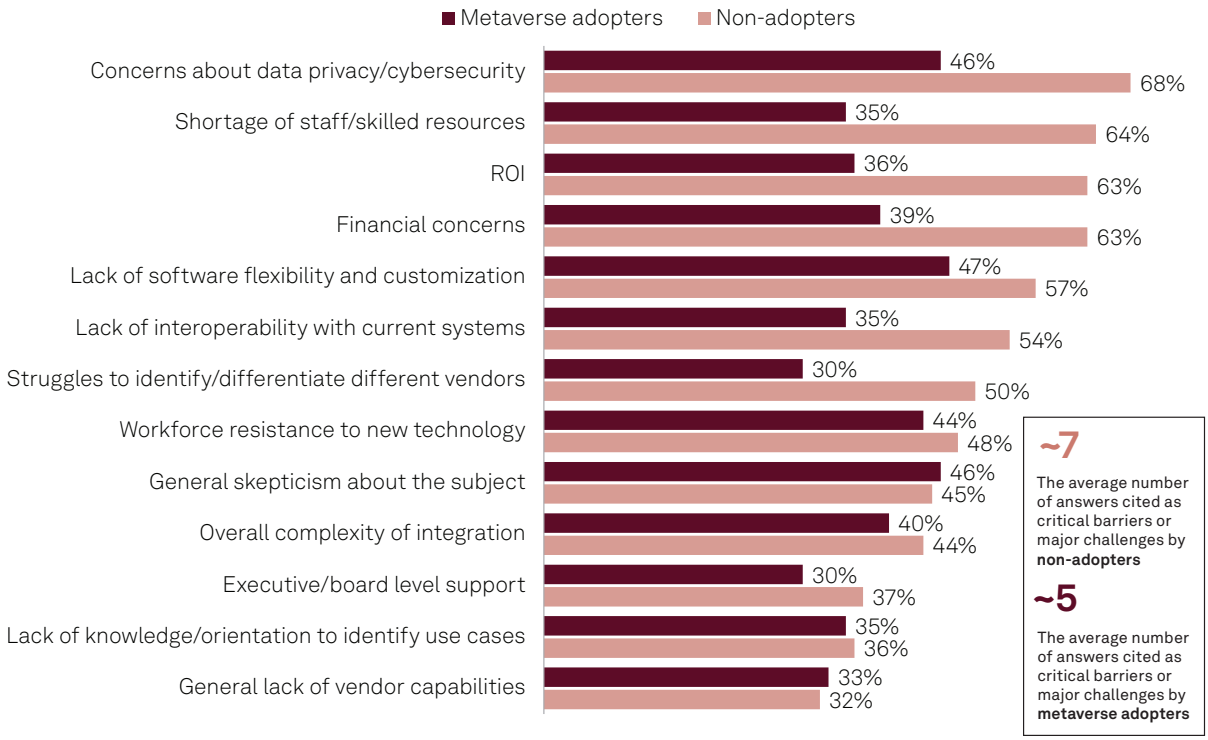
Business trends in the industrial metaverse

Industrial metaverse adopters versus non-adopters

To gain an accurate picture of industrial metaverse adoption, 451 Research asked non-metaverse adopters — who are otherwise not part of this survey — about their perception of challenges. Non-adopters cited far more and different challenges than metaverse adopters; non-adopters cited an average of seven critical barriers or major challenges versus adopters, which cited an average of five.

Non-adopters indicated that a shortage of staff/skilled resources (64%) and financial concerns (63%) are among their top barriers, while metaverse adopters cited lack of software flexibility and customization (48%) as well as workforce resistance to new technology (44%). Those who have successfully navigated the daunting initial adoption challenges are less intimidated by the next set of obstacles; however, the mature stages of adoption bring different (and possibly more) challenges that adopters must navigate.

Figure 4: Metaverse adopters versus non-adopters: Critical barriers/major challenges



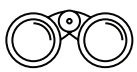
Q. Please rate the primary adoption challenges your organization faces regarding future industrial metaverse-type solutions.
Base: Those who indicated they face a "critical barrier" or "major challenge": those who are currently using or piloting metaverse (n=907); those not using but have aspirations to use longer term (3+ years), or not using and no plans to adopt (n=185).
Source: S&P Global Market Intelligence 451 Research custom metaverse survey, 2024.

Industrial metaverse maturity

Waves of technology innovation have been a disruptive force reshaping global competitive landscapes for decades. Market leaders can harness these innovations to transform their business strategy, operational processes, and products and services to outpace competitors. Smaller companies and startups ride these technology innovation waves to surpass long-standing incumbents. The industrial metaverse is the next great wave: Some organizations have moved rapidly to implement multiple use cases and scale (Leaders), some have installed a few point products on an ad hoc basis (Challengers and Explorers), and some are still watching from afar, having yet to identify a production-ready use case (Observers). However, given metaverse's nascency, where organizations are today on the industrial metaverse wave doesn't necessarily affect their future market standing.

Leaders in the industrial metaverse are distinguished by their early adoption; they are reaping initial financial benefits that come from successful scale. However, there can be a large sunk cost to being first; many first movers reported challenges from investing in now-outdated, unscalable or non-interoperable technologies, commitments from costly digital projects, IT footprints or vendor lock-in. Leaders, on average, also cited more critical barriers and major challenges (5.5) than maturity-lagging peers.

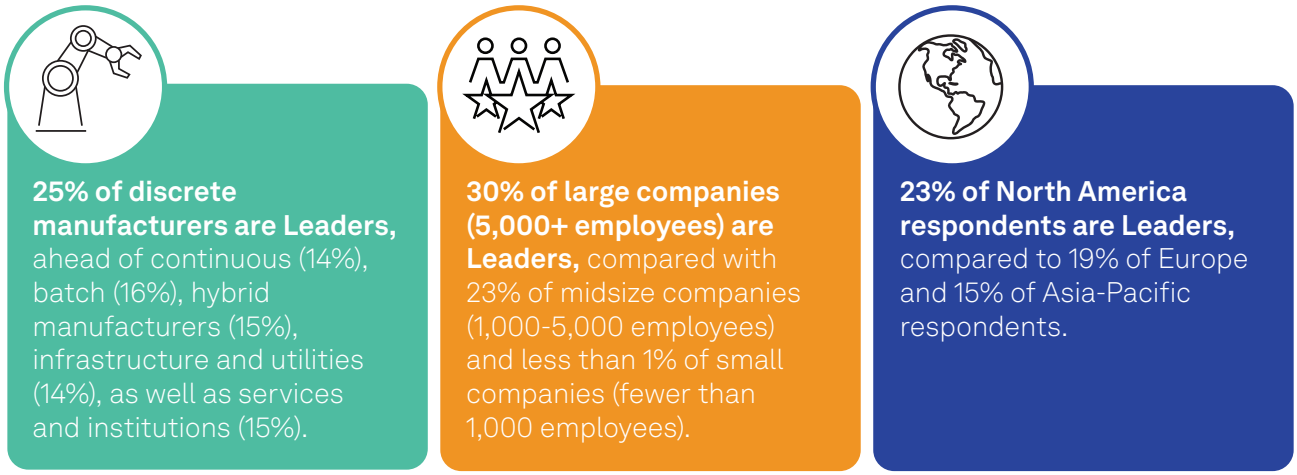
Challengers and Explorers are primed for a possible "second-mover advantage" by implementing the latest technology developments across the industrial metaverse, AR/VR/mixed reality (MR), cloud, IIoT, digital twins and AI/ML. There is a case to be made that many in this category have been more scrupulous in decision-making, limiting industrial metaverse use cases to a few high-impact ones instead of a greater number of less-impactful ones. Additionally, the industrial metaverse project spending gap will shrink among Leaders, Explorers and Challengers; 77% of Leaders, 71% of Explorers and 60% of Challengers expect to spend more than $1 million on industrial metaverse projects in 2024 compared to 57%, 40% and 25%, respectively, in 2023.



Observers have focused on foundational technologies such as IIoT but have yet to implement a single metaverse use case in a production environment. Many Observers are likely facing stalled projects and the challenges associated with "pilot purgatory." However, they still have opportunities to fast-track use cases into production and reap financial benefits in their organization.

Regardless of the potential opportunities for second movers and even third movers, industrial metaverse leaders have earned and recognized strategic, business and financial advantages from being first. These Leaders vary by industry, manufacturing processes, company size, respondent seniority and several other factors.

Figure 5: Leader firmographics



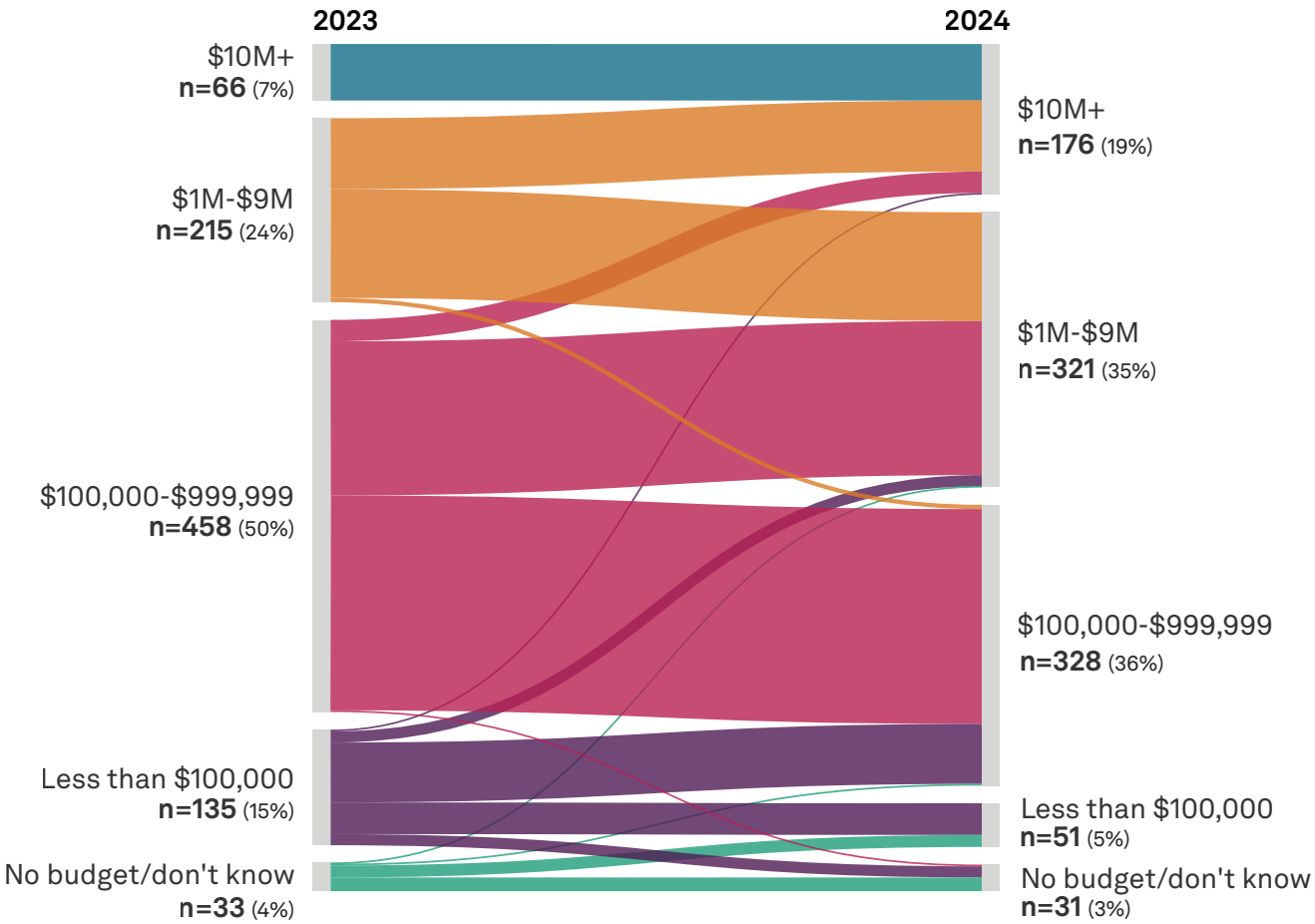
Source: S&P Global Market Intelligence 451 Research custom metaverse survey, 2024.

- **Industry and manufacturing types:** Discrete manufacturers are turning more quickly than their continuous manufacturing counterparts to industrial metaverse applications for product and service differentiation. Most operate in highly competitive markets that require complex and customized products at a rapid pace and high volume, so use cases for manufacturing process planning and product demonstration and visualization are natural fits. Industries that have a higher proportion of respondent Leaders include automotive (29% of all automotive respondents are leaders), datacenter services (28%), electronics (26%), food and beverage (26%), industrial products (38%) and vehicle charging infrastructure (38%).
- **Company size:** Larger organizations with generally larger budgets and greater access to resources and technical skill sets, unsurprisingly, have a higher proportion of respondents (30%) in the Leaders category.

Company-size and metaverse spending deep dive

Industrial organizations have sizable physical operations that require both up-front and ongoing capital investments. The priority for IT spending typically is to maintain industrial operations — or "keep the lights on." With tightened margins and less access to capital, industrial companies' budgets for emerging technologies may be limited, so monetary allocations must be reserved for opportunities that will bring the greatest benefit.

Figure 6: Industrial metaverse spending analysis (2023 versus 2024)

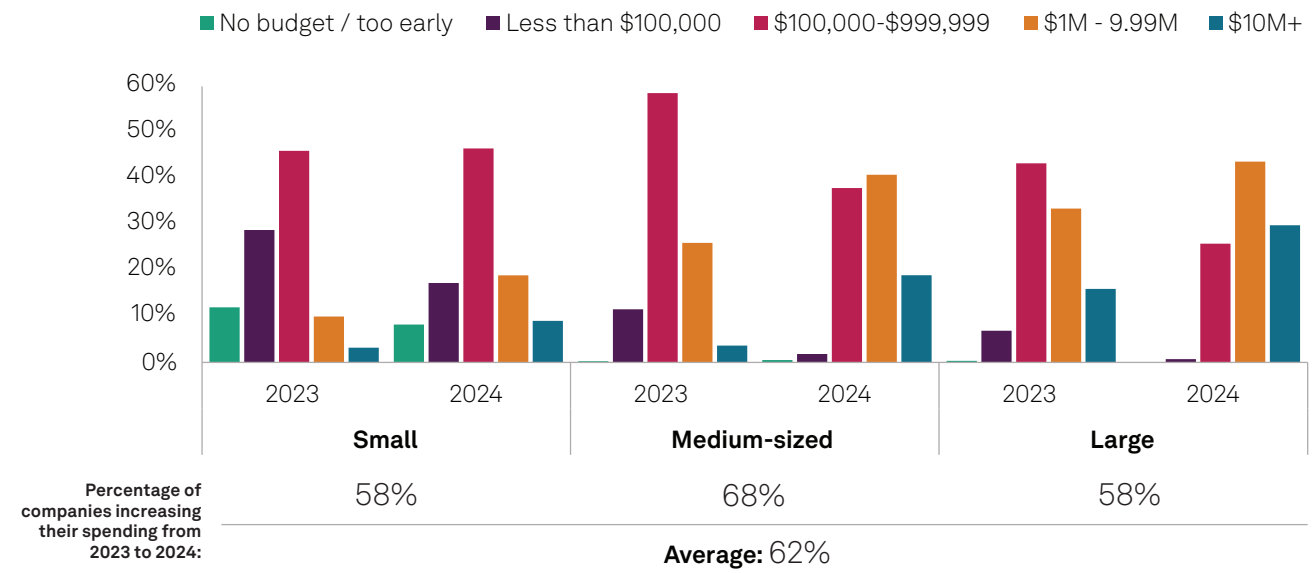


Q. Approximately, what was your organization's 2023 budget for industrial metaverse projects? And, looking ahead, what is your organization's approximate planned budget for 2024?
Base: All respondents (n=907).
Source: S&P Global Market Intelligence 451 Research custom metaverse survey, 2024.

The recognized value of industrial metaverse is reflected in organizations' significant — and growing — investments. Well over half (62%) of survey respondents are planning to increase their budget from 2023 to 2024, and some are making sizable year-over-year jumps. For example, of the 458 organizations that spent between $100,000 and $999,000 in 2023, 180 (39%) plan to spend $1 million-$9.9 million in 2024. Out of 215 organizations that spent $1 million-$9.9 million in 2023, 83 (39%) plan to increase their spending to $10 million or more in 2024.

Dedicating annual spending to any emerging technology is heavily scrutinized in organizations of all sizes. Large organizations (5,000+ employees) with typically more mature digital programs and greater access to resources and capital, unsurprisingly, had the greatest proportion of $1 million-$9.9 million spenders in 2023 (33%), and that percentage is expected to increase to 44% in 2024.

Figure 7: Metaverse spending comparison by company size (2023 versus 2024)



Q. Approximately, what was your organization's 2023 budget for industrial metaverse projects? And, looking ahead, what is your organization's approximate planned budget for 2024?
Base: All respondents (n=907).
Source: S&P Global Market Intelligence 451 Research custom metaverse survey, 2024.

The proportion of large companies spending $10 million or more on industrial metaverse nearly doubled from 2023 (16%) to 2024 (30%). With 58% of large organizations increasing spending across the board, the bulk (74%) will be spending more than $1 million on metaverse in 2024. However, a proportionally greater percentage of medium-sized companies (1,000-4,999 employees) are increasing their spending year over year (68%) than both their larger and smaller counterparts.

Perspectives from the metaverse

Leaders

Partner competencies

"We work with a number of solutions, so integration of any software solution in our landscape is hugely important so we can make it fully integrated that includes pre-built APIs and native integrations. Another important aspect is scale, we need it to support our global operations, which is an issue in small providers. We look at cost, particularly vendors that offer consumption based rather than fixed costs."

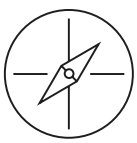
Regional CIO
Global beverage manufacturer, 10,000+ employees, Europe

Challengers

Sustainability

"[Key strategies] You need to increase... your performance, and for my corporation, tied for the first place is results around sustainability. Sustainability is a major factor now. It's actually, we balance performance with sustainability. What kind of a carbon footprint are we producing in the manufacturing space is particularly acute because manufacturing is the ultimate bleeder. That's where most of your carbon intensity comes from. Immediately following that is the priorities around security resiliency, operations efficiency and cost-effectiveness."

Global head of cloud and infrastructure
Pharmaceuticals, >50,000 employees, North America

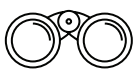


Explorers

Scale

"The biggest pain point is from having a successful pilot with a new technology and then rolling it out, to especially the decentralized locations, because we're covering almost all of Western [country] and very rural areas. We have over 6,000 people working for us, and they're spread over half of [country]. We need to really reach all those people with new tools, new ways of working, and that's a tough challenge."

Head of digitalization
Electricity distribution, 5,000-9,999 employees, Europe



Observers

Workforce

"My main challenge for next year will be to contribute to first find, then onboard, and then to train those resources. That's a top business priority."

CIO
Rail infrastructure/passenger ops, 1,000-4,999 employees, North America

Data

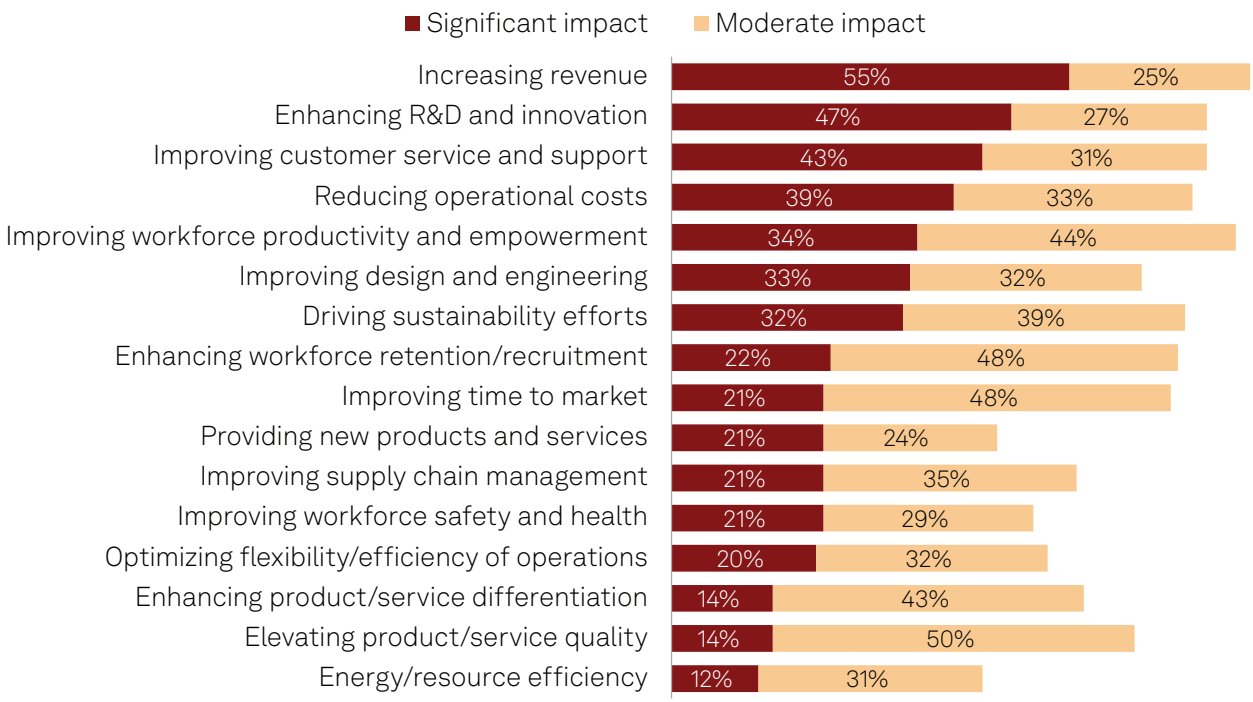
"We have tons of sensor data that we will need to collect, bring them into consistent data format, to be then able to evaluate the data and work with that data."

CIO
Rail infrastructure/passenger ops, 1,000-4,999 employees, North America

Reasons to invest: Business impact of use cases

The survey findings provide valuable insights into areas of interest and impact related to industrial metaverse use cases, illuminating the rationale behind both early adoption and increasing investment in this transformative technology.

Figure 8: Industrial metaverse use cases — business impact



Q. Please rate the impact of your organization's industrial metaverse use cases/planned use cases on the following business and financial outcomes.
Base: All respondents (n=734).
Source: S&P Global Market Intelligence 451 Research custom metaverse survey, 2024.

Business outcomes attainable by organizations that use industrial metaverse span the industrial value chain and organizational hierarchies. Increasing revenue (55% of respondents cited this as having a significant impact), reducing operational costs (39%) and driving sustainability efforts (32%) are top industrial metaverse outcomes and strategic imperatives for industrial C-suite executives. Industrial metaverse outcomes also find their way into a variety of departments across product and service life cycles. They initiate in engineering by spurring R&D innovation (47%) and improving design and engineering (33%), as well as in manufacturing by optimizing flexibility and efficiency of operations (20%), in people-oriented tasks by improving workforce productivity and empowerment (34%) and in customer-facing activities such as improving customer service and support (43%), among countless others.

Figure 9: Top financial and business impacts from industrial metaverse

Top financial and business impacts from industrial metaverse	Leaders	Challengers	Explorers	Observers
Top answer (% who said significant impact)	Enhancing R&D innovation (57%)	Increasing revenue (58%)	Increasing revenue (62%)	Increasing revenue (46%)
2nd	Increasing revenue (54%)	Enhancing R&D innovation (48%)	Enhancing R&D innovation (44%)	Improving customer service/support (43%)
3rd	Improving customer service/support (42%)	Improving customer service/support (46%)	Reducing operational costs (35%)	Improving workforce productivity (38%)
4th	Reducing operational costs (40%)	Improving design and engineering (33%)	Improving customer service/support (35%)	Enhancing R&D innovation (35%)
5th	Improving design and engineering (37%)	Driving sustainability efforts (33%)	Improving workforce productivity (35%)	Improving design and engineering (35%)

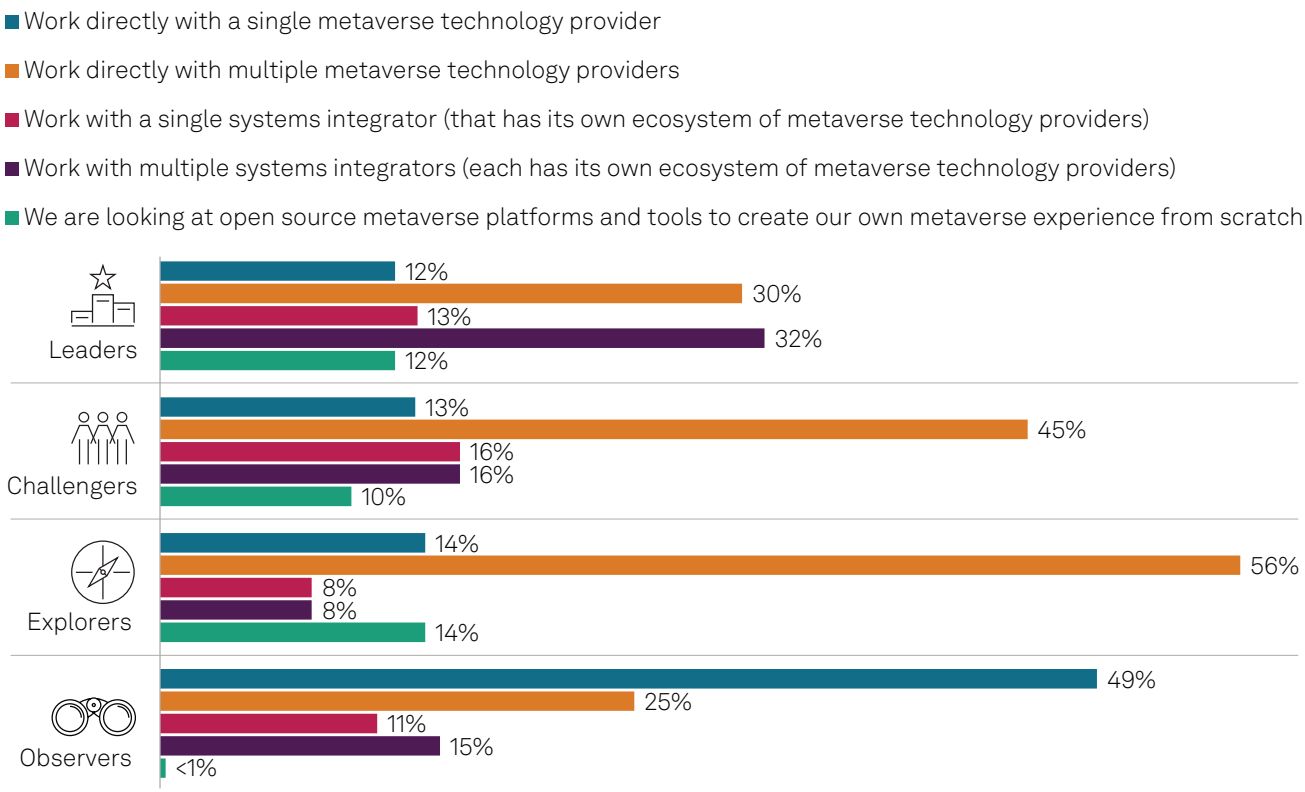
Source: S&P Global Market Intelligence 451 Research custom metaverse survey, 2024.

Leaders, Challengers and Explorers cited many of the same financial and business benefits of industrial metaverse use cases, particularly in driving revenue growth and enhancing R&D innovation. This consistent focus underscores the broad recognition of the industrial metaverse's potential to drive top-line growth and innovation, even though the scale of impact may vary. In contrast, Observers placed less emphasis on innovation: Only 35% cited potential significant impact on R&D innovation. Observers might be misinterpreting the possible transformative benefits of industrial metaverse technologies that other maturity segments are leveraging to drive substantial gains.

Metaverse partnership landscape and strategy

Partnerships and collaborations are a significant part of industrial metaverse development given the broad range of use cases, existing plant and equipment and overall size of the industrial sector worldwide. In the survey, we asked respondents about partner perceptions and competencies.

Figure 10: Metaverse partner strategy



Q. What type of provider are you/would you partner with to deliver industrial metaverse solutions? (or, would you design and build your own metaverse solutions in-house?).
Base: All respondents (n=907).
Source: S&P Global Market Intelligence 451 Research custom metaverse survey, 2024.

Leaders, Challengers, Explorers and Observers are all at different points of maturity across use cases, sites, departments, users and other factors. Industrial metaverse project maturity is a significant driver and indicator of each category's perception of industrial metaverse partners, who they work with and what they value.

- **Leaders**: Leaders are more often implementing strategies involving multiple systems integrators (32%) and technology providers (30%). They have successfully scaled several use cases across multiple sites or departments. As a result, they often require more intensive external support to manage these complex environments.
- **Challengers**: Despite having only slightly fewer use cases (8-9) than Leaders (10+), Challengers exhibit significant variance in partner strategy, with multiple technology providers (45%) the most cited partner strategy. This points to possible shortcomings in Challengers' approach, as they lack an "enterprise-wide digital transformation strategy." Consequently, they aren't leveraging systems integrators to a significant extent, potentially from a lack of interoperability and cohesion between digital and metaverse use cases.
- **Explorers**: Similarly, a high percentage of Explorers reported multiple technology provider partners (56%), suggesting that heavy participation from systems integrators may not yet have been recognized as a need.
- **Observers**: Observers typically lack project maturity and scale, which means they frequently work with just one metaverse technology provider (49%). In most instances, they are limited to trialing metaverse technologies in proofs of concept, pilots or informal plans. Observers may be waiting for a single partner organization to take their metaverse ambitions to full-scale reality.

Conclusions

Given the complexity of the challenge and abundance of information, what are tangible steps industrial organizations can take to form, revitalize or propel their metaverse strategy?

1. **Start small:** Look for strategic, enterprise-wide approaches, but start small with targeted use cases that can drive significant and immediate value. These use cases also drive the development of foundational architectures that evolving use cases can be layered upon.
2. **Think big:** It's crucial to adopt systemic thinking and enterprise-wide architecture rather than rely on point products that lead to pilot and scaling purgatory. This will often require starting with data integration, combining existing sources and potentially deploying or integrating multiple digital twins.

Start small, think big

"We want to move with technologies, and we want to be a leader in the market. At the same time, we need to be cautious in moving too fast. And because people who move fast make mistakes and waste money, and it does not deliver the expected results and sometimes it can backfire, we want to take one step at a time."

CIO
Machinery & equipment
10,000+ employees, North America

3. **Developing a digital-native skill set:** While previous IIoT initiatives have been concerned primarily with instrumentation of industrial machinery, they should now prioritize selecting appropriate digital tools for the workforce. This is needed to attract a new generation of engineers to alleviate a global skills gap and maximize a system-wide approach to digital transformation.
4. **Weave a data fabric to form a single source of truth:** The emergent industrial metaverse is the natural evolution of the digital transformation of industry. Unifying data across processes is key to creating a single source of truth.
5. **Formalize digital or metaverse teams:** In parallel with the unification of data, it is imperative to formalize dedicated digital/metaverse teams. These teams, combining IT and operational technology expertise, play a crucial role in integrating the concepts of software and physical engineering.
6. **Partner with vendors that have key technical competencies:** No single organization can undertake large-scale enterprise-wide metaverse projects alone; partners with key technical capabilities and domain knowledge are necessary. A key consideration across the ecosystem is interoperability. This forms the basis to leverage cloud services and AI/ML/GenAI. Embracing open source, or at the very least adhering to open standards for rich simulation and 3D data, is essential to avoid silos.

Interoperability and scale

"We work with a number of solutions, so integration of any software solution in our landscape is hugely important so we can make it fully integrated. That includes pre-built APIs and native integrations. Another important aspect is scale. We need it to support our global operations, which is an issue in small providers. We look at cost, particularly vendors that offer consumption-based rather than fixed costs."

Regional CIO
Global beverage manufacturer
10,000+ employees, Europe

7. **Metaverse maturity dictates current actions:** What organziations should do next will depend on where they are on the metaverse maturity curve.
   - **Leaders** should pursue further digital twin integration as use-case applications mature and standards continue to develop for interoperability. Unifying fragmented data silos is crucial. Leaders can stay ahead of the pack by driving next-generation metaverse use cases and engendering a culture that quickly extracts value from emerging technologies.
   - **Challengers** and **Explorers** should ensure that explored use cases fit into an open and interoperable future. Consider, for example, whether a given use case also produces data that can contribute to a unified digital twin of the entire system.
   - **Observers** still have time to leverage the efficiencies of industrial metaverse to harness the evolution of industrial IoT instrumentation, predictive maintenance and autonomous robotics, among other use cases and technology innovations.
8. **Do not wait for AR, VR hardware:** Industrial metaverse is not tied exclusively to AR and VR hardware, though these devices can enhance some use cases. At its core, the focus is on utilizing data and digital twins across the industrial life cycle, facilitating real-time interaction among people, devices and applications. Be aware that without a systemic approach, hardware such as AR and VR can create a non-scalable silo, slowing down the wider systemic adoption and benefits of metaverse approaches. Many companies have AR and VR applications, regardless of their actual metaverse maturity.

It is still early in the metaverse maturity journey, and well-informed decisions aligning strategy, business priorities, technical competencies and key stakeholders can propel an organization at any stage toward becoming a leader in both the emergent industrial metaverse and among its industry peers.

Methodology

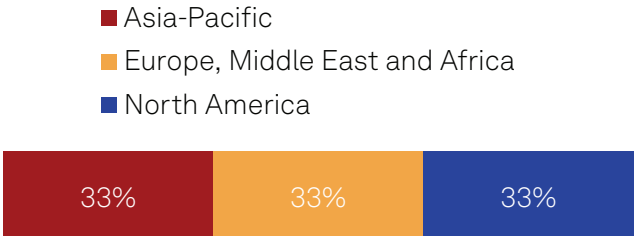
The findings presented in this report draw on a survey fielded in North America, Europe and Asia-Pacific in Q1 2024. The survey initially included 1,092 respondents but screened out 185 organizations that did not have plans to develop metaverse use cases within three years.

The industrial metaverse research study focused on 907 industrial metaverse decision-makers and leaders in organizations with more than 100 employees. The study prioritized respondents with industrial metaverse deployed in pilot and production environments. The research participants were spread across the following manufacturing industries: aerospace, automotive, batteries, chemicals, consumer goods, electronics, food and beverage, machine/industrial products, oil and gas, pharmaceuticals and life sciences, semiconductors and other manufacturing subsectors.

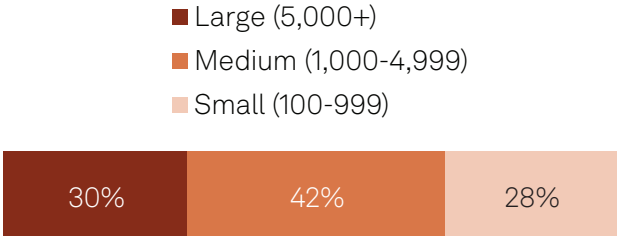
Additionally, there was industry representation from industrial and other related verticals: vehicle charging infrastructure, commercial building, healthcare, higher education, power utilities and rail. Respondent roles were a mix of C-suite, VP-level and directors, and there was a near-even split between respondents in IT, digital and innovation teams and OT/line-of-business. This report also draws on contextual knowledge of additional research conducted by S&P Global Market Intelligence as well as in-depth interviews with similar firmographic representation.

Research firmographics

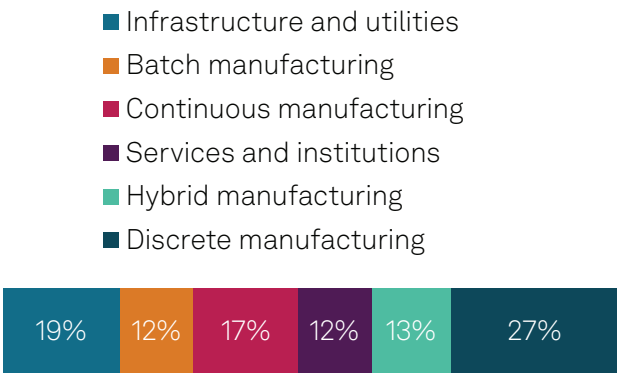
Region



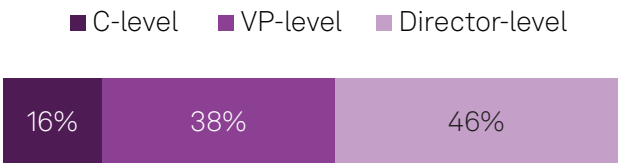
Organization size (number of employees)



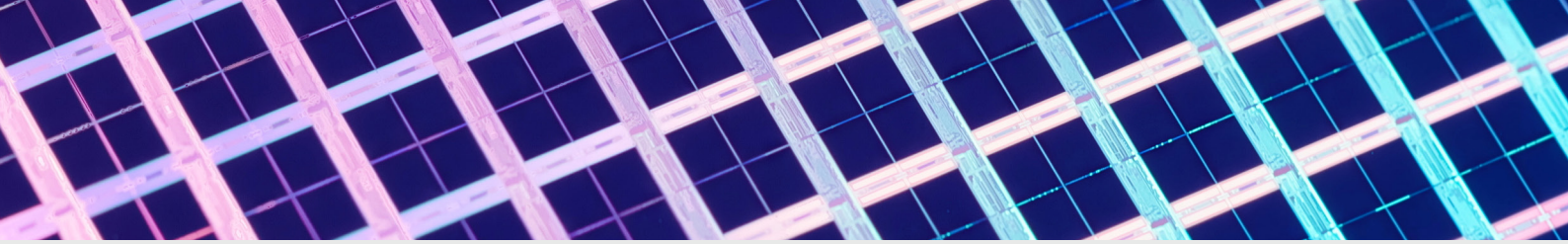
Industry and manufacturing type



Job role/seniority



Source: S&P Global Market Intelligence 451 Research custom metaverse survey, 2024.



Content provided by SIEMENS

Is the Industrial Metaverse for You?

The results of this report clearly show that more businesses are embracing the industrial metaverse, with growing investment particularly from smaller companies and those just starting out. Early use cases are becoming more prevalent, mature, and interconnected, creating significant impact and value. Businesses are already experiencing enhanced innovation, increased revenue, improved customer service, and optimized operations.

However, significant challenges remain, including interoperability issues, a lack of skilled personnel, and the complexity of implementation. Facing these problems, you might ask: is the industrial metaverse really for me? Is it worth the effort? How do I compare to others in my industry? Depending on your maturity level, you might also wonder where to start or what to do next.

To help you navigate these challenges and seize the opportunities, Siemens and 451 Research have developed an online self-assessment tool designed to evaluate your industrial metaverse maturity. This tool provides insights and recommendations tailored to your specific situation and goals. By understanding your current position and identifying the next steps, you can strategically plan your journey towards embracing the industrial metaverse.

Additionally, exploring flexible and interoperable solutions can facilitate this transition. Digital business platforms like Siemens Xcelerator offer scalable options that integrate seamlessly with existing systems, providing a gateway to the industrial metaverse.

We invite you to take the self-assessment and discover how you can leverage the industrial metaverse to drive innovation, efficiency, and competitive advantage in your business. Click here to get started.

About the authors

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David Immerman is a consulting analyst at S&P Global Market Intelligence. He is responsible for executing on a range of custom research initiatives and development of thought leadership across technology sectors including industrial IoT, digital transformation, edge computing, AI/machine learning and fintech, among others, and verticals such as manufacturing and automotive.

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Ian Hughes is a senior research analyst at S&P Global Market Intelligence and has been covering the evolution of industrial IoT from the basics of instrumentation to richer data applications such as predictive maintenance and machine learning at the edge. This coverage is now moving toward digital twins and the real-time industrial metaverse. He looks at changes to the way we interact with technology, and one another, through AI, IoT, game technology and media across what will become the metaverse at work and play.

About this report

A Discovery report is a study based on primary research survey data that assesses the market dynamics of a key enterprise technology segment through the lens of the "on the ground" experience and opinions of real practitioners — what they are doing, and why they are doing it.

About S&P Global Market Intelligence

At S&P Global Market Intelligence, we understand the importance of accurate, deep and insightful information. Our team of experts delivers unrivaled insights and leading data and technology solutions, partnering with customers to expand their perspective, operate with confidence, and make decisions with conviction.

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