McKinsey & Company

McKinsey Technology Trends Outlook 2022

Immersive-reality technologies

August 2022

What is this trend about?

The immersive-reality space has 4 key components

Technology	**Blending technology into the world …**	to see the **world differently …**		… or see a **different world**
				
	Spatial computing Software enables interaction	**Mixed reality (MR)** Graphics linked to reality	**Augmented reality (AR)** Information not linked to reality	**Virtual reality (VR)** 100% computer graphics
Description	Interprets physical space and introduces virtual 3-D objects, allowing users to **interact with environments that feature virtual elements**	**Modifies the real world** through a device, augmenting or diminishing the user's view of the world	**Interacts directly with** and **overlays** onto the dynamic **external reality** (eg, AR glasses with live translation); runs **interactively in 3-D** and real time	**Replaces the real world** (eg, via headsets) by **placing** the **user in** an **entirely digital experience** that uses external cameras/ sensors to render movements in virtual worlds
Experience	N/A	**Merging of reality and MR:** User's sense of being immersed is gone	**Partly immersive:** User holds a sense of presence in the real world with digital overlay	**Fully immersive:** User's visual sensation is controlled by the system inside the virtual world

Immersive-reality technologies will have a significant role to play in the metaverse

Source: McKinsey analysis

What is this trend about? (continued)

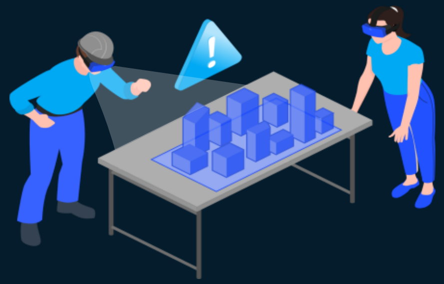
Most mature immersive-reality solutions fall under a few key themes

Not exhaustive

Learning and assessment

Learning and training: Hands-on skills and procedures training—especially useful for simulating unusual or dangerous edge cases that are difficult to simulate safely in real life, thus building muscle memory

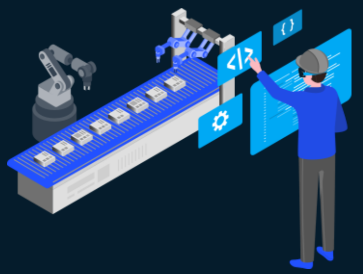
Assessment: Use of the same infrastructure (eg, 3-D models, procedure rules) to stress-test the workforce's knowledge, skill, and capability in safety and efficiency and target further training needs



Product design and development

Product design: Creation of digital twins to enable virtual walk-throughs of a physical environment (eg, construction site) or a physical product (eg, new space satellite), enabling more efficient product prototyping and test simulations

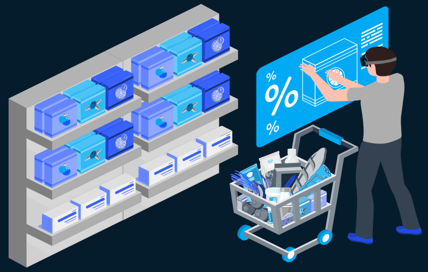
Development: Simulation of process design, such as a software engineer "grabbing" blocks of code overlaid virtually onto factory equipment to redesign the process flow, then pushing the equipment back into production



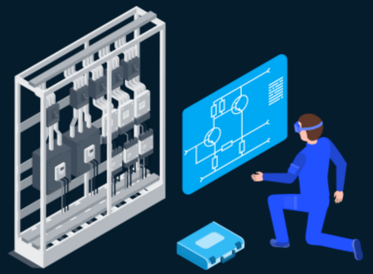
Enhanced situational awareness

Overlay of data visualization enables more productive assessment of situations

Retail example: Store manager observes store while wearing AR glasses that display sales data overlaid on sections and products

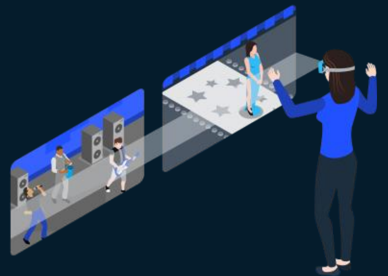


Manufacturing example: Lead engineer conducts factory operations and maintenance remotely; VR tech enables workers to conduct virtual walk-throughs, with visualized data and pop-up decision options for areas requiring maintenance or repair



B2C use cases (eg, gaming, fitness, retail)

Live events: Gaming, virtual workouts, and other virtual events mimicking real-life experiences such as concerts, conferences, sporting events, and fashion shows



Virtual showroom: Shopping by virtually walking through stores, trying on new products, etc

Source: McKinsey analysis

Why should leaders pay attention?

Overall trends

~$1.2 trillion market size by 2035

Global immersive-reality market size is expected to grow at a CAGR of ~24% until 2035, facilitated by several factors, including increased use of smartphones and connected devices and rising adoption of 5G networks

Increasing innovation

2× growth in immersive-reality patents from 2018 to 2021

Growing venture capital investments

~$3.9 billion of venture capital investments made into VR/AR start-ups in 2021, the second-best year historically (after ~$4.4 billion in 2018) as venture capital interest recovers from COVID-19 pandemic

2.2× growth in average ticket size from 2020 to 2021; 1.3× growth from 2018

Growing B2B adoption

~66% CAGR in enterprise adoption of AR through 2026

Need for more collaboration platforms (eg, Virbela, ARuVR) triggered by COVID-19 pandemic to enable remote work

Increasing functionality across industries

Product and service enablement

Rapid prototyping (eg, driven by early-stage amendments and powerful visualization) shortens time to market and **reduces costs drastically**

New services unlocked by engaging consumers in new ways

Development and training scalability

Scalability of training expands across all sectors, particularly for non-desk workers (eg, situational/ emergency training without risking users), while ensuring standardization in quality of training

Process improvement

Faster and more efficient processes possible via early-warning-detection mechanisms, risk management, improved quality assurance, reduced assembly/ construction efforts, and reduced guesswork in manual labor

Source: "Demand for augmented reality in enterprise and consumer markets to create US $175 billion AR market by 2026," ABI Research, June 10, 2021; Chris Metinko, "VR/AR investments increase just as metaverse talk heats up—but that may not be the only reason," Crunchbase News, Jan 21, 2022; "Extended reality market size, share, trends, by type," Emergen Research, Feb 2021; McKinsey analysis

What are the most noteworthy technologies?

AR

- Augmented reality (AR) is **a partly immersive** experience in which **users interact directly with a 3-D overlay** onto the **external reality in real time**
- Examples of AR technology devices include AR projections from phone devices, AR windshield on cars, AR glasses
- Capabilities needed to advance this technology include common use higher resolution displays (eg, 8K), more precise eye sensing and tracking technology to reduce lags and errors in display overlay, etc

VR

- Virtual reality is **a fully immersive** digital experience in which **computer-graphics-rendered virtual worlds replace the real world**
- Examples of VR technology devices include headsets for a fully immersive VR experience
- Capabilities needed to accelerate this technology include specialized lower-latency hardware, improved sensors that allow for full-body virtual tracking, etc

Source: McKinsey analysis

Significant advancements are still required for AR/VR and are 8–10 years out

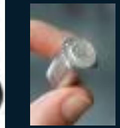
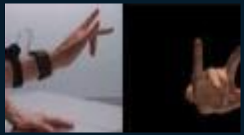
While some capabilities are technically possible today in isolation, **device makers need to consider features** such as battery life, weight, and ergonomics, which adds challenges (eg, 8K displays exist but are too heavy and expensive for common use)

AR requires technology that is significantly superior to that of VR

Unlocking scalability will require **reducing prices by >50%**

What are the most noteworthy technologies? (continued)

A diverse set of sensors and input will be needed, expanding the peripherals market 10−20× from today

Type	Overview	
On-body sensors	On-body sensors are tools to track and identify users and the objects around them to **accurately reflect their limb movements and the physical objects around them in the virtual world** (eg, devices that are handheld or concealed in wearables)	 
Off-body sensors	Off-body sensors allow for more **precise recreation of elements of the physical world** in virtual spaces with consumer applications like Nintendo Wii or enterprise applications such as spatial-mapping hardware	
Haptics	Haptic devices (eg, haptic gloves or vests) **convey the sense of touch to the user** with vibrations to augment virtual experiences	 
Holography and volumetric video	Holograms and volumetric video diffract light across multiple wave fronts to display **high-quality, 3-D representations that can be seen without using a headset** (eg, Microsoft Mesh or Google Project Starline)	
Electromyography (EMG)	EMG is a neuro technology that **detects and records electrical activity from muscles to control movement and manipulate objects** in virtual spaces and is being used in wearables to augment AR/VR headset devices	
Microelectromechanical system (MEMS)	MEMS uses midair ultrasonic waves to **allow users to physically feel tactile experiences without any wearables**	

What disruptions could the trend enable?

Maturity level

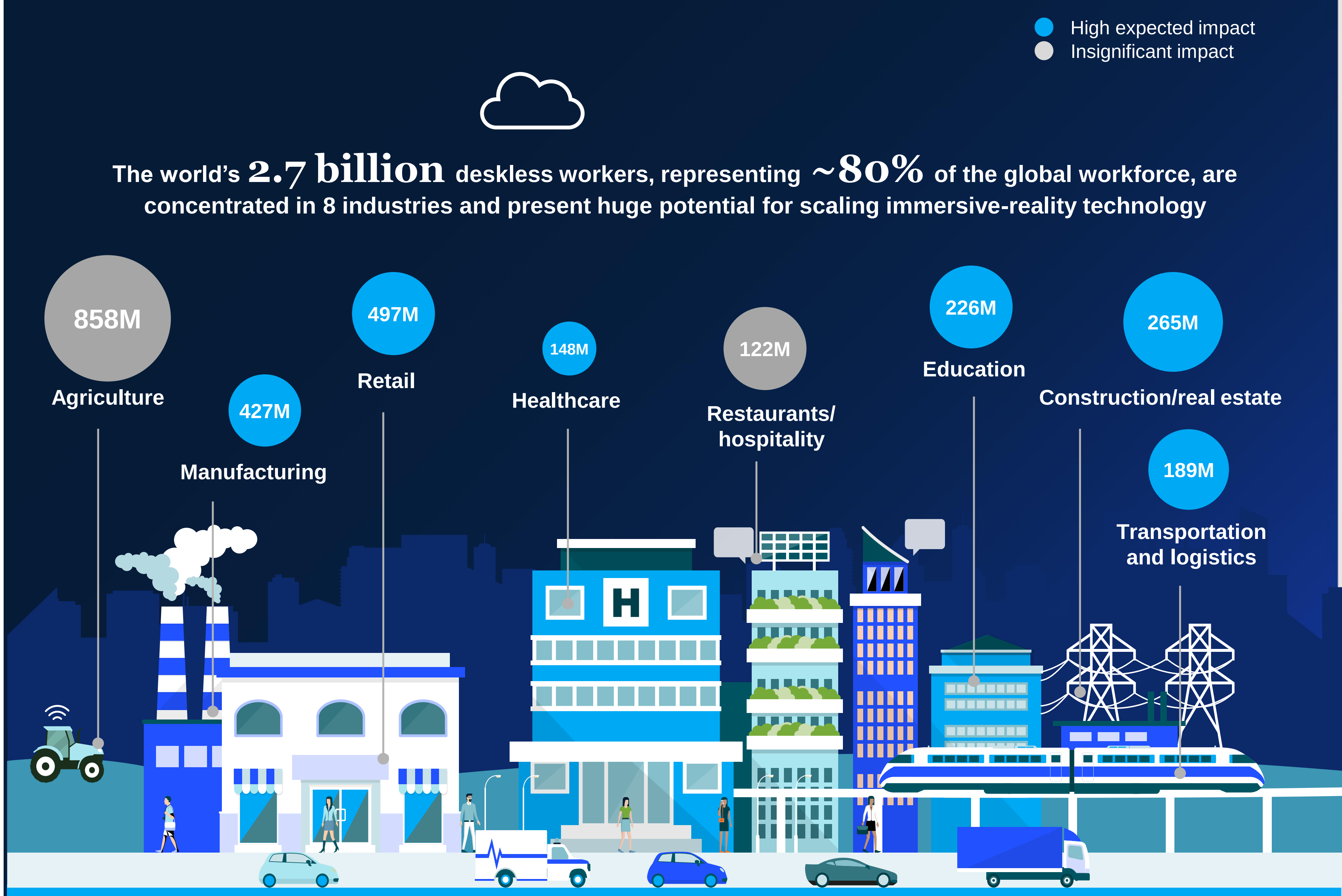
	Near term 0–3 years	**Medium term** 3–10 years	**Long term/end state** 10+ years
AR 	AR **exists mostly as a proof of concept** with **few enterprise use cases;** experiences occur within **narrowly defined environments** (eg, warehouses) and overlay low-fi visuals over the real world	**Consumer AR** is introduced as a **low-fi experience** while **enterprise AR improves**, with augmented visuals interacting more fluidly with external inputs and **usability expanding** out of preprogrammed spaces and use cases	**Consumer AR shrinks and use cases proliferate**, with a seamless digital layer acting as an overlay to the real world; as users navigate fluidly throughout their day, external sensors interpret, interact with, and enhance the physical environment
VR 	**Medium-fidelity VR** experiences offer **limited virtual worlds and experiences;** avatars are manipulated using external peripherals that limit immersion	**High-fidelity** and **comfortable VR** experiences are **available at scale;** avatars are manipulated via body movements captured by sensors	**Virtual worlds** in VR are **almost indistinguishable from real life**, and haptics have improved to give a realistic sense of feel across the body

Source: McKinsey analysis

What industries could be most affected by the trend?

Overall, industries with a higher proportion of non-desk workers are leading in adoption

~75% of deskless workers spend most of their time at work using some form of tech, with >60% reporting lack of satisfaction or feeling the need for improvement in the tech they use

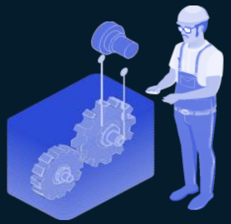
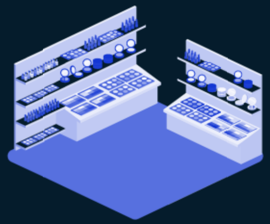
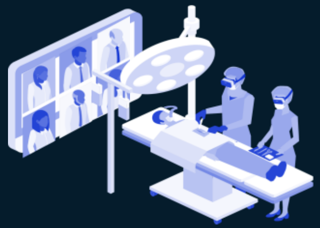


Source: "The rise of the deskless workforce," Emergence, 2018; McKinsey analysis

What industries could be most affected by the trend? (continued)

Use cases are emerging both horizontally and vertically across industries

Not exhaustive

Industry	**Education**	**Automotive and assembly; aerospace and defense**	**Retail**	**Healthcare systems and services**
Example use cases	Learning and development Remote collaboration Field-worker assistance Conferences and events	Digital twins/operations Factory design Product design Training Remote assistance Safety	3-D catalog Virtual store/digital showrooms Interactive try-on Store layout and design Warehouse optimization	Surgical assistance (AR) Telemedicine (mental health, pain management, etc) Imaging/pathology Training R&D/simulations
				
Signifi-cance	**63%** of companies that are metaverse adopters have undertaken learning and development for employees in the metaverse	**~100%** of design of physical products/spaces (eg, factories, warehouses) could be simulated in a synthetic environment	**~33%** of customers who are active on the metaverse have purchased real-world items there	**Increasing efficacy** of immersive-reality solutions in treating mental disorders

Source: Nilufar Baghaei et al., “Extended reality for anxiety and depression therapy amidst mental disorders: A systematic review,” ResearchGate, Mar 2022; “Value creation in the metaverse: The real business of the virtual world,” McKinsey, June 2022

What industries could be most affected by the trend? (continued)

Immersive reality could change the way energy and materials industries operate

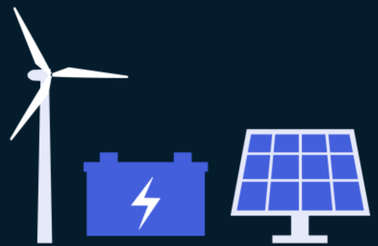
Not exhaustive

Construction and building materials

Creating immersive, virtual environments, giving architects a better sense of a space before it physically exists

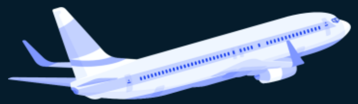
Real estate

Designing interior spaces along with floor and furniture planning, and providing virtual tours of properties to enhance customer experience



Electric power, natural gas, and utilities

Using AR to view overlaid visualization of underground assets and complex components for improved operational safety (eg, advising field technician on what actions to take)



Aviation, travel, and logistics

Diagnosing flow constraints in warehouses and managing vehicle fleets

Media and entertainment

Participating in virtual events mimicking real-life experiences such as concerts, conferences, sporting events, and fashion shows

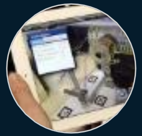
Source: McKinsey analysis

Who has successfully created impact with immersive-reality technologies?

Many industries have started to experiment with AR applications

Information technology and electronics

Fujitsu uses **AR in the sales process** to allow customers to see all product characteristics



Aerospace and defense

Boeing leverages AR to improve manufacturing process efficiency and has achieved a **90% quality increase** and **30% speed increase** on its pilot projects

Aviation, travel, and logistics

Japan Airlines is experimenting with Microsoft HoloLens AR as a **technical training tool** for its maintenance technicians

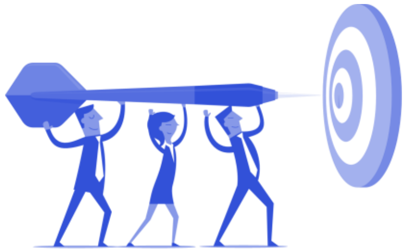
Automotive and assembly

Porsche has **shortened operational time** spent on **addressing issues by 40%** through the use of AR headsets to simulate virtual models of problem vehicles

Source: Company websites

What should leaders consider when engaging with the trend?

Not exhaustive



Benefits

More efficient product prototyping and test simulations through the creation of digital twins to enable virtual walk-throughs of physical environments or new physical products

Process improvement through early-warning-detection mechanisms, risk management, improved quality assurance, on-the-job visual guidance, and more

Introduction of new products and services by engaging consumers in new ways and enhancing customer experiences

Increased collaboration by facilitating more engaging virtual-team interactions, without the need of being physically present

Scalability of trainings by allowing users to develop hands-on skills, especially when simulating unusual situations, all while ensuring consistency in the quality of training provided

Cost savings as a result of effective product development, improved processes, and scalable, quality-assured trainings

Risks and uncertainties

Pace of hardware improvements to enable miniaturization/weight reduction, ruggedness; sensor advances for increased precision, nausea mitigation, etc

Cost reductions required to make many more applications commercially viable and scalable

Uncertainty on whether consumer applications will target niche customer segments or focus broadly on mass markets

End-user devices could take multiple forms, from independent platforms to peripheral accessories for smartphones or a mix of both

Exposure to complex security vulnerabilities must be mitigated, as typical AR/VR applications need access to many technologies (eg, smartphones, body sensors, glasses) and may be linked with social-media accounts and external applications

Concern about user's ability to control what data are collected and how data are processed or shared with third parties (eg, to what extent will users be surveilled?)

Source: McKinsey analysis

What are some topics of debate related to the trend?

Not exhaustive

1	Ways of working	**Will immersive reality shift the new wave of (remote) work?** Many business are reconsidering their remote vs in-person work operating models as COVID-19 measures are relaxed. As immersive-reality tech boosts collaboration and facilitates remote operations, will remote work be here to stay?
2	Scalability	**Will initial ideas continue to stall at proof of concept—or begin to break through to scale? What will be the triggers for breakout success?** Significant tech advancements still required for AR/VR are approximately 8–10 years out. Although some of the required individual capabilities are technically possible today, device makers still need to produce these features (eg, battery life, weight, ergonomics) in conjunction with each other to improve sensory precision, mitigate security and privacy concerns, and broaden consumer applications, among other factors.
3	Enterprise architecture integration	**How will consumer-oriented pioneering platforms integrate with enterprise tech architectures?** Adopting immersive-reality solutions puts a strain on tech architecture. Enterprises will have to evolve their capabilities to integrate with these new technologies while mitigating privacy and security concerns; the investments required to do so are unclear.
4	False information	**To what extent can immersive reality facilitate the spread of false information?** Deepfake technology and mixed reality facilitate misrepresentation (eg, facial-swap features), which could have social implications such as cultural appropriation or the spread of "fake news" for targeted political influence or any other malicious intent.
5	Virtual crimes	**How can virtual crimes be mitigated and regulated?** Ethical questions are emerging around the potential psychological effects of immersive-reality technologies, raising questions around how to deal with different forms of harm, such as virtual violence, bullying, and trespassing.

Source: McKinsey analysis

Additional resources

Related reading

Augmented and virtual reality: The promise and peril of immersive technologies

Product development gets a makeover—with virtual reality

Meet the metaverse: Creating real value in a virtual world

Value creation in the metaverse