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Technology, Media, and Telecommunications Predictions 2023

Contents

Foreword
TMT Predictions 2023

Doing more with less—economic and other factors shift both consumer and enterprise spending in new directions

RISING INFLATION AND interest rates, slowing economies, and plunging consumer confidence have dominated discourses this year. The ripples they generated have heavily influenced the theme for TMT Predictions 2023. Technological innovation and sustainability remain themes, but this year is unusually influenced by external forces.

Rising fuel, utilities, and food costs are forcing many consumers to rethink discretionary spending choices they made during the pandemic. Consumers who were already churning subscription video-on-demand (SVOD) services last year are eagerly shifting to cheaper, ad-supported AVOD services, to the point where we are predicting that all major SVOD services have an AVOD tier by the end of the year. Meanwhile, higher prices at the pumps are making battery electric cars more attractive, driving demand for high-power silicon carbide chips.

Economic conditions are driving a rebound in tech divestitures and growth in M&A activity around gaming as many targets are much cheaper than a year ago. 5G smartphones with a price tag of more than US$1000 aren't quite setting the sales counter on fire; 5G phones for under US$100 are expected

to hit the market sooner than many people think. The chip industry needs to make chips faster and with fewer people, and that's where new kinds of artificial intelligence tools for chip design emerge. Making blockbuster video for all those AVOD viewers takes a lot of time and money… but less time and money if virtual production technologies are used. Meanwhile, retailers are trying to kickstart moribund consumers with social commerce—the multibillion-dollar market you might not know about, but your kids do.

Not everything orbits the economy, of course. We're calling for over 5,000 low Earth orbit satellites by the end of the year, and growth in radiation-hardened chips in higher orbits. Back down on Earth, tech companies are leading other industries in trying to save the planet with many targeting carbon neutrality by 2030.

Economics always matters, of course. It is not yet clear if we're heading for the hoped-for soft landing, with economic recovery by 2024, if not sooner. Or a longer-term period of weakness or stagnation. We look forward to a TMT Predictions 2024 that is not dominated by these issues and returns to an innovation agenda.

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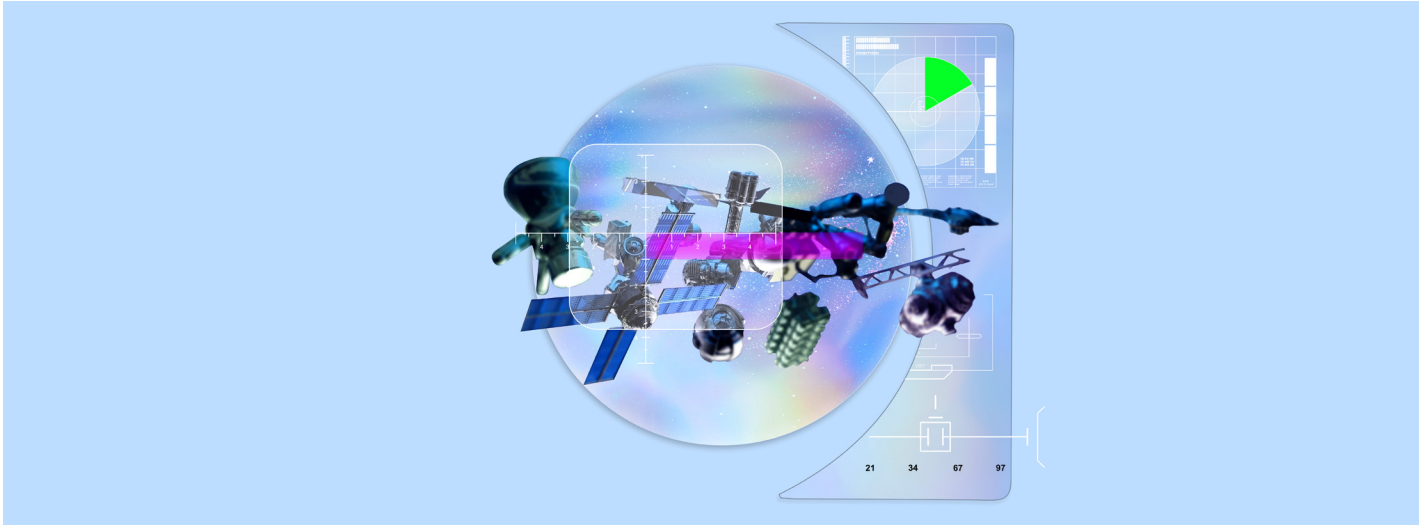
Too congested before we're connected? Broadband satellites will need to navigate a crowded sky

LEO satellites could bring high-speed internet to every corner of the world—if they can stay out of each other's way. Fortunately, adjacent industries are gearing up to help.

David Jarvis, Duncan Stewart, Kevin Westcott, and Ariane Bucaille

N *TMT PREDICTIONS 2020*, we said that low Earth orbit (LEO) satellite broadband constellations would be either a revolution or just a bunch of space junk.[1] Three years later, it still isn't entirely clear which it is—but a lot of companies are betting on the former. Deloitte Global predicts that more than 5,000 broadband satellites will be in LEO by the end of 2023, making up two working constellations providing high-speed internet to nearly a million subscribers on all parts of the planet, no matter how remote. Looking further out, if every organization currently planning to build a LEO constellation succeeds, seven to 10 competing networks could be operational by 2030, with a total of 40,000 to 50,000 satellites serving more than 10 million end users.

Doing choreography … in space

The anticipated surge in satellite broadband deployments spells good news for users. It is likely that new applications will emerge, prices will decline, coverage and reliability will improve, and latency will fall. But several complications could slow the industry down. A much more crowded orbital environment significantly raises the risk of

collisions, requiring higher levels of cooperation and coordination. At the same time, the various national, regional, and global players will likely continue to fight over spectrum, orbital slots, launch capacity, and access to terrestrial markets. Among the major competitors:

SpaceX's Starlink: More than 2,600 working Starlink satellites serving almost half a million subscribers are currently in orbit.[2] Beyond typical consumer use, Starlink has demonstrated its utility for emergency services in a number of recent natural disasters.[3] Multiple airlines have begun exploring and testing the system for high-speed in-flight internet access.[4] SpaceX also received FCC approval to provide mobile connectivity for boats, planes, and other vehicles, fulfilling one of the company's early promises.[5]

Amazon's (Project) Kuiper: Although none of its planned 3,236 satellites are currently in orbit, Amazon announced a multibillion-dollar agreement with three providers in April 2022 to launch most of these satellites over five years.[6] But Amazon will need to hurry: It must have half of its satellites in place by 2026 and the entire constellation in orbit by 2029, or it will lose its FCC authorization.

OneWeb: More than two-thirds of UK-based OneWeb's planned 648 satellites are currently in orbit, and the company is aiming to start global operations by the end of 2023.[7] OneWeb also recently combined with France-based Eutelsat in a US$3.5 billion deal.[8] The combined company intends to focus on enterprise and government connectivity by integrating Eutelsat's geostationary satellites with OneWeb's LEO network.[9]

Additional players include Canada's Telesat, which plans to start launching its 188-satellite Lightspeed network in 2025.[10] Another is Telco-backed AST SpaceMobile, which is planning a constellation of 243 satellites that will allow mobile devices to connect directly to its LEO network.[11] And China,

as part of a national plan, launched six test satellites in March 2022 for the private firm Galaxy Space. China's network may eventually contain up to 13,000 satellites.[12]

The big challenge for these companies? Keeping their satellites out of harm's way. Space surveillance networks currently track more than 31,000 orbiting objects, including more than 6,000 operating satellites.[13] On top of that are an estimated hundreds of thousands of untracked debris fragments, ranging from pieces of destroyed satellites to paint flecks. To keep satellites from colliding with each other and from being struck by debris, it's necessary to know where all those objects are in real time, and with great precision, a discipline known as space situational awareness (SSA). Also essential is effective space traffic management (STM)—that is, robust technical and regulatory standards around launching, operating, and returning satellites to Earth.[14]

Currently, governments generally provide data for SSA, but there are challenges.[15] Dramatically increasing the number of satellites to track could overload the current system from both a technical and operational standpoint. The number of near-collisions—satellites passing within 1 kilometer of each other—has already risen significantly since LEO broadband constellations have started going up.[16]

This challenge is driving the creation and growth of new markets. Prime among these is commercial SSA, which, while niche today, could grow to US$1.4 billion by 2032.[17] SSA providers are building a combination of ground- and space-based sensors along with powerful computer models to track objects in space and predict their orbital paths.[18] A well-developed commercial SSA capability could augment government data and feed a trusted common operating picture. This market can be helped by the funding of the US Office of Space Commerce, which will work to take over civil space traffic management responsibilities as early as 2024.[19]

FIGURE 1

The number of objects launched into low Earth orbit has dramatically increased, driven by commercial satellite constellations

■ Number of objects
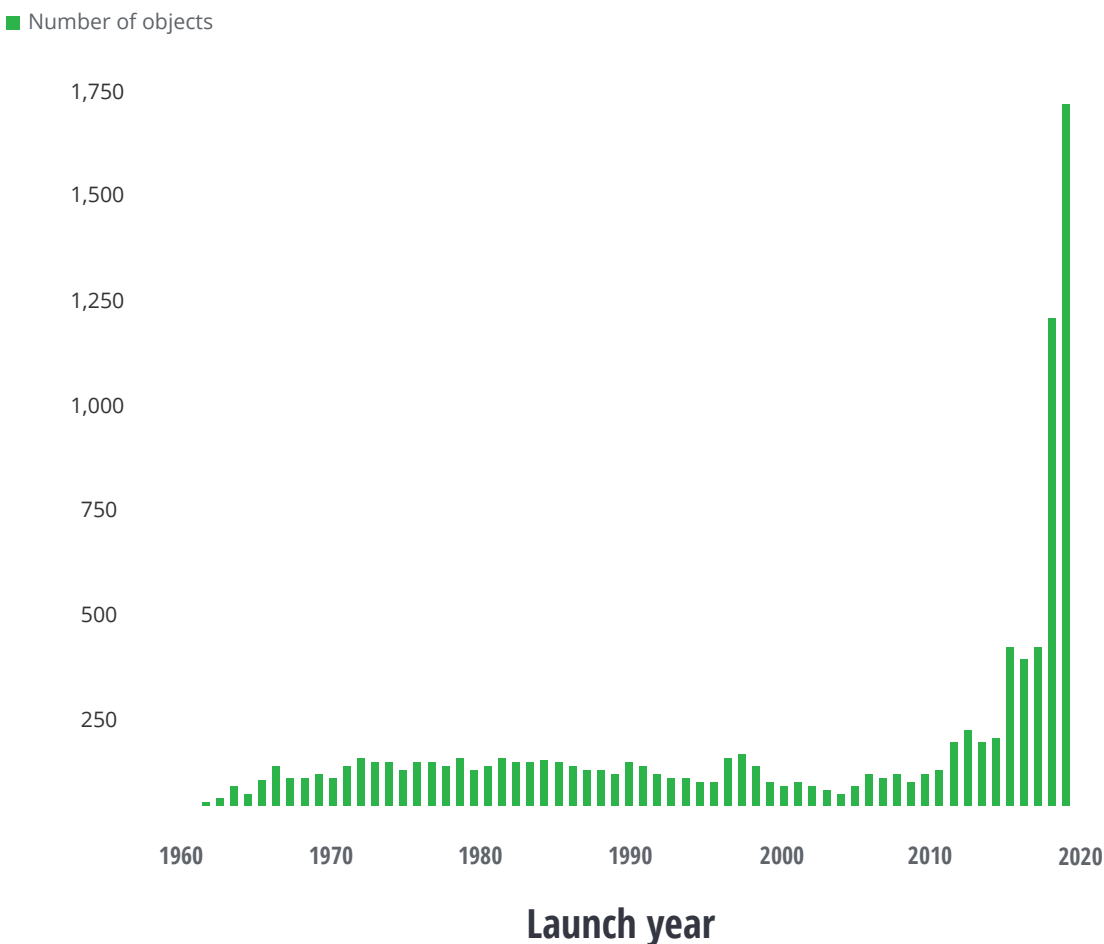
Source: European Space Agency, *ESA's space environment report 2022*, April 22, 2022.

In-orbit satellite servicing and space-debris removal could also receive a boost from LEO satellite constellations. In space-debris removal, a specialized satellite rendezvouses with a dead satellite or object, captures it, and pushes it into a different orbit or the atmosphere to safely burn up. Several proof-of-concept space debris-removal missions have already occurred,[20] and many more are planned in the coming years.[21] In-orbit satellite servicing aims to prolong satellite life: A servicing vehicle could refuel a satellite to extend its usefulness or, if a malfunction occurs, swap out a part to avoid having to scrap the whole thing. The industry-led Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) is currently working to develop standards for this emerging industry.[22]

THE BOTTOM LINE

If the industry continues on its current trajectory, the LEO broadband market will not only grow but also drive the expansion of supporting markets, creating a new and dynamic ecosystem. However, for this ecosystem to be viable in the long term, all involved should focus their attention and resources on protecting the commons of space. Critical uncertainties include:

• How much global cooperation will there be in space traffic management? To what extent will all the players be able to establish and follow formal "rules of the road"?

• Will better-quality SSA data become widely available and used before satellite operators become overwhelmed with managing potential collisions?

• How effectively will improvements in spaceborne computing and processing power, such as those enabled by advanced radiation-hardened chips,[23] facilitate real-time avoidance of debris or other satellites?

• How many more debris-creation events can LEO absorb before things get unsustainable? How will the market respond if things get worse?

So back to the original question: Are LEO satellite constellations a revolution or a bunch of space junk? As we said at the start, the jury's still out. With lots of players in the game and lots of launches to come, the potential for both outcomes still exists—perhaps simultaneously.

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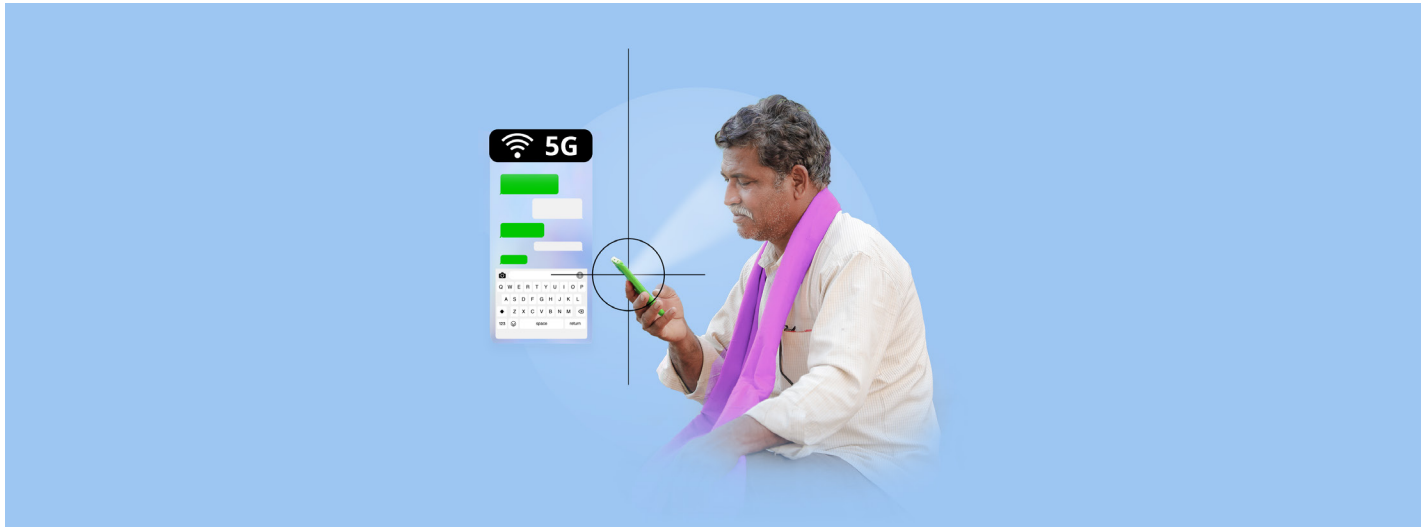
Accessible is possible: Introducing the US$99 5G smartphone

5G phones under US$100 are set to bring advanced wireless to consumers worldwide, with software, ads, and content sales providing the profits.

Ben Stanton, Paul Lee, Craig Wigginton, and Gill Hofmeyr

B ILLIONS OF PEOPLE around the world lack access to any kind of smartphone at all, let alone one with 5G. For many, the cost has been the major barrier—until now. Deloitte Global predicts that 2023 will see the launch of the first 5G smartphones retailing at US$99 or its equivalent in other currencies. These phones will likely represent a very small share of 2023 smartphone sales, but they should eventually make 5G accessible to almost all consumers in almost all markets, accelerating 5G's adoption around the world.

Building phones is cheaper than ever, though vendors will need revenue beyond the sale

A US$99 smartphone may seem far-fetched to consumers in developed economies who might pay upwards of US$1,000 for top-of-the-line models. But devices 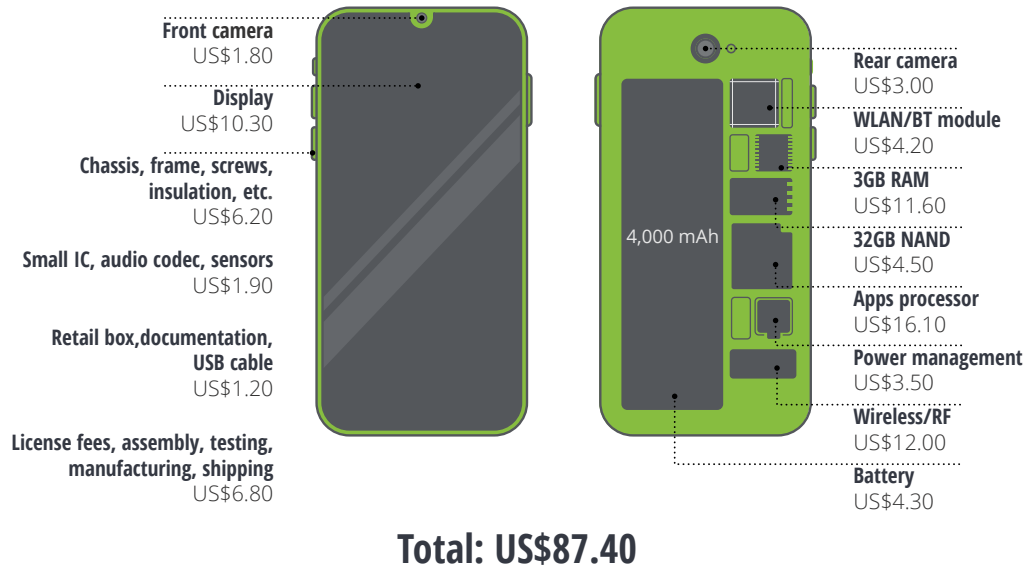at this low price point already exist. In 2022, 84 million phones costing less than US$100 will have shipped, 48% to Asia (excluding China), 8% to China, 11% to Latin America, and 8% to Africa.[1]

FIGURE 1

Low-cost components would make a 5G phone for US$99 possible

Estimated costs to build and deliver a low-cost 5G smartphone in 2023 (USD)

Front camera
US$1.80

Display
US$10.30

Chassis, frame, screws, insulation, etc.
US$6.20

Small IC, audio codec, sensors
US$1.90

Retail box,documentation, USB cable
US$1.20

License fees, assembly, testing, manufacturing, shipping
US$6.80

Rear camera
US$3.00

WLAN/BT module
US$4.20

3GB RAM
US$11.60

32GB NAND
US$4.50

Apps processor
US$16.10

Power management
US$3.50

Wireless/RF
US$12.00

Battery
US$4.30

4,000 mAh

Total: US$87.40

Source: Deloitte Global estimate in collaboration with CCS Insight and Counterpoint Research.

All of these phones are either 3G- or 4G-capable, and Deloitte Global's analysis of smartphone component costs shows that it's entirely possible to build a similar 5G device.

A US$99 5G phone may be similarly sized to a US$999 model, but it would have notably different components: a low-end display, a single-lens camera, a low-power processor, and modest storage capacity. The bill of materials (BoM), shipping, and assembly for such a phone could cost as little as US$87 in 2023 (figure 1), thanks largely to the cost of 5G-capable microprocessors finally falling below US$20 per unit. Business operation costs such as sales and marketing, facilities, and energy usage could add at least another US$40 per device. That adds up to US$127... but some companies with a strong set of cellular, services, and content offerings would likely subsidize the difference to enable a 5G smartphone to sell for a sticker price of US$99 or its equivalent. Beyond

2023, further falls in component prices should make subsidies unnecessary.

Clearly, smartphone vendors can't count on subsidized sales of ultra-cheap phones to turn a profit. Fortunately, many have created revenue streams beyond upfront phone sales throughout the past decade:

- **Preinstalled apps.** A smartphone vendor can charge a third-party developer to preload their applications. In the past, vendors would charge developers on a per-device basis, but performance-based payment, where dynamic preloads measure how apps are actually used once the smartphone is activated, is now more common. For the app developer, this makes preinstalls a viable alternative to online advertisements, which operate on a cost-per-install (CPI) payment model. The CPI for an Android phone, for instance, averages US$1.22, whether or not the user ever opens the app.[2]

- **Advertisements.** In developed markets, it's common to see notifications that promote ecosystems around devices such as audio earbuds and smartwatches. Though sellers of these kinds of products would be unlikely to target buyers of a US$99 phone, other types of companies may find smartphone ads to be just the thing. Local news stories can be served up as notifications, for example, with the smartphone vendor generating money from click-throughs.

- **Content.** Mobile telcos with their own applications and services—which can include gaming, cloud storage, film and TV, news, health, shopping, music, finance, and more—are prime candidates for success with US$99 5G phones. Content revenues have already allowed some telcos in developing markets to provide remarkable subsidies on low-cost own-brand 4G smartphones. Add to that their revenue from compulsory data and calling plans via SIM-lock, and these telcos could find it economically sensible to subsidize their branded devices even further.
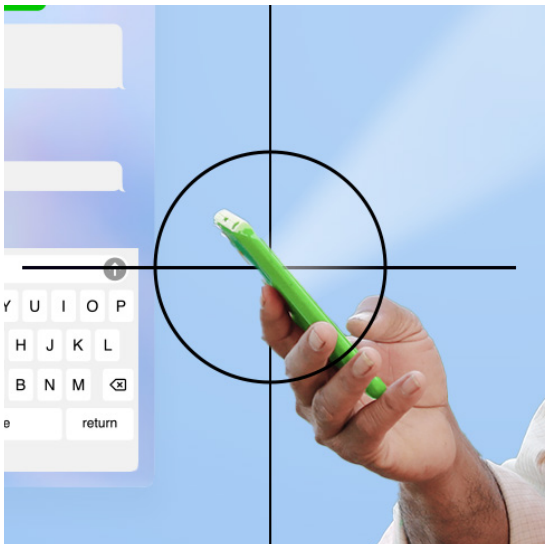
- **App store control.** In many countries and on many smartphones, the smartphone platform, iOS or Android, dictates the app store that customers use. But in China, many smartphone vendors successfully operate their own app stores, generating revenue from app sales and in-app purchases. This revenue allows them to offer subsidies to sell the devices themselves for up to 40% less than the same device would cost elsewhere in the world.[3]

The potential market, in terms of numbers, is huge. The first company to launch a US$99 5G device, be it a smartphone vendor or mobile telco, will gain prestige and a reputation for equity in bringing next-generation technology to the less wealthy. These phones are likely to launch in China first, taking advantage of the country's near-ubiquitous 5G coverage in metropolitan areas. They will most likely be designed and shipped by a smartphone vendor utilizing its own app store and services to sell the hardware at a loss.

Emerging markets such as sub-Saharan Africa and Southeast Asia will follow close on China's heels. In developing regions such as Africa without a significant 5G presence, many telcos aim to deploy a mass of 5G smartphones first before building out their network infrastructures. By future-proofing the phones that their customers use, these telcos could make their 5G networks more profitable on day one. The lack of cheap 5G smartphones with which to pursue this strategy has been a major reason why telcos in these areas have held back from deploying 5G networks.[4] But with US$99 5G phones just around the corner, the business case for telcos could be transformational—mainly because carrying a gigabyte of data is cheaper via 5G network technology than 4G.

THE BOTTOM LINE

The first step is clear: Get 5G phones into customers' hands. But US$99 is still expensive for many people. And beyond the device, people also need to fund regular payments for mobile data and services. Hence, improving access to credit will likely be a crucial prerequisite for the US$99 smartphone market.

This will be a challenge. Twenty-nine percent of people in developing regions are unbanked and so lack a formal credit history[5]; for lenders, issuing credit to this group is high-risk and carries heavy premiums. However, solutions are emerging to reduce lenders' risk exposure. A provider could, for example, send push notifications and remotely lock devices if a customer does not pay their bill. In regions such as Latin America, remote locking has led delinquency rates to drop from 35% to 11%[6]— and if their device is locked, 83% of customers then pay the bill within 15 days, as opposed to several months. In developing markets, many telcos already offer mobile payment and banking solutions, and are well placed to be involved with creating financing.

Telcos have several factors to balance when crafting their long-term 5G strategies. First, they would incur the cost of network deployment, a significant capex outlay. Then, as they take advantage of the greater efficiency per gigabyte of 5G over 4G, they could potentially realize savings. And throughout, they could face uncertainty as they predict how quickly tariff prices will inevitably fall. To develop a winning strategy, therefore, telcos could do well to model profitability over 5G's generational lifecycle. On the demand side, they will also likely need to quantify how many net new customers a US$99 5G phone could attract, as well as how much more data their existing customers could consume.

Perhaps most importantly for telcos, a low-cost 5G smartphone gives them a platform to explore new business models. For example, these devices could become ad-hoc fixed wireless access devices for households with poor fixed-line internet, delivering high-speed broadband for other devices anywhere within network coverage.

It's not just telcos in emerging markets that could benefit from cheap 5G phones. Many manufacturers in developed economies, for example, are eager to experiment with private 5G networks, but many pilots are waiting on the availability of competitively priced 5G modems. A 5G smartphone is not sufficient to drive elements of a smart factory, but it could certainly be used in proofs of concept ahead of large-scale deployments.

Of course, a US$99 5G phone won't have the features and horsepower of a US$1,000 model. From a certain point of view, this raises questions about the purpose of 5G. If 5G is about watching high-quality video, for example, then a cheap 5G phone is pointless—its low-res screen would be unable to display 4K HDR content with a high refresh rate, and users who download the file for an uninterrupted experience may find that the device's limited storage space quickly runs low. But 5G is not just about these showpiece applications. In the long term, it's about unlocking value by providing world-class connectivity to millions who might not currently have it, for work, education, or recreation. At US$99, that's a bargain.

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Acknowledgments

5G's promised land finally arrives: 5G standalone networks can transform enterprise connectivity

The coming migration to 5G standalone core networks is expected to allow for increased device density, reliability, and latency, opening the door to advanced enterprise applications.

Naima Hoque Essing, Pedro Gonçalo Sanguinho, Ariane Bucaille, and Pedro Marques Tavares

BY INTRODUCING VIRTUALIZED, cloud-centric capabilities, 5G standalone (SA) networks are poised to drive disruptive change that could make previous advances in wireless technology (2G/3G/4G) appear incremental. While the numbers are fluid, Deloitte Global expects the number of MNOs investing in 5G SA networks—with trials, planned deployments, or actual rollouts—to double from more than 100 operators in 2022 to at least 200 by the end of 2023. These MNOs are on the leading edge of helping to unlock 5G's long-heralded benefits, opening the door to disruptive use cases that can boost productivity, enhance operational efficiency, increase cost optimization, and create revenue opportunities for both MNOs and their enterprise customers.[1]

FIGURE 1

Investment in 5G SA is rising, comprising a higher proportion of overall 5G investment

Number of MNOs investing in 5G deployments globally

■ 5G of any type   ■ 5G SA networks

Quarter	5G of any type	5G SA networks	Total
Q2 2018	134		
Q3 2018	154		
Q4 2018	182		
Q1 2019	201		
Q2 2019	235		
Q3 2019	328		
Q4 2019	348		
Q1 2020	381		
Q2 2020	388		
Q3 2020	402	52	454
Q4 2020	412	61	473
Q1 2021	428	68	496
Q2 2021	453	82	535
Q3 2021	464	89	553
Q4 2021	481	99	580
Q1 2022	491	110	601
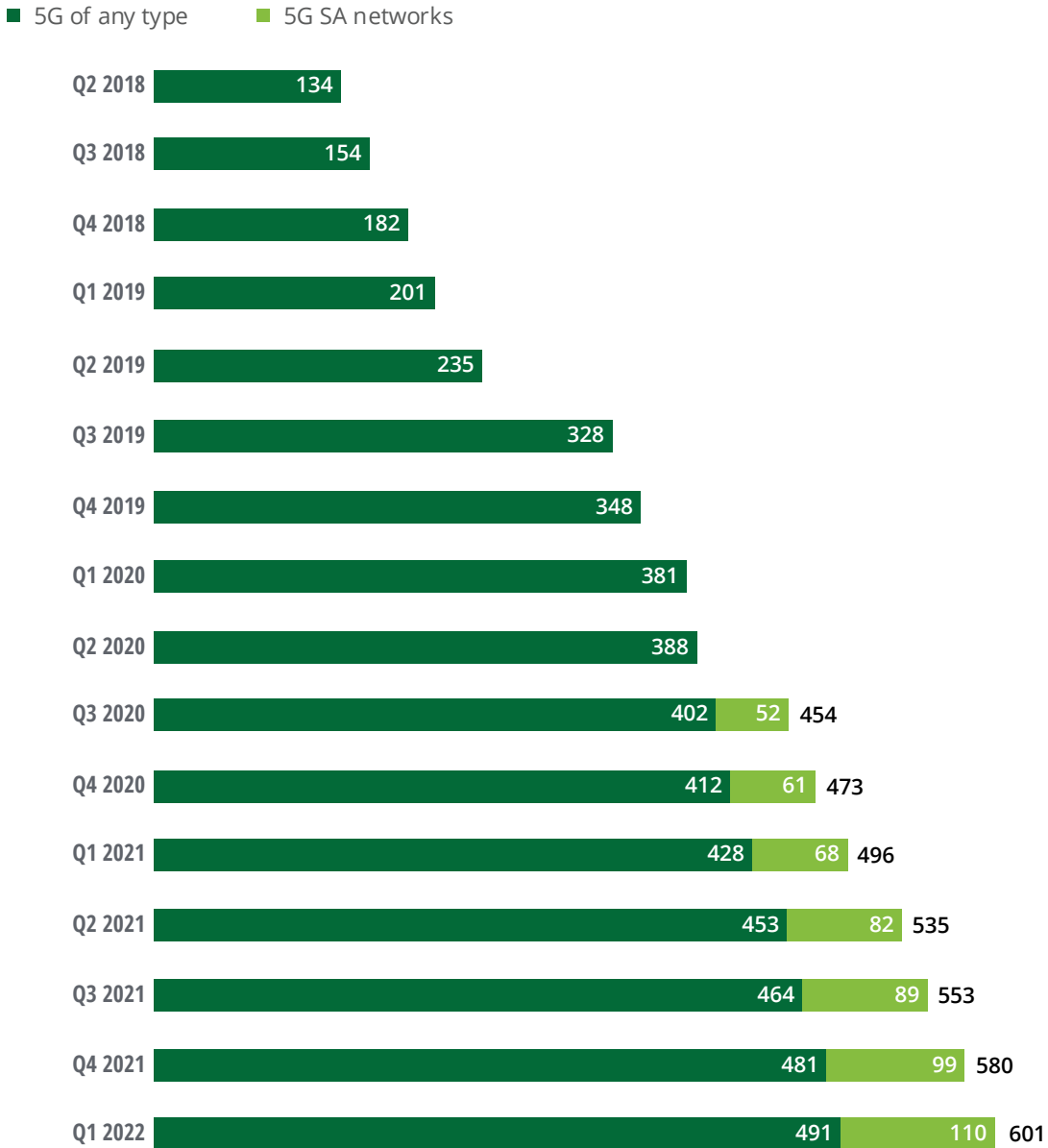
Source: Global Mobile Suppliers Association (GSA), *5G stand-alone June 2022 summary,* accessed August 31, 2022.

With SA architectures, 5G for enterprise can finally come into its own

When MNOs first began implementing 5G wireless networks in 2019, most opted to deploy 5G radios on top of their existing 4G/LTE core network infrastructure in so-called nonstandalone (NSA) deployments. These early NSA network deployments primarily targeted consumers, who could immediately enjoy faster speeds and higher data rates through enhanced mobile broadband (eMBB) when, for example, streaming high-resolution video on their smartphones. But to support 5G's more compelling features, a complete migration to SA networks with 5G radios running on top of a 5G core network infrastructure is necessary. This is because 5G SA enables two additional archetypal 5G use cases beyond eMBB[2] that could be key to unlocking value in an enterprise setting:

- **Massive Internet of Things (mIoT)**, which enables a very high density of connected devices (up to 1 million devices per square km) while ensuring quick and seamless communication among them

- **Ultra-reliable, low-latency communication (URLLC)**, which supports high network reliability and ultra-low latencies of 1 millisecond or less

Ultimately, 5G SA networks could help achieve a unified end-to-end virtualized network architecture with cloud-native orchestration, network functions, and management systems that work consistently from core to edge with carrier-grade quality. This unified platform would offer MNOs many operational benefits, including greater network performance, efficiency, and faster service delivery and innovation cycles.

5G SA's big attraction for MNOs are the new service and revenue opportunities it creates. Along with near-zero latency and massive device density, 5G SA enables MNOs to provide customers—specifically enterprise customers—access at scale to fiber-like speeds, mission-critical reliability, precise location services, and tailored network slices with guaranteed service levels. Armed with these new capabilities, enterprises can begin exploring a broader range of leading-edge applications and business use cases, possibly including self-driving vehicles; precision robotics; drone inspection and delivery services; and AI-driven security, quality control, and predictive maintenance systems.

Why hasn't 5G SA become the industry standard already? Because deploying SA networks involves multiple simultaneous initiatives that require close coordination and integration across technology, operational, and organizational domains. 5G SA involves MNOs migrating core networks, essentially the network's "brains," from monolithic hardware-centric infrastructure to new, lightweight, modular, virtualized, and cloud-based architectures. To do this, existing networks—including highly complex orchestration, operational, and business support systems as well as network functions—would need to be decomposed, recast, and rewritten into software that can operate in various cloud environments with carrier-grade performance. Moreover, these new core systems would have to fully integrate with other elements of the end-to-end network, including edge radio access networks, which are undergoing their own transformation.

These upgrades involve many critical strategic decisions that can significantly impact future operating and capital costs; business, operating, and organizational models; and potential revenue growth and profitability. For instance, one hotly debated topic is whether MNOs should deploy core networks on public clouds or build and operate their own cloud infrastructure. While private on-premise deployments give MNOs more control, they typically require significant upfront

investment and are less scalable. Public clouds offer a ready-built scalable cloud platform but can create challenges in meeting reliability and data privacy requirements. Hybrid approaches may be an option but managing multicloud environments tends to be highly complex.

Another significant hurdle for MNOs may involve transitioning their workforce and methods toward more entrepreneurial, agile, and software-oriented processes needed to operate 5G SA networks effectively. The potentially profound impact of this transition on employee roles and responsibilities, culture and mindsets, and overall ways of working should not be underestimated.

Despite these difficulties, migration to SA seems inevitable. Implementing 5G SA is part of the 3GPP's[3] 5G road map, but more importantly, MNOs could be hard-pressed to compete if they don't. The distinct advantages that MNOs can gain from 5G SA over NSA architectures include:

Reduced complexity and cost. Since SA can support traffic from multiple access technologies, they can effectively converge fixed and wireless, voice and data, consumer and enterprise, or 4G and 5G traffic on a single network, simplifying and reducing the cost of operating multiple networks.

Flexibility and scalability. SA's cloud-based nature offers MNOs more flexibility to locate and manage core network functions wherever needed to help deliver a great customer experience, whether in the cloud, in multiple clouds, at the network edge, in a private data center, or in some combination. SA networks are also easier to scale, which is important to support the future development of hundreds or even thousands of edge locations arising from the growing trend toward distributed (edge) computing.[4]

Responsiveness to demand. Many of 5G SA's new features are possible because it uses a

consistent, programmable platform (known as service-based architecture) that enables MNOs to seamlessly manage distributed locations as a single unified network. This allows SA networks to not only scale but also become more elastic to meet changes in demand without necessarily adding more people, hardware, or cost. In other words, SA essentially migrates MNOs from a lumpy capex to a more granular opex spending model.[5]

New feature development. 5G SA can speed up service delivery and innovation cycles due to its software-based service model as well as its agile continuous innovation and continuous deployment cycles. MNOs can also more easily engage third-party developers to introduce new network functions and features. One promising opportunity is to create more advanced automation tools that utilize big data technologies to reduce network cost and complexity. For example, new AI-driven applications allow SA networks to self-optimize and customize resources in response to changing demand or environmental conditions.[6] Further innovations may also lead to fully automated systems, ultimately enabling closed-loop, zero-touch service fulfillment, provisioning, and assurance.

New revenue opportunities. For instance, many view network slicing as a key opportunity for MNOs to expand their addressable market. With network slicing, MNOs can create and manage multiple distinct virtual networks on the same infrastructure and configure each slice to support different service level requirements for specific customer applications.[7] This could pave the way for operators to move away from selling simple connectivity solutions to offering more advanced value-added services such as private networks, managed network operations, and tailored privacy and security solutions. MNOs may also choose to open their SA platform to third-party developers (similar to what cloud providers do), thereby fostering the development of potential new applications.

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THE BOTTOM LINE

MNOs can take several steps to speed their transition to 5G SA:

- **Determine an appropriate migration plan, deployment model, and cloud strategy.**[8] How an operator decides to move forward can differ widely based on the status of legacy networks. 5G is inherently a cloud technology; thus, MNOs should develop overarching cloud and data management strategies to manage 5G SA. At some point, MNOs may need to take decisive action to invest in fully digitizing and migrating network operations to the cloud.

- **Automate network management systems and organizational structures.** In a data-centric, hyperconnected world, automation is important to reduce cost and complexity. Eventually, MNOs may be able to manage and orchestrate interoperable services across networks on the fly without human intervention.

- **Get the right talent and prepare for culture shock.** Because 5G SA essentially converges networking with IT computing, MNOs may need to hire or upskill engineering talent to augment existing network operating models (NetOps) with IT software-oriented operating models (DevOps). MNOs might also consider augmenting their workforce with outsourced talent to fill experience gaps in specific areas.

- **Carefully choose vendors.** No single vendor offers the broad set of required products and capabilities for a successful 5G SA migration. This is pushing MNOs toward adopting open systems using new best-of-breed vendors instead of relying on a few incumbent suppliers. However, using multiple vendors creates challenges in ensuring that all components integrate and work well together, requiring careful vendor selection and robust integration, testing, and validation methods.

Given all that 5G SA offers, the real question is not whether MNOs will migrate to 5G SA but when and how. The challenges are significant, but the benefits are undeniable: a fully mature 5G capability that unlocks 5G's full potential for enterprise and underpins MNOs' pursuit of greater efficiency, innovation, and value.

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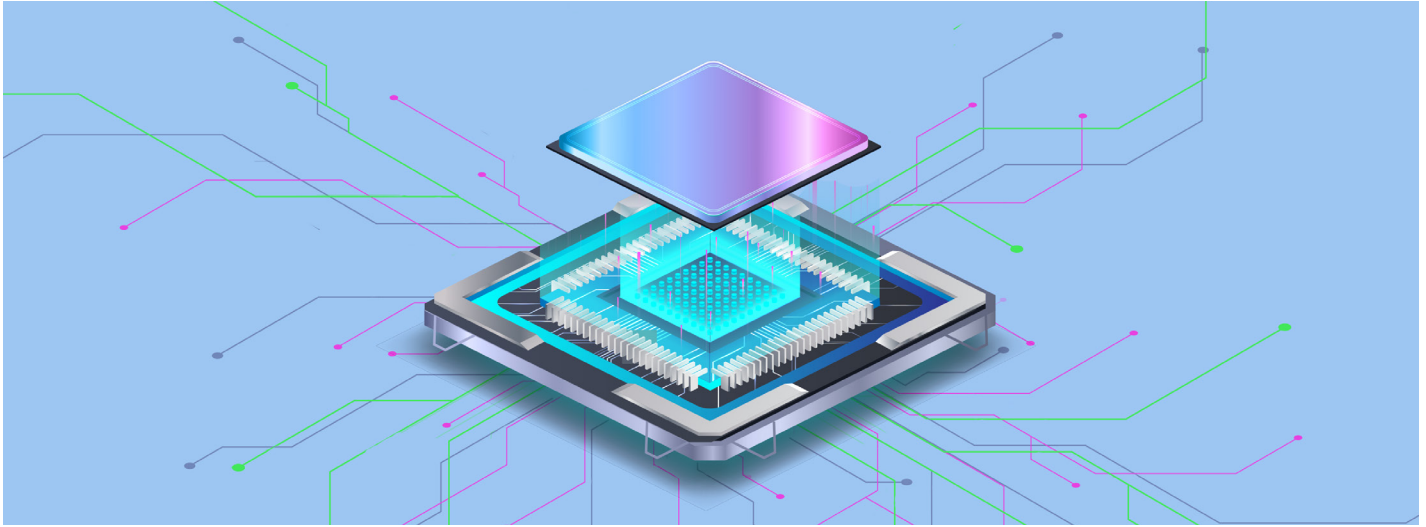
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Acknowledgments

Semiconductors

AI in chip design: Semiconductor companies are using AI to design better chips faster, cheaper, and more efficiently

Recent advances in machine learning are allowing chip companies to solve one of the biggest design problems ever: How do you arrange 100 billion transistors on one square inch?

Jeff Loucks, Duncan Stewart, Christie Simons, and Brandon Kulik

ARTIFICIAL INTELLIGENCE (AI) is fast becoming a powerful aid to human chip engineers in the extremely complex task of semiconductor design. Deloitte Global predicts that the world's leading semiconductor companies will spend US$300 million on internal and third-party AI tools for designing chips in 2023,[1] and that number will grow by 20% annually for the next four years to surpass US$500 million in 2026.[2] That's not a lot of money in the context of 2023's anticipated US$660 billion global semiconductor market,[3] but it's significant for the outsized return on investment. AI design tools are enabling chipmakers to push the boundaries of Moore's law, save time and money, alleviate the talent shortage, and even drag older chip designs into the modern era. At the same time, these tools can increase supply chain security and help mitigate the next chip shortage. Put another way, although a single-seat license for the AI software tools required to

design a chip may cost mere tens of thousands of dollars, the chips designed by such tools could be worth billions.

Time is money: Advanced AI exponentially speeds up chip design

For decades, electronic design automation (EDA) vendors have made tools for chip design—in a US$10 billion-plus industry in 2022, growing at about 8% annually.[4] EDA tools typically use rule-based systems and physics simulation to help human engineers design and validate chips. Some have even incorporated rudimentary AI. In the past year, however, the largest EDA companies have started selling advanced AI-powered tools,[5] while chipmakers and tech companies have developed homegrown AI design tools of their own. These advanced tools are not just experiments. They are being used in the real world across many chip designs likely worth billions of dollars annually. Though they won't replace human designers, their complementary strengths in speed and cost-effectiveness give chipmakers much stronger design capabilities.

Chip design and fabrication are highly complex—and advanced AI can help in three main ways:

Making new and better chips: Chips below the 10 nm process node are found in smartphones, computers, and data centers. They are the fastest-growing part of the chip market,[6] and by far the most profitable. However, at more than US$500 million per new design, they're also the costliest to make.[7] Advanced AI tools can design these chips faster than older methods, reducing costs.

Making old chips better: Two-thirds of all chips sold in 2022 were at the 65 nm process node or larger, a decades-old technology.[8] Taking those old chip designs and moving them to more advanced nodes (a "shrink") makes them physically smaller and more power-efficient, and it doesn't rely on obsolete fabrication equipment. Advanced AI tools allow chipmakers to effect these shrinks faster and cheaper.

Plugging the chip talent gap: About 2 million people work for the chip industry globally in 2022, but with the ongoing drive for chip self-sufficiency in the United States, European Union, and China, the sector needs to find a million more workers by 2030.[9] Advanced AI tools will become increasingly important as a way of bridging the talent gap.

Chips go through three main design phases: system-level design, register transfer-level design (RTL), and finally physical circuit design. It is in this last phase where advanced AI tools can really shine.

FIGURE 1

Growth in advanced AI tools for chip design is expected to be more than double that of EDA tools and more than triple the growth rate of chip sales

Five-year CAGR for chips, EDA tools, and advanced AI design tools (2023–2028)

Advanced AI design tools
20%

EDA tools
8%

Chip sales
6%

Sources: WSTS; Global Markets Insights; and Deloitte Global.

Chip design optimizes three variables—power, performance, and area (PPA)—to produce a chip that minimizes electricity use, maximizes processing speed, and is as small as possible. Optimizing PPA with conventional tools is slow and labor-intensive: Design iterations can take weeks, and the iterations often improve PPA only slightly. It can take years to design a chip; implement the design in physical form; and evaluate, test, and simulate both the design and implementation.

Chips have billions of transistors, represented by modular blocks—which contain elements such as memory subsystems, compute units, control logic systems, and power sources—and standard cells. In highly complex chips, these modular blocks are connected by up to 50 kilometers of wires. When blocks aren't optimally arranged, it takes more wiring and space to connect blocks. Unintended electric charges between components—which are called parasitics—can impede performance and sap power.

Advanced AI tools can test human designs by finding placement errors that increase power consumption, impede performance, or use space inefficiently; suggesting improvements; and then simulating and testing those. These tools learn from prior iterations to improve PPA until it reaches its limit. But what's truly revolutionary is that advanced AI can do this autonomously, generating better PPAs than human designers using traditional EDA tools—and sometimes do it in hours with a single design engineer compared to weeks or months with an engineering team.
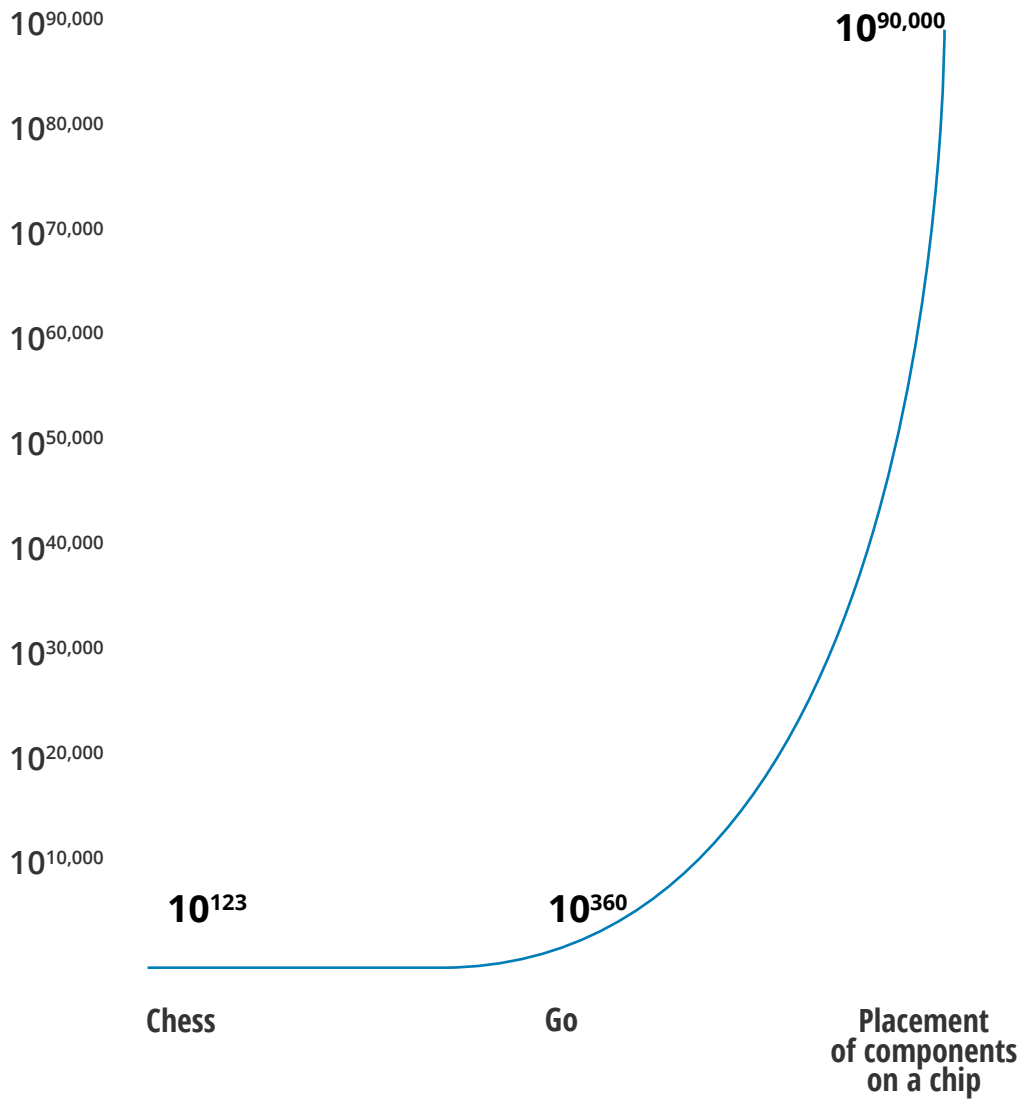
These advanced AI capabilities fall almost entirely into two categories: graph neural networks (GNNs) and reinforcement learning (RL). GNNs are a type of machine learning algorithm specialized for analyzing graphs—data structures that contain "nodes," which can be any object, and "edges," which define the relationship between nodes.[10] Traditional deep learning neural networks struggle with graphs,[11] but GNNs extract information from graphs, make useful predictions about their connections, and rearrange nodes while preserving the key relationships.[12] Because chip structure is essentially graph-like—macro blocks and standard cells are node-like and the wires connecting them are edge-like—GNNs are ideal for analyzing and optimizing chips.

RL turns physical chip design into a graph optimization "game." It's the same technology Google used to defeat the human champion in the strategy board game *Go*, which is even more complicated than chess and was thought to be beyond AI's abilities. Physical chip design is exponentially more complex still (figure 2), but RL tackles it in the same way. It trains on thousands of "games"—chip floor plans, which simulate chip designs to find the best PPA arrangements. The AI-generated floor plans are reinforced by a mix of rewards from the human designers for designs that optimize PPA, such as those that reduce wire length, congestion, density, power consumption, and area,[13] and punishments for suboptimal designs. These reinforcements improve the RL system over time, teaching it to generate better designs autonomously.[14]

FIGURE 2

If you thought seeing AI beat a human at chess and Go was impressive, wait until you see it design a chip

Chip designs have exponentially more possible configurations than either chess or Go

$10^{90,000}$

$10^{80,000}$

$10^{70,000}$

$10^{60,000}$

$10^{50,000}$

$10^{40,000}$

$10^{30,000}$

$10^{20,000}$

$10^{10,000}$

$10^{90,000}$

10^{123}

10^{360}

Chess

Go

Placement of components on a chip

Source: Adapted from Synopsys, "What is Design Space Optimization?," July 21, 2020.

The combination of GNNs and RLs is delivering PPAs whose performance equals or exceeds those produced by experienced designers, using fewer human engineers and in far less time. Some recent real-world results:

- MIT's AI tool developed circuit designs that were 2.3 times more energy-efficient than human-designed circuits.[15]

- MediaTek used AI tools to trim a key processor component's size by 5% and reduce power consumption by 6%.[16]

- Cadence improved a 5 nm mobile chip's performance by 14% and reduced its power consumption by 3%, using AI plus a single engineer for 10 days instead of 10 engineers for several months.[17]

- Alphabet consistently produces chip floor plans that exceed experienced human designers in PPA metrics in six hours instead of weeks and months.[18]

- NVIDIA used its RL tool to design circuits 25% smaller than those designed by humans using today's EDA tools, with similar performance.[19]

THE BOTTOM LINE

Major chipmakers and designers are using the latest AI to design chips today, even at advanced nodes. In fact, some chips are getting so complex that advanced AI may soon be required. For instance, the largest chip design from Synopsys contains more than 1.2 trillion transistors and 400,000 AI-optimized cores.[20]

Advanced AI is also becoming available through cloud-based EDA services, expanding the addressable market. Once on the cloud, it is available to smaller companies with less technical skill and compute power, not just experts and market leaders.[21]

The biggest semi companies could even use advanced AI to develop new services to monetize. By expanding their GNN and RL capabilities, these companies could not only generate their own designs but also offer design and co-design services to their top customers, including co-developing vertical-specific chips.

AI can be useful to the chip industry for more than just designing chips. For example, it can be used to improve fault detection by visual inspection of wafers by almost nine times.[22] It can also allow chip companies to address supply chain challenges such as managing a network of outsourced semiconductor assembly and test providers.[23]

For a few years, there have been chips designed *for* AI; now, there are chips designed *by* AI. What comes next? AI will likely start co-designing both the hardware and the software that powers AI itself—creating an innovation flywheel that might power the 21st century.

Endnotes

1. Deloitte Global estimates that the market for third-party AI chip design software from the major vendors was valued at about US$150 million in 2022 and will be worth over more than US$200 million in 2023. Further, we estimate that the internal use of AI design tools by large chip companies is worth about the same size.

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Acknowledgments

Supercharged semiconductors: Chips made of newer materials surge ahead, handling the volts that would fry silicon chips

Gallium nitride and silicon carbide semiconductors are gaining speed as high-voltage, high-power applications such as consumer electronics chargers and battery electric cars become more common.

Duncan Stewart, Karthik Ramachandran, Christie Simons, and Brandon Kulik

THOUGH SILICON HAS long been the standard for making the chips in our phones, computers, and data centers, it has one troublesome weakness: It's not well suited for the higher voltages and power levels needed for increasingly common applications such as battery electric vehicles (BEVs), super-efficient consumer electronics chargers, powerful solar panels, and advanced military applications. That's why Deloitte Global predicts that chips made of high-power

semiconducting materials, primarily gallium nitride (GaN) and silicon carbide (SiC), will sell a combined US$3.3 billion in 2023, up almost 40% from 2022. Though that's only a fraction of 2023's anticipated US$660 billion global semiconductor market,[1] the expansion of this fraction could go into turbo mode. Growth in these types of chips, collectively known as power compound semiconductors, is expected to accelerate to close to 60% in 2024, recording revenues of more than

US$5 billion. And given their importance in fast-growing industries and national security, countries, and regions are working hard to ensure they have adequate local manufacturing capacity.

GaN and SiC chips charge and drive ahead, saving the planet

First, a caveat: Power compound semiconductors are not expected to make silicon chips obsolete. Silicon is and will likely continue to be a semiconducting wonder material. A silicon chip the size of a thumbnail can contain billions of transistors that run on scant milliwatts of power at a volt or two. That means that consumer battery-powered devices last for many hours and data centers don't get too hot.

But the silicon processors in PCs, smartphones, and data centers are low-voltage devices, working at around 1–1.5 volts. That's nowhere near the 120 or 240 volts that even an ordinary household

power outlet delivers. If a smartphone chip were connected directly into those sockets, it would literally fry.

A host of rapidly growing applications need higher voltages still, and that means chips that can handle tens, hundreds, or even thousands of volts. For example, fast direct-current chargers for BEVs run at 480 volts,[2] and while BEVs' internal battery and motor systems typically run at 400 volts today, most BEVs are expected to operate at 800 volts by 2025.[3] Other uses for power compound semiconductors include wind turbines, solar farms, power supplies of all kinds, electric trains, aerospace and defense systems … and the list goes on.[4] Although special silicon-based power semiconductors called power MOSFETs have been used in such equipment for years, chips based on GaN and SiC allow these systems to be smaller, cheaper, more efficient, and denser, as well as enabling them to operate at higher frequencies and temperatures.

FIGURE 1

The power compound semiconductor market is accelerating fast

Annual combined sales of silicon carbide (SiC) and gallium nitride (GaN) power semiconductors (US$ billions)

■ SiC   ■ GaN
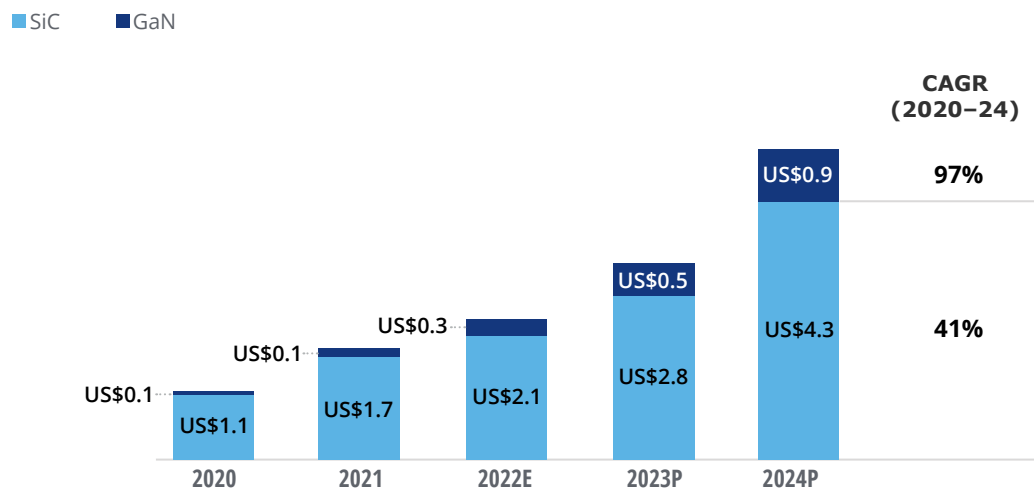
Note: E indicates estimated value and P indicates predicted value.

Source: Deloitte analysis based on information gathered from *Compound semiconductors: The crown joule of high voltage, Cowen Research*, accessed June 2022 via AlphaSense.

By 2026, consumer electronics chargers are expected to compose 66% of the GaN chip market, while automotive applications, mainly BEVs, could account for as much as 60% of the SiC chip market.

Interestingly, GaN and SiC chips don't really compete directly with each other: They each have a market they dominate. By 2026, consumer electronics chargers are expected to compose 66% of the GaN chip market,[5] while automotive applications, mainly BEVs, could account for as much as 60% of the SiC chip market.[6] Both uses have sustainability benefits as well as pragmatic ones.

GaN chips are well suited for use in chargers for consumer electronic devices, of which there are more than 10 billion worldwide.[7] That's actually a more complex process than one might think. Specialized chips sit between the 120 or 240 volts that come out of the wall plug and the batteries on a smartphone, which charge at 5 volts. These chips, in conjunction with the power management ICs (PMICs) typically in the smartphone, make sure the battery charges smoothly and safely as it gets closer to full charge, without overheating. For this use,

silicon power MOSFETs are increasingly giving way to GaN chips, which are smaller than equivalent silicon chips and therefore can be squeezed into smaller chargers. The biggest gain, though, is for the planet: GaN chip chargers operate at 98% efficiency, compared with 90% efficiency for silicon chip chargers.[8] Eight percentage points might not seem like much, but across 10 billion devices, they add up to gigawatts of energy saved each year.

SiC chips are expected to garner an estimated US$2.8 billion in revenue in 2023, and this figure will likely continue to expand on the back of BEV industry growth. The number of BEVs sold worldwide doubled to 6.6 million in 2021 from 2020, and sales in Q1 2022 were three-quarters higher than in the same period in 2021.[9] Further, as of Q2 2022, BEVs represented one in ten new passenger vehicles sold in Europe[10]—a new high—and one analyst is forecasting that in July 2023, more than half of all new vehicles sold in the United Kingdom will be BEVs.[11] In fact, especially as BEVs move from 400 to 800 volts internally, the prediction that SiC chips will record revenues of as much as US$2.8 billion in 2023 could prove conservative. One leading SiC semiconductor manufacturer reported on its Q2 2022 earnings call that SiC chip sales had doubled quarter over quarter; it also announced that it expected SiC chip sales for the full year to double to about US$1 billion, and that it had increased its three-year-forward order book of SiC chip sales to US$4 billion from the previous guidance of US$2.6 billion.[12]

THE BOTTOM LINE

A few things need to happen before GaN, SiC, and other power semiconductors truly boom. First, new facilities (fabs) for making these chips would have to be built—and new SiC and GaN fabs are indeed moving into production around the world (figure 2). However, both the fabs and the materials needed for them raise thorny supply chain and national security issues. Silicon, carbon, and nitrogen are all abundant and available, but currently almost all gallium comes from France, Kazakhstan, and Russia.[13] As with other elements and gases used in semi manufacturing with a small number of possible sources, manufacturing risk is therefore higher.

On the other hand, the geographical distribution of power semiconductor manufacturing differs significantly from traditional silicon semiconductor manufacturing, where 80% of global capacity is concentrated in East Asia—almost all of it in Taiwan, South Korea, Japan, and China.[14] Although these four countries have their fair share of existing and planned power semiconductor fabs, so too do the Europe, Middle East, and Africa region; the United States; and, to a lesser extent, Southeast Asia (figure 2).[15] Hence, from a supply chain perspective, the power semiconductor industry, as well as the BEV and renewable energy industries that rely on them, seems comparatively self-sufficient and resilient.

FIGURE 2

Power compound semiconductor manufacturing capacity is distributed across global regions
Number of existing and planned fabs, silicon carbide (SiC) and gallium nitride (GaN) combined, 2022 to 2026, estimated

Europe, Middle East, and Africa	~16
North America	~13
China	~13
Japan, South Korea, and Taiwan	~12
Southeast Asia	~7

Notes: Southeast Asia includes Thailand, Malaysia, Singapore, Indonesia, and the Philippines. Values reflect Deloitte's estimates based on publicly available sources.

Source: Multiple public sources.

An interesting challenge for power semiconductor manufacturers is the difficulty of developing technology-specific design tools, manufacturing tools, and packaging, test, and assembly capabilities for each technology. For instance, SiC wafers need to be etched, doped, and thinned differently from silicon chips.[16]

With so much technology and tools to be developed, it's not surprising that a lot of money has been pumped in to manufacture and develop these highly specialized chips. In China, three major SiC manufacturers have earmarked a total of US$4 billion in capital expenditures (capex) for this purpose during 2022 and beyond.[17] Moreover, the country continues to see large rounds of PE and VC funding for SiC-based start-ups (estimated at US$1.5 billion total in June 2022 alone).[18] In 2021, China even witnessed the first SiC IPO of more than US$300 million, as well as another filed by a substrate producer.[19]

It's not just China, either. SiC and GaN makers in the US, Europe, Japan, and South Korea committed to making at least US$10 billion in total capex in 2022.[20] A GaN company in Canada raised almost C$200 million from VCs, a US GaN company went public via SPAC for over US$1 billion, and a big French SiC company bought a smaller French SiC company late in 2021.[21]

Neither SiC nor GaN are expected to replace silicon in the trillions of chips for which silicon is now, and will likely always be, superior. But although they will remain niche, power semiconductors' advantages in withstanding high voltages—and the need for more of the products they support— mean that this is one niche market that's likely to grow significantly faster than the silicon chip mainstream.

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That's just rad! Radiation-hardened chips take space tech and nuclear energy to new heights

The next generation of rad-hard chips is helping bring devices used in high-radiation environments into the 21st century at last.

Duncan Stewart, David Jarvis, Christie Simons, and Gillian Crossan

THEY'RE SMALL, THEY'RE smart, and they can tolerate radiation levels that would bring most other chips to their knees. Deloitte Global predicts that the radiation-hardened (rad-hard) electronics market will top US$1.5 billion in sales globally in 2023.[1] That's just a fraction of the expected US$660 billion-plus total chip market for the year,[2] but these chips are mighty because of what they enable, not how much money they represent.

Advanced rad-hard chips could transform whole industries

Ionizing radiation, about a trillion times more energetic than the UV that causes skin cancer, is bad for chips. Ionizing radiation can damage chips cumulatively over time (measured by total ionizing dose or TID), degrading performance and eventually making the device useless. Another radiation effect is caused by high-energy particles.

These cause single-event effects and flip the value of a transistor from one to zero or vice versa on a processor or in memory—a phenomenon called a "bitflip." After enough of those flips, calculations are ruined, or a permanent and fatal error called a "latch-up" can occur.[3]

Even on Earth, bitflips can be caused by solar flares of high-energy particles entering the Earth's atmosphere. In space, single-event effects are a concern, given the small transistor sizes. Meanwhile, TID is a concern in longer-term missions. Several terrestrial applications (such as nuclear fusion and cleanup at Fukushima[4]) require hardness towards gamma radiation. In another example, making the medical devices that are exposed to X-rays radiation-tolerant will help extend their longevity.[5]

Although rad-hard chips can be useful for all sorts of applications, two of the biggest are in space and nuclear energy.

Space. Space is a harsh environment for chips. Vibration, severe thermal variations, electrostatic discharge, and G-forces on launch all require space-bound chips to be tougher than those in the average smartphone. Of these dangers, radiation is arguably the biggest of them all. Earth's atmosphere is a highly effective radiation shield. But satellites in orbit, especially higher orbits, are above much of the atmosphere and thus continuously exposed to high levels of damaging radiation, and intermittently exposed to even higher radiation levels when the sun is at its most active. Except for inside the shielded portion of the International Space Station, most chips in space today are "legacy chips", radiation tolerant, but made with older technologies that render them incapable of the kind of processing we take for granted on even a mid-range smartphone: AI image processing, graphics manipulation, and so on. For this reason, many space-based devices are "dumb terminals": They capture images, provide connectivity, and maneuver themselves, but

HOW RAD-HARD CHIPS ARE MADE

There are two approaches to make chips rad-hard: the physical and the logical. In the first (the focus of this prediction) chips are physically made differently: They are made of different materials such as silicon carbide (SiC) or gallium nitride (GaN) (see companion prediction on these materials), or the processing layer of silicon can be on an insulating layer or substrate. Other options include using bipolar integrated circuits instead of traditional CMOS, leveraging DRAM instead of SRAM, shielding with depleted boron, or radiation hardening by design. Moreover, in case of space applications, normal packages won't be able to withstand the G-force and other environmental conditions. Therefore, rad-hard chips require special packages (e.g., ceramic) that can withstand higher G-forces and wider temperature ranges better than other common materials. Design and layout techniques can also be used to harden a technology. Logical hardening can be accomplished via various kinds of redundancy, but also special hardened latches, layout techniques, and timing circuits.

require Earth-based processing to assist in all those things. They need to send everything down to Earth, wait for Earth to figure out what to do, then wait for Earth to transmit the right commands back. This can be slow.

New generations of rad-hard electronics for space environments will likely change that, with potentially enormous benefits. For example, NASA's Space Cube is a family of FPGA onboard systems that help boost onboard computing capability, autonomy, and artificial intelligence/machine learning (AI/ML) in space.[6] With such advancements, spacecraft can become smarter, last longer, and be more reliable, all at the same time. Imaging satellites could observe a natural disaster

such as an undersea earthquake and send tsunami alerts hours earlier, potentially saving millions of lives. Illegal methane emissions (methane contributes to short-term global warming 85 times more than CO_2)[7] could be detected in real time, and offenders more quickly caught and fined. Satellites at risk of collision could move—on their own initiative—much faster than they can today, mitigating the risk of runaway collisions and debris in orbit.[8]

Nuclear energy. Although nuclear fission energy production has decreased in the last 20 years due to concerns about safety and waste, the clock is ticking on reaching the Paris Agreement's 2030 climate goals, and fission is attracting renewed attention as a result.[9] Multiple new, modern nuclear power plants, smaller and safer than those from the past, have been proposed for the next

decade. These new kinds of nuclear reactors are already being enabled by increasingly advanced rad-hard chips.

However, the Holy Grail of nuclear energy is not fission, but likely fusion. Cleaner, greener, and (theoretically) even more powerful, successful fusion reactors could help solve the planet's greenhouse gas emissions in a few decades. But making fusion work requires magnetic fields, high pressures, and constantly fluctuating temperatures, all of which need to be sensed, interpreted, and controlled with chips that are both extremely powerful and extremely radiation-resistant.[10] With recent progress making fusion power possibly more feasible than previously thought,[11] the need to run these reactors could be a key driver of demand for rad-hard chips by the end of the decade.

THE BOTTOM LINE

As the recent chip shortage has highlighted, it isn't a great idea to have the manufacturing of any given kind of chip in only one or two plants. Countries and regions will likely want to make sure that they have local suppliers and makers of rad-hard chips. As an example, the US federal government is spending US$170 million to advance rad-hard chip manufacturing in Minnesota.[12]

Rad-hard chips are important for military and national security too. Secret military surveillance satellites and nuclear weapons would both be key examples. Chip self-sufficiency for all military applications is low: As of 2021, only 2% of the chips used by US military systems were made in trusted US-based foundries.[13]

Interestingly, shorter-duration missions at lower altitudes could even use commercial, off-the-shelf (COTS) chips that are radiation hardened at the system level instead of dedicated, special rad-hard chips. This could represent a marked shift in the rad-hard field, lowering the cost of chips for certain space applications.[14]

As mentioned above, another area of using rad-hard chips in space is integrating AI/ML capabilities and bringing edge computing to space applications. This could alleviate the need to send all the pictures and images they capture back to the Earth for further analysis and insight—and over a limited network bandwidth. By integrating AI/ML capabilities alongside rad-hard chips onboard, the space equipment can potentially handle all the advanced analytics by itself—image detection, image classification, automated decision, and timely action.[15]

Besides bolstering onboard analytics, companies are experimenting with launching analytics-heavy payloads into orbit, dedicated to performing advanced data processing and analytics. Such dedicated, compute-intensive satellites can serve as hubs in delivering edge computing services to other orbiting satellites.[16]

Companies and governments will likely want to encourage continued research and development of rad-hard technologies. Recent initiatives, such as NASA's High-Performance Spaceflight Computing (HPSC) project, focus on enabling next-generation space missions using advanced chips and modern architecture—all with the intent of supporting the ambitious plan of taking humans back to the Moon and forward to Mars. NASA and Microchip have recently collaborated on a US$50 million project to develop a spaceborne processor that will outperform current industry processors by 100 times.[17]

Paths to continue exploring include materials such as compound semiconductors (GaN and SiC), use of traditional silicon in new ways (FinFET and SOI), and creating rad-hard versions of popular and useful commercial technologies such as ARM or RISC-V.[18] Moreover, the advanced tech nodes and smaller linewidths at sub-10 nm—which several chip majors are piloting today—can help reduce the overall weight of the launch unit. This can be critical to containing the overall project cost, while improving the mission's success probability.

The biggest challenge will likely be for the satellite industry. For decades, space-based sensors relied on Earth-based processing. Significantly increasing onboard processing and memory is a whole new opportunity: It will be exciting to see what the industry can do with these new capabilities over the next few years.

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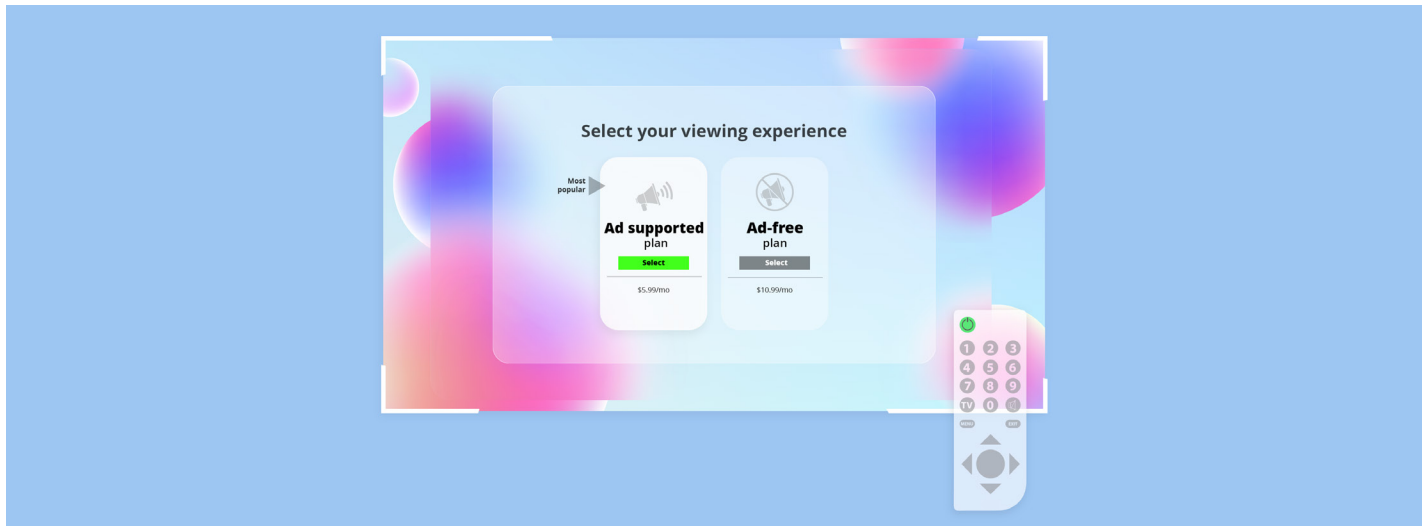
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Acknowledgments

Screens and media

Everyone's watching: AVOD finds an increasingly receptive audience

AVOD's appeal surges as price-conscious viewers become more willing to watch ads in exchange for discounted or free streaming video.

Paul Lee, Jeff Loucks, and Kevin Westcott

CONSUMER AND INDUSTRY economics are making the case for ad-funded streaming video services increasingly compelling. Deloitte Global predicts that, by the end of 2023, approaching two-thirds of consumers in developed countries will use at least one advertising video-on-demand (AVOD) service monthly—a 5% increase over the prior year. It further predicts that, by the end of 2023, all major subscription video-on-demand (SVOD) services in developed markets will have launched an ad-funded tier to complement ad-free options. By the end of 2024, half of these providers will also have launched a free ad-supported streaming TV (FAST) service. And, by 2030, it is expected that most online video service subscriptions will be partially or wholly ad-funded, catching up with emerging markets where ad-funded video-on-demand has always been the norm—an evolution that Deloitte Global predicted in 2020.[1]

We also note that ad-funded tiers from SVOD players will be joining existing ad-funded streaming services from broadcasters in most markets that have existed for over a decade. (Our analysis includes all platforms that offer professionally produced content, but excludes platforms that host user-generated content as this reflects a different business model, often predicated on low production costs.)

Consumers will seek out discounts amid rising content prices and other inflationary pressures

In developed markets, many streaming video services offered an ad-free experience as part of the benefit of a subscription. The expectation was that once viewers had become used to viewing without the interruption of ad breaks, they would never go back.

However, the proliferation of streaming services, each with its own set of must-watch content and rising fees, has made the fully ad-free experience harder to afford for many households, even among consumers in the wealthiest countries.

A single premium, ad-free subscription ranges from US$5 to US$20, a monthly cost affordable to many households.[2] However, when tentpole content—the most popular and talked about programming—becomes split across four or five providers, subscription costs quickly add up. For example, when HBO Max launched in the US market in 2020, it featured *Friends* and *The Big Bang Theory*.[3] *Modern Family* is now available on Disney Plus.[4] *Schitt's Creek* became available on Hulu in the United States as of October 2022. In all cases, these major series were previously hosted on different platforms.[5] Additionally, inflation has also climbed steeply, erasing income gains for many consumers.[6] The combination of these factors is nudging the mass market adoption of AVOD.

Advertising-supported tiers typically offer consumers a 50% discount in exchange for between four and 10 minutes of ads per hour. Viewers trade ads for more affordable access to favored content. Consuming commercials is just one option taken to cut cost: Another common choice is an annual up-front payment to get a couple months for free.

Deloitte Global has been polling consumers across multiple markets, asking which service tier they would choose when signing up to a new streaming video service. Across all markets, most consumers indicated they would choose an ad-supported tier, either at half price, or free (figure 1).

In addition to ad-supported, discounted SVOD, 47% of consumers across developed markets already watch ad-supported streaming services based exclusively on professionally produced content, most of which is typically free (figure 2). These are usually offered by national broadcasters or studios.

Some consumers might grumble that, post price rises, the only streaming service tier that fits their budget has ads. After all, advertising is already ubiquitous by default in most media, from broadcast TV, to mobile games, to live concerts. Cities teem with digital billboards; retail chains have in-store ad networks. So, introducing ads to streaming video is a change, but not a revolution. Furthermore, the ad load for AVOD services from former SVOD providers is likely to be moderate, with about four minutes per hour being standard in 2023. Ad minutes for broadcast TV, by comparison, may be double or even triple this during peak time.

Content providers will look to AVOD for subscriber and revenue growth

For "traditional" SVOD providers that launched without ads, a key reason for introducing advertising

FIGURE 1

In most countries, consumers prefer ad-supported video options that remove or reduce subscription fees

	Brazil	Germany	Japan	United Kingdom	United States
No ads/ monthly fee	**40%** ------ R$40	**38%** ------ €12	**30%** ------ ¥1,500	**39%** ------ £10	**41%** ------ US$12
6 minutes of ads per hour/ monthly fee	**26%** ------ R$20	**21%** ------ €6	**15%** ------ ¥750	**17%** ------ £5	**25%** ------ US$6
12 minutes of ads per hour/no monthly subscription fee	**34%**	**41%**	**55%**	**44%**	**34%**

Source: Data from Kevin Westcott et al., *2022 Digital media trends, 16th edition,* Deloitte Insights, March 28, 2022.

FIGURE 2

Nearly half of consumers watch ad-supported streaming video services
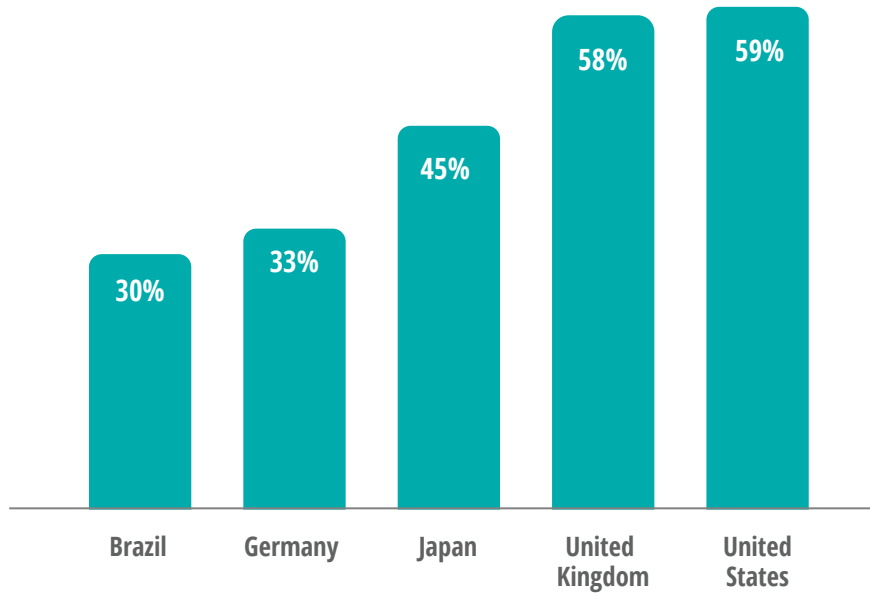
Source: Data from Kevin Westcott et al., *2022 Digital media trends, 16th edition,* Deloitte Insights, March 28, 2022.

is to maintain growth, especially in developed markets in which net subscriber additions have become particularly challenging in 2022.

AVOD both offers an entry-level price option to new subscribers, and also a lower-cost option to existing subscribers who might otherwise cancel (churn from) a service. Since 2020, churn has become a fundamental challenge to SVOD players. In the United States, cancelation rates have hovered around 37% since the start of the decade. In most other markets, churn rates are just a little lower but the impact of churn on profitability is equally debilitating, given subscriber acquisition costs (figure 3). Cost or perceived value for money has become the primary typical driver of cancelation in 2022 and may be even more influential in 2023.

A fundamental driver for adding AVOD is to generate an additional revenue stream from advertising. As of mid-2022, many VOD-only content players were operating at a loss, with profitability contingent on adding users. For traditional broadcasters, AVOD offers an additional source of revenue, drawn from linear ad budgets, and, importantly, online video ad budgets that would previously have gone to online-only video providers.

In offering AVOD, providers are addressing pent-up demand from advertisers, who highly value the ability to show their ads on a large TV screen, as this tends to have more impact than the same ad shown on a smartphone. In recent years, the decline of viewing of broadcast TV has reduced the supply of younger viewers watching ads; AVOD,

FIGURE 3

Churn is a serious problem for SVOD providers in developed markets

Percentage of consumers who have canceled at least one streaming video subscription in the past six months
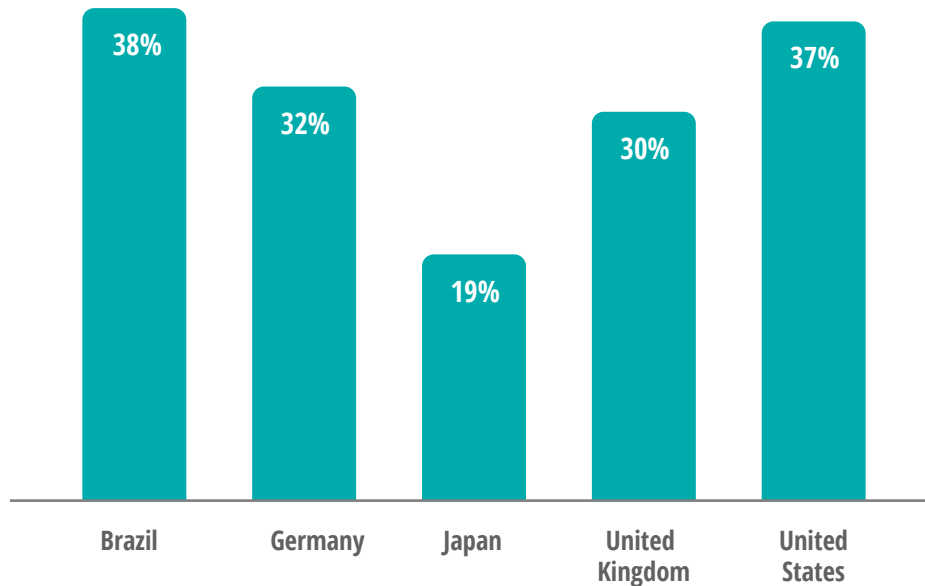
Source: Data from Kevin Westcott et al., *2022 Digital media trends, 16th edition,* Deloitte Insights, March 28, 2022.

which is predominantly watched on TV sets, and which is generally adept at aggregating 16–34-year-old viewers, addresses that demand, at a premium

price and with targeting. In the US market, CPMs for AVOD could readily be more than US$50. In European markets, they should reach US$30.

THE BOTTOM LINE

AVOD's resurgence is healthy for the wider television industry. For SVOD providers, it unlocks an additional revenue stream and could reduce churn; for broadcasters, it raises the profile of a service they've been offering for years; for consumers, it enables continued, lower-cost access to their favorite content, albeit with the (minor) wrinkle of having to watch ads. While AVOD is not for every viewer, it's likely to appeal to the majority, even in the wealthiest of markets.

The transition to AVOD won't however be a walk in the park. Consumers should be migrated gracefully. SVOD providers may need to restructure, add sales capabilities, reformat existing content, commission differently, measure ad impact, and change culture.

One of the biggest challenges will to be make ad breaks as enjoyable as possible. This isn't just about a low volume of ads per hour; variety is critical. Repetitious ads, even in small quantities, are tedious. The range of commercials shown should be similar or superior to that for traditional television. For this to happen, content providers should replicate the ad sales organization and culture that traditional broadcasters have had for decades. For some SVOD players with a traditional broadcaster heritage, this should be easier; for streamers that have never sold advertising, the learning curve will likely be steeper.

Content that was commissioned for an ad-free service may require reediting to identify natural breaks to show ads. By contrast, library content that was originally edited to include ad breaks at regular intervals may not require any changes. Some licensed content may not permit the insertion of ads, so agreements may need to be revised. Content providers may also need to replicate the episodic release of content that broadcasters have perfected over the decades such that their tentpole releases are popular enough to drive the national conversation. For this to happen, new content should be teased and released at regular intervals, rather than a season at a time.

New arrivals to the AVOD market should note that its size will vary by market, with the United States leading in the long run, as it's the largest TV ad market globally. The US TV ad market, at a forecast US$70 billion in 2022, is 10 times bigger than the United Kingdom's.[7] Furthermore, in markets such as the United Kingdom, SVOD-to-AVOD converts will compete with existing ad-funded services from national broadcasters whose outputs have for many years driven the national conversation.

The introduction of ads into services that previously lacked them should be considered a progression, not a step backward. In the long term, funding the content that consumers want to see requires a blend of subscription and advertising revenues. This has long been the norm—not the exception—for almost all media. The virtue of the AVOD model is that it is inclusive of everyone, regardless of income. People may well love an ad-free experience, but not if it makes content unaffordable.

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Acknowledgments

Live sports: The next arena for the streaming wars

As streamers take a growing share of a thriving market, can they go the distance?

David Jarvis, Paul Lee, Pete Giorgio, and Kevin Westcott

FROM FOOTBALL (SOCCER) to cricket to baseball to golf, streaming video providers around the world are spending billions of dollars on live sports rights in a bid to attract, retain, and monetize an increasingly fickle audience. Deloitte Global predicts that in 2023, streamers will spend over US$6 billion on exclusive major sports rights in the largest global markets.[1] To put that into perspective, in 2021, the combined content spend by all streaming providers was about US$50 billion.[2] Streamers' spending on sports rights is a relatively small, but significant, proportion of that total. The growth in expenditures on live sports content underscores the increasing interdependence between streaming providers and the largest sports leagues.

The rules are changing for streaming providers and sports organizations

Streaming services are the latest to enter the live sports ring, with cable, broadcast, and satellite services all contending for fans. In one corner stand entertainment companies and regional sports networks with traditional linear channels that also offer a streaming service.[3] In another corner are the "pure play" streaming providers who have only their streaming service as an option to reach consumers. In the third corner, there are tech companies looking to broaden the reach of their streaming services and increase time spent within their ecosystem. Finally, leagues and individual teams are launching specialized

streaming services to establish direct connections and serve super-fans.[4]

Two recent examples highlight the enterprising approaches that streaming providers are taking. In a unique global deal, Apple has committed to spend at least US$2.5 billion for the sole rights to stream every US Major League Soccer (MLS) game over the next 10 years via a dedicated Apple TV app.[5] MLS season ticket holders will be able to access the app for free, but everyone else will need to pay for

this content (some games will be available for free to Apple TV+ subscribers). Meanwhile, Viacom18 successfully acquired domestic digital rights to the Indian Premier League's (IPL) cricket games in a five-year, US$3 billion deal.[6] Disney, which previously won both the digital and linear broadcast rights, will pay IPL US$3 billion over the same period to retain the broadcast rights. Disney also recently won digital and linear broadcast rights in India for International Cricket Council events through 2027.[7]

FIGURE 1

Companies are paying record amounts to stream live sports
Notable recent live sports rights streaming deals

League	Sport	Company	Geography	Total deal value (value per year)	Deal length
National Football League (*Thursday Night Football*)	American football	Amazon	United States	US$13.2B (US$1.2B/year)	11 years 2022–2033
Indian Premier League (Digital rights)	Cricket	Viacom18	India	US$3B (US$600M/year)	5 years 2023–2027
Premier League	Football (soccer)	Viaplay	9 European countries	US$2.7B (US$450M/year)	6 years 2022–2028
Serie A	Football (soccer)	DAZN	Italy	US$2.5B (US$840M/year)	3 years 2021–2024
Major League Soccer	Football (soccer)	Apple	Global	US$2.5B (US$250M/year)	10 years 2023–2032
LaLiga	Football (soccer)	DAZN	Spain	US$2.4B (US$470M/year)	5 years 2022–2027
Ligue 1	Football (soccer)	Amazon	France	US$750M (US$250M/year)	3 years 2021–2024
Major League Baseball (*Friday Night Baseball*)	Baseball	Apple	8 countries currently	US$595M (US$85M/year)	7 years 2022–2029

Notes: Some deal values were converted from euros to US dollars at the September 20, 2022 exchange rate of 1.00 euro = 1.00 US dollar. Value per year is the deal value averaged across the duration of the contract.
Source: Multiple public sources.[8]

Both streaming providers and sports organizations have much to gain from their growing symbiosis. Facing greater competition and more subscriber churn, many streaming providers are using live sports as a differentiator to help attract and retain subscribers. Providers also want to use live sporting events to entice advertisers, who see their sizable audiences as a smart investment.[9] Sports organizations, on their end, want to monetize their rights further, expand access to products, and pursue younger consumers.

Premium sports competitions such as the Premier League, IPL, National Football League (NFL), and National Basketball Association (NBA), depend on media rights as a major source of revenue (along with ticket sales, sponsorships, and merchandise) and see streaming providers adding to that revenue.[10] For smaller and newer sports and leagues, streaming services may offer the benefit of coverage for the first time as a pathway to greater awareness and further growth.[11] Streaming providers can also help grow the global audience for a sport, giving viewers in different countries easier access to sports they might not be as familiar with.

The good news is that fans may get access to even more content related to their favorite sports (e.g., original shows and documentaries, historical games, associated secondary competitions, etc.). Streaming services could also provide new innovations around personalization, interactivity, and real-time data analysis. In the near future, we should see more experimentation from streaming providers looking to offer more tailored experiences. There have already been some initial forays into integrating sports betting by FuboTV, and Amazon is planning on offering multiple feeds for their NFL games in the US market, allowing fans to choose their viewing experience.[12]

That said, the fragmentation of rights across even more platforms could make it more difficult for fans to access what they want to watch when they want to watch it—not to mention create added cost and complexity. Many fans already have to maintain subscriptions to one or more pay TV providers and multiple streaming services to watch their favorite team or sport. This could lead to increasingly frustrated and burdened fans who may miss out on the content they love.[13] Sports leagues and streamers should ensure that they aren't creating artificial barriers to fan engagement.

Another challenge is that high-quality live sports is technically harder to stream than broadcast. Sports content tends to be fast-paced, necessitating a higher frame rate than other genres.[14] Sports fans also demand high picture quality and superb reliability, particularly with premium-priced subscriptions. Additionally, sporting events are more sensitive to latency issues—delays in the delivery of content—and with streaming, those delays can extend for as long as a minute.[15] Looking ahead, streaming won't be able to deliver experiences such as in-game betting and interactivity unless the issues with latency are resolved.

The complete transition of live sports entertainment to streaming won't happen overnight, if ever. Traditional broadcasters will likely remain by far the main buyer of major sports rights for quite some time, albeit with a smaller share. One reason for this is the tenure of sports rights: Depending on the geography and sport, contracts range from three to 10 years. This means that for some major sports, such as the NFL, the next opportunity for streaming providers to bid for rights and grow their share will not be till the early 2030s. Another is that rights holders may not want to risk a critical revenue stream when current linear broadcasts are already high-quality, low-latency, and have significant preexisting production and distribution infrastructure already in place. It is also worth noting that free-to-air sports broadcasts have, historically, been critical to growing overall awareness of sports and creating new fans.

THE BOTTOM LINE

It will take a couple of rights cycles before the future of watching live sports becomes clear. The next big indicator could be when the NBA announces new deals for the US market starting in 2025.[16] For sports streaming to go the distance, sports organizations and entertainment companies should consider several key things:

- **Put the fan first.** Skillfully use first-party data to understand fans' needs and preferences and deliver the right amount of quality content, easy access, an engaging user experience, and exclusive perks, all at a reasonable cost.

- **Expand the streaming service's influence.** Consider integrating it with social media, sports betting, gaming, fantasy sports, and other digital engagement channels.

- **Improve streaming's technical aspects.** Enhance broadcast quality (for instance, by eventually moving from 4K to 8K resolution), reduce latency, and eliminate service interruptions.

It is important for both streaming providers and sports organizations to reflect on balancing their short- and long-term needs. Pure-play streaming providers and tech companies should consider if the high cost of live sports rights is worth it. Will it help attract and retain subscribers? Will it drive a halo effect for their other products and services? Traditional entertainment companies with both linear channels and streaming services should decide which service to prioritize when it comes to investment. And sports organizations should ask if their media deals are both meeting their current fans' needs and cultivating the next generation of fans. Finding astute answers to critical questions like these will be key to what separates the champions from the runners-up.

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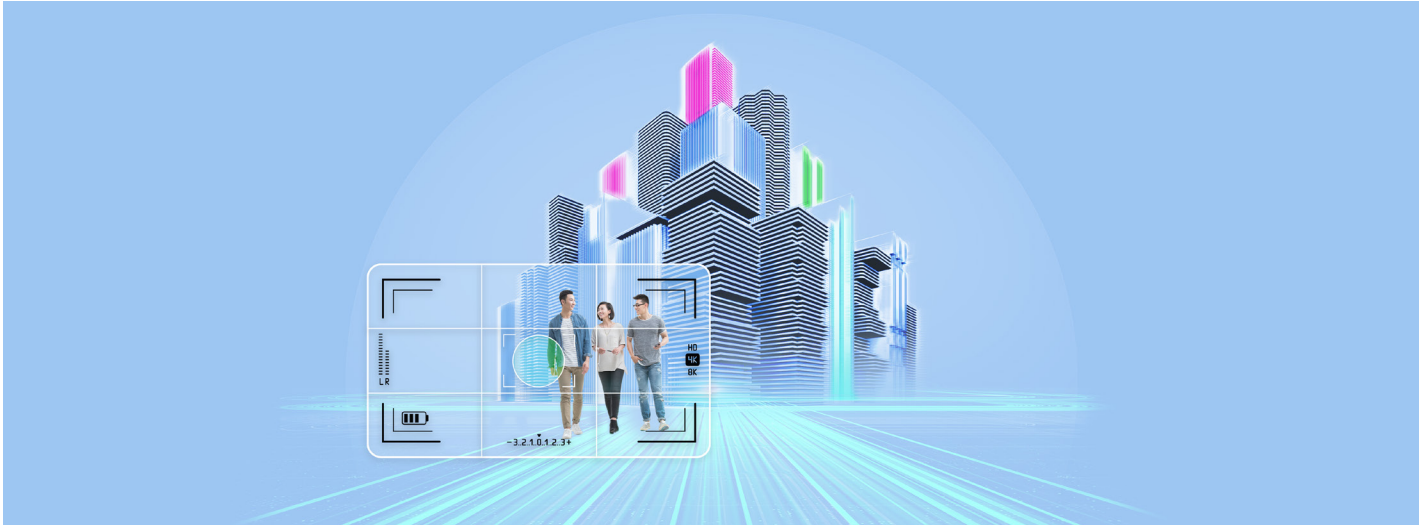
Virtual production gets real: Bringing real-time visual effects onto the set

Digital tools and technologies are bringing virtual effects to physical sets and making production more flexible and cost-effective—freeing creativity from previous constraints.

Chris Arkenberg, Jeff Loucks, Kevin Westcott, and Gillian Crossan

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THE TOOLS AND techniques of virtual production are steadily transforming film and cinema production, increasing flexibility, shortening production times, and bringing real-time computer-generated imagery (CGI) and visual effects out of postproduction and onto real-life sets. Deloitte Global predicts that the market for virtual production tools will grow to US$2.2 billion in 2023—up 20% from an estimated US$1.8 billion in 2022. Multiple forces are driving this growth: audiences demanding film and television genres that rely heavily on digital capabilities; streaming video services embracing these genres to fill production slates and reduce costs; greater reliance on digital tools as workforces become more remote

and distributed; and the ambitions of some top game engine providers to better serve the film and video production market.

Virtual production brings the impossible to the set

CGI and visual effects have been enriching cinematic storytelling for decades. The 2001 cinematic adaptation of J.R.R. Tolkien's *The Lord of the Rings* was an example of how these tools and techniques came together to push the boundaries of visual storytelling.

However, behind the scenes, there was a disconnect between what was possible during on-set production and what had to be postproduced with software. Actors performing in front of green screens were prompted to imagine the sets and effects that would be added afterward. Directors and cinematographers could see a person in a motion-capture suit on set but not the 3D-rendered creature they would become on screen. Fantastic settings couldn't be visualized until postproduction. Moreover, many shots were on location, requiring studios to fly crews and gear to the site, contend with the whims of local conditions, and incur high costs in money, time, and uncertainty. As more studios entered the market and pressures to reduce costs and time-to-screen mounted, filmmakers became increasingly constrained by these limitations.

Virtual production offers greater freedom and flexibility. Using technologies such as game engines, LED volumes, and augmented reality, virtual production can bring real-time computer-generated graphics and visual effects directly into the production process, enabling everyone on set to see and interact with them. Sets can be built inside a game engine or captured using photogrammetry—for example, by scanning the surfaces of a Paris neighborhood to create a 3D model. The virtual set and its effects can then be rendered in high-resolution on LED volumes—walls and ceilings made of LED screens that surround the physical set—transforming a sound stage in Burbank into that Paris neighborhood. Actors can see digital sets and elements and react to them more naturally. Cameras with augmented reality layers let operators and cinematographers see more dynamic digital assets such as virtual characters driven by motion-capture actors. Stage cameras can align with virtual cameras to precisely track movements across physical and virtual spaces.

And virtual production's benefits can extend far beyond what it enables on set. For many producers, it's an invaluable tool for making the filmmaking process much more flexible. For example, objects in the digital set can be repositioned on demand, and lighting between real and virtual elements can be more easily matched. Production time can be shortened, costs can be reduced, time and location constraints can be removed, and creativity can become more unbounded.[1]

As studios support more streaming video services—or launch their own—many highly competitive production pipelines are taking advantage of virtual production. For instance, using virtual production, ILM turned a few soundstages and a backlot into 2019's *The Mandalorian*, bringing an alien universe with cinema-quality effects to streaming TV.[2] The show's success has been cited as a catalyst for virtual-production adoption.[3]
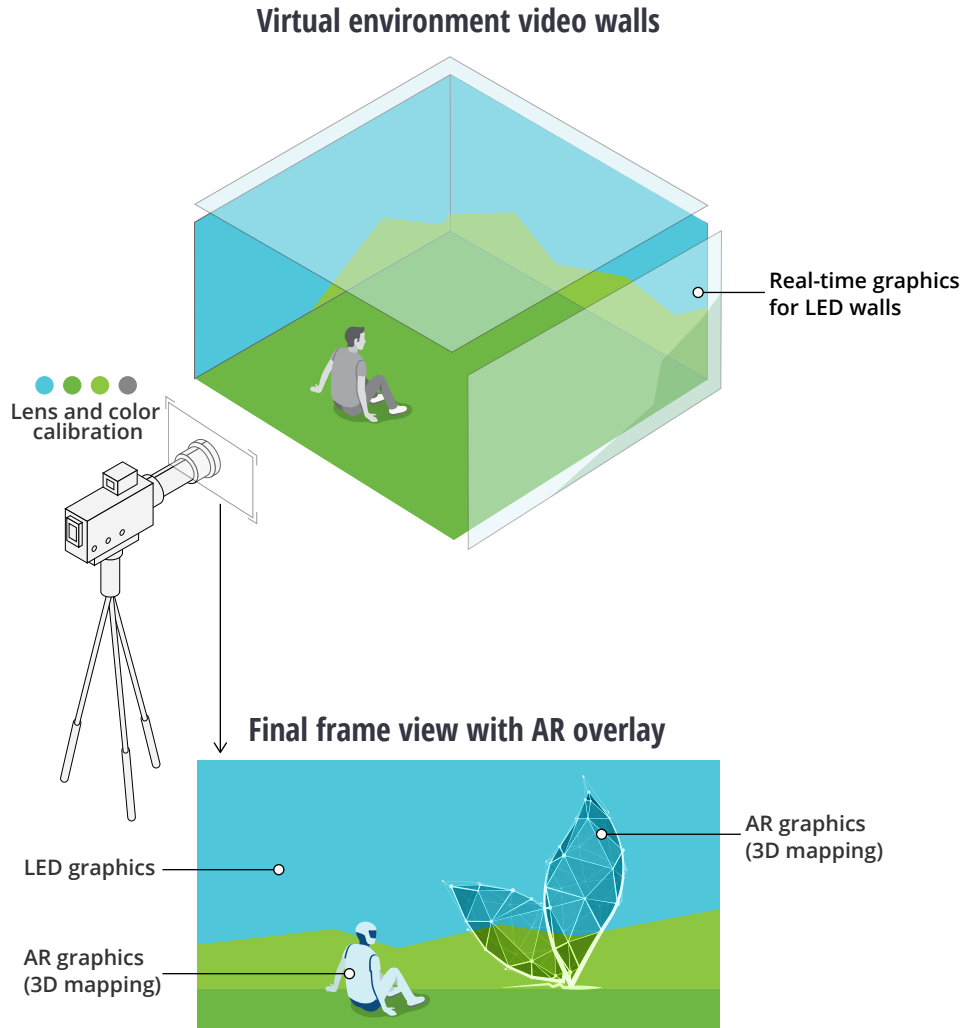
There's certainly no shortage of demand for content with spectacular—and often otherworldly—visuals. Over the past decade, adventure and action movies have become the most successful film genres, followed closely by fantasy and sci fi. Such stories are a perfect stage for CGI and visual effects, and they increasingly require virtual production capabilities that enable the impossible and transport actors and audiences into other worlds.[4] Leading streaming video services are also filling their programming with these genres, with virtual production being central to developing effects and experiences that satisfy their demanding audiences.[5]

The COVID-19 pandemic helped underscore virtual production's value and boosted its adoption.[6] Closures and social distancing shifted audiences from theaters and mobile to in-home viewing just as leading media and entertainment providers were launching their streaming video services.

FIGURE 1

Virtual production brings digital effects to the physical set

LED walls show virtual sets and elements, while augmented reality (AR) overlays let camera operators see other real-time effects like characters mapped onto actors

Virtual environment video walls

Real-time graphics for LED walls

Lens and color calibration

Final frame view with AR overlay

AR graphics (3D mapping)

LED graphics

AR graphics (3D mapping)

Source: Deloitte analysis.

The need for streamers and studios to fill their catalogs with original content without sacrificing quantity or quality pushed studios toward virtual production and visual effects, especially for the more popular visual effects–rich genres. The pandemic also required mostly colocated production teams to adopt remote and distributed workflows. Instead of flying people to filming locations or bringing them together on sets, studios turned to virtual production solutions that could replicate those production elements.

Advances in developing hyperrealistic video games have been a key enabler of virtual production. The Unreal Engine from Epic Games has been recognized as a pioneer in using high-performance computing, 3D modeling, and physics to enable the shift from laborious and time-consuming postproduction to photorealistic and real-time rendering on-set—advancing their own games' capabilities in the process.[7] Other game engine leaders, like Unity Technologies, are also enabling the convergence of 3D gaming experiences and 2D storytelling, which will likely spark more movement of intellectual property (IP), audiences, and entertainment between them. On the way to the promised land of the metaverse, the collaboration between film and gaming could unleash new forms of entertainment that mix cinematic storytelling, immersive and social gaming, and real-time broadcasts.

THE BOTTOM LINE

Virtual production has already gained a strong foothold in film and TV studios and is poised to move from early adoption to early majority.[8] The flexibility and freedom that it offers storytellers and production crews are a spur to its increasing use. And with competition among streamers heating up and audiences facing a possible recession, cost pressures on content development are likely to become stronger, prompting more studies to rely on virtual production to reduce costs and time to market.

One potential headwind, however, is that virtual production itself represents a significant investment. Even though—if planned well—it can cost less and be quicker than traditional techniques, the tools involved can be complicated and difficult to use, requiring significant training as well as sophisticated and expensive hardware. Qualified virtual production talent is currently scarce—and therefore costly. In addition, the landscape of bespoke providers is fragmented.[9] Larger and more established studios have assembled their own virtual production toolchains and are learning how best to integrate them into production—but smaller studios and streamers moving into CGI-based entertainment may instead partner with third-party providers that can provide the talent, software, and hardware in the same package. All these users will likely reckon with uneven standards, setup and tracking challenges, and the nuances of seamlessly blending the physical and digital.[10]

Virtual production also affects how productions are planned and financed. Because it shifts much of the work that was done in postproduction into the preproduction phase, studios must do more up-front work to build digital assets, match colors, and properly set up hardware and software. This can deter investors who balk at having to provide funding earlier in production.

Over time, however, the cost, expertise, and funding barriers will likely come down as the virtual production market grows. And as the industry matures and best practices are discovered, virtual production is becoming easier to use. The interplay of gaming and video production could potentially generate a feedback loop of content development as digital assets like sets, characters, and imagery can move more easily between mediums. More studios are pursuing franchises built around "universes" that can be experienced through video and gaming—and more audiences are becoming used to engaging with rich, imaginative, and hyperrealistic virtual worlds. As entertainment becomes increasingly social and interactive, the technologies of virtual production will likely be seen as fundamental building blocks and enablers of the emerging metaverse.

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Acknowledgments

As seen in your feed: Shopping goes social, trending past US$1 trillion in annual sales

Propelled by social media influencers and digital-native consumers, social commerce is laying the groundwork for a broader shoppable media landscape.

Brooke Auxier, Ariane Bucaille, Kevin Westcott, and Dennis Ortiz

THE SOCIAL MEDIA feed is the new storefront—and users are doing more than just window shopping. Deloitte Global predicts that the market for social commerce will surpass US$1 trillion globally in 2023 (figure 1).[1] That's assuming an approximate CAGR of 25%—not unreasonable considering past growth trends and the continued reliance on all things mobile and digital—driven by the purchases of the more than 2 billion people expected to shop on a social media platform in 2023.[2]
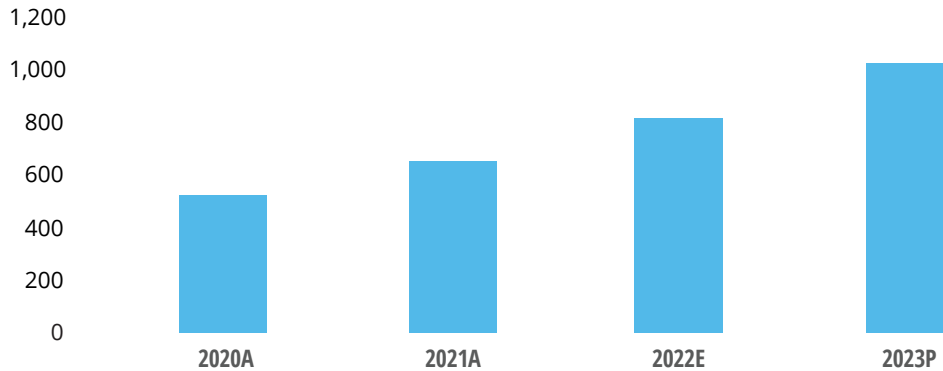
Shopping on social: The ultimate in inspiration and instant gratification

Social commerce—a consumer experience on a social platform that blends the point of inspiration and the point of purchase—marries serendipitous product discovery with effortless digital payment to create shopping opportunities that are hard for many to resist. Imagine seeing your favorite influencer's latest post in your social feed—and they're wearing the coolest pair of shoes you've

FIGURE 1

The global social commerce market is expected to continue to expand, possibly topping US$1 trillion in annual sales in 2023

Global social commerce market (US$ billions)

Note: 2020 and 2021 are actual numbers, 2022 is Deloitte's estimate of sales, and 2023 is Deloitte's prediction.
Source: Deloitte Global analysis.

ever seen. With a couple of quick taps, you can add those exact shoes to your virtual cart, "buy now" with a mobile payment service, and get them delivered to your doorstep within a few days. All without leaving your couch … or your device.

Social commerce—a consumer experience on a social platform that blends the point of inspiration and the point of purchase—marries serendipitous product discovery with effortless digital payment to create shopping opportunities that are hard for many to resist.

With an expected 5 billion social media users worldwide in 2023,[3] the social commerce market is growing faster than traditional e-commerce,[4] and it
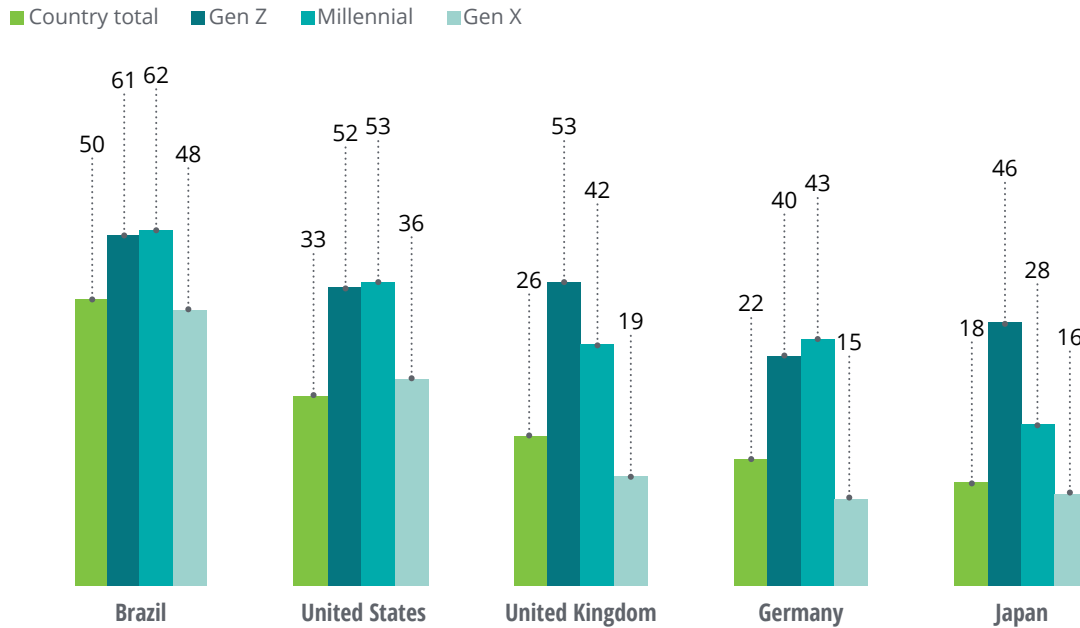
shows no signs of slowing down. Fueled initially by a surge in popularity during COVID-19,[5] the market is continuing to expand despite ebbs and flows in the pandemic. Research from 2021 shows that about a third of US consumers had ever made a purchase directly on social media, and an even larger share said that seeing a product on social media was part of their buying journey.[6]

So what's behind all this growth? In large part, it's the rise of the "creator economy," the cadre of millions of "influencers" or "creators" who use their clout to promote, advertise, and sell products to their captivated audiences. These online personalities have global reach: In many countries, including the United States, the United Kingdom, Germany, Brazil, and Japan, at least 60% of people say they follow influencers. To convert these loyal fans into repeat customers—which is largely how they monetize their online content[7]—influencers build relationships with their followers, encourage community among their devotees, and sell their lifestyle with every new snap and selfie. Many make thousands of dollars per post, though compensation varies widely based on the number of followers they have on a given platform.[8]

FIGURE 2

Gen Z and Millennial consumers are most likely to say their buying decisions are influenced by social media influencers

Percentage of consumers who say social media influencers completely or somewhat influence their buying decisions

■ Country total ■ Gen Z ■ Millennial ■ Gen X

Brazil: 50, 61, 62, 48
United States: 33, 52, 53, 36
United Kingdom: 26, 53, 42, 19
Germany: 22, 40, 43, 15
Japan: 18, 46, 28, 16

Note: N (all Brazil consumers) = 1,000; N (all US consumers) = 2,000; N (all UK consumers) = 1,002; N (all Germany consumers) = 1,002; N (all Japan consumers) = 1,000.
Source: Kevin Westcott et al., *2022 Digital media trends, 16th edition*, Deloitte Insights, March 28, 2022.

Social media users have proven a receptive audience for influencers' sales tactics. One-third of US consumers, for instance, say that social media influencers … well … influence their buying decisions. In Brazil, that figure increases to 50%, perhaps because people in Brazil are more likely to use social media and follow influencers compared to people in the other countries surveyed.[9] The influence of social influencers is likely higher still in markets like China, where the social commerce landscape is even more developed and sophisticated.[10]

At around 20% of the global population, Millennials currently dominate the social commerce market (figure 2).[11] But not to be overlooked is the maturation of many Gen Zs to an age where many have more money to spend. Gen Z is the world's biggest generational cohort, accounting for more

than 30% of the population worldwide,[12] and most of this burgeoning generation of digital natives tend to be all social, all online, all the time. Nearly all Gen Zs surveyed across the United States, the United Kingdom, Germany, Brazil, and Japan say they use social media platforms, with 85% of responding US Gen Z social media users saying they go on social media *daily*. Further, more than half of US Gen Zs say they use social media for shopping inspiration,[13] which is the first, and arguably the most important, step in the purchasing journey. In the future, Gen Zs are expected to continue to be very much online, where they'll continue to get hypertargeted and personalized ads for products they want and need—straight from the influencers they already know and love.

THE BOTTOM LINE

The expanding social commerce ecosystem is full of opportunity for brands, social platforms, and developers alike. Brands and influencers should focus their efforts on discovering which product categories are ripe for social commerce as well as tracking cultural shifts in user behaviors and buying preferences.

The creator economy—and the content influencers produce and post—has increased media consumption on social platforms overall, making these platforms ideal channels for brands to capture potential customers where they are already spending their time. Identifying and activating an inclusive cohort of influencers, who not only represent the brand but can relate to and connect with ideal customers, could thus be central to cracking the social commerce code.[14]

In addition, brands can benefit by utilizing social advertising's hypertargeted and personalized features. Social media algorithms that determine which ads are displayed in a user's feed can be highly effective, drawing on billions of data points and powerful analytics to understand consumers and their needs. More than four in 10 consumers surveyed across the United States, the United Kingdom, Germany, Brazil, and Japan say they see ads on social media for things they have been looking for.[15] Launching novel social shopping experiences, such as livestreamed events (already highly successful in China)[16] or augmented reality–powered try-ons, could also be key.

Most social platforms are already benefiting from influencers' success in reaching and selling to their audiences: the platform gains new avenues for monetization, and it retains users who are captivated by influencer content. These platforms, as well as technology developers, can seek to further cash in by building infrastructures and capabilities that support fully integrated, intuitive shopping and payment experiences—not just on social media, but on streaming video platforms, gaming services, music and podcast services, and just about everywhere else in the future metaverse.

As social commerce evolves globally through continued experimentation and by looking to more mature markets for guidance, it has the opportunity to draft the blueprint for the broader shoppable media landscape, making new products easier to find, simpler to pay for, and quicker to buy across digital experiences. Looking beyond 2023, most digital experiences are expected to be considered "shoppable," and the same tap-to-purchase behavior available on social media platforms will likely be possible with other online services, too. Imagine watching a cooking show on a streaming video service. Just pause, select the recipe, add the items to your virtual grocery cart, select a delivery time, use mobile payment, wait for the doorbell to ring—and voila! Dinner is served.

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Acknowledgments
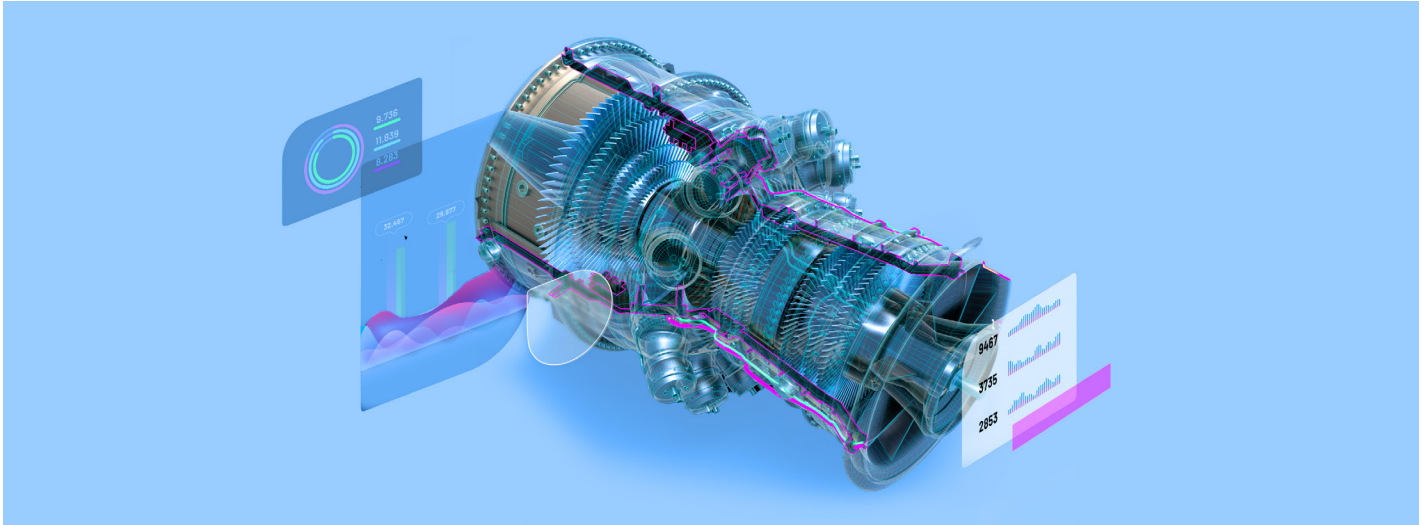
Will VR go from niche to mainstream? It all depends on compelling VR content

Applications that capitalize on virtual reality's unique capabilities will be key to enabling VR to enjoy a significant growth rate.

Paul Lee, Chris Arkenberg, Ben Stanton, and Allan Cook

F YOU DON'T yet know anyone who has a *Meta Quest*, *HTC VIVE*, or *Sony PlayStation® VR*, check in again at the end of the year. Deloitte Global predicts that the virtual reality (VR) market will generate US\$7 billion in revenue globally in 2023, an impressive 50% increase over 2022's US\$4.7 billion. Ninety percent of that revenue will come from headset kit sales, of which 14 million units averaging US\$450 each are expected to sell in 2023. The remainder, generated by the much smaller software market, will consist mostly of VR content—principally games, but also some enterprise applications—which will see revenues of

approximately US\$0.7 billion. We further predict that the installed base of actively used VR headsets will reach 22 million in 2023, almost 50% higher than that of mid-2022.

VR's success will depend on doing what other devices can't

When Deloitte first sized the VR market in 2016,[1] it stood at US\$1 billion for hardware and software combined, so a US\$7 billion year represents quite the growth rate over the years. This growth is being

catalyzed in part by improvements in the underlying technology, including greater processing power, better screens, and richer audio. 2023's headsets should offer higher frame rates, higher-resolution displays, and enhanced spatial audio (which enables users to better discern the direction of sounds, such as a speaker's voice), enabling an even more realistic immersive experience. Better ergonomics, including lighter weight and better ventilation, would also assist.

That said, in terms of numbers, VR has a long way to go to catch up with other digital devices. Smartphones alone count almost 5 billion users worldwide,[2] and billions also use PCs, tablets, and TV sets. Even smart speakers, a relatively new device that launched in 2017, will likely boast an installed base of more than 500 million units by the end of 2023.[3] At an active installed base of just 22 million in 2023, VR will therefore remain relatively niche for the time being.

VR's future growth will hinge on creating applications for consumers and enterprises that take full advantage of the immersive medium and encourage repeat usage. Advances in social VR games, next-gen storytelling, remote travel and education, and enterprise training and collaboration could all help drive adoption. However, if VR use cases overindex on its novelty, or if applications are hard to scale or simply work better on other devices, it's unlikely to reach the adoption rate of other consumer devices. VR hardware and software providers understand this: In 2023, we expect the industry to progress greatly in identifying the specific consumer and enterprise applications for which VR is optimal, able to address needs not currently being met by other devices or, indeed, by real-world experiences.

The most suitable use cases will be for immersive applications that do not require frequent, precise control, like entering text. These applications would mostly track a user's hands, and increasingly their eyes and bodies, as input. Games can also

access inputs from game controllers or steering wheels. Because VR users who are moving around risk bumping into real-life objects or people, VR experiences are more fit for dedicated spaces rather than communal settings. Headsets and positional tracking devices can model the physical spaces in which users don headsets and even track their body movements.

Due to current battery limitations for untethered headsets—and fatigue for some users—VR will also be more appropriate for uses that last for tens of minutes at a time rather than hours.[4] For some users, too, the heat generated by a headset may cause dryness of the eyes.[5] This means that they won't use VR for a full day—but again, they may not need to for it to be useful.

Games are likely to be one of VR's major applications in the consumer space, particularly in immersive genres such as first-person shooters, racing games, and simulators. VR's big advantage for these types of games is its much higher degree of immersion. While big TV screens and monitors offer an ever-larger field of view, VR views have no edges at all. With *Sony* launching its second-generation VR headset in early 2023,[6] and roughly 20 major games likely to launch for VR or with a VR option in 2023,[7] more gamers may be tempted to try VR. One limitation, however, may be that even leading VR multiplayer games are often limited to just 10 players together in a session, while many of the most popular 2D games on consoles and PCs can host multiplayer experiences with up to 150 players simultaneously. For VR to convert more multiplayer gamers, it may need to have stronger synchronization supported by next-generation networks.[8]

Other consumer VR content may include genres such as horror that use immersion to intensify the experience.[9] Remote travel and education uses will also serve some niche consumer experiences. Additionally, VR is likely to be increasingly used for mindfulness, with users donning a headset to be

transported to a tropical rainforest minus the humidity, or to gaze at the northern lights without the cold.

For enterprise uses, VR's opportunity lies in simulating work experiences, visualizing enterprise and industrial-scale systems, and overcoming the challenges of distance. For example, 2023's VR systems are likely to excel at hosting meetings for small teams that are unable to gather in person. Some may find VR-enabled virtual meetings superior to a "traditional" 2D video call, as VR makes it easier to see and hear who is speaking at any given time. VR avatars could also prompt better engagement with meetings by attendees who might otherwise, in a 2D video call, be tempted to turn off video and read email or play games on their phone.

VR can also be used for immersive training and work simulations alongside in-person and 2D video classrooms. Workers can train using virtual interfaces and machine models, run customer simulations, and practice emergency response drills without risk of failure. Such simulations can leverage the use of digital twins—virtual 3D models of physical systems connected to real-time data sensors—ranging from digitized 3D models of machinery to entire factories or towns recreated as functioning digital objects.[10] Enabling users to "touch" and manipulate digital models directly would contribute to the emergence of the enterprise metaverse, which seeks to bring remote collaborators together into virtual spaces where they can interact with 3D objects, assemblies, and systems.

THE BOTTOM LINE

Encouraging greater usage, especially among consumers, relies on both the quality and the quantity of VR content. Devices such as smartphones, tablets, and connected TVs have thrived on the availability of millions of apps. For VR to thrive, dedicated VR apps will need to see greater amounts of innovation. As of mid-2022, VR apps only numbered in the low thousands.[11] Moreover, consumer VR today competes for attention with phones, tablets, consoles, and PCs—a fiendish set of rivals— further demanding high-quality innovation from VR developers.

FIGURE 1

Relatively few people own virtual reality headsets today
Percentage of respondents who owned or had access to a VR headset in 2022

United States
12%

Italy
8%

United Kingdom
8%

Germany
6%

Canada
6%

Japan
3%
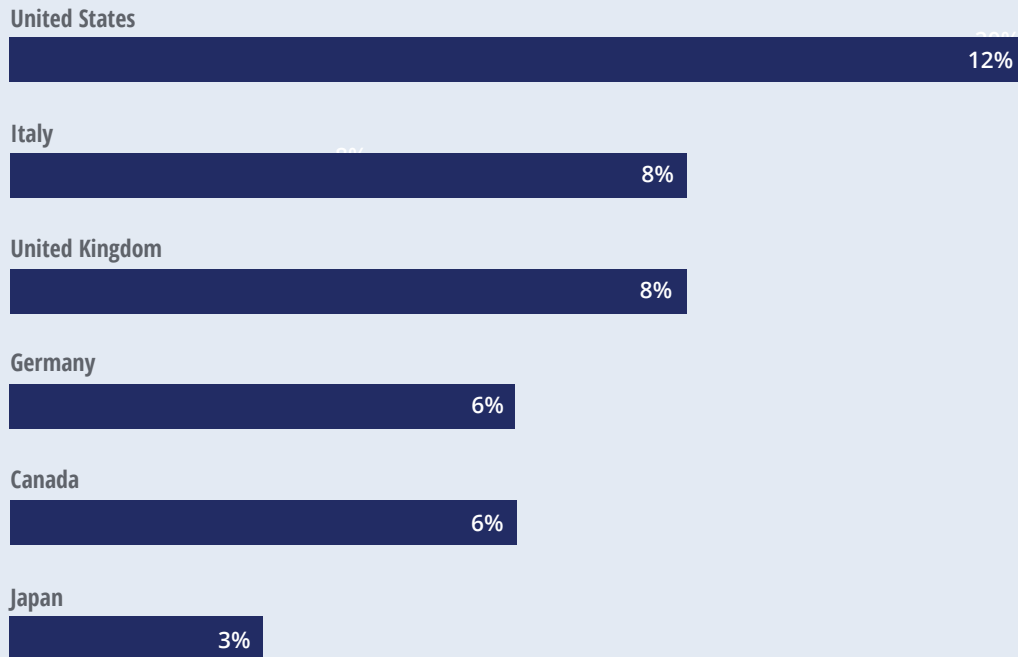
Sources: Data from *Digital Consumer Trends*, Global Edition, Deloitte, April–July 2022; other Deloitte sources.

For enterprises, leaders should be very clear about which applications are uniquely or best suited to each device, bearing in mind that the scope of business applications is likely to be limited in the near term. It's worth remembering in this regard that the first smartphones were used predominantly for email before expanding to their plethora of other uses; VR may follow the same trajectory. Enterprises should carefully track the success of their VR deployments and identify which applications gain traction versus those that employees abandon after a few uses. Some may be reluctant to use VR, finding the idea of being strapped into an apparatus that controls their field of view overwhelming, and occasionally nauseating, rather than exhilarating. Businesses may also need other capabilities to support VR's use, including technical support, connectivity, security, and even potential compliance support for data collection or deployment in critical use cases. For example, some VR headsets enable eye-tracking, which represents a new personal data set that will need to be controlled.

Despite challenges like these, the VR market has plenty of momentum for continued growth. Putting on a VR headset, there is an undeniable moment of awe and a sense of being in an actual "place". The challenge is what to do next. If consumer and enterprise applications become more useful and more widespread, people should use VR headsets and peripherals more and more, and be more and more apt to buy content to run on them. The hardware and software markets could then feed off each other in a virtuous cycle of growth, taking VR beyond niche at last.

Endnotes

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Acknowledgments

Technology

Battle for the enterprise edge:
Providers prepare to pounce
on the emerging enterprise
edge computing market

Cloud, telco, equipment, and platform companies are vying for a share of enterprise investments in edge services and products that make computing faster, safer, and cheaper.

Naima Hoque Essing, Jack Fritz, Ariane Bucaille, and Craig Wigginton

THE ENTERPRISE EDGE is fast becoming the new frontier of digital transformation, and the size of the prize is sending companies of all types—public cloud hyperscalers, communication service providers, infrastructure equipment manufacturers, management platform providers, and others—scrambling for a piece of the growing pie. Deloitte Global examined the edge as a compelling opportunity in its 2021 *Predictions* publication.[1] Some of the headwinds we identified then have slowed the market's evolution and the willingness of enterprises to invest. As the market

develops, a clearer view of the major players' offerings and strategies has emerged and Deloitte Global predicts that the enterprise market for edge computing will grow at 22% in 2023,[2] compared to 4% growth in spending on enterprise networking equipment and 6% on overall enterprise IT for the same year.[3] Most of this growth will likely come from expenditures on hardware initially but will migrate toward software and services as the market matures. While enterprise spending on edge computing is gaining traction, it is off a relatively small base.

FIGURE 1

Growth in enterprise edge infrastructure spending is far outpacing growth in network equipment and overall IT spending
Estimated market growth rates in 2023

22%		
	4%	**6%**
Enterprise spending on edge hardware infrastructure	**Enterprise network equipment spending**	**Information technology spending**
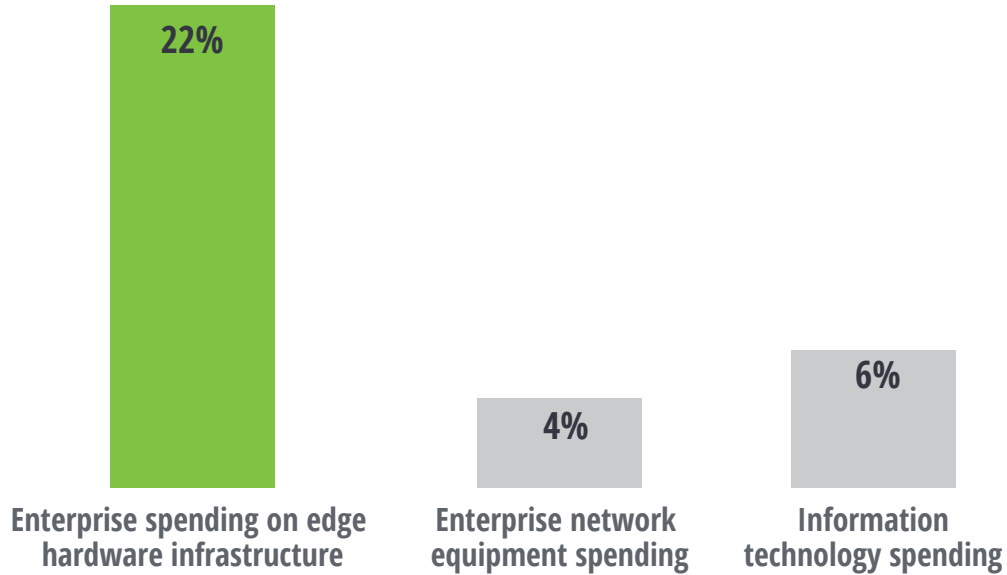
Source: Based on Deloitte analysis of IDC, Gartner, Omdia, TBR, HPE, AvidThink, Precedence Research, Grandview, and STL forecasts.

As enterprises pursue edge computing's benefits, providers are eager to oblige

Billions of devices connect to the internet: smartphones, computers, security cameras, machine sensors, and many more. Devices like these generate massive amounts of data, most of which travels over the internet to applications running in the cloud. The cloud, in turn, is powered by enormous, centralized data centers and platforms operated and offered by a few organizations.

The problem with this is that, as the number of connection points explodes to 150 billion devices generating 175 zettabytes of data by 2025,[4] sending all that data to faraway clouds for processing will become increasingly inefficient and expensive. Moreover, this model may not be able

to deliver the real-time data and response times demanded by newer applications. Consequently, more organizations are considering a hybrid cloud model that augments existing cloud strategies with edge computing.

Edge computing distributes the cloud's scalable and elastic computing capabilities closer to where devices generate and consume data. These locations can be as varied as an enterprise's on-premise server, a communication service provider's central office or cell tower, a hyperscaler's regional data center, an end-user device, or any point in between.

Since data doesn't have to travel as far, using edge computing can help reduce network resources, cut transit costs, improve reliability, reduce latency,[5] and, perhaps most importantly, enhance enterprise control over data and applications.

For example, edge computing can help organizations meet increasingly stringent data sovereignty, privacy, and security requirements by keeping sensitive data on premise. What's more, when edge computing is combined with advanced connectivity options—especially 5G—it can deliver flexible, near real-time response times for data-heavy, artificial intelligence–driven, time-sensitive, or mission-critical applications. The combination of low latency, advanced connectivity, and enhanced data control makes many IoT use cases, such as the video analytics and computer vision used in security and quality control, immersive mixed reality training, autonomous vehicles, and precision robotics, much more feasible.

The developing edge computing ecosystem is highly diverse. While chipset makers, device manufacturers, application developers, security specialists, and system integrators also feature prominently, we'll focus on four categories of companies that are active in the edge computing market: public cloud hyperscalers, communications service providers (CSPs), infrastructure equipment vendors, and cloud management platforms.

FIGURE 2

Players in the edge computing market face a crowded field

Notable companies in the edge computing value chain

Public cloud hyperscalers	• Amazon Web Services (AWS) • Microsoft Azure • Google Cloud
Communication service providers	• Telstra • Verizon • KDDI • SK Telecom • T-Mobile • Orange • Telenor • Telefónica • AT&T • Vodafone
Infrastructure equipment vendors	• Dell • Nokia • Cisco • JMA Wireless • Mavenir • Ericsson • Hewlett Packard Enterprise (HPE)
Edge cloud management platforms	• Red Hat • VMware • Nutanix • MobiledgeX • Amdocs

Source: Multiple public sources.

Public cloud hyperscalers. Hyperscalers are likely to play a key role in standardizing, simplifying, and commercializing enterprise edge computing solutions, leveraging their platforms, ecosystems, and marketplaces to deliver easy-to-consume, right-sized, yet scalable and affordable solutions. Hyperscalers are treating edge computing as an extension of their existing cloud business, regionalizing and scaling their massive global cloud infrastructures into smaller formats that can enable customers to process workloads closer to or in their facilities. As part of this effort, many are partnering with CSPs, content delivery networks, cell tower owners, and others with highly distributed network facilities to colocate these scaled-down edge cloud platforms close to potential clients. Some hyperscalers are shrinking their cloud platforms even further to deliver turnkey edge computing platforms that enterprise customers can deploy on their own hardware infrastructure in their own environments. To pursue this market, they are partnering with specialized system integrators and others to extend their sales channels into specific industry verticals.

CSPs. CSPs are also well-equipped to offer packaged edge computing solutions. Besides providing the connectivity between the hyperscaler's centralized cloud and the enterprise's on-premise data centers, servers, or devices, a number of them believe that they can also profit from offering edge computing solutions in conjunction with secure and reliable connectivity to enable real-time applications. These CSPs are taking measured steps toward developing their edge computing infrastructures, platforms (often in conjunction with a hyperscaler), and services, collectively known as multi-access edge computing (MEC).[6] As part of a MEC offering, CSPs can use their 5G networks to deliver a wide range of à la carte or fully managed connectivity, compute, storage, and security edge services, or even develop their own B2B and B2C applications tailored to an enterprise's specific needs.

Many CSPs have well-established relationships, credibility, and trust with enterprise customers on which to build their MEC business. On the other hand, many still need to develop their strategy, value proposition, business and operating models, partnerships, and customer-centric sales capabilities to effectively offer and deliver these services.

Infrastructure equipment vendors. For infrastructure equipment vendors, edge computing provides more opportunities to supply service providers, since the increasingly virtualized and open (based on common standards) nature of networks is lowering barriers to entry and allowing for greater vendor diversity. As Dell CEO Michael Dell recently observed, "There are seven million cellular base stations worldwide, and every one of those is becoming a data center"[7]—presumably to which Dell intends to supply edge infrastructure solutions. Indeed, at Mobile World Congress 2022 (MWC 2022), not only Dell but HPE, Cisco, and other IT hardware vendors announced new edge-to-cloud computing solutions for CSPs and enterprise customers.

In pursuing these new opportunities, many IT equipment vendors are evolving their increasingly commoditized hardware-centric product portfolios into more value-added, software-centric, and consumption-based business models. An example of this trend is HPE, which in 2018 committed more than US$4 billion to build its edge computing business around the cloud and service-based business model that it announced at MWC 2022.

Networking infrastructure vendors are also getting in the game. Given greater spectrum availability, common architectures, and use case requirements, edge computing and private cellular networks are often implemented concurrently. Accordingly, the markets for edge computing and private cellular networks are developing hand in hand, leading to partnerships up and down the tech stack and across the value chain. Because cellular networks require a different skill set from edge computing,

these combined deployments expand revenue opportunities for networking infrastructure vendors with specialized knowledge of radio technologies.

Edge cloud management platforms. Because edge computing has numerous deployment options, each involving a different slate of vendors and applications, an abstraction layer—that is, an edge-cloud management platform—can be used to reduce the complexity of administrating these disparate, heterogeneous environments. These management platforms increasingly seek to provide a common operating system with centralized tools, KPIs, and dashboards, making it easier for operators, enterprises, and developers to tailor performance and security policies in diverse, hybrid environments. The programmable platforms use application programming interfaces (APIs) to control the underlying physical network infrastructure. Because these APIs are increasingly becoming standardized, open-source, and thus vendor-agnostic, their use promotes greater interoperability among the mix-and-match components from different vendors. They can also increasingly blur the distinction between infrastructure and applications as network functions and capabilities are increasingly implemented through code rather than infrastructure.

THE BOTTOM LINE

While the market for edge computing products and services is potentially huge, providers may have to wait a while for customers to catch up. Many enterprises and other organizations are rethinking their cloud, data center, and networking strategies for how best to take advantage of new edge computing capabilities. In doing so, they are evaluating where to best place workloads in a hybrid cloud/edge model—and how they can secure and access data in a data center that exists at the core, cloud, and edge.

Inevitably though, enterprises will likely solve these kinds of issues and increase their edge computing investments. And as they do, the various providers' success in capturing share may depend not on an "us versus them" mentality, but rather on working together to realize the market's potential. Telcos, hyperscalers, equipment vendors, and platform providers may often find themselves serving the same customers, each providing a different value proposition. Natural synergies will often arise in consequence—for instance, many cross-industry partnerships are forming to offer enterprises a wide range of integrated compute and networking solutions to support turnkey computer vision, virtual and augmented reality, machine learning, and other data-intensive or connected-device applications.[8] For this reason, it's safe to say that the edge computing business will likely rely on partnerships and ecosystems and not on end-to-end solution providers in every case.

Endnotes

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Acknowledgments

Tech's climate commitment: Organizational and personal impacts are pushing tech leaders toward faster climate action

The technology industry has set ambitious deadlines for achieving net-zero. Operational efficiencies, sustainable products, and tech innovations can help it get there.

Susanne Hupfer, Karthik Ramachandran, Ariane Bucaille, and Gillian Crossan

ACHIEVING NET-ZERO[1] IS a priority for many organizations today, and the technology industry is taking the imperative to heart. Deloitte Global predicts that in 2023, the tech industry will move faster on climate action than nontech industries. By "move faster," we mean that more tech companies say they're aiming for net-zero by 2030 than nontech companies. Deloitte's

*2022 CxO Sustainability* survey, which polled more than 2,000 C-suite executives worldwide, found that technology executives viewed net-zero as a more urgent priority: They were 13% more likely to target net-zero by 2030, and 24% less likely to push that goal past 2030 or have no plans (figure 1).[2]

FIGURE 1

Overall, the tech industry has set more ambitious deadlines for achieving net-zero than nontech industries

Percentage reporting when their company plans to achieve net-zero carbon emissions

■ Tech CxOs ■ Nontech CxOs
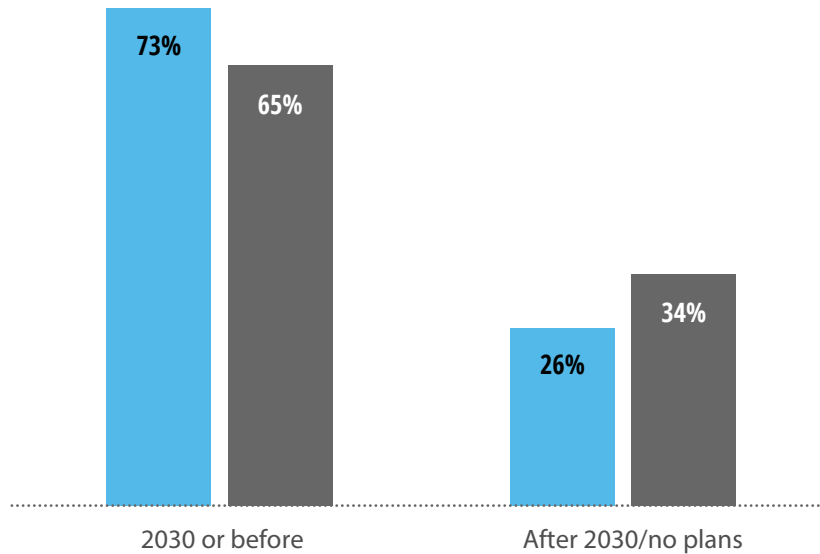
Notes: Analysis based on survey of 2,083 C-level executives from 21 countries. Small percentages of "Don't know" responses have not been shown.
Source: Deloitte, *Deloitte 2022 CxO Sustainability Report: The disconnect between ambition and impact*, 2022.

Tech executives feel increasingly concerned and impacted. They're also more likely to act.

That tech leaders are in a hurry to mitigate climate change may not be surprising, considering the attitudes and experiences they reported in Deloitte's survey. Tech executive respondents were more likely to be worried about climate change than those in other industries, and more likely to report personal impacts (figure 2).[3] Their direct experience with climate-driven adversity may be one reason they intend to act quickly.

Organizational impacts from climate change are growing—and quickly. Thirty-seven percent of surveyed tech executives reported that their organization is already experiencing a scarcity of

resources such as water and energy—up eight points from a similar Deloitte survey conducted only eight months earlier. Thirty-eight percent said that they were feeling the cost of climate change mitigation—more than double the prior survey's percent. And 42% percent said that their operations had been affected by climate-related disasters or weather events—up 18 points from the earlier survey.

These organizational disturbances are often consequential. For example, during London's record-breaking July 2022 heat wave, two global tech companies' cloud-based data centers experienced service disruptions due to cooling failures.[4] In August, facing historic heat and drought that jeopardized the region's power supply, China's Sichuan province shut down factories, including electronics component makers that

FIGURE 2

Tech leaders worry more about climate change and suffer greater impacts, but they're also more optimistic about making a difference and more likely to act

Tech and nontech executives' views, experiences, and actions on climate change

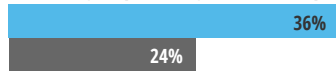■ Tech CxOs ■ Nontech CxOs

Concern and impact
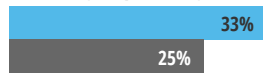
Company is "very concerned" about climate change
- Tech CxOs: 72%
- Nontech CxOs: 61%

Personally impacted by extreme heat in past year
- Tech CxOs: 61%
- Nontech CxOs: 46%

Personally impacted by wildfires in past year
- Tech CxOs: 36%
- Nontech CxOs: 24%

Personally impacted by water shortages in past year
- Tech CxOs: 33%
- Nontech CxOs: 25%

Optimism

Strongly agree that immediate action can limit climate change's worst impacts
- Tech CxOs: 56%
- Nontech CxOs: 46%

Action

Company has been training employees on climate change actions and impact
- Tech CxOs: 65%
- Nontech CxOs: 55%

Company has created a senior position/function responsible for driving sustainability initiatives
- Tech CxOs: 57%
- Nontech CxOs: 52%

Company has received SBTi validation of its GHG reduction targets
- Tech CxOs: 40%
- Nontech CxOs: 34%

Note: Analysis based on survey of 2,083 C-level executives from 21 countries.

Source: Deloitte, *Deloitte 2022 CxO Sustainability Report: The disconnect between ambition and impact*, 2022.

supply major tech companies.[5] In 2019, US scientists were forced to power down one of the world's most powerful supercomputers twice in two weeks due to preemptive multi-day power cuts intended to mitigate wildfire risk in northern California.[6] And in 2021, severe winter storms in Texas triggered days of power outages and closed three major semiconductor plants.[7]

Stakeholder pressure is lending additional weight to these organizational and personal incentives. These include investors as well as customers, board members, and especially US and EU regulators that mandate more rigorous disclosures on greenhouse gas (GHG) emissions, environmental risks, and mitigation actions.[8]

Despite confronting these challenges and pressures, tech leaders aren't throwing their hands up in despair. On the contrary: The 2022 Deloitte survey found that tech executives were *more* likely than executives in other industries to believe that immediate action could mitigate climate change's worst impacts. Nine in ten of the surveyed tech

leaders believed that their companies' current sustainability initiatives will help mitigate climate change. And eight in ten believed their efforts would boost investor and customer satisfaction, employee morale, brand recognition, operating margins, revenue from new businesses, supply chain resilience, and innovation.[9]

What's more, tech companies were more likely than nontech companies to have taken several steps toward mitigating climate change: creating a senior position to drive sustainability efforts, training employees on climate change actions, and publicly committing to a GHG reduction target through the Science-Based Targets Initiative (SBTi)—a coalition that helps companies set goals and timelines for reducing emissions (figure 2).[10] As of August 2022, 338 of the 3,545 companies that have committed to developing net-zero targets with the SBTi were from the technology sector, making it the second-largest industry segment represented.[11] More than four in ten of these tech signatories have already set emissions reduction targets.

Other signals also point to the tech industry's sustainability leadership. For instance, a 2021 analysis found that of the top 10 US companies by market value, the five with the earliest deadlines for reaching net-zero were all tech giants.[12] The tech industry is already among the biggest global buyers of renewable energy: In 2021, tech giants were responsible for more than half the corporate purchase agreements for clean energy.[13] On the regulatory front, too, some large tech companies have themselves been advocating for mandatory disclosures on climate change.[14]

Such leadership is welcome from an industry estimated to be responsible for 2–3% of the world's GHG emissions, mainly due to the enormous energy demands of technology manufacturing processes, billions of connected devices, and proliferating data centers.[15] The good news is that the tech industry is starting from a smaller carbon footprint than others, and it has many opportunities to both reduce that footprint and help others do so.[16] We're seeing tech companies lead in several broad ways such as:

1. *Tackling carbon reduction more aggressively— and influencing ecosystems.* Tech giants are investing heavily in global solar and wind farm projects to power their operations.[17] Addressing the broader value chain, Apple is helping its suppliers shift to renewable energy and also investing in a new solar farm to account for the energy consumed by its product users.[18] Aiming for half its shipments to be carbon-neutral by 2030, Amazon has launched package deliveries that use e-cargo bikes, people on foot, and electronic vehicles.[19] And Google intends to run on carbon-free energy 24/7 by 2030, which involves innovations like geothermal power and smartly routing computing tasks to locations

with carbon-free electricity.[20] Some tech leaders are also influencing broader ecosystems to commit to net-zero: The Climate Pledge, for instance, was co-founded by Amazon in 2019 and now has nearly 400 signatories, including several other large tech companies.[21]

2. *Making their products more climate friendly.* Some tech companies are tackling the e-waste problem by using more recycled materials in products, designing them for better repair and recycling, and promoting a circular economy for electronics.[22] Having recovered two billion pounds of discarded electronics and used 100 million pounds of recycled material in new products by 2020, Dell now aims to have most of its product content made from renewable or recycled material by 2030.[23] And Apple is purchasing the first commercial, low-carbon aluminum for use in its phones.[24]

3. *Creating climate tech that tracks and mitigates the effects of climate change—for themselves and their customers.*[25] For example, several tech companies have debuted tools that help customers track emissions from their cloud and software use.[26] Others are investing in carbon capture technologies.[27] Still others are using analytics and robotics to decrease energy consumption: For instance, Google has been using DeepMind AI software to trim its data centers' power usage and to predict power output from wind farms.[28] And companies can use tech advances such as environmental monitoring satellites, IoT, data analysis, blockchain, and AI to increase efficiencies in buildings, manufacturing, and agriculture; improve data center management; and reduce traffic congestion.[29]

THE BOTTOM LINE

To meet the challenge of climate change, tech leaders can consider how their company's mission, operations, business models, and products and services may need to adapt:

• *Commit to net-zero*. A critical first step is to be clear about the company's plan and timeline for getting to net-zero. Leaders should consider having their company's reduction targets validated by an external organization.

• *Improve management and governance*. Tech companies may need to update their management and governance, such as creating a senior position to drive climate initiatives and linking executive compensation to sustainability performance. Improving governance and data management processes and controls can help ensure thorough and accurate disclosures.

• *Adapt operations*. Organizations may need to rethink both operations and production. They may need to make buildings, equipment, and manufacturing more energy-efficient, use more sustainable materials, reduce travel, train employees on new practices, and purchase renewable energy.

• *Reconsider the product portfolio*. Companies can choose to double down on products and services with the most potential to reduce carbon. For example, Vodafone aims to help its customers reduce carbon emissions by 350 million tons by 2030, mainly by supplying IoT services for fleet management, logistics, manufacturing, and metering.[30] Through digital innovation, tech companies can help accelerate the decarbonization of other industries.[31]

• *Address the value chain*. In the tech sector, value chain emissions are estimated to be 7 times greater than operational emissions.[32] Rather than focusing narrowly on their operations, organizations can work collaboratively with suppliers and partners to meet sustainability criteria.[33] Ultimately it may be productive to take a comprehensive systems approach, recognizing that today's industries will likely transform into complex, interconnected net-zero systems.[34]

Like any industry, tech is vulnerable to climate change risks. But technology executives, more than most, seem to appreciate how vulnerable they are, and many are making strong commitments to do something about it. In 2023, the race to net-zero may see tech companies well represented in the vanguard.

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Acknowledgments

Mergers and acquisitions

Let's make a deal—in gaming! Gaming M&A is growing on the back of consolidation, portfolio plays, and game tech

Video game companies, video streamers, and even hyperscalers pursue gaming M&A for talent, tech, and intellectual property to expand portfolios and quickly access new markets.

Chris Arkenberg and Kevin Westcott

VIDEO GAME COMPANIES are thriving, and so is the market for buying and selling them. In 2022, deal flow—the number of gaming deals—accelerated.[1] Deloitte Global predicts that, in 2023, the number of game company mergers and acquisitions (M&A) will increase by around 25%, slightly slower than the estimated 30% quarterly growth in 2022. We anticipate that this year's larger deals will mainly seek to acquire

audiences and IP, while smaller deals will focus more on technologies and Web3 solutions.

Overall deal value in 2023 will likely decline considerably year over year, but only because of a few historically exceptional deals in 2022. However, those exceptional acquisitions could set the bar even higher for competition in the coming year. Even though the year's total deal value will

probably decline, the continued strength in deal volume underscores the importance of gaming to the broader media and entertainment industry.

In a thriving industry, more media and entertainment companies see growth in gaming

Growth in video gaming was already strong and sustained when the COVID-19 pandemic, with its lockdowns and social distancing, gave the industry an additional boost. Now, even with more people returning to public and in-person entertainment options, engagement with games has continued. This is especially true among younger players, who increasingly compete and socialize on multiplayer game services and spend considerable sums on in-game goods and content. Game services, experiences, and business models are innovating, console supply chains are loosening up to meet pent-up demand for next-gen experiences, and many anticipated games that were delayed in 2022 are now set to reach players in the coming year.

Innovation is driving the number of gamers—not to mention revenue—higher. In Deloitte's *2022 digital media trends* survey of 2,009 US consumers, almost all Generation Z, millennials, and even Generation X respondents said they game regularly, averaging 11 hours every week.[2] One market research firm anticipated that 3 billion people worldwide will be habitual game players by the end of 2022. Driven by game sales, subscriptions to game services, and in-game purchases of virtual goods and content, game company revenues hit an estimated US$200 billion for the year.[3]

With the industry doing so well, it's no surprise that competitors and opportunists are lining up for M&A-driven growth opportunities. Game companies are consolidating, competing for access

to gaming audiences and IP,[4] and acquiring smaller businesses that provide components and services to the gaming ecosystem.[5] Short of M&A, some are buying up shares in key ecosystem providers.[6] Many media and entertainment companies are looking to expand their portfolios into gaming to keep younger generations under their roof;[7] some of these are buying game companies for their leading franchises, seeking to develop more IP across film, streaming, and games.[8] And new Web3-native disruptors are gathering users around their early metaverse experiences. Their blockchain-based games tilted toward the Web3 metaverse have attracted large amounts of funding,[9] and could offer acquirers an appealing buffet of emerging technologies, new business models, and rare talent.

In Deloitte's *2022 digital media trends* survey of US consumers, almost all Generation Z, millennials, and even Generation X respondents said they game regularly, averaging 11 hours every week.

If M&A is so attractive to game companies right now, why do we expect 2023's deal values to fall short of 2022's? While the volume of deals should be high, large equity declines across the stock market are lowering game companies' valuations, making them cheaper to buy. This could bring down overall deal value while stoking more acquisitions. However, rising interest rates, looming recessionary pressures, and macroeconomic uncertainty may sideline some potential acquirers, leaving M&A growth opportunities to those with deeper pockets and a

longer view of the opportunities. Gaming's overall resilience may also come into question. In the second half of 2022, revenues from gaming services and in-game purchases began to cool, likely due to a combination of tightening wallets and a renewed interest in live, in-person entertainment in the summer months. Analysts will look for revenues to rebound in 2023, but if service subscriptions and in-game purchases remain down, it may signal that 2021 and 2022's numbers were a pandemic-induced bump rather than a permanent rise.

Even so, it's worth noting that some of 2022's deals were so huge that they would be hard to top under any circumstances. The largest-ever video gaming acquisition took place in Q1 2022 (pending regulatory approval), as did two other highly notable multibillion-dollar purchases; the value of these three acquisitions was greater than the total deal value in all of 2021—which itself saw an estimated US$60 billion changing hands across approximately 600 deals.[10] However, such deals may ignite greater competition, consolidation, and concentration as more of the fragmented video game industry is scooped up by a handful of the largest gaming companies—some of which are also the largest hyperscale platform companies.[11] Indeed, 2023 may see stronger moves by deep-pocketed tech behemoths taking stakes in gaming.

THE BOTTOM LINE

In general, M&A activity looks to be heating up, but gaming M&A may be especially active.[12] Although the overall deal value for gaming M&A may be down from 2022 to 2023, it is still likely to be higher than prior years. We expect deal flow for gaming M&A to continue to accelerate, particularly for smaller acquisitions. Game companies will compete for access to increasingly lucrative audiences; they will seek tools and technologies that address existing challenges, such as ensuring fair play and providing moderation in social games; they will also look to reinforce game development and services, such as procedural environment generation, deeper audience analytics, and ad tech. They may also place bets on emerging metaverse and Web3 solutions, despite a potentially lingering "crypto winter"[13] and softening virtual real estate markets.[14]

Content will likely play a notable role as more top gaming companies and leading hyperscale platform players seek to expand their portfolios and stake a claim at the convergence of media IP, gaming, and the young metaverse. Savvy providers are acquiring rights to stories that lend themselves to "cinematic universes" that can be experienced through film, streaming video, and games.[15] Increasingly, we expect more studios to expand their presence across these media.

A growing number of gaming deals will also likely bring the Western and Asian gaming markets closer together.[16] In 2022, a number of acquirers from the United States and European Union took stakes in Asian gaming companies to access Asian players and grab IP that has proved successful in the West. Meanwhile, leading game companies in China, Japan, and South Korea made acquisitions and strategic investments in Western gaming assets. Gaming has become a global business, and game companies going up for sale now attract many other suitors than just competing game companies.

Film and TV studios, major entertainment companies, hyperscale social and platform companies, and private equity, all see opportunities in the gaming industry. Though 2023 may bring many uncertainties, many leaders considering M&A as a growth strategy may view these uncertainties as an opportunity to position their businesses for long-term success.

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Acknowledgments

TMT divestitures make a comeback: 2023 deal values in tech, media, and telecom may bounce back strongly

Many TMT companies are aiming to become smaller and more focused. Bottom-line pressure and high interest from private equity and venture capital firms can make it easier in 2023.

Karthik Ramachandran, Duncan Stewart, Sriram Prakash, and Gillian Crossan

DUE TO MACROECONOMIC headwinds, business disruptions, and a weak IPO market, TMT divestitures took a nosedive in 2022 from 2021's record-setting values: Through the first half of 2022, total divestiture deal value fell 64% from the first half of 2021, while volume went down by only 21%. However, divestitures are now poised to bounce back to near-record highs. Deloitte Global predicts that the total value of TMT divestitures in 2023 could expand by 25–50% year over year to range from US$250–300 billion, well above the US$244 billion average for the period 2016–2020. The increase in total value will likely come from a rise in both deal values and volumes (figure 1) as the business and investment environment improves and deal volume returns to historic levels.[1]

ABOUT THE PREDICTION METHODOLOGY

The US$250–300 billion total deal value we're predicting for 2023 is based on our expectation that deal volume will revert to historic levels, while deal value will rebound sharply following the drop in 2022.

Although 2022 was a dramatic outlier, deal volume over the six preceding years was remarkably stable, showing just 3% variability (2,200 ± 60 deals per year). We anticipate that the growth drivers discussed in this chapter will lead deal volume to bounce back to about 2,000–2,100 deals—just shy of the long-term average—in 2023.

In sharp contrast, total annual deal value fluctuated substantially from 2016 to 2021, showing about 37% variability (roughly US$300 billion ± US$110 billion per year). Top reasons for robust divestiture activity in certain years include mega-divestments (2018), a rush in deals during the year's second half (2020), and broad-based activity consistent with wider M&A trends (2021). The specific estimate for 2023 values is based on our expectation for a spurt in PE-led and corporate deals coupled with the confluence of growth drivers we discuss here.

FIGURE 1

TMT divestitures are expected to bounce back strongly in 2023

TMT divestitures, 2016−2023
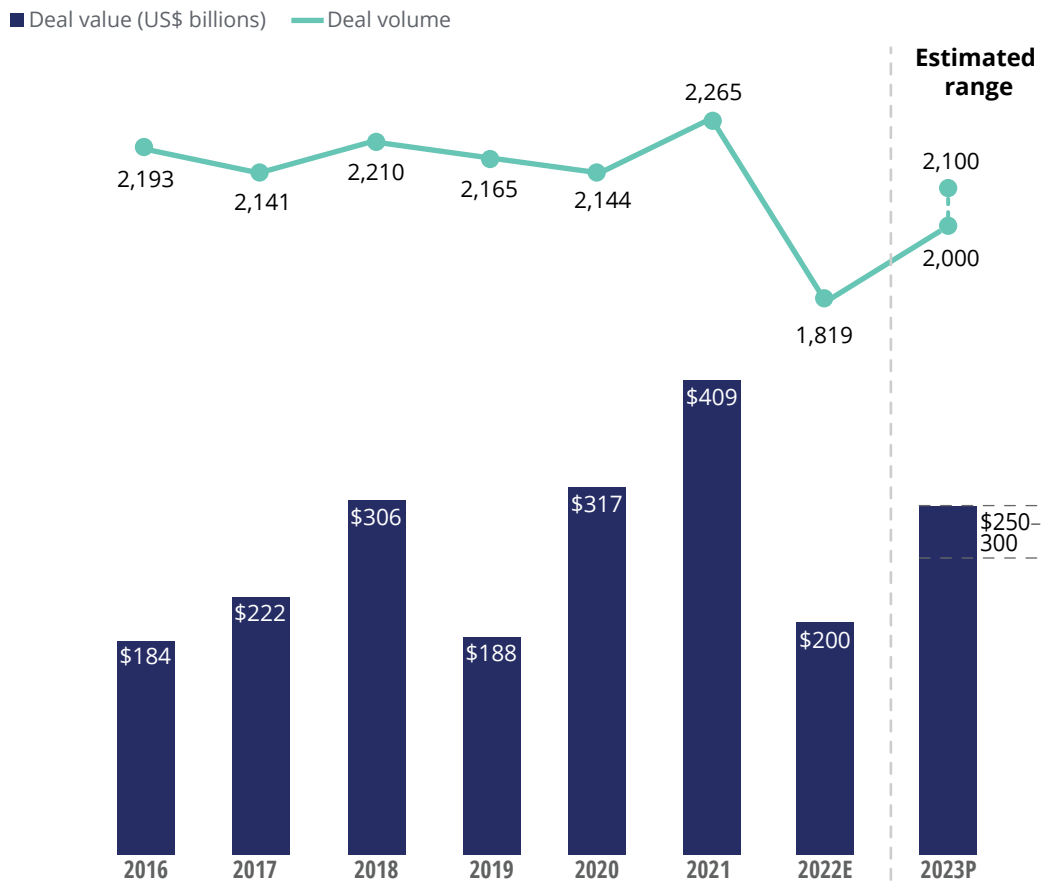
Note: E indicates estimated value and P denotes predicted value. See endnote 1 for methodology.
Source: Deloitte analysis based on data extracted from Refinitiv database in July 2022.

Divesting now could appeal to sellers and buyers alike

The decrease in divestiture activity in the first half of 2022 had many drivers: recession worries, tighter credit markets, spiraling supply chain issues, and concerns about bottom-line impact. In addition, companies were most likely still taking stock of their asset portfolios following 2021's robust M&A and divestiture season. But many TMT companies still see divestitures as a path to becoming more agile in dealing with future uncertainties, and as conditions improve, they will likely once more begin to act. In fact, Deloitte's *2022 Global Divestiture Survey* found that corporate leaders expect to step up divestiture activity going forward.[2]

The decrease in divestiture activity in the first half of 2022 had many drivers: recession worries, tighter credit markets, spiraling supply chain issues, and concerns about bottom-line impact.

We expect the recovery in TMT divestiture transactions will probably begin sometime in mid-2023, driven by several converging factors. Macroeconomic uncertainties and business disruptions may prompt companies to reassess their strategic business assets—including which ones it makes sense to hold onto.[3] Additionally, activist investors are likely to press for divestitures soon, as a variety of challenges have led to disappointing earnings and falling share prices.[4] Private equity investors (PEs) and select venture capital firms (VCs)[5] may become more aggressive buyers by

mid-2023 as they see more stable fund flows and highly attractive valuations compared to late 2021.

TMT executives are looking to divestitures to accomplish a variety of goals. Some are aiming to sharpen one or both entities' focus on their core business;[6] others want to unlock value from specific investments and assets;[7] and some are doing both as part of their portfolio recalibration efforts. All of these goals will likely involve offloading noncore business divisions, suggesting that the growth in 2023's deal activity will begin with an increase in the number of such niche, small-size transactions, with deal value following. Additionally, companies planning mega-mergers need to comply with regulations that mandate divesting certain assets before the mergers are approved.

As exit options, we expect corporate IPOs and especially SPAC-led deals to further weaken over the next 12–18 months due to higher valuations and rising interest rates. Given the muted IPO scene, we expect PE buyers to be more active in acquiring divested assets than strategic corporate buyers. PE firms are flush with record amounts of dry powder, and they will use it to chase select assets that they believe will yield higher ROI.[8] Sellers should prime the assets that they intend to sell off, as the market is less likely to simply "take over" assets available for sale.

In the technology sector, noncore assets, specialized software businesses that have the potential to scale, and financially struggling divisions with proven business models will be attractive candidates for both sellers and buyers.[9] Large, diversified semiconductor and electronics companies will likely continue to spin off select fab operations and facilities to focus on the core and preserve margins.[10] From the buyers' standpoint, PE investors can take advantage of the public funding announced by several governments, and could consider co-investing with interested chip companies to acquire fab operations that get spun off. Deal activity may be further accelerated by

regulators potentially forcing some larger tech companies to divest for anti-trust concerns.

Meanwhile, the media-telecom convergence trend seems to be slowing down, with some major telcos starting to look at prospective buyers for their media assets—especially, film and TV businesses—which could prompt de-mergers. But a more prominent driver behind many media and entertainment divestitures is digitization and consumer behavior. Consumers continue to change how they consume content as well as their spending on telecom, media, and entertainment services. Ongoing streaming wars and personal financial constraints are leading consumers to reduce their number of subscriptions: Deloitte's 2022 *Digital Media Trends* study found that almost 50% of US consumers felt that they pay too much for streaming video services, driving one in three to plan to cut back.[11] Further, they are making very specific choices about what content and

services they want to spend their money on.[12] For media and entertainment majors and conglomerates offering content, broadcasting, connectivity, and entertainment, these consumer trends may prompt them to shed parts of their operations, not only to focus on their core business, but also to strengthen their financial position.

Deloitte's 2022 *Charting New Horizons M&A report* suggests that telecom companies may deploy a range of defensive M&A strategies to safeguard their core businesses. For instance, they could continue to sell off select nonstrategic assets as part of a defensive strategy.[13] Telecom tower and infrastructure companies as well as mobile broadband service providers may seek to sell noncore assets such as media services and large data centers to invest more in high-growth areas and initiatives such as 5G, fixed wireless access, or edge computing.

THE BOTTOM LINE

TMT executives considering divestitures face a number of issues, including funding, rising borrowing costs, supply chain uncertainties, and a murky global macroeconomic outlook. Against this backdrop, leaders may need to consider several actions to ready themselves for successful deals:

Prepare for increased regulatory scrutiny: Geopolitical tensions have reached fever pitch over the past two to three years. Moreover, digitization and tech advancements are blurring boundaries and borders, data privacy concerns are intensifying, and several major countries are pushing forward with localization to gain economic strength. These factors are driving numerous regulatory changes[14] that present complexities for divestitures, especially for cross-border deals.[15] Further complicating things is that for divestitures involving targets operating in multiple regions, regulatory authorities from all of those regions will scrutinize the transactions. Whether as a buyer or a seller, companies should be highly cognizant of the specific regulations in the countries and regions where they play.

Focus on and prioritize core capabilities: A TMT company may have niche capabilities in one or more high-growth areas, such as health and well-being apps, smart home tech, advanced materials, augmented or virtual reality, or machine learning/deep learning, to name just a few. However, it may sometimes make sense to divest specific business units containing even those "attractive" opportunities if they are not contributing to the larger business vision and objectives. These types of spin-offs can allow companies to direct capital and resources towards other areas that better serve them and their customers.[16]

Gear up to transform while transacting: A deliberate and a well-planned post-deal strategy can help TMT companies increase the benefits they gain from divestitures.[17] Even as they execute the transactions, TMT executives should place equal emphasis on optimizing the end state.[18]

Demonstrate progress and positive outcomes in ESG: ESG is no longer a nice-to-have, but a vital factor driving asset managers' and PEs' investment decisions.[19] It has become imperative for TMT companies—especially in the tech industry—to demonstrate tangible ESG outcomes to be attractive to potential buyers.[20] Some companies may want to spin off assets with poor ESG characteristics to distance themselves from the parent company.

All in all, TMT companies should find it easier to shed parts of their business in 2023 than they did the year before. With PEs under investor pressure to deploy their financial firepower and willing to consider riskier deals than in the recent past, perhaps the time is ripe for TMT executives to take a close look at what should be retained and what can be let go.

Endnotes

1. This chapter uses "divestiture" to refer to transactions in which the parent company is losing a majority interest in the target company, or the target is disposing of some of its assets – where the target is a TMT company. The data in figure 1 reflects divestiture transactions across all global regions.

2. Deloitte, *2022 Global Divestiture Survey: Realizing value in a fast-paced market,* 2022.

3. Paul Silverglate, *2022 Technology Industry Outlook*, Deloitte, January 2022.

4. Deloitte's *2022 Global Deloitte Divestiture Survey* found that shareholder activism is once more emerging as a driver for sellers to consider divestitures.

5. Though VCs rarely invest in classic divested assets from companies, they are now evaluating technology management buyout spin-offs, in which the VC invests in small tech companies and funds their promising business ideas in niche areas.

6. For instance, VMware spun off from Dell in 2021 to further strengthen its cloud infrastructure and virtualization software presence, while enabling Dell to focus more on its core enterprise data center and PC markets.

7. For example, the Chinese manufacturing conglomerate BYD Co Ltd has filed for an IPO for its semiconductor business, BYD Semiconductor, to support BYD's expansion into power semiconductors and optoelectronics.

8. The global PE industry's dry powder was pegged at US$1.78 trillion in February 2022, based on an article that cited Preqin's estimates. See: Maera Tezuka and Madeleine Farman, "Another PE dry powder record set; VC rounds in US fintech surged in 2021," S&P Global Market Intelligence, February 11, 2022.

9. As such, software company valuations dropped more steeply than their broader tech peers during H1 2022. Based on Deloitte's analysis of publicly available sources, one US tech-software sector ETF was down nearly 34% year over year (YoY) as of August 31, 2022, compared with a 21% fall in the NASDAQ-100 Index (which represents the broader technology industry) and a 13% fall in the S&P 500 during the same period.

10. For instance, in 2020, one large tech company diversified its microchip manufacturing unit to focus more on its core chip R&D business instead of manufacturing. In another example, a PE firm acquired a major US-based semiconductor player's fab production facility in the United States.

11. Kevin Westcott et al., *2022 Deloitte digital media trends, 16th edition: Towards the metaverse*, Deloitte Insights, March 28, 2022.

12. Deloitte's 2022 Digital Media Trends survey (16th edition) revealed that 41% of US consumers cited price and 30% noted a lack of interesting content as key reasons for canceling their subscriptions.

13. Iain Macmillan, Mark Purowitz, and Sriram Prakash, *Charting new horizons: M&A and the path to thrive*, Deloitte, 2022.

14. Louise Nash et al., "Ukraine crisis: Changing M&A transactions for technology companies," Inside Tech Media, May 23, 2022.

15. Deloitte's *2022 Global Divestiture Survey* found that, of the surveyed sellers (across all industries) that took more time than expected to complete their most recent divestiture, 48% cited regulatory approvals as an important reason, up from 40% in both the 2020 and 2017 surveys.

16. For example, in H1 2022, companies in the high-tech semiconductor and electronics space have divested niche business units in areas such as discrete components (diodes, connectors, video/audio devices), assemblies, and packaging/test equipment because these did not align with their strategic focus areas.

17. Deloitte, *2022 Global Divestiture Survey: Realizing value in a fast-paced market.*

18. Deloitte, "Driving divestiture value: Transacting and transforming on parallel tracks," October 4, 2020.

19. Deloitte, "Incorporating ESG across investment portfolios may open access to capital," 2020.

20. Besides reducing emissions and energy consumption in their own facilities, they are under growing pressure to monitor their suppliers' ESG progress. See: Deloitte, "ESG in Technology, Media & Telecommunications: Driving value through sustainability," accessed October 10, 2022.

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