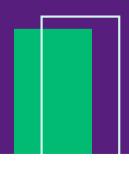




2023 & BEYOND PREDICTIONS









Welcome



Geoff Blaber
CEO, CCS Insight

For our 17th set of predictions for the coming years we examine potential changes ahead for the digital world, for the digital society, and for the digital self. There's no doubt that all these areas will be disrupted by advances in technology and shifts in the commercial and regulatory landscapes. We hope that this year's 100 predictions illuminate the opportunities, warn of the pitfalls, and above all, provoke further thought.

The digital world is sure to experience economic upheaval in 2023 and beyond; in addition, new legislation like the EU's Digital Markets Act is poised to alter the global regulatory environment. For the digital society, the changing nature of connectivity and virtual spaces will mean that some long-imagined concepts begin to take shape. The digital self will be able to choose from a wealth of innovative devices, applications and services as they engage with an increasing array of new experiences.

To see the CCS Insight team discuss our predictions and give further insights, go to ccsinsight.com/predictions. In three concise videos our analysts set out what we believe the next decade has in store for the connected world. The recordings also feature executive interviews with EE, Qualcomm and Samsung Electronics. Our Predictions event wouldn't be possible without these sponsors and I'd like to thank them for their generous support.

Full Steam Ahead for Networks as Demand Continues to Surge

Amid geopolitical turbulence, demand for connectivity has never been greater. Soaring usage continues to push the telecom industry for faster, broader and more resilient networks.

It's been suggested that global mobile data traffic, excluding fixed wireless access, is projected to reach a staggering 39GB per smartphone per month in 2027.

But it's easy to forget that for many, getting connected simply isn't an option. Almost half of the world's population aren't yet online, including 450 million people that live in areas without coverage of mobile broadband.

New solutions based on satellite broadband can help lessen connectivity inequalities by quickly providing coverage to an extremely wide area. This has proved one of the hottest topics of 2022, receiving a host of announcements from telecom operators, satellite providers and device-makers.

One that grabbed many headlines was a partnership between Starlink and T-Mobile US, aimed at offering voice and data services over satellite to almost any smartphone in the US. Its vision is to end mobile dead zones by bringing connectivity to places where traditional terrestrial networks haven't yet been able to reach.

It has also been heartening to hear of recent efforts to help vulnerable members of society or those struggling to pay their bills. This is becoming increasingly relevant as the cost-of-living crisis deepens. Means-tested social tariffs are becoming commonplace, but there's plenty more that the industry and government can do.

Worldwide, more than 200 operators have now launched commercial 5G services. CCS Insight forecasts that total 5G connections will grow from about 1.2 billion in 2022 to 4.5 billion at the end of 2026, representing 33% of mobile connections globally. China will continue to dominate adoption, claiming 54% of the total.

One of the main drivers of long-term adoption of 5G is more affordable devices. CCS Insight expects that 75% of mobile phone shipments will be 5G-enabled by 2026, with only the lowest-priced products still not yet supporting the technology.

The path to standalone 5G is also well underway, with early network launches now live in markets including South Korea, Germany and the US. For many, this heralds the real start of the 5G journey, opening a host of new opportunities, particularly in enterprise.

In the UK, EE is gearing up to launch full commercial standalone 5G services in 2023. Earlier this year, it showcased the technology's potential at the Green Planet augmented reality experience in London. Visitors using supporting smartphones were able to travel through five digitally enhanced worlds: Rainforest, Freshwater, Saltwater, Desert and Seasonal. Narration by naturalist Sir David Attenborough illustrated how plants can be aggressive and competitive, and that they can form intriguing relationships with animals.

In August, EE announced it had combined four carrier components on its live standalone 5G network, using 2.1 GHz, 2.6 GHz, 3.4 GHz and 3.6 GHz frequencies — an achievement it said was a European first.

But it's not just about 5G. Over the past year, EE has expanded its 4G coverage in rural areas by 1,000 square miles, upgrading more than 4,000 sites in the process. This includes 27 of the 28 masts in Scotland that form part of the government's 4G Infill programme. The operator expects 90% geographical coverage of 4G in the UK by 2025, up from 86% today, bolstered by ongoing deployment of 800 MHz frequencies.

In full-fibre networks, BT's Openreach unit continues to make impressive progress. Spurred by intensifying competition and recent regulatory clarity, it passed 8 million premises in July 2022, which represents almost a third of the 25 million target slated for December 2026. In its fiscal 1Q22/23, Openreach passed a record 763,000 premises at an average of 59,000 per week.

The UK was initially slow to move to full fibre, quickly falling behind other European markets, notably France and Spain. But waves of investment from outside the telecom sector have supported dozens of alternative providers, many focussed on local areas or rural locations. In May 2022, watchdog Ofcom highlighted that this trend helped the proportion of homes able to access full fibre increase to 33%, up from 28% at the end of 2021. It added that about 66% of UK homes — just over 19 million — now have access to a gigabit broadband connection, up from just 37% a year ago.

It's full steam ahead for network deployment across the sector as consumers and businesses show no let-up in their thirst to stay connected.





A Regulatory Renaissance

An inescapable theme of this year's predictions is regulation of the tech sector. Although we've scrutinized the prospect of a tighter regulatory environment before, the world is now on the cusp of action rather than just rhetoric.

The Digital Markets Act (DMA) in Europe and the American Innovation and Choice Online Act and Open App Markets Act in the US threaten to end an era of unfettered expansion, with significant curbs and penalties looming for large technology platforms. This could either be viewed as a hard reset for the entire industry or an ineffective and temporary spanner in the works for tech juggernauts — to some extent this is in the hands of European and US governments and regulators. However, we believe that change will be profound, permanent and have considerable consequences for society and the market environment in which tech companies of all sizes operate.

Although EU and US legislation differ in detail, their philosophies are broadly similar. Their aim is to prohibit big tech companies from arbitrarily discriminating against competitors, preventing the promotion of a company's own products over rivals' and ensuring an open and competitive ecosystem of applications for users.

Europe's DMA applies to "gatekeepers", defined as companies with over 45 million active users in the EU and 10,000 annual business users. Market capitalization must be at least €75 billion or annual revenue of more than €7.5 billion. By contrast, the American Innovation and Choice Online Act only affects those with a market capitalization of \$550 billion in the past 12 months or at least 1 billion global users. It also requires at least 50 million monthly active users or 100,000 business users in the US. The Open App Markets Act refers to app stores with over 50 million US users. The DMA clearly casts a much wider net.

The DMA was passed by the European Parliament in July 2022 and comes into force in November 2022. In the US, the path for legislation is less clear. The American Innovation and Choice Online Act could go to a Senate vote before the midterm elections but isn't yet scheduled. With the proposed bill sparking intense lobbying from opponents and the prospect of a change in majority in the Senate after the midterm elections, the timing remains a question mark and the regulatory road could prove a long one.

CCS Insight believes that EU legislation will have the bigger impact in the near term. We predict that the DMA will force a change in behaviour from large tech players in Europe that is likely to ripple through business operations globally. It will also further motivate US politicians keen to avoid a scenario in which Europe defines the antitrust agenda without US involvement. A degree of harmony and consistency between US and EU legislation would be a clear advantage but is by no means assured.

Exactly what shape final legislation takes and when it gets passed is difficult to predict. There's bipartisan support in the US for tighter rules, but considerable disagreement on key principles. The consensus is that the central role of digital platforms in economic and social prosperity means that innovation must be able to thrive broadly, rather than remain concentrated among the few.

However, the counterargument has a similar tone: clamping down on the tech sector will see investment and innovation suffer and user experience falter. The question is whether innovation is best fostered broadly through open competitive marketplaces or determined by a minority of platforms operating at significant scale. Consensus has undoubtedly shifted to the former.

So what's likely to change given our expectation that the DMA will quickly change corporate behaviour beyond EU borders?

Search and shopping. Under the DMA, companies won't be able to favour their own products over those of rivals in search results. For example, Amazon couldn't list its own-branded products above competitors and Google wouldn't be able to highlight its own shopping service in a Google search. We predict this will cease completely within two years because of the DMA.

Pre-installed smartphone apps. These will change within three years. The "self-preferencing" provision in the DMA means that smartphone-makers or platform providers can no longer pre-install their own apps where alternative solutions are available. We expect Apple, Google, Samsung and others to firmly resist the move initially but ultimately move toward offering a choice during device set-up, in a bid to minimize disruption to the user experience and make it clear that other options exist.

Interoperability and linking of services. The same rationale applies here. For example, if Meta's Facebook app links to WhatsApp or Messenger, it will have to offer the provision for third-party services to link just as seamlessly. This should see increased scope for service interoperability. Messaging is highlighted specifically, with gatekeepers required to ensure that messaging platforms are open and interoperable. This is another area that's likely to see resistance, given the importance of closed messaging platforms to many large ecosystems. Subsequently, we expect a slow and gradual shift toward greater interoperability between messaging services over the coming years.

In-app payments. This area has drawn a lot of attention, with concessions made to provide more choice for developers and

users. But these have been on an ad hoc basis. CCS Insight believes the DMA will deliver sweeping change, enabling developers to offer alternative payment mechanisms in apps. This is likely to be among the more immediate changes in the next 18 months.

"Sideloading" and third-party app stores. Sideloading allows users to install software through a distribution method that isn't approved by the device-maker. It's supported by the Android operating system but has been resisted by Apple on the grounds of security, and we believe the DMA will lead to a drawn-out battle on the issue. Despite claims that sideloading will open the door to alternative app stores, we expect it to have minimal impact, muted by security concerns as established providers fight it. Most people will continue to use established app stores, and other options are likely to come from a small number of alternative providers with comparable scale — the likes of Amazon, Meta and Microsoft.

The timing and significance of wholesale changes to the regulatory climate in any market are shrouded in uncertainty. But at a time of great economic uncertainty, mounting tension between the US and China and heightened focus on the domestic technology supply chain, the move toward regulation adds layers of complexity. Few governments will wish to jeopardize a tech industry that is vital to economic prosperity, long-term competitiveness and security on the global stage.

However, although these dynamics may slow regulatory change in the US, sentiment has shifted. The DMA stands to pave the way for enormous change reaching far beyond European borders.



Qualcomm

Samsung Driving Innovation as a Consumer Electronics Leader

As one of the largest consumer electronics companies in the world, Samsung is perfectly placed to take advantage of the opportunities in the digital society that we outline in this year's predictions.

As part of our Predictions event, I talked to Patrick Chomet, Executive Vice President, Mobile eXperience Business, Samsung Electronics, about the company's activities. You can watch the interview at ccsinsight.com/predictions. We touched on numerous areas that the company is working on to deliver ever-better products with greater synergies between them, as well as focussing on important societal issues such as the environment and health.

Samsung has long committed to building an ecosystem of products, and its SmartThings platform has emerged as the central point that gives users control of their devices. It spans multiple areas such as domestic appliances, televisions, smartphones, tablets, PCs and wearables.

The ecosystem reinforces consumer engagement by offering a more connected experience across devices that promotes loyalty to the Samsung brand. A good example of this is the work that Samsung has done with Google and Microsoft to enhance the experience on Samsung's entire range of smartphones, but notably on Samsung's foldable products and the latest Galaxy Watch devices. The combination of a smartphone and watch is a good example of giving users a richer experience, particularly in areas such as health and wellness.

In conversation, Patrick described health as the next big thing on mobile devices, and Samsung has an expectation that health and wellness will emerge as a cornerstone capability of connected devices in a similar way to how Internet access and a camera are now taken for granted on smartphones.

The company's journey started with an initial focus on casual fitness tracking such as steps taken, and progressing to deeper health monitoring, management and prediction. New capabilities, such as blood pressure and ECG measurement and detailed monitoring of sleep and body composition, are playing an important role in evolving this capability.

A Foldable Future

Another area where Samsung has been investing heavily is in its range of foldable smartphones. Samsung has been innovating in this area for more than a decade and has emerged as the marketmaker for the product category with its two designs, the Galaxy Z Flip and Galaxy Z Fold.

The Z Flip is a more fashion-centric product that Samsung describes as a "game-changer in self-expression" and the device phone has clearly resonated with consumers, who like the compact design and other features such as FlexCam, the ability to stand the phone up to take video calls and selfies.

The focus of the Z Fold is on productivity — providing a device that blends a traditional smartphone with a mini tablet. However, as Patrick and I discussed, Samsung knows that its excellence in hardware engineering must be matched by outstanding software to deliver innovative, high-quality cutting-edge devices. It has enhanced the software on its devices to make the most of the new ways of using such a flexible device.

Everyday Sustainability

Like other consumer electronics companies, Samsung recognizes the serious and ongoing importance of sustainability. The company recently announced a new environmental strategy with the goal of achieving net zero emissions for its Device eXperience Division by 2030, together with big investments in the development of innovative technologies that can help with its green goals.

Samsung's mobile devices are starting to incorporate more recycled plastics, including discarded fishing nets, and this approach will be expanded into additional products. For example, the recently announced Galaxy Buds 2 Pro have more than 90 percent of all the plastic components by weight made from recycled materials.

Digital Leadership

Samsung is acutely aware that there's no room for complacency in the highly competitive consumer electronics arena. We expect it to continue to innovate to maintain its leading position, and we believe Samsung is well-positioned to tackle the changes ahead in the digital world, for digital communities and for the digital individual.

The predictions on the following pages examine some of these potential changes. I'd like to thank Samsung and our other sponsors for supporting CCS Insight's glimpse into the future of the connected world.



SAMSUNG

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SPOTLIGHT: Private Mobile Network Market

More and more businesses are exploring the huge potential of private mobile networks, but this remains a complex landscape, where cloud platforms, Open RAN suppliers and mobile operators are challenging the status quo.

Revealing insight into deployments, applications, industry sectors and projections for private mobile networks, CCS Insight's Spotlight research delivers the rich and customizable data you need to zoom in on early opportunities in this burgeoning global market.

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SILICON FOUNDATIONS

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Despite geopolitical turmoil with mainland China, Taiwan's leading-edge silicon production stays above 60% of global output until at least 2030. Despite the surge in regional investments in the US and Europe, strong demand for leading-edge process technology and silicon products consolidates dependence on TSMC's foundry capacity in Taiwan for the rest of the decade.

2 By 2025, Apple's annual spending on custom silicon exceeds \$10 billion

Apple's decades-long journey to design and build its own chips continues to expand with M series processors for Macs and iPads. The expected addition of a custom 5G modem into iPhones is estimated to account for an additional \$2 billion in total spending on custom silicon. Although Apple is not considered a semiconductor manufacturer, its expenditure places it in the top 12 globally in terms of semiconductor revenue. Apple cracks the global top 10 rankings by 2026 as it relies more on in-house silicon for its growing product lines.

3 New competitors in enterprise-grade server CPUs come to market by 2026

Diversification in enterprise computing is well underway, with AMD and Ampere gaining notable customer wins among cloud providers, and AWS Graviton forming the centrepiece of Amazon's custom silicon designs. A wealth of further Arm CPU development expands the market. Software developers prioritize porting to Arm architectures in the coming years as wider availability and greater adoption of Arm-based enterprise server CPUs stimulates demand.

By 2030, at least five major operators claim that quantum security capabilities make their mobile networks unhackable

Based on the quantum properties of photons, quantum key distribution becomes increasingly adopted as a technique for sharing encryption across a network connection. Data that is encrypted using quantum entanglement can only go to its intended destination, with its intended recipient holding the only key to unlock that data, therefore mitigating potential interception. Quantum key distribution offers a breakthrough for data security, with the potential for numerous mainstream applications in which data encryption is paramount, such as government, financial and healthcare sectors, and even connected cars

5 A Chinese smartphone manufacturer launches a semiconductor business unit by 2025

Following heavy investment in silicon designed in-house, initially used to bolster own-brand smartphones, a Chinese smartphone-maker moves to license chip designs and sell semiconductors to rivals.



Against a background of quantum capabilities being explored in mobile networks, a quantum radio receiver is designed to deliver higher capacity and sensitivity in radio performance than previous traditional solutions, along with energy savings. Quantuminduced atomic sensitivity enables deployment as passive optical receivers in remote areas lacking network coverage, or hard-to-reach locations where mobile connectivity is difficult to deploy, such as urban canyons or underground. Quantumenabled radio is likely to evolve into a mainstream principle for networks during the development cycle for 6G.







In the next five years, semiconductor manufacturing becomes increasingly segmented

Leading semiconductor manufacturing requires immense resources. Major spending by TSMC, Intel and Samsung makes it harder for rivals to keep up, creating a large competitive gap. The next five years see the market become increasingly segmented, with specialists focussing on older process nodes for specific technologies. This trend restricts efforts to diversify semiconductor supply.

8 By the end of 2024, Broadcom sells its radio frequency and wireless chip business to focus on enterprise hardware and software products

Driven in part by the pending acquisition of VMware, which brings the company deeper into the enterprise space, Broadcom divests its radio frequency and wireless connectivity chip business. It is no longer considered core to Broadcom's business focus, especially as its long-term supply contract with Apple is set to expire in two to three years' time.

9 By 2030, mainland China emerges as a leading supplier of outsourced semiconductor assembly and testing

Although China's front-end semiconductor manufacturing ambitions have been crippled by trade restrictions, its back-end outsourced semiconductor assembly and testing business thrives. The country becomes a leading global destination for silicon packaging services by the end of the decade, thanks to its improved integrated circuit packaging capabilities and cost-competitiveness. Whereas front-end semiconductor fabrication relies largely on leading-edge Western technology, chip-level assembly and testing employ mature technologies and established manufacturing equipment.









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Quantum computers achieve 60-second coherence time by 2025

Unlike classical computers, quantum computers are limited by coherence time: effectively, a limit on how long a qubit retains information, influencing how long an equation can be run on a quantum computer, which influences how useful it could be in solving an equation. Quantum computers available today measure coherence times in microseconds. By 2025, a gate-model quantum computer achieves a 60-second coherence time, unlocking more potential for enterprises to start experimenting with trial applications.

1 Demand for discrete graphics cards and GPUs declines from 2026

Discrete GPUs in computing products have been a growth story in recent years thanks to consumer demand for immersive gaming and other graphically intensive computing tasks. They remain relevant for segments such as high-performance gaming, but advances in silicon-level chip packaging enable CPU makers to reconfigure the overall system-on-chip to scale GPU capabilities up or down. Integrated GPUs enable traditional system-on-chip providers to take PC and laptop designs away from suppliers of discrete GPUs. The trend toward integrated GPU capability and price competitiveness benefits the likes of AMD, Apple and Intel to the detriment of Nvidia

12 Hardware resource sharing influences the next generation of cloud infrastructure by allowing hyperscale providers to lower costs by 2025

New technologies allow for greater composability of virtual infrastructure from pools of processor, memory, storage and network capacity. This lets cloud platform operators serve a variety of workloads without overprovisioning or wasting resources. These changes also extend the service life of cloud infrastructure, creating cost-savings in capacity planning and operating expenses for hyperscale cloud providers — which in some form trickle down to their customers.



The automotive sector reshapes the semiconductor supply chain from 2025

The imbalance between supply and demand in semiconductors has had widespread impact and sparked calls for more resiliency. However, this view is made impractical by the dominance of a small number of chipmakers such as TSMC and Samsung. Both are expanding their manufacturing internationally, but the need for large and lengthy investments means domestic manufacturing continues to account for most volume over the next five years. And despite subsidies in the EU and US encouraging some manufacturing to move to these regions, significant change in the supply chain must be driven by demand. The past decade has seen the smartphone drive semiconductor growth. From 2025, a more global automotive market, the onset of autonomy and prioritization of greater supply chain resiliency combine to reshape the semiconductor supply chain.

M Start-ups that focus on custom artificial intelligence silicon begin to consolidate by 2025

Adoption of artificial intelligence and machine learning by enterprises is likely to continue at a rapid pace, but silicon start-ups looking to capitalize on the trend consolidate as they find it harder to gain customers, and as Amazon and Google build their own accelerators, limiting two major routes to market. Alongside factors like manufacturing costs and delays, this results in lean times for several custom chip firms. Although start-ups' patent portfolios hold some value, cloud platforms and infrastructure suppliers mostly pursue their engineering talent as they seek to strengthen their own competitiveness in artificial intelligence and machine learning, and in custom silicon development generally.

(B) Apple integrates its own 5G modem into the A series processor for a single-chip solution in the 2025 iPhone

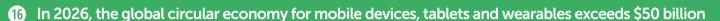
Apple is the only leading manufacturer using discrete chip solutions, with separate processor and modem silicon. By adding in-house modem chip capability aided by its acquisition of Intel's modem unit, Apple's chips offer improved performance and power savings. The integrated single-chip iPhone processor and modem is introduced in 2025, coinciding with TSMC's shift to a 3 nm process.





SUSTAINABILITY

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Led by industry and government commitments to reach sustainability targets, rising service-linked ownership of devices and a growing industry focussed on automating the refurbishing of devices, the circular economy expands strongly over the next five years. It experiences a compound annual growth rate of 27% from 2021's \$15 billion total. Consumers benefit from lower prices for premium devices and increasingly make choices based on the environmental impact of the devices they own.

2023 sees solar charging become an integral part of smart camera and doorbell design

As solar cell performance improves and smart cameras proliferate, manufacturers move from secondary solar accessories to an integrated solution that trickle charges the devices. This is marketed as an environmental benefit, but also provides a significant improvement to the customer experience, as users no longer need to run power to cameras or change batteries.

18 Major semiconductor foundries commit to net zero manufacturing targets of 2035 for energy use and material recycling

Focus on environmental goals has recently been accelerated by severe shortages in electricity, fresh water, process gasses and raw materials. These manufacturing challenges motivate foundries to invest in more-sustainable production methods. Leading chipmakers commit to a net zero production target of 2035 or sooner to meet industry production demand as well as profitability goals.

19 Standards for benchmarking the carbon footprint of telecom networks are introduced by 2025

To counter the carbon emissions of their networks, many operators are pursuing ambitious plans to reduce power usage by opting for less power-intensive technologies, switching off older networks and embracing carbon offsetting. At present, there is no industry standard for measuring energy used by a network, and therefore no benchmark of operators against targets for reduction of carbon emissions. Potentially championed by a respected global industry authority such as the ITU, a set of standards emerges, not only enabling operators to back up claims of net carbon neutrality but also giving a yardstick for industry regulators and governments.

20 By 2027, commitment to recycling old devices is a differentiating factor in the electronic device industry

Consumers are growing increasingly environmentally conscious and recognize that device-makers need to start recycling old devices. As financial markets reward greener companies, disclosure of information about what happens to discarded products becomes an important metric that companies choose to share in their earnings announcements, and over time regulators define standards and start requiring that all major device manufacturers report such measures.

21) By 2027, a central marketplace emerges for IT architectures, platforms and software distributions with low carbon emissions

The push toward low-carbon operations increases significantly over the next few years, driving the progress of communitybased projects that address the environmental impact of application development. An offshoot marketplace from a popular open-source community hub offers a shopfront for software providers. Successful implementations are nuanced and dependant on differentiating factors that standardize with maturity. Development and delivery teams begin to use submissions and use of the marketplace as a benchmark of their capabilities.





By 2030, the proportion of discarded phones that are recycled for parts and materials grows to no more than 5%

Currently, about 700 million phones are discarded annually, but less than 0.01% are recycled for parts and materials. Despite the huge volume opportunity associated with mobile phones, other device categories such as automotive electronics. PCs and displays have higher rates of recycling for components and precious metals. Processes currently used for the collection and recycling of larger devices start to extend to smartphones and wearables, which are typically more difficult to recycle. This is prompted by the finite availability and rising cost of metals used in electronics such as gold, silver, copper, platinum, tin and palladium.



By 2027, mobile apps enable users to track their carbon footprint in real time

Increased awareness of climate change sees people monitor their impact on the environment in the same way that many track their daily number of steps. Areas include domestic heating and lighting, grocery purchases, leisure activities and video watching. Rewards and incentives spark competition and encourage more sustainable behaviour. The apps operate though a wide range of sensors and connected devices combined with complex algorithms.

More and more personal electronics are marketed on their energy efficiency

The rising cost of energy in 2022, alongside proposed EU legislation covering smartphone efficiency and durability ratings, pushes electronics manufacturers to develop and adopt a range of efficiency ratings similar to those used for domestic appliances.

In 2023, half of households in Western Europe have at least one second-hand connected device

Our research conducted in several Western markets suggests that more than a third of people have bought a pre-owned device in the past, and more than half are interested in buying pre-owned products. Several factors whet appetite for second-hand devices, with pricing and green reasons being the main motivators.



Devices, the Internet and the systems supporting them currently account for about 7% of global greenhouse emissions, which is a similar amount to that produced by the airline industry. A new standards body enables websites, platforms and mobile apps to sport a logo certifying their use of high-contrast colours, darker design themes, standard typefaces and simpler, cleaner code.

2) By 2026, geopolitical rivalry for exotic metals intensifies

Nations and private companies look to gain further influence in Africa and other developing, mineral-rich regions to ensure a steady supply of rare-earth minerals such as lithium, cobalt and palladium. They engage in intense competition, which leads to heightened tensions, particularly between the US and China, with moves such as restrictions on the use of materials by certain countries or some companies.

By 2024, an international standard develops for calculating the carbon emissions of cloud services

As many global organizations focus on measuring carbon emissions, a concerted effort aligns calculation processes and standardizes the equations used. A new standards body is formed to create and advance a standard, regulated framework. It follows the alignment processes used for international accounting methods and other industry metrics.

In 2023, a major manufacturer offers a multiyear servicing and repair plan for devices over a certain price

A growing proportion of consumers opt for higher-quality, longer-lasting devices, and are interested in repairing rather than replacing expensive devices. A major brand successfully differentiates itself by providing high-quality, long-lasting products backed by a servicing and repair experience.



Discover new opportunities and get ahead of trends with CCS Insight's global survey tracking consumer attitudes to connected devices and purchasing intentions.

Our bi-monthly survey provides data and insight about established device categories as well as emerging technologies, so you can stay in tune with fast-changing expectations.







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INFRASTRUCTURE ADVANCES

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Within five years governments are forced to rethink the way spectrum is sold

Network operators push back on the upfront costs of acquiring spectrum licences. As moves toward 6G technology start to gather momentum, governments expect windfalls from spectrum auctions, but some are forced to rethink the practice and move to a "pay as you use" model, with payments being made over the whole duration of the licence rather than prior to deployment.

China's early development of 6G results in at least two competing standards in the East and West

Early 6G progress reaches a roadblock as escalating sociopolitical tensions prompt China to develop its own ecosystem. China quickly takes the lead with a massive research and development budget, crushing hopes of a single global standard in a rerun of the technological split between Europe and the US during the 3G era.

32 Sharing of spectrum becomes a fundamental part of many 6G auctions

Airwaves are allocated on the expectation that they are shared by the winners with other parties where possible, whether voluntarily or for financial compensation. The terahertz range is the focus because of the huge amount of spectrum available and its spatial diversity, which is suitable for a wide range of local deployments beyond the licence holder. It represents a change of course for regulators, with greater emphasis on collaboration between stakeholders to maximize the value of spectrum rather than raising government funds.

33 Roaming of 5G network slices becomes a hot topic during 2023

An exciting new feature of 5G for enterprises, network slicing enables customers to specify parameters of the service they are delivering to specific groups of people or devices. Devices roam between networks; some internationally, others roaming between public and private networks without moving very far. As network slices are adopted in private networks, customers also want to have that customized service delivered over public networks to employees and end devices, and it becomes important to include network slices in roaming arrangements.

34 By 2026, a standardized methodology to measure network performance emerges

Consolidation among testing specialists drives this, creating a smaller number of more powerful and influential bodies. It marks a move away from today's inconsistency, which makes it difficult for customers to evaluate network performance because of a wide range of approaches, allowing for spurious claims of network supremacy. The move is encouraged by regulators, which are keen to push providers to offer a better service and to help customers make informed choices. Areas of focus include coverage, latency, reliability and speed.

In 2023, Open RAN accounts for more than 10% of 5G radio access network deployments in India

Open RAN is an attractive proposition in emerging markets where consumer average revenue per user for mobile services is low and telecom operators often struggle to earn a return on their investment. This is particularly true in India, because of the size of the country and potential scale of network deployment necessary. Recognizing this, local operators turn to Open RAN to unify and automate different generations of network technology, and avoid being overly reliant on infrastructure suppliers at a time when they may not wish to appear to be favouring the East or West in their selection of technology partners.





The current narrative for private 5G networks focusses on 5G's connectivity capabilities: higher capacity, higher device density and lower latency. There are early moves to incorporate app stores and make it easier for customers to configure the networks and target specific uses. Over the next few years, this systemic approach is extended to support several connectivity options, a wide range of proprietary and third-party applications, preconfigured connectors to larger IoT platforms, APIs and location technologies, along with easily configurable roaming onto public 5G networks. Open RAN is a catalyst for this change in positioning, as the open-source world is much more used to this type of ecosystem.

By 2024 a major mobile network suffers an outage as multiple DNS gateways fail simultaneously

Domain name system gateways are an essential part of Internet infrastructure, translating human-readable hostnames into IP addresses and performing other vital functions. Multiple simultaneous failures result in a blackout that stretches over several days as the operator and its infrastructure suppliers scramble to restore service. The incident provokes a rethink of network resilience and architectures.

Over half of the countries in the world have 5G networks by 2023

As more and more countries launch networks, 5G promises improvements in the reach of mobile connectivity, speeds and bandwidth for more regions. In June 2022, the percentage of countries with launched 5G networks stood at 43%, up from 29% in June 2021, according to GSA data. Given this strong development, and despite worsening macroeconomic conditions, 5G networks are well-positioned to be deployed in 50% of countries by the end of 2023, with new deployments in India, and some parts of Africa set to launch their first 5G networks.



CONNECTIVITY PROVIDERS

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By 2025, at least five leading telecom operators offering 5G private mobile network services announce specialization by market segments

Private mobile networks are resourceintensive projects for operators, owing to the complex digital transformation needs of a business or venue. To add value, telecom providers need to adopt a consultative approach to serving enterprises. It is impossible to do this for the entire range of opportunities, so operators start to specialize with industry sectors such as healthcare and manufacturing, or by segments of private mobile networks such as critical communications, smart industry and IoT, and indoor mobile communications. They concede other markets for private mobile networks, offering only wholesale connectivity.

40 By 2025 satellite broadband provider Starlink is spun off from SpaceX as a publicly listed company

As Starlink's revenue becomes more predictable and it gains more and more users, the company is spun off to raise capital to expand its constellation of satellites and meet growing demand for its services.

Weak global economic growth in 2022 and 2023 stalls adoption of 5G in half of the emerging markets of Asia—Pacific, Africa and Latin America for at least two years

Unfavourable economic conditions of high inflation, low growth and weak consumer spending lead to delays in telecom operators' investments in infrastructure in some emerging markets, particularly those that are slower with their spectrum allocation process and operators' plans for 5G deployment. In addition, slower-than-expected sales of 5G-enabled devices further drag service adoption, even in markets where 5G launches in 2023.





At least three tier-one European operators buy mobile network management services from Rakuten Symphony by 2025

The Japanese company is looking to cement itself internationally as an alternative supplier of 4G and 5G services. The deals with established telecom providers are a significant development for the fledgling Open RAN technology and a huge endorsement of its credentials. The deals build on Rakuten Symphony's first European agreement with German entrant 181 Drillisch in 2021.

By 2026, a leading telecom operator moves away from naming specific technologies in its marketing

The provider begins to describe its services in the broad category of connectivity, rather than using terms such as 4G, 5G, fibre and Wi-Fi. Most customers only care about getting a strong connection, not which underlying technology provides it. The move helps to simplify tariffs and boost strategies for converged services, but risks some initial confusion now that some terms are well-known by consumers.

44 Telecom becomes a significant driver of major cloud players' capital expenditure by 2025

By this point, at least 25% of telecom operators have some of their network in cloud services run by major hyperscale cloud providers. These are among the most demanding workloads in the cloud, with high-availability expectations, traffic that constantly moves geographically, exponentially rising traffic, tight latency constraints and — increasingly — rigid service parameters defined in network slices. This combination starts to be a significant prompt for cloud investment and expansion as providers gain telecom customers.







(5) By 2025, a telecom provider claims to offer global coverage

The worldwide service is achieved mainly through satellite connectivity as it can cover extremely wide areas and is aimed at world travellers and high networth individuals. It is supported by the operator's existing fixed-line and mobile networks, cloud-edge infrastructure and extensive roaming partnerships. However, the claim is strongly disputed, with detractors alleging that there are substantial caveats.

By 2025, at least 25 telecom operators offer connected car services as an add-on to consumer 5G plans

Operators strike partnerships with vehicle manufacturers using e-SIM technology in a last-ditch effort to create a meaningful application of 5G for consumers. Initially, the focus is on in-vehicle connectivity, but later expands to include diagnostics, entertainment services, personalized offers with third-party retailers, security and tracking.



REGULATION

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Cyberattacks have become a major weapon in hybrid wars, threatening economic damage and political instability. To avoid damage to businesses of strategic importance, governments take steps to protect the major players in their economy, targeting companies above a certain annual revenue or a certain number of employees. So far, governments have protected strategic infrastructure such as banking, electricity and water supplies, telecommunications and transportation. They extend their security mandate to cover other businesses, including retailers and manufacturers that support a large supply network of businesses and jobs, such as a large automotive company.

By 2025, smartphone-makers and platform providers offer competing alternatives to their own apps

The "self-preferencing" provision in the EU's Digital Markets Act means that smartphone-makers and platform providers can no longer pre-install their own apps where alternative solutions are available. Initially, Apple, Google, Samsung and others firmly resist the move, but ultimately shift toward offering a choice during device set-up in a bid to minimize disruption to the user experience and make it clear that other options exist.

Google Topics succeeds in building a large ecosystem for privacy-based advertising by 2024, triggering others to follow

The world of website cookies has shifted from a privacy nightmare to a user frustration because of all the consent forms involved. Google has been trying to replace cookies for some time and Topics is its latest attempt to create an approach to targeted advertising that better respects privacy. It takes over from Federated Learning of Cohorts, which drew huge criticism and was abandoned in January 2022.

By 2025, at least one European country mandates that large tech companies contribute to the cost of telecom networks

The landmark ruling follows escalating calls from the telecom industry that companies generating the most traffic, such as Google, Meta and Netflix, should help to fund the expensive roll-out and maintenance of the networks that support them. Recent comments from the EU suggest some sympathy for the plea, and a high-profile case involving Netflix in South Korea could set crucial precedent.

The EU's Digital Markets Act ends preferred product placement in search results by 2024

The new legislation prevents companies from favouring their own products above those of rivals in search results on their own platforms. For example, Amazon could not list its own-branded products above those of competitors, and Google would not be able to highlight its own shopping service in a Google search. This type of activity ceases completely by the end of 2024.

52 In 2023, concerns about content moderation delay US tech legislation

The American Innovation and Choice Online Act and the Open App Markets Act form the first tangible efforts by the US government to regulate the technology industry. The bill for the former legislation states a platform "cannot discriminate in the application or enforcement of the terms of service in a way that would harm competition". Designed to address anticompetitive behaviour, there are concerns that the legislation could result in a lower standard of content moderation if web platforms fear decisions being penalized as discriminatory. This contributes to legislative delays in 2023, leaving the Digital Markets Act in Europe as the new yardstick for the operation of global online platforms.







By 2024, a government in Western Europe outlaws fan tokens in professional sports

Fan tokens are typically blockchain-based assets that give membership perks to supporters of sports teams, such as the ability to vote on certain issues. However, much like cryptocurrencies, they represent a volatile investment, with some fans already losing money through tokens depreciating in value. This hazardous financial element prompts a European government to ban fan tokens in professional sports, expressing concerns for the financial welfare of supporters.

Clear signs of a Russian-Chinese "splinternet" emerge by 2023

The combination of Western companies boycotting the Russian market, and Russian authorities restricting access to international online platforms and websites has reduced the number of digital services available in Russia. Chinese technology companies look to fill the void left by their Western counterparts, expanding their e-commerce, social media platforms, digital payments and messaging applications into Russia as the influence of Western technology giants wanes.

A fierce battle emerges between satellite broadband suppliers and national spectrum authorities in 2023

National regulators become concerned that the unrestricted geographic coverage of satellite broadband, coupled with better performance and mobility at more affordable prices, could reduce the value of cellular spectrum. This proves particularly relevant to the use of 5G spectrum in the 12 GHz band planned for cellular urban deployments, which could interfere with frequencies used by low-Earth orbit satellite companies. These conflicts of interest in spectrum use and service offerings inextricably drive each group to pursue differing market strategies of urban and rural deployments.









NEW

OPPORTUNITIES

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56 Amazon's diversification into new industries causes shockwaves in 2023

Before Covid-19, Amazon was widely seen as a threat as it expanded in several directions, launching new services in pharmaceuticals, healthcare and more. When the pandemic struck, forcing it to cope with constraints to keep its staff safe and to meet rapidly growing demand, the company achieved growth of over 40% per year thanks to its core businesses of retail and cloud. As the world returns to normal, Amazon reverts to its previous strategy, focussing initially on healthcare and pharmaceuticals — and other industries again start to feel threatened.

By the end of 2023, Netflix changes content strategy and becomes very similar to Amazon Prime Video

Since it launched digital streaming, Netflix has had a pure business model, exclusively offering subscriptions to its catalogue of movies and TV series. A recent slowdown in user growth has prompted it to introduce a cheaper ad-funded subscription. It starts to experiment more with games, sports events, animated content and other business models, and by the end of 2023 becomes a lot more like Amazon Prime Video.

By 2030, a third of Apple's revenue comes from software and services

Apple's software and services business unit accounts for a growing proportion of the company's total revenue, creating a recurring revenue stream from owners of Apple devices. In addition to further growth in existing services, other business lines emerge such as virtual or augmented reality hardware, unlocking additional service and software revenue in the form of subscription services, enterprise software and more. Growth in existing and new services results in a third of Apple's revenue being derived from its software and services business unit, despite steady demand for its hardware.







By 2023 digital twin provider PTC becomes an acquisition target

The company draws the attention of a major technology provider looking to strengthen its own representation of an immersive digital world. PTC is an established provider of augmented reality, digital twin modelling product, with a well-regarded operational track record. Interest is unlikely to come from companies with established ecosystems for connected products, such as Microsoft and Amazon. Google, Broadcom, Cisco, Verizon and AT&T are potential suitors as they seek to round out their software and hardware for the representation of connected products.

In 2023, Cisco acquires an end-point monitoring and security player

Cisco has been building up its network observability capabilities for a couple of years, as part of its strategy to ensure IT teams retain control and visibility with the shift to hybrid working. However, it still has a gap at the end point, in monitoring and securing employees' devices. Building on previous acquisitions such as AppDynamics, Observable Networks and ThousandEyes, Cisco targets a specialist independent player such as Absolute Software to fill this gap.

61 By 2025, Amazon Luna is the most successful newcomer to cloud gaming

Luna, a cloud gaming service that uses Amazon Web Services, launched in the US in 2020. Over the next couple of years, Amazon promotes its offering in new markets, capitalizing on its access to about 200 million Amazon Prime subscribers and 140 million monthly users of the Twitch gaming platform to build an offering that overtakes other new alternatives and provides notable competition to Microsoft and Sony.



Having successfully established itself in financial services with Apple Pay and other products, Apple makes a tentative move into health insurance, initially in partnership with a major US insurer. It exploits its strong position in personal health, primarily through the Apple Watch, to gain a competitive edge and eventually moves more comprehensively into the health insurance market to help address structural challenges in the US healthcare market and lower costs for consumers.

Major telecom operators spin off successful IoT businesses to create shareholder value and further growth in IoT

More and more operators follow pioneers like Deutsche Telekom and divest IoT units. The new companies have greater independence in the connectivity options they offer, without being tightly tied to the parent network. They gain freedom to price their connectivity outside the telecom context, and are better able to pursue higher-value IoT opportunities up the technology stack. Many telecom operators have struggled to do this, even though they know the bulk of the value is not in the connectivity itself.

64 By 2025, Netflix triggers a wave of consolidation among streaming providers by acquiring several local players in multiple countries

One of the problems Netflix faces is the rapid rise in new streaming platforms; some are large, strongly branded players such as Disney+, others are smaller businesses, operating in a few markets, mostly outside the US and Western Europe. In trying to remain the largest player, Netflix starts to acquire smaller, regional providers with similar strategies to expand its catalogue, market presence and user numbers.

By 2026, more companies follow Tesla in investing in mineral supply chains

With demand for lithium and other essential metals outpacing supply, prices have increased significantly and uncertainty about sources has grown. Owning mines or investing in mining companies offers cost savings and strategic advantages in supply chain management. Manufacturers of electric vehicles and other products needing large rechargeable batteries are the first to make such moves, but other companies that need a significant supply of rechargeable batteries — such as smartphone manufacturers — may also follow suit.

66 Amazon is the first major online retailer to open service in Ukraine after the war ends

As part of a significant expansion into Eastern Europe beyond its operations in Poland, Amazon is the first leading player to open online retail in Ukraine after the end of the Russian invasion, assuming the country does not fall to Russia. Despite the logistical difficulties of operating in a country that is being rebuilt, Amazon sees the reconstruction as a large opportunity to serve citizens and to build a substantial business as life in Ukraine gradually returns to normal.







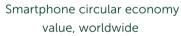




PULSE:

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PERSONAL FUTURES

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By 2028, a "blockchain of you" lets developers build viable digital twins of people to support personalized services

The availability of digital twins of individuals that ingest encrypted data and supported by artificial intelligence allows multiple industries to offer deeper levels of personalization. For example, the healthcare and pharmaceutical industries could use the technology for decisions about treatments. The technology also offers the potential for a broader spectrum of medical apps to be developed. Crucially, it ensures more efficient recruitment and effective application of medical trials.

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By 2023, the integration of biometric logins allows streaming services to clamp down on password sharing

Login and user authentication using biometrics such as facial recognition and fingerprints are becoming increasingly commonplace, and streaming services such as Netflix turn to these processes to validate users. Much like mobile bank accounts, apps require the user to log in every time they are used, making it far harder for people to share credentials. This is increasingly important for video streaming platforms as the industry matures and the conversation shifts from adding subscribers to retaining them and increasing their spending.

By 2030, intelligent wireless body monitoring leads to pervasive and personalized healthcare

Next-generation wearables, earbuds and smart glasses from major brands work together to incorporate advanced biometric sensors that go beyond cardiovascular functions, to provide metrics such as blood flow, body temperature, brain activity, dietary requirements, emotion detection, oxygen consumption and swallowing activities. Combined with machine learning and 5G, the large number of sensors provide the opportunity for huge personal, individualized data sets. Deeper and smarter insights into the body means that devices can serve as a preventive health tool, flagging up any deviations from the user's norm, detecting subtle changes and providing lifestyle advice.







App mirroring for parental controls is commonplace by 2024, but raises serious privacy concerns

TikTok's introduction of parental controls enabling parents to sync and control specific content and settings in their child's TikTok account was a responsible step forward from the Chinese firm and widely applauded. The move paves the way for similar moves from other social networks, sparking debate and scrutiny of the balance between parental visibility, security for children and their right to privacy.

To 2024, more headsets enable head-related transfer function capabilities to personalize audio

The development of spatial audio has seen significant improvements over the past couple of years, with the likes of Apple, Samsung, Dolby and Sony all promoting 3D audio. Personalized head-related transfer function technology enhances audio by adapting to individual ear shapes and using head-tracking sensors. By 2024, growth in metaverse content results in a more collaborative approach to standards in Android and other operating systems. This enables several more brands to offer improved spatial audio experiences.

In 2023, tech firms offering health insights partner with grocery delivery companies

Health insight platforms from companies such as Apple, Fitbit and Samsung aim to help users improve their well-being, with diet and nutrition an underdeveloped area at present. This gap presents opportunities for partnerships with grocery or food delivery companies such as Getir and Deliveroo, which use the tech players' platforms to point customers to specific items based on their needs.

In 2023, efforts by Amazon and Google to add more-proactive intelligence to their smart assistants are met with public backlash

Efforts to improve smart assistants are well underway as the likes of Alexa and Google Assistant seek to increase their usefulness, for example by sensing when to turn lights on or off based on user presence. However, a continued push in this direction prompts backlash from users as they feel that assistants have become invasive or too focussed on monetization, such as Alexa reminding users to buy groceries through Amazon Fresh or to sign up to Prime Music.





CHANGING WORKPLACE

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74 The role of software delivery orchestrator rises in prominence by 2024

In many organizations, software delivery is far from an efficient process. DevOps, a process that focusses on easing the transition of developed software into production, does not always work as smoothly as billed. Greater complexity in the interaction of software systems and services, combined with high expectations of resilient and effective solutions, means more support is needed at handover points. Companies come to place more emphasis on the role of software delivery orchestrator a mediator who embodies domain knowledge and business, risk and people expertise to organize pragmatic, operational-focussed collaboration and direction. Such roles are seen as instrumental in delivering cost-effective software as scrum masters were seen as the linchpin of successful agile development processes.



As teams struggle with how to stay connected with colleagues and maintain camaraderie, tools like Slack, Microsoft Teams and Zoom introduce immersive spaces that enable people to feel like they are working alongside colleagues. With this technology, trailblazed by companies like Virbela, organizations create virtual campuses, allowing employees to move between virtual rooms for different projects or levels of focussed work. Spaces use spatial audio to replicate the concept of overhearing conversations in an open office environment

By 2024, half of all office-based businesses upgrade their workplace connectivity to support online meetings

With many employees continuing to regularly work remotely, online meetings remain a dominant feature of collaboration, even for those working in offices. This puts significant pressure on the bandwidth and performance of businesses' office network infrastructure, triggering a rush to upgrade and modernize to meet demand, from network infrastructure to corporate Wi-Fi and 5G connectivity services.





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2024 sees the inception of a UK school examination board focussed on digital skills

Discussions begin between leading technology providers, the UK government and educators to create an examination board that ensures educational consistency and quality aligned with the country's educational frameworks, especially the new T Level qualifications. Ultimately, the board focusses on equipping school-leavers with core digital skills, allowing them to join the workforce and immediately advance digital agendas without a computer science-based university degree.

Demand for software that measures and tracks the link between employee experience and customer experience accelerates in 2023

Businesses have long understood the importance of the customer experience, but many are now starting to recognize the impact of the employee experience, not just on employee retention, but on core business metrics like customer retention and revenue growth. This drives interest in technology from companies like Qualtrics that measures the relationship between the employee and customer experiences, which in turn helps companies demonstrate the impact of their investments in the employee experience.

A post-pandemic recalibration of enterprise strategy drives 15% growth in IT investment in 2023 and 2024

The rising cost of services and wages places growing demands on IT investment in businesses, but this is not the only factor influencing investment expectations. The shift to hybrid work and accelerated digital transformation brought about by the pandemic both drive businesses to dramatically rethink their IT strategy. From operational processes to IT infrastructure, long-held assumptions are re-evaluated and reimagined for the new digital era, resulting in a wave of new IT investment, despite growing pressures of a tightening global economy. In practice, this dwarfs the scale of change businesses have faced since the start of the pandemic.



WRTUAL WORLDS

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Adoption of smart glasses has been hindered by backlash about their implications for privacy. To alleviate concerns, augmented reality brands trial a range of technologies to allow people to opt out of being recorded by smart glasses in public, blurring video capture where a non-consenting person is located. Solutions include Apple's use of the ultrawideband technology in its Find My application, AirTags and other products, as well as an application similar to contact tracing, allowing the public to select their privacy settings when near wearers of smart glasses.

In 2023, a major smartphone-maker's smart glasses open a market for remote consumer assistance

Remote support using augmented reality is already an important application in many industries. The advent of augmented reality glasses targeted at consumers leads to services and software providing instructions on basic repairs and maintenance for consumer goods such as home appliances, cars and electronics. Over time, this expands to digital health, veterinary services, interior design and more.

Through 2024, the emergence of augmented reality headsets for consumers sparks a rush for augmented advertising space

We have predicted that augmented reality headsets for consumers begin to arrive in earnest over the coming years. As part of this, new methods and locations for advertising are created, such as projecting digital adverts onto famous landmarks. Companies such as Google and Apple, which already have their own map platforms, are able to combine this with hardware to charge for advertising space.

By 2024, augmented reality technology becomes a central element of unboxing tech products

Manufacturers seeking to offer more sustainable packaging add a QR code to augment the unboxing and set-up experience. This allows interactive packaging to "come to life" on a smartphone screen and offers digital step-by-step "getting started" instructions, replacing physical guides in the box.

Apple's venture into spatial computing entirely avoids using established terminology such as virtual reality, augmented reality or the metaverse

In a bid to build its own distinct ecosystem for spatial computing, Apple declines to use established terminology to describe its devices, rebranding technologies and concepts. This extends a divergence in approaches between Apple and other major tech companies focussing on this area.

By 2033, almost 30% of people in developed markets own a virtual reality headset and almost 20% own an augmented reality headset

Companies spend large sums to build awareness of extended reality and immersive content, and to bolster adoption of headsets by consumers and enterprises through new product launches. Their efforts pay off, and by 2033, ownership of augmented and virtual reality headsets reaches significant levels.

Meta opens physical stores in at least 10 major cities by 2023

As the company seeks to ignite interest in its Portal hardware, virtual reality devices, and its eventual augmented reality devices, Meta opens more stores following its first venture in California in May 2022. It also seeks to partner with existing retailers to demonstrate the technology more effectively in primary locations to articulate the value of the metaverse and reach the mass market with Meta devices.



Through 2027, the battle to own the virtual reality and augmented reality arena produces friction between Google, Meta and Microsoft

We expect the initial virtual reality and augmented reality landscape to be fragmented because of a lack of standards and portability for apps and services, meaning that big tech companies must seek to house developers. Much like with the smartphone, Apple defends its platform through tight interoperability between hardware and software. This leaves its rivals to spar for the rest of the market.

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The operators succumb to growing hype surrounding the metaverse amid struggles to develop innovative services for consumers and position their brands at the core of the latest technology. They offer bundles that include devices, sports or gaming passes and premium connectivity, accompanied by strong marketing campaigns.

By 2025, Meta launches a virtual reality headset controlled by an inbuilt neural sensor

Currently, most headsets come with hand-held controllers, but there are efforts to transition away from these to make devices more user-friendly. Using the technology acquired with neural interface company CTRL-labs in 2019, Meta ships a headset without any controllers at all as it implements neural sensing along with other body-sensing technology like hand-tracking.







CONNECTED DEVICES

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Over the next three years, Apple's focus on developing a vehicle shifts to CarPlay

Apple's automotive ambitions have long been the subject of debate. Its strategy is caught between two realities. It needs to find an area that can further its ecosystem advantage and grow revenue as the iPhone business plateaus. However, automotive development is intensely complicated, characterized by long development times and low margins. Although Apple's near-term ambition has shifted to software, as evidenced by recent CarPlay announcements, over the next few years the company continues to evaluate its options and maintains a team focussed on building vehicles.

By the end of 2026, more than 25 million people access the Internet through a mobile phone connected directly to satellites

This move beyond traditional cellular network connectivity is driven by technology developed by AST SpaceMobile, rather than satellite capability in the latest smartphones. Partnerships between the US company and telecom operators enable people in remote places to get connected for the first time. Although it bypasses today's mobile infrastructure, it is seen as a largely complementary service to existing networks.

An external system to communicate autonomous vehicles' intentions undergoes on-road testing by 2026

These machine—human interfaces aim to convey visual information about an autonomous vehicle to other road users, especially pedestrians or non-autonomous vehicles, decreasing the risk of confusion or collisions. Early precursors include elements of the Nissan IDS Concept, Volvo 360c and Mercedes-Benz F015 concept vehicles. None of these have been tested in the real world and there is no evidence proving their effectiveness with the numerous potentially dangerous variables presented by human road users. In 2026, the need for autonomous vehicles to communicate with pedestrians and human-controlled vehicles leads to an effective interface being developed and undertaking commercial on-road trials.







Over the next two years, Google's Pixel Watch fails to significantly increase the number of Android smartwatch users

The Pixel Watch struggles to differentiate itself with uses that draw on Google's existing capabilities and fails to realize the promise of bringing seamless computing to consumers. Android smartphone owners opt for other devices powered by Wear OS and those running real-time operating systems, and as a result, the Pixel Watch fails to move the dial on the market share of Wear OS

94 Apple launches a foldable iPad in 2024

Rather than making a foldable iPhone, the company shuns the trend and dips its toe in the water with a super-premium iPad with a flexible display. This sparks a frenzy of speculation about a subsequent foldable iPhone, but Apple resists the pressure and sticks with its established smartphone formula for several more years.

By 2027 there are an average of six connected devices per person in Western economies

Currently CCS Insight's Connected Consumer Radar service indicates about four connected consumer devices per person. This increases over the next five years as connectivity proliferates into wearable technology and other consumer devices.

96 In 2023, an Indian smartphone-maker breaks into the international market, challenging established players

Our previous prediction of a successful Indian smartphone brand comes to fruition. The Indian government maintains efforts to grow local technology companies by providing incentives. This leads to domestic and international expansion opportunities for homegrown smartphone manufacturers. Domestic scale builds as the roll-out of 5G networks kicks off in India, and a local manufacturer secures a deal with a major multinational network operator to offer its phones in Western markets





By 2025, one in two houses in Spain has a robot vacuum cleaner

Our Connected Consumer Radar shows that Spain is one of the front runners in adoption of robot vacuum cleaners, with ownership at 36% of households in the first half of 2022. Among those who do not yet own one, desire to purchase is higher than for many other smart devices. Strong awareness, ease of use and a growing selection of models make robot vacuum cleaners a sought-after gadget, with adoption in Spain surpassing 50% of dwellings by the end of 2025.

In 2023, the number of 5G phone models passes 1,000

According to GSA data, the 12 months to June 2022 alone saw the announcement of 311 5G phones, taking the total to 706 and putting the 1,000 mark well in sight. This is still only a fraction of LTE-enabled phones, however, which totalled more than 11,500 devices in June 2022. The growth rates of the numbers of LTE and 5G phones means that the latter overtakes former only by 2030.

By 2024, a major European operator launches a kids' smartwatch-as-a-service offering

Kids' smartwatches have largely failed to take off outside China, as markets such as Western Europe and North America have shown little interest in the devices. In a bid to overcome barriers such as concerns about the price of watches and their expiry as children grow, an operator offers an as-a-service offering that allows for regular upgrades, includes insurance and provides other relevant benefits all for one monthly bill.

In 2024, India overtakes China to become the world's largest mobile phone market by sales volume

As the Chinese market matures and replacement cycles become longer, demand for mobile phones flattens, echoing trends in other mature markets. In contrast, India's economic development sees the prices of mobile phones drop, creating room for growth and helping demand outpace that in China. India's rise is also fuelled by the auction of 5G licences sparking strong adoption of smartphones, cementing the country as the world's largest smartphone market in 2026.



RESEARCH AREAS

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Business IoT

Get crucial, practical insight into industrial applications of the Internet of things with analysis that interrogates business issues and the technology moves underpinning them, the implications of growing machine learning capabilities, time to market and the involvement of telecom firms as networks transform.

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Stay connected to the critical movements in software development, delivery and life cycle management. We track the shifts shaping the sector's evolution, scan the supplier landscape, survey stakeholders and look at the peripheral forces at play, evaluating the implications of macro-level change, giving you decision-ready insight to move fast and sustain productivity.

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Market Tracking

Get ahead of the competition with our datarich research. We provide real-world insight in a customizable format, enabling you to identify market opportunities. Strengthened by pithy analysis of technology adoption, distribution channels and supply chains, and complemented by market projections, we offer the data you need to navigate trends.

Mobile Phones

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Telecom Operators

Stay connected to the critical movements in operators' strategies with our analysis of innovation and disruption. We scrutinize business models, relationships with big tech and other market dynamics with holistic and precise views. Our research identifies drivers of change before technologies are proven and offers insights from our survey into buying behaviour.

Wearables

Stay in the loop on this dynamic sector's next big trends, whether they are the launch of the next must-have smartwatch or fitness tracker, the emergence of a new type of product or an imminent move by a major player. We zero in on shipment volumes and values, monitoring every market move and clarifying the impact on your business through expert commentary and analysis.

Virtual and Augmented Reality

In a fluid and rapidly evolving market, technology advances are increasingly blurring the line between the real and the virtual. Separate the disruptive from the overhyped, sustain high-level agility and develop your strategy based on the latest developments and our survey of virtual reality users, providing invaluable insight for those who don't want to get left behind.

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Workplace technology is undergoing a great wave of change. Businesses are reliant on technology to support day-to-day operations, to connect and enable their staff, and to create a fertile platform for business growth and innovation. We help suppliers of workplace technology tell their story and be heard above the noise.



MEETTHE TEAM

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Geoff Blaber
CEO

geoffblaber

Geoff was appointed CEO in early 2021 after leading CCS Insight's expansion in North America. He has over 20 years' experience in the technology sector.



Shaun Collins
Executive Chairman

Gashauncollins

Shaun founded CCS Insight in 1993 after a highprofile career in the fledgling cellular industry, including European account director for Motorola.





An industry veteran with over 25 years' experience, Ben worked at Gartner, Mobile Streams, Lucent and Vodafone before joining CCS Insight in 2006.



Martin Garner
Chief Operating Officer

martin_garner

In addition to his executive role, Martin leads research into agenda-setting Internet companies and business applications of the Internet of things.



Bola Rotibi
Chief of Enterprise Research

debolarotibi

Bola is a Chartered Engineer and has over 25 years of practical expertise spanning engineering, software development and IT analysis.



Marina Koytcheva
Vice President, Forecasting

marinakoytcheva

Marina has an extensive background in market analysis and forecasting, and before joining CCS Insight was part of Nokia's Strategic Intelligence team.



Simon BryantVice President, Channel and Supply Chain

Simon has successfully delivered many large custom and continuous research programmes during his 20-plus years in the industry.



A leading industry voice in cellular technologies, Wayne covers research about mobile devices, wireless technology and associated supply chains.



Leading CCS Insight's coverage of network operators and their strategies, Kester previously worked at Nokia and Informa Telecoms and Media.



Richard Webb
Director, Network Infrastructure

Grichardawebb

With over 20 years' experience in market analysis, Richard leads our research into 5G infrastructure. He previously worked at IHS Markit and Omdia.





James SandersPrincipal Analyst, Cloud and Infrastructure

James focusses on the computing infrastructure that powers enterprise workloads spanning public, hybrid and private cloud platforms.



Leo focusses on research into wearables, virtual reality and augmented reality; before joining CCS Insight, he worked in BT's Global Services division.



Parul SaxenaSenior Analyst, Data and
Consumer Research

Parul brings experience in business intelligence reporting and market research. Before joining CCS Insight she worked at IBM, Datamonitor and WNS.



James Manning Smith Senior Analyst, Forecasting

James has researched global technology markets since 2016, specializing in consumer electronics, entertainment content and education technology.



Luke Pearce Senior Analyst, Channel and Supply Chain

Luke joined CCS Insight in 2022 and is responsible for developing research methodologies within the business.



Maria Bell Senior Analyst

Maria has over 10 years' leadership expertise in clinical and biopharmaceutical research. She joined CCS Insight in 2022.



Jordan Cox Analyst, Channel and Supply Chain

Jordan joined CCS Insight in 2022 with responsibility for the preparation of reports and conducting quantitative and qualitative research.



Kane McKenna Analyst, Wearables

Kane has been researching various global technology industries since 2019; he joined CCS Insight in 2022.





Alex Pendleton Analyst, Channel and Supply Chain

Alex graduated from the University of Leeds with a BSc in Economics, including an exchange year in the US.



Jonathan ChapmanSales Manager

Jonathan is an account management specialist with a strong background in managing large global accounts within marketing services and events industries.



Emma Hoare Account Manager

Emma joined CCS Insight in late 2021 and has a background in marketing, events, social media management and PR.



Marco Rossi Business Development Executive

Marco joined CCS Insight in February 2022. He speaks a variety of European languages as well as Mandarin Chinese.

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