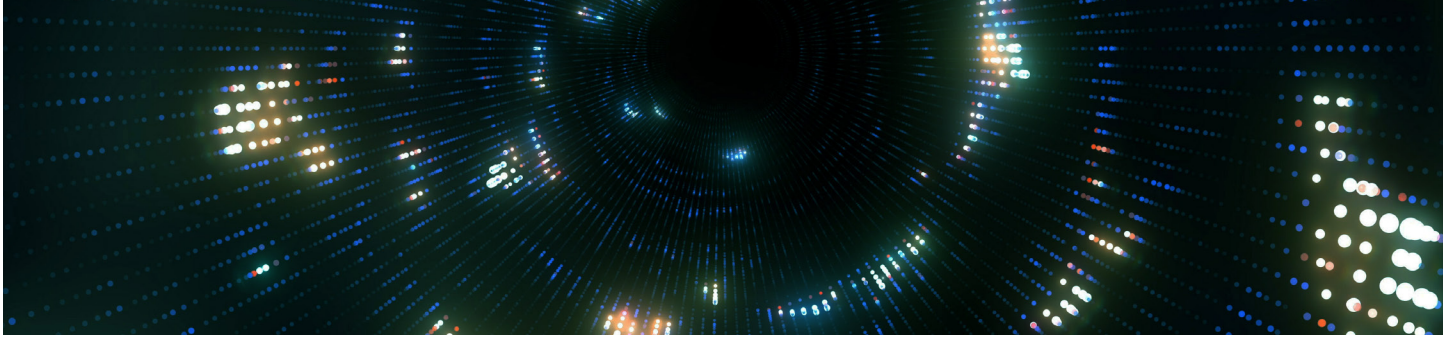
70 TECHNOLOGY TRENDS THAT WILL—AND WILL NOT—SHAPE 2022



From Our Chief Research Officer

Dear Colleagues,

The year 2021 was a tumultuous one full of challenges. It is clear that 2022 will continue along that vein and perhaps see some of the trends of 2021 become further exacerbated. The ABI Research team of analysts has taken a position on some of the most telling trends that they expect to happen in 2022 and those that they don't expect to materialize, despite the hype, column inches, and mass media focus.

The fallout from COVID-19 prevention measures, the process of transitioning from pandemic to endemic disease, and global political tensions weigh heavily on the coming year's fortunes. Supply chain issues look set to continue, 5G will continue to struggle in the enterprise sector and won't be seen on the production line, UWB will start to bring precise location to the fore, and the Chinese vendor community will retain its stranglehold on the IoT module market. These are among the **35 predictions of what will happen** and **35 predictions of what will not happen.**

This whitepaper is a tool for our readers to help shape their understanding of the key critical trends that look set to materialize in 2022 as the world begins to emerge from the shadow of COVID-19. It also highlights those much-vaunted trends that are less likely to have meaningful impact in 2022.

Our team at ABI Research stands ready to continue to support our clients as they take advantage of the opportunities that periods of change provide and looks forward to arming them with the key decision tools they need to act with speed, appropriateness, and efficiency.

The year 2022 will be challenging, but it also holds great promise and great opportunity.

Stuart Carlaw
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Research Service Areas

1 Ecosystem Disaggregation to Dilute Incumbents' Stranglehold on the Market

Ecosystem disaggregation trends like open Radio Access Network (RAN), public cloud, and 5G core networks point to a gradual evolution in product architecture from integrated designs toward modular stacks. An "all-in-one" approach, championed by integrated vendors (e.g., Ericsson, Huawei, Nokia, and ZTE), is eventually complemented by "best-of-breed" modular solutions provided by new suppliers like Altiostar and Mavenir.

In other words, the modular nature of key industry trends alters the industry structure because it opens new opportunities for pure-play software vendors to sell, buy, and assemble plug-compatible components and subsystems. This, in turn, gives rise to a diluted degree of differentiation because a population of non-integrated vendors starts to compete with integrated suppliers that occupy a dominant position in the ecosystem. If integration in the past was a competitive necessity, in the future, it may become a competitive disadvantage, if not approached with prudence. Winners will be those vendors that strike a balance between integrated architectures and software-based, modular solutions. That way, they can compete effectively with granular business modules that solve problems and create value.

2 Communication Service Providers Building Cloud-Native 5G Networks Will First Deploy Core Network Functions as Containers in Virtual Machines

A trend that is picking up pace is for Mobile Service Providers (MSPs) to embrace public clouds for growth opportunities outside of the consumer market. The most interesting scenario for this type of collaboration will be for Communication Service Providers (CSPs) to partner with public cloud providers to seek operational efficiencies for non-network workloads. For example, AT&T has partnered with Microsoft, in order to bring Azure workloads to AT&T's edge computing locations. This is the first case when a CSP can offer something unique to a webscale. These exclusive partnerships could restrict the partnering potential of CSPs, but ABI Research expects several of these partnerships to be announced during 2022, and even making webscale giants vital for the success of enterprise 5G applications.

The role that public clouds will play in how CSPs position themselves in the future remains to be seen. However, CSPs should consider staking their success on the ability to make commitments today that may not pay off until years into the future. In other words, their strategy should begin with a high tolerance for risk and what they do not know over cloud and associated economic models, rather than what they do know. Successful strategies must be built on a degree of unpredictability, not in spite of it.

3 Public Cloud for Core Networks Not Taking Off in 2022

The industry is witnessing a tectonic shift in the core network domain. For example, On June 30, Microsoft announced that it intends to acquire AT&T's Intellectual Property (IP) and human capital for AT&T's Network Cloud Platform. By contrast, Verizon announced recently that it will use its public cloud selectively. Verizon deploys its own cloud infrastructure to host its 5G core network. This may well be a prudent move by Verizon and provides a lesson that can be applied broadly. CSPs should understand that, at a very fundamental level, optionality, monetization potential, and sustainable competencies come from control and integration, particularly in the core network.

For now, CSPs' strategic high ground is the core network, especially with 5G Next Generation Core (NGC) that promises to deliver enterprise applications, including network slicing and low-latency applications. Broadly speaking, the winners will be those that not only keep an eye on the present, but also look out to the future. Verizon's public cloud strategy preserves the present, and that is a balanced decision. By contrast, AT&T's partnership is arguably aimed at the future by pursuing a novel strategy that hedges its bets. That matters. But whether it is sufficient is a function of the companies that AT&T—and the broader CSP community—competes with, now and in the future.

4 Core Network Components and Many Cloud-Native Network Functions Will Not be Deployed Directly on Bare Metal

Although the cloud-native proposition includes microservices that are highly agile and can be spun up immediately for ultra-low-latency application when deployed on bare metal, there will not be mass deployments of Cloud-Native Network Functions (CNFs) on bare metal yet. Instead, CSPs will opt for an evolution toward CNFs that entails a single platform that can host both VNFs and CNFs, often through VMs.

Cloud-native technologies (i.e., containers and microservices) are steadily encroaching on the telco ecosystem and promote scalability, resilience across hybrid (virtual and physical) architectures, and ultra-rapid deployment and innovation cycles. This is now becoming a critical priority for Communication System Providers (CSPs) who wish to compete against webscales for Business-to-Business (B2B) and enterprise 5G.

At present, there is no "one-size-fits-all" approach for cloud-native tools. However, ABI Research expects to see some common denominators appearing in 2022 across all market activities; specifically, the need to industrialize existing domain-specific and narrow deployments, scale across multiple geographies, and bring to market easy to consume products. These are not trivial and remain some of the biggest hurdles for the industry to pursue new growth with more manageable and automated networks. ABI Research expects the industry at large to join forces in 2022 to establish standards for cloud-native tools and methodologies in a bid to render them ready for telco networks. But caution must be taken that such standards do not retard speed and efficiency by trying to adapt these cloud-native solutions into a rigid telco framework that most vendors and CSPs are accustomed to, but to start with a fresh approach.

5 Arm Will be Forced to Change Its Business Model to Sustain Innovation

It was announced over a year ago that an agreement had been reached for NVIDIA to acquire Arm for US$40 billion, despite the takeover still needing approval from the European Union (EU) and several regulators around the world, as well as from Arm's IP licensees. However, this development has uncovered numerous concerns about Arm's future, and chief among them is the lack of synergy needed to transform itself and grow beyond just licensing its IP. Arm is in crucial need of expanding its engineering resources, while revamping its business model and technology offerings, if it wants to cope effectively with the phenomenal demand for technology innovation required to sustain the mobile and the computing ecosystems, and to become a key solution provider for the markets it serves.

With or without the NVIDIA acquisition, if Arm's Research and Development (R&D) and engineering resources do not evolve in line with market demand for innovation, then the entire industry will be slowed because it is Arm's Instruction Set Architectures (ISAs) and micro-architectures that are the foundation platforms for innovation in the mobile computing markets. Therefore, it will be incumbent on the industry to inject billions of dollars to expand Arm's R&D and sustain innovation because the company cannot achieve this objective under the current status quo. If this is not addressed, then Arm will not be able to execute on its ambitious plans with the resources it has currently, which could become a major issue that will affect the entire industry.

6 Smartphone Vendor Landscape Will Change (and Huawei Will be Close to a Market Exit)

Despite the extremely challenging industry backdrop of a global pandemic, geopolitical trade wars, and chipset shortages, the smartphone market has been remarkably resilient. Although global smartphone shipments did drop in 2020, the growth of 5G during the year was stellar, and this is set to continue, although market uncertainties regarding component supply constraints and COVID-19 are likely to linger. While shipments are set to return to pre-pandemic levels, the vendor landscape is set to change drastically with LG making the decision to leave the smartphone market by the end of July 2021, citing enormous competitive pressures. However, a key casualty of the geopolitical wars is Huawei. From being a top-two vendor in 2019, Huawei now has a real struggle on its hands to stay in the smartphone market in the longer term and rebuild its tainted brand outside of China.

Its shipments have been steadily dwindling since 2020, with competitors such as Samsung, Apple, Xiaomi, OPPO, and Vivo all taking market share at its expense, with a collapse of its high-end offerings expected in 2022 due to lack of access to leading technology. Unless the trade embargo lifts, which now looks like it might intensify rather than wane, the company will become entirely reliant on markets in China, other parts of Asia, and Africa to survive, mainly with 4G, and is expected to exit the market in 2023, unless a resolution can be found. It can be argued that Huawei's anticipated descent will reach a tipping point that could see a fundamental reshaping of the mobile device supply chain and chipset market, and having a significant bearing on the landscape of China's influential smartphone market, potentially blighting 5G innovation in the short term.

7 Pandemic-Fueled Growth Will Continue for the Wearables and Wireless Headsets Sectors

The onset of COVID-19 has seen demand for wearables and wireless headsets grow significantly as a result of changes in lifestyle and consumer behavior instigated by the pandemic. Smartwatches and fitness trackers have evolved into effective and reliable health and activity monitoring devices that have experienced an increase in demand as consumers become more health conscious, embracing a need to track and monitor health vitals. This demand is expected to continue, primarily due to the increasing number of use cases and their improved features tracking functions, such as performing Electrocardiograms and monitoring blood oxygen levels, heart rates, autonomic nervous system and recovery, and sleep patterns. The pandemic is also promoting the democratization of some practical mobile features, such as contactless payment, voice control, and wireless charging, which all help minimize contact with other devices or surfaces.

Additionally, with more time being spent at home, the pandemic has seen an uptick in the use of wireless headsets, driven by the need for personalized audio experiences that minimize external distractions and achieve high-quality sound. ABI Research forecasts that wireless headset shipments will reach more than 1 billion units in 2026 and will lead the smart accessories market. Demand will be driven further by lower device costs in combination with technological innovations, such as Bluetooth Low Energy (BLE) Audio, Tiny Machine Learning (TinyML), and built-in sensors that will unlock new use cases and applications. True wireless headsets are the most promising wearable category, and upcoming advancements in noise cancellation technology will also enhance the user experience and support a wider range of use cases. Moreover, true wireless headsets will become key drivers for the growth/adoption of voice assistants, as voice control becomes the primary user interface for hands-free control of smart devices. Other promising headset applications include music therapy that can treat anxiety or sleeping disorders, which becomes more efficient with the expected advancements in spatial sound, noise cancellation, and integration of digital assistants. ABI Research forecasts that global true wireless headset shipments will surpass 600 million units in 2026.

8 5G mmWave Smartphone Shipments Will Not (Yet) Reach Critical Mass in 2022

The industry's move toward the use of 5G New Radio (NR) Millimeter Wave (mmWave) technology had been challenging to be of practical use in mobile devices, mainly due to limited coverage and being overly costly to implement. However, with many of these technology barriers having been overcome, 5G mmWave is now a commercial reality in smartphones as the complexity of integrating it into smartphones has been addressed through the use of an evolved system approach and a fully integrated Radio Frequency (RF) module design, offering improved performance, latency, reliability, and efficiency.

After a slow start, mainly limited to the U.S. market, ecosystem momentum for mobile mmWave is gathering pace as a number of regions are targeting deployments, expanding across North America, Europe, and Asia-Pacific, led by operators in the countries of Japan, Russia, Italy, South Korea, and Australia, with China expected to join the roster in early 2022, coinciding with its hosting of the Winter Olympics. Even with tangible indicators that mmWave is beginning to appear in greater numbers of smartphone models, now including Apple iPhone Stock Keeping Units (SKUs), and has matured enough to support ultra-thin foldable smartphone designs, it is not expected to hit a critical mass of smartphone shipments in 2021 and will account for less than 5% of global sales.

An mmWave smartphone sales inflection point is expected by 2022, as it is forecast that, by this stage, mobile operators will need to extend their network capacity and performance beyond sub-6 Gigahertz (GHz), forcing many to turn to mmWave.

9 Smartphone Manufacturing Will Not Relocate Quickly Outside of China

As the pandemic started to take a grip on the devices industry, it quickly became clear that many in the smartphone supply chain were woefully unprepared to react quickly and had been over reliant on one market—China—for their manufacture and component supply. This led to the realization for many that a change and re-evaluation of their strategies was needed in a shake-up of production and supply chains. Many vendors considered diversifying production, and reducing their reliance on a single country, manufacturer, or technology supplier, thereby alleviating future supply chain risks.

The outbreak has contributed to many along the supply chain accelerating and building up production capacity outside of China and rearranging their supplier deployments, crystallizing a need to fully understand their risk and exposure all along the chain. However, this will not happen overnight, as such an undertaking is not easy and relocating outside of China will take time. In the longer term, it will be incumbent on vendors and suppliers to put in place robust contingency planning to decentralize future production and mitigate future market disruptions. Implementing a fundamental change in production is not just about building a device, but also managing the supply chain and procurement process, which are still inextricably linked to China.

10 China Will Become the Leading Nation within the 5G Enterprise Market

China is the world's largest 5G consumer market, with more than 400 million 5G end-device connections. Currently, the country is ready to accelerate enterprise 5G adoption, as industrial adoption presents greater opportunity than consumer services. Currently, 5G applications have been deployed across 20 different industries, primarily in manufacturing, energy, healthcare, tourism, and agriculture. In addition, more mature applications are also emerging in the port and mining sectors. A key success factor is China's spectrum strategy. The authority has reserved the 6 GHz band for 5G deployment entirely, unlike the United States, which saw the full allocation to Wi-Fi and other technologies. Considering China's rapid 5G development, sufficient spectrum resources are crucial. The 6 GHz band would play an important role in providing wide-area coverage like the 3.5 GHz band, providing opportunities for future enterprise applications.

11 RIC and SMO Platforms Will Create a Foundation for New Applications and Innovation

Open RAN will continue to be deployed across the world, but mobile operators will start paying more attention to RAN Intelligent Controller (RIC) and Service Management and Orchestration (SMO) platforms, as these can be deployed in brownfield networks. ABI Research expects infrastructure vendors (Ericsson, Nokia) and networking platform vendors (Juniper Networks, VMWare) to launch RIC/SMO platforms and start creating developer communities around them. This may lead to fragmentation in the market but will prove that openness can introduce agility and new types of applications in the network, predominantly for automation and optimization. ABI Research expects 2022 to be a major year for RIC/SMO announcements, as more interfaces are fully specified by the ORAN Alliance and tests/trials accelerate.

12 Hyperscalers Will Become the Platform Vendor of Choice for Enterprises

Enterprises are facing a tectonic change to their way of operation, as Industry 4.0 requires the full digitization of production processes and enterprise workflows. To support this, hyperscalers are emerging as a powerful vendor to provide necessary digitization platform capabilities. Their on-premises offerings, including Amazon Web Services (AWS) Outposts and Azure Private Edge Zones, guarantee data integrity and sovereignty to enterprises, while having the necessary platform architecture expertise to be able to provide this as affordably as possible.

All major hyperscalers have spent 2021 putting their enterprise offerings in place, so they are ready to expand and take over traditional telco and Information Technology (IT) infrastructure vendor businesses.

13 Enterprise 5G Will Not Gain the Desired Market Traction in 2022

Enterprises are looking at 5G for two reasons. First and foremost, Time-Sensitive Networking (TSN) will allow for millisecond latencies, and five-nines availability and reliability of network coverage. Second, deterministic networking protects the enterprise network from unauthorized access or interference. All these capabilities are standardized within The 3rd Generation Partnership Project's (3GPP) so-called Release 16, which enterprises have been eagerly awaiting. While the 3GPP froze Release 16 in mid-2020, Release 16-capable devices are still not entering the market, and we will likely have to wait until 2023 to see any noticeable announcements.

In addition, the telco industry still has a long way to go in designing appealing enterprise 5G offerings that consider industry-specific requirements. The telco industry must, therefore, understand that the window of opportunity for enterprise 5G is closing, as enterprises are considering non-cellular technology alternatives.

14 5G Supply Chain Challenges Will Not Be Lifted

The U.S. government entity list has created a balkanized market where Chinese vendors have remained confined to the Chinese market for growth, and western vendors have now been denied access to the lucrative and massive Chinese 5G market. ABI Research expects these restrictions to remain in place in 2022 without further escalation from either side. Moreover, the semiconductor shortage will continue, affecting Chinese vendors the most. Huawei and ZTE are expected to face additional shortages for their flagship products, namely smartphones and Massive Multiple Input, Multiple Output (mMIMO) antennas, causing them to slow down sales in markets outside China to satisfy large orders by China Mobile, China Telecom, and China Unicom.

Regardless, Huawei, ZTE, and other Chinese vendors have invested significant capital and effort in 6G R&D already, and will continue to do so in 2022, meaning that 6G Intellectual Property Rights (IPR) may be dominated by China. This may create complications, market distortions, or even standards fragmentation if Chinese vendors are banned from major international markets in the future.

15 5G Enterprise Spectrums in the Asia-Pacific Region Will Not Achieve Alignment

In the Asia-Pacific region, there is a disparate outlook on the prospects of 5G enterprise spectrums. Compared to China's push for the 6 GHz spectrum band, South Korea has published the release of the 4.7 GHz and 28 GHz bands to operators and non-telcos as enterprise spectrums for 5G deployment. In 2020, Taiwan saw the establishment of the world's first smart factory powered by a private 5G mmWave network. In Southeast Asia, Malaysia is likely not supporting the drive of 5G enterprise spectrums.

Similarly, no 5G enterprise spectrum has been published to date for Indonesia, considering the severe lack of spectrum resources with too many operators. Companies planning to deploy their own 5G network would have to collaborate with the operators. These examples indicate the disparity between the 5G deployment methodology across regions, which would likely perpetuate until new policies or plans are launched to override the existing ones.

16 Telco Infrastructure Vendors to Remain Profitable Due to Massive MIMO Expertise

In 2022, ABI research expects operators to continue to deploy mMIMO in new markets. Moreover, operators that have already launched 5G will start deploying the new generation of 5G mMIMO to improve network performance and lower energy consumption. Ericsson and Nokia will experience a healthy business, which will also be driven by Huawei equipment swap-outs. For mMIMO, 64T64R will be mainly deployed in dense urban areas with high data traffic, while 32T32R will likely be sufficient for urban and suburban areas. There will be regional differences in terms of mMIMO deployments, with Japan, South Korea, and Europe deploying 32T32R, while the United States is actively deploying 64T64R. As 5G starts to move toward the suburbs, Chinese operators will start deploying 32T32R instead of 64T64R, which will also be driven by the semiconductor shortage among Chinese vendors.

17 Direct Satellite-to-Phone Services to Take Off from 2022

The commercial launch of satellite-to-mobile phone communication is set to happen in 2022. Industry pioneers, such as Lynk, AST SpaceMobile, and Omnispace, have been developing a Low-Earth Orbit (LEO) satellite communication platform to enable mobile users to communicate via satellites without requiring any additional hardware. Lately, Lynk has demonstrated two-way data exchange between a cellular phone and a Low Earth Orbit (LEO) satellite. Similarly, AST SpaceMobile and Rakuten Mobile have also announced the start of testing the technology in 2021.

Discussions between satellite operators and Mobile Network Operators (MNOs) to launch direct communication between satellites and mobile phones are currently in progress. The services are expected to enter the market once regulation agreements are set in 2022. 3GPP Release 17, which includes discussion regarding the integration of satellite platforms and 5G infrastructure, is set to be completed in 2022. This is expected to be the main driving force for direct satellite-to-mobile phone communication services from 2022 onward.

18 Starlink Will Not Be a Global Player

Starlink, the potential Initial Public Offering (IPO) spin-off to SpaceX, has made great strides in getting more than 1,600 LEO satellites into space. This is transforming the experience of rural users frustrated by not being able to access always-on broadband speed, but it will still be a while before Starlink has the comprehensive satellite constellation coverage to provide backhaul links to mobile cellular operators. If Starlink does want to take on the global backhaul links market, it would potentially need close to its maximum constellation target of 42,000 satellites.

19 LEO Satellite Broadband Will Not Gain a Significant User Base in Home Broadband Market in 2022

LEO satellite companies, including SpaceX, OneWeb, and Amazon's Project Kuiper, are gearing up to compete with terrestrial and other satellite broadband services. The high cost of LEO satellite receivers (US$500 at present) is likely to be a barrier to gaining significant adoption. The trend is true for most of the addressable market because emerging markets are the key regions with a lack of fixed broadband infrastructure. Unless there is competition from other LEO operators to boost the user base, which can ultimately boost economies of scale and bring down the hardware cost, LEO satellite broadband services are likely to have only limited adoption in the home broadband market in near future.

20 mmWave Deployment Will Not Accelerate

U.S. mobile operators are now focusing on C-band deployments following the recent spectrum auction, realigning their previous strategy to deploy mmWave first. U.S. operators have relied on existing (low-band) and mmWave spectrum to deploy initial 5G services, but both have faced challenges. Now that mid-band spectrum is available in the United States, all operators will likely shift to it, to take advantage of global economies of scale and technical maturity of C-band mMIMO units. Moreover, Europe and China are deploying mmWave 5G for specific, niche use cases, meaning that mmWave will not be mainstream technology in 2022. ABI Research expects that mmWave 5G will likely accelerate once C-band 5G networks are congested, which is not expected in 2022 or even in 2023 in many regions. However, the wide availability of smartphones may translate to a rapid uptake of mmWave once 5G is launched on a large scale globally.

21 The Proliferation of TinyML

TinyML is already showing massive potential and will be on the path to becoming the largest segment of the edge Machine Learning (ML) market by shipment volume. ABI Research forecasts total shipments of 1.2 billion devices with TinyML chipsets in 2022. This means more devices will be shipped with TinyML chipsets, as compared to those with edge ML chipsets. In addition, the proliferation of ultra-low-power ML applications means more brownfield devices will also be equipped with ML models for on-device anomaly detection, condition monitoring, and predictive maintenance.

22 The Commercialization of the Neuromorphic Chipset

With the recent release of Intel's Loihi 2 neuromorphic chip, research in neuromorphic and Spiking Neural Networks (SNNs) will increasingly involve the industry and provide a hint about the sort of commercial Artificial Intelligence (AI) applications in which these networks can integrated. Other neuromorphic chipset vendors to take note of are BrainChip and GrAI Matter Labs. Neuromorphic chips can implement the currently popular Deep Neural Networks (DNNs) as well. However, the use of SNNs will provide the most significant benefits in the long term, with superior performance in latency response and energy efficiency.

23 A Single Regulation to Govern AI

Following in the footsteps of the EU and China, more and more countries are preparing their regulations to govern the design, development, and deployment of AI. However, ABI Research believes that no nation will rely on a single regulation to govern AI. Instead, countries will develop guidelines, standards, and regulations to oversee various aspects of AI, including data collection, storage, model transparency, future update, and legal responsibilities. A good example will be the EU, which relies on General Data Protection Regulation (GDPR), ethics governance framework, risk-based legislative framework, and conformity assessments to govern AI.

24 Wide-Scale Adoption of Novel AI Compute Methods

Further scaling up of DNNs will soon result in unsustainable environmental costs, but a quick uptake of SNNs is not in the cards. As a novel computing technique, neuromorphic chipsets will take a while to become mainstream. Relatedly, there will also not be an uptake of more advanced AI methods, such as neural-symbolic models, but here, too, the industry will eventually have to go where only academia has gone so far, if vendors want to make any significant inroads in implementing AI applications that can tackle extrapolation and goal-directed reasoning.

25

Increasing AI Presence and Usage in Augmented and Virtual Reality

Enterprises have been leaning into AI to extract the maximum value from hardware, platforms, and services. Augmented Reality (AR)/Virtual Reality (VR)-specific usage has missed some of this momentum due to its more nascent state, but that is changing rapidly. More than 20 million active users will leverage AI for augmented reality usage in 2022. AI for machine vision is in place but will grow in capability, increasing captured data and enabling greater analytics and insight potential for platforms. Prediction and automation are a significant value add for any organization, and the increased data flowing from and through AR/VR devices, combined with AI/ML, create a hotbed for both prediction and automation of worker-facing and backend systems.

26

Apple AR/VR Hardware

The year 2022 was slotted as the likely release of the company's first foray into Head-Mounted Devices (HMDs), but that looks increasingly less likely with supply chain slowdowns and general market readiness signs for the company. Even if a product ships in 2022, it will be late in the year and will not have time to prove impactful in the market. The first product slated from the company is likely to be a prosumer and/or enterprise-grade VR headset targeting content creation, and will be a testbed for Apple's services that have not yet ventured into AR/VR proper. While competition is ramping up on paper—most notably from Facebook (Meta)—supply chain and market readiness are universal barriers, so Apple will not feel substantial competitive pressure in 2022.

27 ePassport Shipments Will Rebound

A Year-on-Year (YoY) recovery of 26% for ePassport shipments will happen in 2022, after a sharp decline of -41% between 2019 and 2020. With most borders having been closed and almost no international travel opportunities, replacement rates for the credentials dropped significantly. With the passport market not expected to return to pre-COVID-19 levels until 2024, the chipset shortage will have a negligible effect on the shipment volumes for passports due to already low demand for the application.

28 The Rise of Secure Application Programming Interface Management Solutions for 5G

With the rollout of service-based architecture in 5G networks, the mass deployment of Application Programming Interfaces (APIs) is imminent. Having chosen to use the widely established REST architecture, 3GPP has opened the door for developers to create plug-and-play solutions and enable seamless integration of third-party applications with the 5G core network. While this approach offers a host of benefits for enterprise adoption and cloud assimilation, it also creates new risks in improper asset and interface management through API exploits, particularly where it relates to the protection of network functions' service APIs that will support the microservice architecture.

While interconnect security will be partially addressed by the Security Edge Protection Proxy (SEPP) and N32 interface through authentication and transport security technologies (e.g., Transport Layer Security (TLS), OAuth2, etc.), this gives rise to new complexities and issues in terms of operational management, not the least for the support of a Public Key Infrastructure (PKI), for example.

These new imperatives are driving the need for a management platform for API service interface security that can provide secure issuance and storage of certificates (other secrets), flexible support for real-time monitoring, and secure updates, as well as a high degree of automation. These types of platforms will be key to accelerating enterprise usage of 5G. The year 2022 will see the rise of platform solutions for 5G networks that promise to decomplexify the deployment of trusted applications, and notably the authentication and secure management of APIs and the data communicated to and from each.

29 Non-Fungible Tokens Will Not Bring Enterprise Blockchain Back into Favor

Blockchain's star has somewhat waned since its hype peak in 2017/2018, and various applications over the last few years have purported to bring it back into the limelight. Non-Fungible Tokens (NFT) are promising to do just that, and interest around the Ethereum-based technology has spiked in the last few months, notably in the music, art, and Internet culture space. The vast sums being exchanged over NFTs have understandably raised hopes for the application, breathing new life into blockchain interest, as NFTs could potentially also be leveraged to serve more enterprise-focused applications in real estate and manufacturing.

The reality, however, is that enterprise blockchain is a slow-burner. The passion that drives individuals (from artists to fans) has driven the success of NFTs in that space; a mirror of the incentives that drive the market for cryptocurrency and altcoins. But despite the promise that NFTs offer for asset holding in enterprises, for example, there are too many barriers and obstacles that bar blockchain's mass emergence. Enterprises are more cautious and certainly more risk-averse. Too often sold as a feature, rather than an underlying technology, there are difficulties in translating the actual value that NFTs, and blockchain in general, can bring to enterprises. Beyond that, issues surrounding energy consumption (not very sustainable), pandemic-related reprioritization, legal grey areas, and a general lack of proper understanding of how the technology works all impact the appeal of what would otherwise be a compelling technology. The year 2022 will not be the one for blockchain's revival. Instead, it will continue to prove its case in small, incremental ways over a much longer and sustained period.

30 Fully-Automated Security Systems Will Not Be as "Intelligent" as Hoped

Fully-fledged security automation will not be the panacea over the looming cyberthreat horizon. The lack of manpower on the IT security side of (connected) things is a well-known issue that, unfortunately, has been exacerbated during the past decade because the number of connected devices is growing exponentially, but not the number of security analysts available to manage them. Organizations are always in a defensive, reactive mode to secure each newly adopted technology and this is not effective for thwarting the highly sophisticated and ever-evolving cyberthreats in the Internet of Things (IoT).

Ultimately, this costs industries and governments hundreds of billions of dollars in the form of ransomware, infrastructure disruption, outright damage, and cyber-warfare. There is little doubt that security automation provides a much-needed shot in the arm for organizations, lowering alert fatigue and providing a backbone for incidence response. Unfortunately, due to the heterogenous and fragmented nature of the IoT, truly autonomous security is almost impossible at this point in time, leaving IT services at a severe disadvantage.

31 Contactless Ticketing Will Not Overcome the Chipset Shortage

YoY growth will not be seen in 2022 for the contactless ticketing microcontroller or memory market, as the chipset shortage impacts on its critical year. It has been well documented that the semiconductor industry is currently going through a high level of uncertainty. Driven by recovering economies and the continued upward trajectory of hyper-connectivity and subsequent requirement for computing power, the demand for chips exceeded all expectations in 2021 and supply could not keep up. The chipset shortage is expected to worsen in 2022 as demand continues on its upward trajectory with no new capacity created to help improve supply in the shorter term.

32 Increasingly Challenging AI Workloads Will Drive Adoption of Heterogenous Compute in the High-Performance Computing Cluster

The variety and complexity of High-Performance Computing (HPC) workloads will see an increase in the number of heterogeneous compute servers being deployed in HPC solutions. A trillion parameter AI models will start to be viewed as normal and pressure to solve workloads in the most efficient manner in terms of time and power will see efforts concentrated on ensuring that the most appropriate hardware component is working on any given compute task. Workload classification will become important as multiple processor architectures, vector, scalar, matrix, and spatial become more closely aligned and integrated in HPC systems.

33 The Exponential Boom in Edge Computing Will Not Come to Fruition

Edge computing, both Mobile-Access Edge Computing (MEC), and general edge computing, will continue to increase in deployment numbers, but the deployments in 2022 will be mostly critical ones made by early adopters and not the start of the boom that is eagerly forecast. Edge computing use cases and financial viability are tightly coupled to 5G cellular networks, both public and private. The availability of affordable 5G services on which edge computing will thrive is not yet a global reality. As a result, edge computing adoption will be slower than anticipated.

34 Hardware-Based Robot Operating System Optimization

Robotics processor vendors will increasingly offer Robot Operating System (ROS)-based solutions for hardware acceleration across the entirety of robotics offerings. This should help tackle the problem of system integration and entice developers to adopt more off-the-shelf processors and hardware. Furthermore, the hardware-software optimization will provide a set of benchmarks and standards for the field, which is fairly fragmented at the moment, accelerating the time-to-market. As a total of 45,000 cobots and 452,000 mobile robots are expected to be shipped in 2022, a 65% and 51% Y-o-Y growth, end users are expected to benefit from the tighter integration.

35 5G Comes to Robots and Drones

5G deployment has started to mature worldwide, with more 5G devices expected to launch in the next few years. With the launch of Qualcomm's RB5 processor for robots and drones, 5G-enabled robots and drones will be among them. 5G is expected to play a critical role in enabling on-device ML for robots and drones, allowing them to feature highly-accurate object detection, autonomous navigation, facial recognition, and pose estimation. In addition, these robots and drones can constantly connect to the cloud, using cloud-based analytics and storage for resource-intensive tasks. More than 30% of mobile robots are expected to feature cellular connectivity by 2025.

36 The Democratization of Robotics Expertise

While the emergence of ROS and various robotics startups will offer real advances in the short term, robotics as a whole suffers from a significant shortage in expertise. In the long run, this will have an adverse effect on development and commercialization. Considerable investment in resource- and time-intensive areas requiring experts from different fields is badly needed, but this will not happen anytime soon.

37

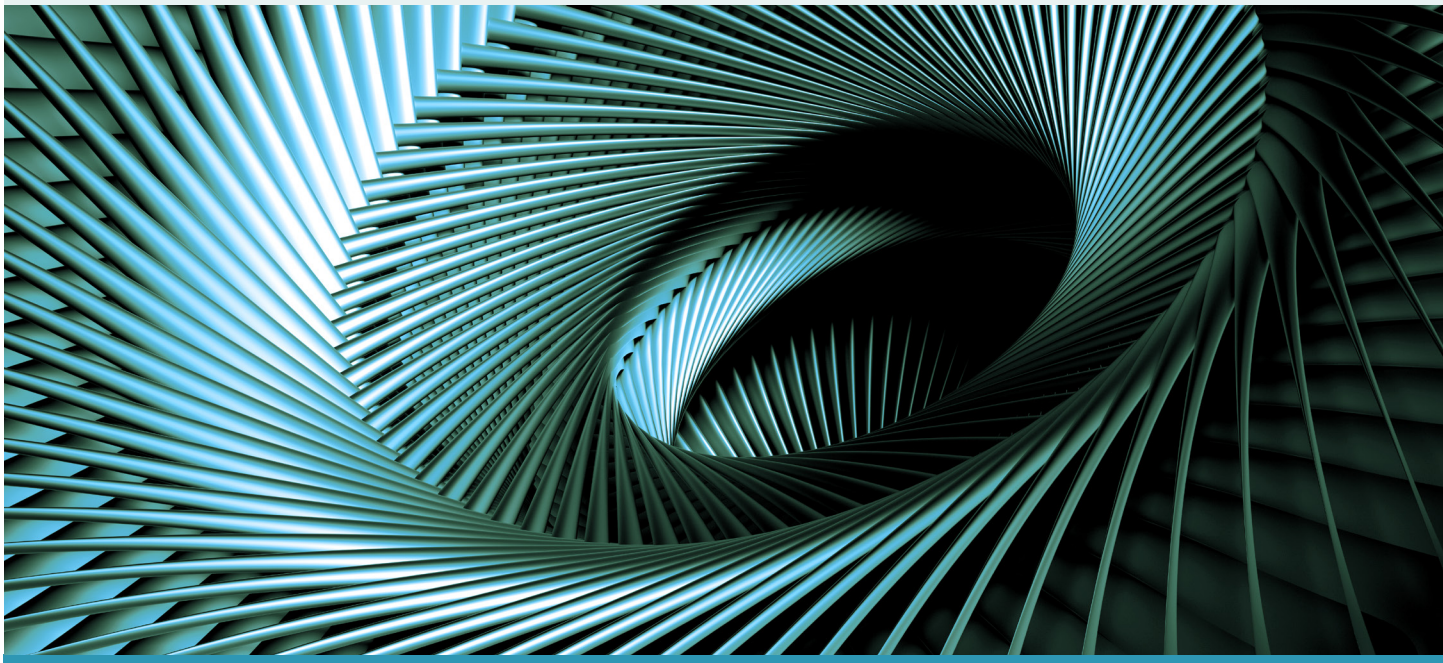
Digital Threads Extended to Outsiders

Suppliers of industrial applications, such as simulation software and product life cycle management, are moving from providing only on-premises solutions and are making their solutions available via the cloud and offered on a Software-as-a-Service (SaaS) basis. Suppliers will emphasize the ability to work on projects regardless of location and the capability to ensure traceability of design changes to deliver a digital thread across teams, but also so that customers can open the solutions to collaborate with their technology partners and suppliers on designs. In theory, the extension of the digital thread to outsiders will accelerate innovation cycles and identify issues earlier; however, to protect their IP, customers will need to think carefully about guardrails regarding who is gaining access and traceability surrounding their activities.

38

Rise of Digital Twin Marketplaces

Manufacturers need a range of capabilities to deploy digital twins, including Computer-Aided Design (CAD) modeling, connectivity, cloud computing, Industrial Internet of Things (IIoT) software platforms, remote monitoring, hardware for shop floor workers (tablets, AR glasses), physics-based simulation, ML, and systems integration. This is because digital twins are not a technology, but a composition of solutions aimed at bridging the physical and digital worlds, from design through simulation, manufacturing, assembly, and after-sales service and support. Over the last few years, digital twins have grown from a concept to become mainstream with the help of IIoT dashboards and near-real-time reporting. This level of maturity has been accompanied by new thought constructs, such as the use and implementation of AI at scale, changing requirements like the need for model libraries and standards bodies, and soon, the emergence of digital twin marketplaces that enable Independent Software Vendors (ISVs and other third parties to build relevant tools for the ecosystem. These tools are essential for continued value creation and the wider democratization and adoption of digital twins. Spending on industrial digital twins will grow from US$4.6 billion in 2022 to US$33.9 billion in 2030 at a 28% Compound Annual Growth Rate (CAGR).



39 5G Will Not Permeate the Production Line

As of July 2021, there were 84 sites with publicly announced private cellular network (4G/5G) deployments (see ABI Research's Shared Spectrum and Private Networks Tracker report (MD-SSPT-21). All are at large companies and facilities, with examples including ABB, Airbus, BASF, Daimler AG, Ford, Haier, Konecranes, and Nippon Steel. While important, current deployments are mostly used as campus networks or in a lab or intermediary production development center for non-industrial production applications. Standards work by 3GPP and 5G-ACIA continues to advance adoption and use of the technology; however, the device ecosystem and implementation/management functions lag. There is also a question of relevance: two-thirds of manufacturers employ fewer than 20 people. In its current form, working with and trialing 5G in manufacturing favors large companies/factories with the R&D capital to test and learn. These larger companies and locations have started to evaluate the cost and benefits of different deployment scenarios (a key progression); however, 5G will not be relied upon for production-critical applications at scale until 2024.

40 Digital Solutions Will Not Scale in Either Mining or Oil Firms

Everything concerning mining and oil firms is gigantic: the equipment used, the scale of the sites both above and underground, the inherent danger of the operations, and the distances involved in getting the minerals. In theory, these firms should be a hotbed for digital transformation. In some respects, opportunities exist for drones collecting data, analytics deployed on the images collected, digital twins created of sites; all underpinned by cellular networks. But — and this is a big but — many sites operate independently of headquarters or, in the case of oil firms, often under the aegis of a joint venture. Unlike in other sectors, such as food & beverage, a Chief Operating Officer (CEO) at headquarters cannot dictate the implementation of a particular solution. Therefore, suppliers should treat the sites as autonomous entities with site managers having the discretion to deploy solutions that fit their site's requirement at a particular moment. In addition, suppliers will need relevant references from engagements with other relevant sites to be considered. When considering these verticals, it would be a mistake for suppliers to focus their time solely on engaging with the C-Suite at headquarters, they need to get boots on the ground and engage with individual sites.

41

China's IoT Module Vendors' Market Share Will Not Be Challenged

Chinese vendors were responsible for 76% of all cellular module shipments in 2020, with the strongest individual performer, Quectel, taking a 34% share of the 300 million units manufactured globally. Chinese dominance will only increase by the end of 2022 and in the years to come. The vendors there have forged strong supply-side relationships with western semiconductor manufacturers to give their products global appeal. And, as integrators of other companies' components, they represent no meaningful original IP threat to western powers, so they are not subject to the same restrictions as Chinese state-run entity Huawei. At one time, Huawei was the only Chinese module vendor effectively competing on the international stage, but today its market share is no more than 2%. The international aspiration of this new breed is only growing, and the most determined Chinese vendors already realize close to 70% of their income from overseas markets. Western module vendors will not be able to, nor will they even seek to impact their Chinese competitors' market share.

While this notion might be controversial, it is still the truth. The best metric for measuring competitiveness and success is changing, from unit shipments, to turnover and profitability. Therefore, module vendor strategies must extend well beyond hardware to the integration of software and services, as well as to the discrete picking and choosing of which module products lines to develop. Some vendors will target only those that return the best opportunity-cost results, as their focus extends not just to revenue, but to margins. There will always be vendors that exist to supply whatever there is any demand for, and to sell as much as possible to as many as possible, regardless of how commoditized a product is. This is good and necessary for the IoT and fulfills a need. Plus, low-margin high-volume trade is a perfectly valid business model—just ask Amazon. But cellular IoT module vendors will (and are) becoming less directly comparable by design, as their individual long-term strategies are honed to target one of the three: unit sales, income, or profit.

42 Regional Stimulus Packages Will Drive IoT Adoption from Utility Service Providers

While IoT adoption from Utility Service Providers (USPs) will be driven by regional stimulus packages, markets will continue to be cautious with their capital spending on new technology solutions. USPs (energy and water) will remain one of the largest adopters of massive IoT solutions, as they continue to implement their grid digitalization programs that started more than a decade ago. A utility's primary objective in implementing the IoT will be to add resilience to their operational processes and support growing consumer demands to shift from the use of fossil fuels and move toward renewable resources. However, the degree of USPs' shift to renewable resources this decade will depend directly on the regional government's financial assistance and regulatory policy reforms.

43 Sustainability Convergence with the IoT

Companies around the world provided sustainability plans on decreasing their carbon footprint that will come to action in the future decade. Meanwhile, suppliers are also facing market changes. Growing competition in the market and rejection of governmental subsidies will shape the market and force Operations and Maintenance (O&M) teams to reduce expenses and improve efficiency of their wind power plants and solar farms. To achieve these goals, we will see a new market development in the sustainable energy and IoT domain.

In 2022, the IoT will continue to transform the sustainable energy markets, such as wind, solar, biothermal, and nuclear power generation industries. IoT analytics will provide wind energy suppliers with real-time data on their power plants and storage assets, as well as their customers' consumption, to ensure continuous energy generation and distribution. IoT solutions also guarantee the adjustment of business operations for dramatically increased revenue. There is an expectation to see a shift in pricing and demand for sensors, actuators, and gateways, because all of these devices are needed to predict failures and assure the overall efficiency of used equipment, specifically for sustainable power generation. This trend is the most accurate for green technology companies that will continue to reduce operational expenses, reserve funds for innovations, and deliver more affordable green energy.

44 Software Will Lead Asset Visibility Initiatives

Amazon, considered by some to have the best supply chain management system in the world, is lighting a fire across a range of business segments, but particularly in retail, grocery, electronics, and superstores. This "speed of business" driver with customers expecting to shop from their computer with access to a breadth of product options and receive their choice of product in as short as one day is just one driver among others, such as trade wars, compliance and regulatory requirements, and cost management. Visibility is a challenge due to the varied means of moving a product across multiple regions and delivery modes covering ocean, air, freight forwarders, and drayage carriers, in addition to the multiple systems that hold data on product movement, such as Enterprise Resource Planning (ERP), Warehouse Management System (WMS), Transportation Management System (TMS), serialization software and real-time tracking platforms. Tackling this complexity is best accomplished by the unique approaches of software providers that focus not only on aggregating disparate supply chain datasets, but also on addressing the different pain points in the product journey where issues develop. Interesting software aggregators to watch include Descartes, Agistix, and EVRYTHNG.

45 Device Innovation Will Take a Back Seat to Software Development in the Asset Visibility Domain

The availability of Low-Power Wide-Area (LPWA) technology created the expectation that new tracker devices could be powered by batteries, operated for months, and connected deep inside buildings via Wide-Area Networks (WANs). The possibility of a single device to handle tracking of parcels, pallets, and other shipments is alluring, but the hype has been tempered by lower-than-expected LPWA device adoption. Software has tried to address the void; however, that does not mean that device innovation has withered. Quite the contrary, new technologies are stepping in to drive further device miniaturization and performance for a range of wireless radio technologies. These include device-based location and cloud-based location that can remove the need for Global Navigation Satellite System (GNSS) chips; energy harvesting technologies to remove the need for batteries; and AI technologies, such as TinyML, that enable event-based communications sending data only for the events that matter.

46 Utility Service Providers Will Not Invest in New Infrastructure

After a decade of financial uncertainty from the recession, trade wars, political tumult, and a global pandemic, enterprises' priority will remain to stabilize revenue inflows before setting aside expansive capital outlays for new supply infrastructure.

USPs that have already implemented smart meters have benefited from real-time energy consumption data to efficient load/demand forecasting and bolstering supply, avoiding any unsavory service disruptions during the COVID-19 pandemic. This has not only allowed utilities to improve their operational efficiencies and grid stability but to improve billing accuracy through remote smart meter readings, helping USPs manage revenue inflows.

As we slowly emerge from the severity of the COVID-19 pandemic, smart meter implementation programs will gather pace; however, some of the key factors to watch include the following:

- Utilities that had already started smart meter implementation programs will begin to accelerate rollouts in 2022, but implementations in North America and Europe will be partly hit due to smart meter shipment delays.
- Utilities that are in the advanced stages of metering programs will begin to invest more in AI-based IoT analytics to automate the distribution grid and facilitate growth in Distributed Energy Resources (DERs).
- As smart meters deliver benefits that have been advocated over decades to many USPs, service providers that still operate traditional dumb meters will be hard-pressed to automate their metering infrastructure with smart meters to not only improve the resiliency of their distribution grid, but also for revenue protection.

47 Radio Frequency Identification Will Not Be Replaced

While active IoT devices are seeing huge growth in shipment numbers, driven partly by lower costs and smaller form factors, they will not replace passive Radio Frequency Identification (RFID), which has also seen a broad resurgence after its failure to meet enterprise needs nearly two decades ago. While companies need real-time tracking and monitoring in certain settings, near-real-time and point-to-point tracking are considered sufficient to meet many current enterprise needs, at an affordable and scalable price point.

48 Largest IoT Connectivity Providers Will Continue to Lead the Way

Nothing succeeds like success. From the end of 2019 until the end the end of 2020, the Vodafone Group's installed base of cellular IoT connections increased from 99 million to 118 million. That's a YoY growth rate of 19%.

While high growth rates are typical at the start of a market, or on a company's entry into a market, Vodafone is not new to the IoT and has been in the market for three decades, and having such high yearly growth more than 10 years on is impressive. The rate of growth is increasing as well—Vodafone will eclipse 140 million installed connections by the end of 2021.

This does not mean there is no opportunity for new entrants. However, they need to find an angle and target an IoT niche that is either not currently considered or inadequately served. For example, 1NCE has built a base of 10 million IoT connections in only 3 years on the premise of providing the simplest possible and most accessible tariff plan as its conversation starter. Many specialist IoT Mobile Virtual Network Operators (MVNOs), such as KORE Wireless, have strategies that position connectivity as a means to a greater end, layering specialist and professional services on top. Traditional wireless carriers are often content with just the pure play connectivity revenue. For Vodafone, connectivity revenue has historically been 75% to 80% of its IoT income. No one is going to challenge Vodafone or AT&T on their quantity of IoT connections, but there is plenty to compete for in the realm of added value, in a market where there is no theoretical limit to the quantity of things to connect.

49 The Rollout of Next-Gen LPWA Networks Like Cat-M and NB-IoT Will Drive Adoption of Lightweight M2M

Typically, Low-Power Wide-Area Networks (LPWANs) have functioned based on unlicensed spectrum connectivity like Long-Range WAN (LoRaWAN) or proprietary protocols like Sigfox. The emergence of Narrowband-Internet of Things (NB-IoT) and Cat-M puts Lightweight M2M (LwM2M) in the limelight because LwM2M is User Datagram Protocol (UDP)-based, which has lower data packet transmission loss over NB-IoT networks than its counterpart Transmission Control Protocol (TCP)-based protocols like MQTT according to IEEE research.

50 LwM2M Will Not Replace MQTT

MQTT is pre-dominant in the industrial (manufacturing) domain, while LwM2M is more present in utilities/energy, in particular with smart meters. MQTT and LwM2M cater to different application segments because MQTT is TCP-based, while LwM2M is UDP-based. A TCP-based protocol has a persistent connection, allowing it to function in industrial applications that require acknowledgement that data has been sent and received, while a UDP-based protocol works in lightweight applications that do not have overheads, such as Acknowledgement (ACK) messages and do not require data packet re-transmission. The two protocols excel in different application segments.

51

Ultra-Wideband's Acceleration Will Propel Precise Location Technologies to the Mainstream

Thanks to its unique precision, robustness, and reliability, Ultra-Wideband (UWB) has re-emerged as a secure, fine-ranging technology capable of enabling a wide range of innovative location-based user experiences and services that previous wireless technologies have been unable to effectively support. This includes a combination of device-to-device and device-to-infrastructure applications, including hands-free secure vehicle and building access, indoor localization, asset tracking, hands-free payments, seamless smart home interaction and automation, AR, gaming, and a whole range of emerging smart building, smart city, industrial, and other IoT applications. While there are numerous hurdles for the technology to overcome, including standardization and interoperability, widespread chipset and device availability, greater education, and awareness, among others, it is clear that UWB technology will increasingly become a ubiquitous technology embedded within smartphones and vehicles, which will act as a catalyst for large-scale UWB adoption across a whole range of new IoT applications.

In Real-Time Location System (RTLS) environments, UWB will continue to grow. Vendors like Ubisense, Kinexon, Siemens, Eliko, Sewio, Quarion, Zebra, Tracktio, and Pozyx, among many others, are helping the technology grow across a number of precision RTLS applications within industrial, warehouse and logistics, and sports tracking applications. Combined, UWB is expected to reach 500 million annual shipments in 2022, growing to 1.5 billion by 2026, according to ABI Research.

52

5G Positioning Will Not Replace Alternative RTLS Technologies

The ability of 5G to combine connectivity with high-precision positioning has the potential to significantly enhance the value proposition of 5G rollouts and enable new Location-Based Services (LBS) within a variety of enterprises. Within end-market verticals, such as manufacturing, healthcare, warehousing and supply chain, transportation, and oil, gas, and mining, it is clear there is growing sentiment that 5G positioning is beneficial thanks to its ability to combine telco and positioning use cases into a single infrastructure, and that it can address use cases that other technologies have struggled to address to date, for a variety of reasons. There is a growing acknowledgement that 5G positioning is emerging to make LBS more accurate, precise, reliable, and seamless across both indoor and outdoor environments. However, 5G positioning is very much in the early days of maturity, and there are a number of obstacles that need to be addressed.

53

A Boom for AI and ML

The role of AI and ML in the media & entertainment industry will increase significantly in 2022, with revenue forecasted to surpass US$ 9.5 billion in 2022 when video ad tech is included. Due to competitive pressures from direct-to-consumer services, it has become a necessity for incumbents (i.e., pay TV operators, broadcasters) to reduce costs, limit churn, and extract as much value from existing customers. AI/ML's role here will increase to better target households with promotions, automate more workflows, and better secure the operators' content and services.

AI/ML will also play a growing role in the ad tech space to improve personalization and contextually aware advertisements, and serve as grounds for differentiation. This is especially critical following changes to third-party tracking devices (i.e., Identifier for Advertisers (IDFA) and third-party cookies) and increasing focus on privacy. The corollary of these trends is that the ad market will not suffer as severely as some had feared due to the changing privacy landscape.

54

The Metaverse Will Not Arrive Fully Formed

The metaverse, despite all the headlines and investments, will not arrive in 2022 or, for that matter, within the typical 5-year forecast window. The metaverse is still more of a buzzword and vision than a fully-fledged end goal with a defined date of arrival. What we have today is a number of tech companies building their version of a "metaverse," but this multiverse is not fully interconnected, does not yet widely employ open standards, and certainly has not fully embraced Extended Reality (XR)—all tenets of the metaverse vision (some would also add the cryptoeconomy to the list, which is also not in place).

However, this does not mean that all this talk about the metaverse is premature, rather the tech industry will continue to lay the foundation and build toward this metaverse future. It may take the better part of a decade before that "completed" form of the metaverse begins to take shape, but there will be plenty of opportunity between now and then. When the metaverse does arrive, it will truly transform the way we live our lives and, in the process, generate tremendous opportunities for a host of technologies, including 5G/6G, edge and cloud compute, XR, and AI/ML.

55 Smart Urban Sensors Are on Their Way to Ubiquity

While progress in bringing connected sensors to a range of smart cities assets has been slow in the past decade, never reaching any significant scale, the future looks decidedly more promising. The installed base of LiDAR sensors in Smart Cities will start to gain traction in 2022 and reach over 2.5 million by the end of the decade. The number of use cases where sensors can offer added value in terms of addressing urban challenges, such as efficiency improvements and cost savings, sustainability and decarbonization, circularity, and security and resilience is multiplying. Key sensor-based solutions include automated traffic management at intersections, people density and flow tracking for COVID-19 distancing, wider security surveillance and occupancy monitoring in buildings and microcities, active connected infrastructure with embedded energy generation and signage, air quality sensors, gas leaks, and gunshot detection, and—yes—sensors measuring the condition of green infrastructure.

Much of this momentum is due to both the emergence of powerful edge AI compute, unlocking more value and insights from captured data, including predictive intelligence, and an increasing range of high-performance sensor technologies, including Light Detection and Ranging (LiDAR), InfraRed, and radar, next to legacy low-cost camera sensors, the quality of which has also improved. This opens up new addressable markets for vendors like Quanergy, Velodyne, and FLIR. Additionally, city governments are now also waking up to the real possibility of sensor data monetization, representing much needed new revenue sources in the post COVID-19 era.

56 Green Solutions Will Be a Priority for COVID-19 Recovery in Cities

Following the ongoing recovery from the COVID-19 pandemic and the completion of the COP26 event in Glasgow, sustainability and net zero will again be a priority for cities. Sustainability and the progress toward net zero had been put on the back burner thanks to the COVID-19 pandemic, but this will change in 2022. Following COP26, the EU's Green Deal and pledges from cities and governments across the globe will again make sustainability a priority. The effects of climate change are being more keenly felt YoY with wildfires, droughts, and record rainfall affecting nearly every region.

Key smart city technologies, such as digital twins, NB-IoT sensors for essential services, and electric micro-mobility, are popular investment opportunities for cities. These can be used to increase the sustainability of cities, decarbonize the environment, and move an area toward net zero targets. The proper use of these technologies and ongoing investment and development are critical to their success.

57 Despite the Increase in Popularity of the Circular Economy, There Will Be No Measurable Growth

The circular economy will not start to pick up any measurable increase in the next 12 months and is expected to fall to 8.5% circularity in 2022 before it starts to increase. The circular economy principle is growing in popularity across cities and those who govern them; however, it is in the very early stages of development and will not pick up any measurable momentum in the next year.

As the world leaders in the circular economy, such as Amsterdam and Glasgow, start to devise ways to measure, implement, and encourage the circular economy, only then will it gain momentum. It is an area that will be growing, but it is not expected to rapidly increase until there is further Proof of Concept (PoC) and a meaningful method to measure its delivery. In the meantime, the increase in connectivity, the IoT, and better data processing will help us to understand the circularity of items and services in cities. City-level data are the key to the success of the circular economy as place-based solutions are often required to ensure success.

58 New Urban Concepts Will Not Be More Than a Remote Dream

In 2021, eye-catching "from scratch" greenfield urban visions, such as The Line and Telosa, were announced, proposing fundamentally new concepts for city living based on green, pedestrianized, and 20-minute neighborhoods served by driverless, mobile, and on-demand retail and delivery units, while moving traditional transportation, utilities, and other infrastructure to underground levels. Many of these concepts and mega projects will never see the light of day or have been halted due to a lack of funding, sometimes related to COVID-19. While these new city visions offer a glimpse into a more humanized, sustainable, and resilient urban future, the reality dictates retrofitting and/or upgrading existing urban infrastructure. Both the complexity and the high costs of these brownfield projects are limiting the scale and impact of urban innovation in the near term. However, the driving forces behind new urban principles will remain powerful and will gradually but irreversibly transform urbanization in the next decades.

59 Matter Will Finally Matter

After a few missed deadlines and delays, the Matter specification and the first products to support it will come to market in 2022. The arrival of the application layer specification will surprise few, but the scale and impact of its initial adoption perhaps will be a surprise. The combined weight of Amazon, Apple, and Google behind the project not only ensures ready adoption across their own smart home offerings but has also drawn more than 200 additional companies to develop and prepare Matter for adoption.

Smart home Original Equipment Manufacturers (OEMs), including Signify, Schneider Electric, and many others, will also aim to quickly deliver Matter compliance in their own products. But Matter adoption will also force smart home OEMs to make key strategic decisions. Players will be faced with either continuing with the expense and greater control of maintaining dedicated apps and support for their smart home products or handing over that functionality to any Matter-compliant smart home platform provider. Smart home platform providers are wary of Matter support delivering their install base over to their largest competitors. Matter will arrive in 2022 and the smart home industry should prepare to adopt existing business and revenue models.

60 Companion Robotics Will Not Go Mainstream

After several years of leading social robotics companies either shutting up shop or withdrawing their commercial offerings, 2021 saw renewed investment and focus on the market and its potential. No news was bigger that Amazon's attention-grabbing entry into social robotics with the launch of its first social robot, the Astro. However, despite the enormous potential for social/companion robotics, 2022 will not be the breakout year the industry is hoping for, despite the scale, pricing, and awareness that a player like Amazon can bring to an emerging technology market.

Rather than a kickstart to a broad consumer market, the Astro is best understood as an introductory product for Amazon itself, as much as for the wider consumer market. Awareness is growing regarding how social robotics can play a valuable role in the monitoring and care of key consumer demographics, especially in senior care. Players, such as Intuition Robotics, are approaching the market without Amazon's resources, but with a specific focus on the demands of elderly healthcare providers. Ultimately, both approaches will lay the foundations for broader adoption but the market still must determine the appeal of key aspects, including form factor, broad functionality/specific capabilities, and end-user comfort, and 2022 will have come and gone before much of that work is honed.

61 An Inflection Point for Autonomous Driving Subscription Models

Today, autonomous functionalities are charged a one-off fee on top of the vehicle price: Cadillac's Super Cruise adds US$8,740 and Tesla's Full Self Driving (FSD) adds US$10,000 to the purchase value. However, the high price tags discourage adoption, with only an estimated 27% of Tesla owners purchasing the Autopilot/ FSD package. Also, one-off fees do not provide recurrent revenue to carmakers, even though they are continuously investing in new Autonomous Vehicle (AV) functionalities. Therefore, subscription plans that provide customers with the benefit of using existing AV functions and activate new ones on-demand Over-the-Air (OTA) are set to become the dominant strategy adopted by carmakers moving forward.

Tesla, which often sets trends in the automotive industry, recently introduced a subscription model charging owners US$199 per month to activate FSD. Customers who have already purchased Enhanced Autopilot are subject to a lower US$99 per month fee for FSD. Ford, on the other hand, will charge between US$995 and US$2,600 upfront for the hardware of its "hands-free" BlueCruise driver-assist system, launching in 2022, and US$600 for a 3-year software subscription. It is still unclear whether subscriptions will include the hardware costs or if customers will have to pay for it upfront. However, it is fair to say that carmakers will monetize AV functionalities via subscriptions, and 2022 will signal the inflection point for the shift in the business model.

62 A Protracted Period of Semi-Autonomous Driving Rollouts Kicks Off in 2022

While 2022 will see the tentative launch of a few small-scale robotaxi services, the largest opportunity for AV technology will be driver-supervised, semi-autonomous applications for years to come. Under the Society of Automotive Engineers' (SAE) definitions of autonomous driving, a Level 2 application can be any combination of steering, acceleration, and braking assistance, as long as the driver retains their overall responsibility and role as supervisor.

This has opened up an opportunity for OEMs to roll out more and more autonomous features, monetizing their sizable investments in AV technologies without the need for a new driverless regulatory environment, or exposing themselves to the liability that comes with unsupervised autonomous features. General Motors' planned addition of UltraCruise to SuperCruise, representing an evolution from driver-supervised highway driving to driver-supervised urban driving, clearly illustrates the direction of travel in the automotive industry. Furthermore, the launch of Intel Mobileye's SuperCruise system on a variety of ZEEKR models will see drivers given access to a host of autonomous functions normally associated with highly autonomous prototypes, but under their supervision.

When automotive OEMs first began investing heavily in AV technology, it was done in the belief that the technology would deliver fully autonomous operation in the early 2020s, and along with it a new revenue opportunity based around mobility services. Instead, OEMs find themselves in the midst of an unprecedent supply chain crisis, with the prospect of driverless mobility services still a number of years away. Automakers will lean heavily on the semi-autonomous vehicle, so-called "Level 2+" opportunity from 2022 onward.

63 New Vehicle Sales Will Not Bounce Back

Despite optimism at the beginning of the year for an aggressive rebound in new vehicle sales, the automotive industry is expected to exhibit little or no growth by the beginning of 2022, with ABI Research projecting global growth of only 1.3% in 2021. In Europe, new vehicle sales are expected to contract slightly in 2021, which is even a worse performance than the record-breaking 2020.

The automotive supply chain remains unable to meet pent-up demand, thanks to the shortage of critical semiconductors. A reliance on outdated semiconductor process technologies with limited production capacity, proprietary designs, and an opaque demand-signaling process has prolonged the semiconductor crisis in the automotive sector, with no quick fixes for problems that have been years in the making. Therefore, the consequences of the decision made by automakers in 2020 to cancel their existing semiconductor orders will last beyond 2022. Ultimately, ABI Research does not expect new automotive sales to return to the 90-million mark, last seen in 2018, until 2023 at the earliest.

64 No Explosive Take-up for Google Automotive Services, Despite the Hype

Despite the volume of carmakers' announcements that Google Automotive Services (GAS) would be implemented in their entire car line from 2021, they have been very cautious about implementing it into production vehicles. Most have opted to deploy it in select high-end or low-volume models (e.g., GMC Hummer EV, Renault Mégane E-Tech Electric) as an "experiment," while other options are being tested. GM, for instance, committed to GAS but has recently announced Ultifi. This Linux-based end-to-end software platform will enable on-demand vehicle features, OTA updates, communication with smart home devices, Vehicle-to-Everything (V2X), and even access to apps (possibly overlapping GAS). Although GM stated that Ultifi would run alongside the Android Automotive Operating System (OS), speculations are that it will temporarily use GAS in a few vehicle lines until Ultifi and its app ecosystem are enhanced.

These cautious implementations result from concerns about a lack of differentiation, the ownership of the vehicle experience, app store, and user data, how GAS could impact future OTA revenue, and whether Google will ultimately commit to GAS in the long term. It is important to highlight that carmakers' ownership of infotainment systems is already compromised as users prefer mirroring (e.g., Android Auto, Apple CarPlay) over the embedded experience. Also, although many are looking to implement strategies for ongoing monetization of the installed base via OTA updates, car OEMs still have a traditional transactional mindset. Thus, reservations over GAS could lose importance if the first vehicles featuring it start to outsell competitor models. Regardless, 2022 will certainly not be the year of mass deployment of GAS.

65 Automation Will Address Labor Shortages and Profitability Issues

Continued labor shortages, the desire for contactless purchasing and delivery, and expansive e-commerce with declining delivery windows all lead to the need to supplement human labor across the supply chain through autonomy and robotics. Cost also plays a role with >50% of shipping costs associated with last-mile delivery alone, putting further pressure on margins. Software automation is needed to address the complexities of fast-changing demand and omnichannel fulfillment, along with its impact on variations to locations, materials, and resources. Robots, cobots, and automation software will grow out of necessity across the supply chain from factory to fulfillment, retail, road, and sidewalk. Governments will continue to allow a variety of autonomous form factors to proliferate based on the factors above.

66 Acceleration of Digitized Supply Chain Transformation

Digital supply chain transformation efforts will ramp up. Companies that have been putting it off will now make it a priority, primarily due to global supply chain disruptions. The disruptions, which are mostly driven by the COVID-19 pandemic, have left many supply chains unprepared to react to significant disturbances that are occurring on a global scale. Demand uncertainty combined with supply volatility will continue to challenge companies in achieving targets and delivering business results. There is now a sharp awareness among executives that disruptions can happen at any time and that supply chains need digital solutions to make them agile and resilient, while providing end-to-end visibility. Additionally, as economies continue to recover from the pandemic and adapt to many changes in demand and supply, more companies are expected to establish processes like multi-echelon distribution networks, centralized planning, simulation capabilities, and scenario planning. Companies could leverage this to assess the changes in parameters, such as lead times and ordering frequencies, and react accordingly.

67

No End in Sight for Global Supply Chain Disruption

Currently, there is not only a shortage of semiconductors, but also items like medical equipment, electronic items, apparel, and many consumer-packaged goods. The pandemic has disrupted every aspect of the global supply chain. Apart from lags in critical processes like production and procurement, there have also been continued scarcities that influence logistics, including packaging, shipping pallets, and other products that are detrimental to transporting goods globally. Scarcity of materials has caused the prices of an abundance of items, such as cars and phones, to go higher. Although the pandemic has made supply and order volume extremely volatile, it is not the only factor at fault. Scaled down production, port congestion, and reshoring efforts, coupled with decades of lean inventories kept by companies to adopt the Just-In-Time (JIT) model to limit costs, have also largely contributed to the disruptions. It is hard to determine when the shortages will end, but there are good reasons to believe that the trend will continue well into the end of 2022, and possibly longer. Shortages and delays are expected to affect this year's holiday shopping season. Major retailers are planning to combat this by ramping up their inventories; however these initiatives might worsen the shortages due to port and warehouse congestion.

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No Relief from Semiconductor Shortage

A combination of factors will take until 2023 to resolve shortage issues through additional capacity, verification of real demand (versus panic 2X to 3X orders), and the inflationary impact on consumer spending on products. Continued risk factors include social/political risks, such as China/Taiwan relations linked to TSMC's 53% foundry share and being only one of two (the other is Samsung) currently producing 5 Nanometer (nm) products, with 3 nm on the horizon next year, and the ability to bring new fab capacity online, on time, especially for tight engineering specified automotive and commercial vehicles. In addition, China's Jiangsu province experienced week-long suspensions in manufacturing from government curbs of electricity due to coal shortages. Multiple fabs are running at 100% or greater, stretching out lead times, but with not enough additive capacity to absorb rising IoT/connected solutions. COVID-19 variants and the impact on nations without high vaccination rates also play a role in permitting staffing of facilities and transportation of finished goods and semiconductor supplies.

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Wi-Fi 6E to Accelerate the 6 GHz Market in 2022

Wi-Fi 6E will see a large amount of growth during the coming years within device types, such as smartphones, PCs, networking equipment, tablets, and home entertainment, with chipset shipment growth expected to ramp up considerably in 2022. The technology provides access to the 6 GHz band, improved speeds, reduced latencies, and support for more simultaneous connectivity over previous Wi-Fi protocols. Markets such as high-density environments, residential backhaul, AR/VR, healthcare, education, and retail will drive growth within Wi-Fi 6E, ensuring that devices take advantage of the technology's ability to provide improved connectivity.

A large number of devices will reach the market, ensuring that consumer and enterprise users have access to this improved connectivity, with more chipset and device companies entering the market throughout 2022 and beyond. Wi-Fi 6E chipsets for smartphones, networking, Access Points (APs), gateways, enterprise applications, and other client devices are available from companies such as Intel, Broadcom, Qualcomm, NXP, Infineon, and MediaTek. Current Wi-Fi 6E devices include networking equipment from Aruba Networks, ASUS, Linksys, NETGEAR, and TP-Link; smartphones from Samsung, Xiaomi, and ASUS; and TVs and laptops from Samsung. Many countries and regions across the world have already released the 6 GHz band for unlicensed Wi-Fi usage, and more will follow, enabling a greater number of users to take advantage of the technology.

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HaLow Will Build Success But Will Not Become the Major Wi-Fi IoT Technology Overnight

Despite Wi-Fi HaLow expecting to see new certification by the end of 2021, allowing products to become certified, the technology will not see rapid and immediate growth throughout the next 12 months. While the technology offers low-power consumption, a large range, high data rates, flexibility, and reduced interference for IoT applications, the technology will continue to see a number of challenges. In particular, there are many competing, well-established technologies that offer similar advantages for IoT devices, such as BLE, Zigbee, Thread, LPWA, and even Wi-Fi 6. These technologies have gained momentum within the IoT market, with a large number of companies active within the area, creating a vast competitive landscape that will be difficult for Wi-Fi HaLow to enter. This has, in turn, led to few large companies focusing on developing Wi-Fi HaLow solutions.

As a result, it has also taken a while for HaLow to reach the market. However, with the certification program imminent, HaLow now has the potential to carve out success across a number of market verticals, including smart home, video surveillance, condition-based monitoring, and wireless sensor networks. Companies such as Morse Micro, NEWRACOM, Adapt-IP, Palma Ceia SemiDesign, and Silex Technology, among others, are currently active within the Wi-Fi HaLow market and are actively supporting the technology.

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