68
TECHNOLOGY TRENDS THAT WILL SHAPE 2021:

👍 PREDICTIONS FOR WHAT WILL

👎 AND WILL NOT

HAPPEN IN THE YEAR AHEAD

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LETTER FROM OUR CHIEF RESEARCH OFFICER

Dear Industry Colleagues,

We are nearly finished with one of the most challenging years the world has ever seen. We have had change thrust upon us all, and the fundamental machinations of standard business processes have been stressed to the point where change has manifested itself as an evolutionary necessity. There is a pressing need for all organizations to put a finger on what will stimulate market responses and what the fabric of those new paradigms will look like. There are several potential outcomes for every new situation, and never have the table stakes been higher.

The team of analysts at ABI Research has made 68 predictions of things that will and will not happen in 2021. These predictions are informed by the many hundreds of in-person interviews we conduct every year, the millions of original data points we produce, and the collegiate approach to research that allows our analysts to collaborate beyond static silos and see trends early in the gray margins where market boundaries rub against each other and cause friction.

In this period of uncertainty and change, there is one polestar of unflinching truth: technology will be the most powerful tool in ensuring corporate health. Technology evolution, implementation, and enthusiasm must be embraced by all companies, no matter their tier of the corporate strata or the end market in which they reside. A resilient company that is well set to grow once this pandemic ends will be characterized by its digital agility as much as anything else.

This whitepaper will help you see those fundamental trends early and take a view on those trends that are buoyed by hyperbole and those that are sure to be uncomfortable realities. Now is the time to double down on the right technology investment.

Stuart Carlaw
Chief Research Officer
ABI Research

5G CORE AND EDGE NETWORKS

1 IT-OT-CT CONVERGENCE TO CREATE AN IDENTITY CRISIS WITHIN THE INDUSTRY VALUE CHAIN

Many telco industry players consider enterprise digital transformation the next cash cow for boosting revenue streams. However, to address this market and simplify the technology complexity for business implementers, these players need to provide more integrated Information Technology (IT)-Operational Technology (OT)-Customer Technology (CT) solutions whereby operation data, applications, and services can be connected across IT and OT systems regardless of whether they are located in the cloud or at the edge of the infrastructure.

However, this development pushes solution makers, be they Connectivity Service Providers (CSPs), hyperscalers, or system integrators, to extend their influence, expertise, and outreach across IT, OT, and CT, which blurs the boundaries between these spheres.

While in 2020 players have come together to co-develop and experiment with End-to-End (E2E) IT/OT/CT solutions, 2021 will be the year they will look at how to monetize these solutions. This situation will create an identity crisis within the new converged value chain, where CSPs could transform from connectivity providers to IT/OT service providers, and hyperscalers could seek to add connectivity to their portfolios.

These dynamics may even promote organizational integration across IT/OT/CT domains and could lead key industry players to venture into major acquisitions to fill in the gaps in their portfolios. For example, it will not be surprising to see large webscale companies like Amazon, Microsoft, and Google acquiring a network infrastructure vendor like Nokia or Ericsson to become Hyperscale Network Operators (HNOs).

Malik Saadi, Vice President, Strategic Technologies

2 5G EDGE COMPUTING EFFORTS WILL BE BROUGHT TO MARKET BY HYPERSCALERS

The recent collaboration between Telefónica and Deutsche Telekom is a case in point. Their joint endeavor showcases how CSPs collaborate by leveraging 5G to build a multi-operator, federated edge cloud. In this case, it was a mobile cloud gaming demonstration, a consumer use case.

For enterprises, the opportunity is vast, so it may be more optimal for CSPs to go beyond a singular strategy by collaborating and co-creating with technology providers. Companies like Amazon, Microsoft, and IBM are conscious of these dynamics and have positioned themselves accordingly. Telco-specific solutions like Amazon Web Services (AWS) Wavelength, Microsoft Azure Edge Zones, and IBM.

Telco Network Cloud can complement CSPs' connectivity offerings to bring vertical industry solutions to the market. These players view themselves as component and service builders that range from scalable cloud infrastructure to high-level platform services with sophisticated data analytics and applications.

ABI Research expects 2021 to be the first year when these partnerships align to bring edge computing to market for consumer and enterprise applications. While MobileEdgeX and similar initiatives are promising, hyperscale efforts will be much more likely to commercialize edge computing.

Don Alusha, Senior Analyst

3 | **SUBSCRIPTION-BASED ENTERPRISE BUSINESS MODELS REMAIN A DISTANT REALITY FOR TELCOS**

Hyperscalers are leading the market in consumption economics, or Operational Expenditure (OPEX) models. This trend is now picking up pace in telcos, with an increasing appetite for new technology delivery models. From a technology supplier's perspective, the commercial imperative is stark: depart from a finite supply of physical equipment, enhanced by feature differentiation and characterized by scarcity, and move to a monetization model where the supply is essentially infinite. The former promotes differentiation and avoids product surplus, whereas the latter offers convenience and scale at commodity-like economics, the chief appealing factor among solution adopters.

Increasingly, the CSP community also realizes that consumption patterns (in a cloud world) are quite different. Though very subtle, what is happening is increased consumerization of telco technologies. *In other words, the purchase patterns of the past were predicated on high switching costs, relatively low volume, high price, and a pay-up-front Capital Expenditure (CAPEX) model.*

Conversely, the future purchase pattern will be predicated on high volumes, low pricing, and a pay-as-you-go OPEX model. Though there is no doubt that consumption economics is coming, it demands new business models for the telco industry. At present, CSPs are not ready to fully embrace consumption economics. Neither are vendors.

Both parties must realize that the skills required in managing services processes are very different from those that drive successful product companies. Telecommunications is an asset-intensive industry with expertise in managing factories and supply chains, developing technologies, and understanding the cost of goods sold, inventory turns, and manufacturing.

Human-intensive services are entirely different. For example, in services and OPEX-based models, technology providers do not manufacture a product to then sell it. They sell a capability. They sell knowledge. They create it at the same time they deliver it. The business model is different, and so are the economics. As-a-Service (aaS) business models hold promise for the industry, but in 2021 they are certain to remain a distant reality.

Don Alusha, Senior Analyst

4 | **TELCO OPERATORS WILL TRY AND FAIL IN SOFTWARE VALUE CREATION**

There is a shift in the telco value chain that results from the Internet, software platforms, and the cloud enabling zero distribution and zero transactional costs. The fundamental nature of cloud software, including Artificial Intelligence (AI) and Machine Learning (ML), is all about abundance.

The critical competence is the ability to provide a superior experience and/or solve specific business problems. Rakuten's decision to rename its Network Operations Center (NOC) as a Service Experience Center (SEC) further drives that point home. Software platforms constitute a key pillar for new "horizontal" growth forays into enterprise verticals centered around company-level uniqueness in terms of product requirements.

A horizontal, software-centric way of building, marketing, and selling solutions is, therefore, a key next step for CSPs if they are to become adept at thinking horizontally. Software offers agility and the ability to drive innovation frequently, but this is not straightforward and effortless for a CAPEX-heavy telco industry. CSPs must come to grips with the new reality.

The new world in cellular must start with a foundation on software and Application Programming Interface (API)-led connectivity. Further, the continued convergence of cloud software and cellular may well mean that, in addition to bolting on software capabilities, CSPs must learn how to build them in 2021 and onward.

Don Alusha, Senior Analyst

5G CORE AND EDGE NETWORKS

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CLOUD-NATIVE COMPUTING GATHERS MUCH DESERVED HYPE, BUT WILL NOT BE MAINSTREAM YET IN 2021

There is widespread consensus that cloud-native computing will be a key enabler for a digitized telco ecosystem. Following the lead of webscale companies, such as Google and Amazon, the telco industry is beginning to integrate cloud-native computing into their operations. Cloud-Native Functions (CNFs) allow CSPs to use a micro-services architecture that can offer the kind of dynamic elasticity and scalability that webscale companies possess. This, in turn, will benefit CSPs by improving efficiency for fully-automated life cycle management of network functions, Business Support Systems (BSSs)/Operations Support Systems (OSSs), and digital services. For example, current processes for changing service offerings require lengthy code re-writes, but CNFs will give the flexibility to tear up/down digital services through software configuration, thus improving Time-to-Market (TTM).

And this hype is not unsubstantiated: Three UK announced a 15% reduction in headcount last year in its bid to move its operations to the cloud, which includes deploying virtualized core network functions and cloudified OSSs. Rakuten is also spearheading the cloud-native trend, leveraging its greenfield deployment advantage to release a fully cloud-native platform, which it announced this year. However, ABI Research analyzed the hype and found that, while there is indeed a trend toward CNFs, most of the telco industry is still based mainly on Virtual Machines (VMs) that run Virtual Network Functions (VNFs).

TELCO CLOUD REVENUE BY COMPONENT TYPE (WORLD MARKETS, FORECAST: 2020-2025)
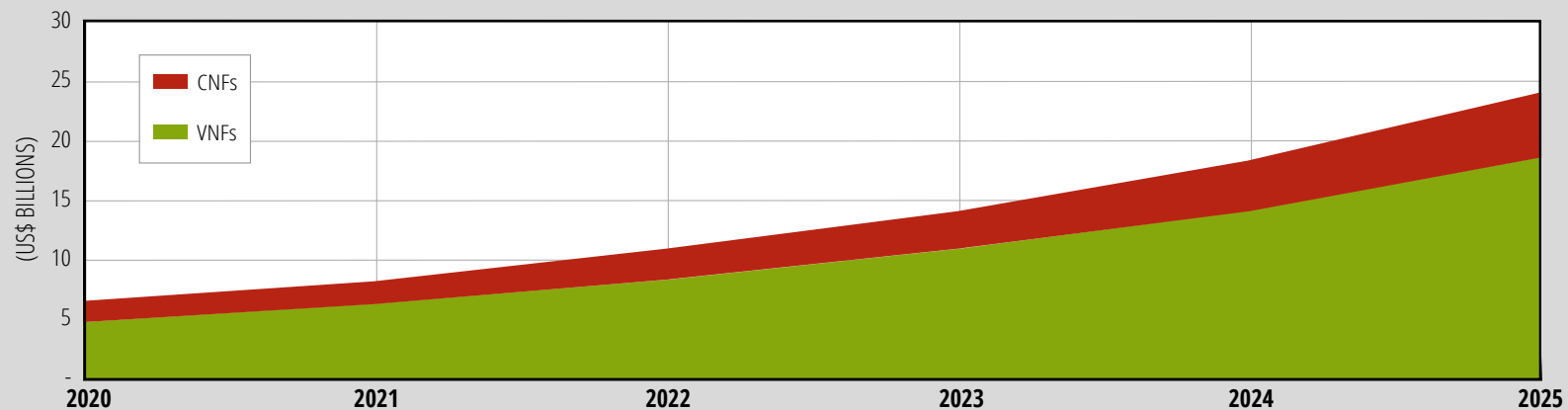
As seen in the chart above, CNFs will not become a mainstay in 2021. The forecast revenue for CNFs remains about one-third of VNFs. This is not surprising considering that the transformation to CFNs requires a retooling of both skills and internal processes and mindsets to adopt new ways of working, such as Continuous Integration (CI) DevOps approaches. Furthermore, many CSPs are operating on legacy equipment, and the move toward cloud-native is not as simple as flipping a switch. There must be a gradual process of determining which legacy equipment to upgrade first while ensuring no disruptions to day-to-day operations. While there is certainly a well-deserved trend and evolution toward using CNFs, we must be mindful of the current market situation and understand that it will not yet gain critical mass in 2021.

Kangrui Ling, Research Analyst

5G DEVICES, SMARTPHONES, AND WEARABLES

PREMATURE ACCELERATION OF 5G WILL DROP SMARTPHONE PRICE POINT TO BELOW US$200 IN 2021

The 5G smartphone market is now outperforming its predecessor generations on nearly every metric. Between the number of mobile devices, subscribers, and networks available at launch, 5G is the most accelerated mobile technology generation ever launched. However, 5G brings with it a whole raft of technical challenges, features, and functionalities, as well as new radio elements for supporting new radio bands and combinations, all of which can lead to substantial changes in the design of mobile devices. This complexity level is not just limited to the high end, as the availability of 5G smartphone models will become more diverse, brought to market quickly at a wide variety of price points, democratizing the 5G experience.

Many leading Original Equipment Manufacturers (OEMs) are expected to push deeper into the lower-priced 5G smartphone segment. This will be the main growth driver for accelerating adoption in 2021 and beyond, aided by the continuing availability of more affordable 5G chipsets, notably those from Qualcomm, MediaTek, and UNISOC.

This seismic shift to lower price tiers means that 5G at the high end will be squeezed, witnessing rapid saturation, and room at the top will quickly evaporate. This will undoubtedly be good news for smartphone replacement cycles and technology migration in the short term, but this rapid change, particularly when compared to previous generations, is potentially detrimental to the market in the mid- to long-term.

The accelerated migration of 5G to lower-tier smartphones will have a knock-on effect on Average Selling Prices (ASPs) and the market's overall profitability. Indeed, with such a relatively shortened time for those across the value chain to extract decent margins from the market, it is expected that many will start to follow an aggressive pricing strategy to avoid possible declines in overall profits. Furthermore, with the expected frantic pace of plunging 5G smartphone prices, it would be of little surprise if 2021 saw 5G smartphones fall below the US$200 mark, driven by the availability of cheaper components and pricing policies of chipset vendors.

David McQueen, Research Director

5G DEVICES, SMARTPHONES, AND WEARABLES

7 **CONSOLIDATION IN THE SMARTPHONE RF SUPPLY CHAIN WILL HAPPEN IN 2021 AS VENDORS EMBRACE SYSTEM-LEVEL RADIO DESIGNS**

With the market for 5G devices set to grow exponentially over the next 18 months, several complex challenges lie ahead for OEMs. Chief among these is the ability to integrate the whole 5G cellular system design into their devices, from the antenna to the modem, supporting cellular innovation as it emerges. This needs to be done while still maximizing device performance, thereby optimizing power consumption without compromising overall device design, TTM, scale, or cost.

To overcome these challenges, OEMs will need to move away from component assembly and adopt system-level radio design to handle this complexity to focus more effectively on customer experiences and deliver more reliable products, reaping the most benefits from 5G adoption.

This delegation of modem-Radio Frequency (RF) system design to specialist suppliers offers advantages. Still, such a strategic approach has been carried out by few in the market, thus far. Currently, Qualcomm is the only supplier able to offer an E2E product portfolio from the antenna to the modem. It is expected that 5G third-party modem-RF system design will become a mainstream approach in support of "challenger" OEMs. Still, it could also prove an invaluable weapon for new entrants.

Fundamentally, the shift to 5G has implemented a change in the focal point for chipset design wins. From once being modem-centric, the market will move fast to one that is RF-centric, and players with solid RF E2E designs will have a strong market advantage. While chipset and components suppliers with comprehensive RF and modem portfolios can benefit OEMs, it is the change in emphasis by the captive smartphone OEMs, namely Samsung, Apple, and Huawei, that will be most keenly observed as they move from modem and/or application processor-led to encompass the RF in the future.

These vendors all still lack key RF components in their portfolios and, as they will want to reduce their dependence on a single vendor, they will be obliged to extend their captivity to the RF business. This will be carried out through acquisitions in 2021, leading to further consolidation in the RF business.

David McQueen, Research Director

8 OPEN-SOURCE COMPUTING HARDWARE DEVELOPMENT WILL REACH A POINT OF NO RETURN IN 2021

Open-source computing hardware is not a new concept, but a framework that has been instrumental in developing System-on-Chips (SoCs) based on Field-Programmable Gate Array (FPGA) and Application-Specific Integrated Circuit (ASIC) architectures. When it comes to open-source applied to general-purpose Central Processing Units (CPUs), Graphics Processing Units (GPUs), and Digital Signal Processors (DSPs), there are a few open-source architectures available today, including OpenSPARC, Amber, and OpenRISC, but the RISC-V architecture is the closest to a silicon implementation so far.

However, only a handful of processor chips based on this architecture is available in the marketplace today. RISC-V is still struggling to attract a wider ecosystem around its development, despite the support by key industry players, such as Alibaba, CEVA, Google, Huawei, IBM, Imagination, Infineon, MediaTek, NVIDIA, Qualcomm, Samsung, Xilinx, and many others. *However, the potential acquisition of Arm by NVIDIA, which should materialize in 2021, could have a significant impact on open-source computing hardware development in particular and the entire computing industry in general.*

In fact, if successful with the Arm acquisition, NVIDIA will inherit the largest computing ecosystem out there, addressing many industries, including mobile and Internet of Things (IoT) devices, as well as becoming increasingly entrenched in High-Performance Computing (HPC) and server markets. However, NVIDIA will have to consider its options when it comes to the future of Arm architectures. Suppose the company intends to keep control over Arm architectures. In that case, this could invite many Arm licensees, some of which are also NVIDIA's competitors, to consider embracing RISC-V and build an ecosystem around this architecture.

Alternatively, NVIDIA could consider open-sourcing Arm architectures, which could create an earthquake of disruption in the entire computing market, sparking a major development within the semiconductor industry and enabling the RISC ecosystem to expand beyond the mobile and IoT markets. This will enable the RISC ecosystem to challenge Intel's x86 in many areas, including the HPC and Personal Computer (PC) markets. *Whatever happens, ABI Research expects that open-source hardware computing market development will reach a point of no return in 2021. This will mark the start of a new era of computing hardware innovation.*

David McQueen, Research Director

5G DEVICES, SMARTPHONES, AND WEARABLES

9

GOING BACK TO THE FUTURE? SMARTPHONE VENDOR LANDSCAPE WON'T LOOK THE SAME BY THE END OF 2021

There had been much optimism about in the smartphone market as countries started to emerge from the Coronavirus pandemic, gradually witnessing supply chains, buyer behavior, and demand returning to some level of normality. Coupled with a quick expansion of 5G down the price tiers, it points to a market that is gradually coming under control and is on track to expand rapidly in 2021. *However, while it is not clear what the full extent or lasting ramifications of COVID-19 will be on the mobile device ecosystem, the pandemic is now overshadowed by geopolitical trade wars. These could be a major impediment to the future development of the mobile devices market.*

At the center of the storm is Huawei, banned from acquiring parts and software featuring U.S. technologies or selling its products in the United States and to its closest allies. In the short term, Huawei has fought back and retrenched in its own Chinese market to bolster sales, thus avoiding a significantly worse shipments performance than it may have had otherwise. Huawei's anticipated descent at the hands of an increasingly restrictive U.S. trade ban will reach a tipping point that could see a fundamental reshaping of the supply chain and chipset market, while having a significant bearing on the global smartphone vendor landscape. Huawei has also made some drastic decisions to keep its smartphone business afloat, notably aggressively building up stockpiles of processor chips and components to beat the trade ban, which has severely restricted its 5G innovation.

The company's survival hinges on securing a supply of chipsets, which could quite feasibly run out by 2Q 2021. As a lead global player with around a 20% share of smartphones, Huawei is struggling to stay in the market in the longer term and rebuild its now tainted brand outside of China. However, this would not be the first time that a major player in the smartphone market has floundered, whether or not through any perceived fault of its own. Indeed, it may spell good news to many of its competitors, with Chinese compatriots, such as Xiaomi, OPPO, Vivo, and OnePlus, not forgetting Samsung, Apple, and Google, all waiting to fill market share left across the price tiers at Huawei's expense. In a more unexpected turn of events, Huawei's possible demise may also see the resurrection of some once-notable vendors looking to fill the void, with brands like Motorola, LG, Nokia-HMD, and Sony all potentially stepping up volume shipments and share in 2021, giving the global smartphone market a new vendor landscape, but one with a distinctly retro feel.

David McQueen, Research Director

5G DEVICES, SMARTPHONES, AND WEARABLES

10 **DESPITE AN INCREASE IN ECOSYSTEM MOMENTUM, 5G mmWAVE SMARTPHONE SHIPMENTS WON'T REACH CRITICAL MASS IN 2021**

In the not too distant past, the industry's move toward the use of 5G New Radio (NR) mmWave technology had been derided as being too challenging to be of practical use in mobile devices, mainly due to limited coverage and being overtly costly to implement. However, and more recently, many of these technology barriers have been overcome, and 5G mmWave is now a commercial reality in smartphones.

The complexity of integrating mmWave in smartphones has been addressed by using an evolved system approach and a fully integrated RF module design, offering improved performance, latency, reliability, and efficiency. Moreover, the rapid miniaturization and continual iterative enhancements of these modules have helped bring mmWave to compact smartphone industrial designs.

After a slow start, mainly limited to the U.S. market, ecosystem momentum for mobile mmWave is gathering pace as many regions are targeting deployments, expanding across North America, Europe, and Asia, led by operators in the countries of Japan, Russia, Italy, South Korea, and Australia. Implementing the technology in tight combination with 5G NR sub-6 Gigahertz (GHz) and dual connectivity with LTE, mmWave is starting to gain impetus. It's keeping its promise of new business opportunities and enhanced mobile experiences while supporting advanced mobility features, such as beamforming and beam tracking. However, 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. This is mainly due to a market skew toward China for 5G smartphone sales, which currently does not favor mmWave, but this share will dwindle over subsequent years, signaling a wider adoption of mmWave smartphones.

David McQueen, Research Director

11 ENTERPRISES STARTING TO BE SPOILED BY HYPERSCALERS' OPEX-BASED MODELS

Hyperscalers are now targeting the very same enterprise verticals as CSPs. For example, Amazon offers multiple devices for either edge or on-premises deployments: Snowcone, Snowball, Wavelength, Out-posts, and Greengrass IoT.

Meanwhile, CSPs are still drawing their strategies and have not executed on the promise of private cellular, 5G, and network slicing for enterprise verticals. On the other hand, hyperscalers are already deploying enterprise digitization solutions, most of which are usage- or subscription-based instead of upfront, CAPEX-based solutions that telco systems demand today.

This will likely make the enterprise vertical domain accustomed to these OPEX-based models, meaning telco operators will meet with difficulty when implementing any business model with a heavy upfront CAPEX component. Telco operators will need to adapt to this model to survive, especially in the Small and Medium Enterprise (SME) segment.

Dimitris Mavrakis, Senior Research Director

12 HYPERSCALERS WILL DOMINATE ENTERPRISE DIGITIZATION EFFORTS, WILL ALSO START OFFERING PRIVATE CELLULAR

While 2020 has seen AWS, Google, and Microsoft all advancing and underlining their telco ambitions to provide enterprise connectivity solutions, 2021 will see the continuation and extension of this trend. Their existing ties with enterprises for cloud storage, as well as their general openness toward service-based offerings, will make them particularly attractive to enterprises.

Their ambition will be to co-create these with partnerships specifically for last-mile connectivity. *Their existing excellent ties to a large base of developers allow them to deploy the network as a platform and leave application development to specialist programmers.* This will start to include cellular network functionality that will even overtake Mobile Network Operator (MNO) efforts.

Leo Gergs, Research Analyst

**13** **GEOPOLITICS WILL START INFLUENCING CELLULAR STANDARDS**

While 2020 has seen an increasing number of countries in Europe and Latin America following the United States in restricting the role of certain "high-risk" vendors from 5G deployments, 2021 will show the indirect effect this geopolitically motivated move will have on cellular standardization work.

Until now, Chinese vendors have been among the top contributors to The 3rd Generation Partnership Project (3GPP) standardization. *With the number of countries deciding to restrict the role of Huawei and ZTE in deploying 5G networks (effectively excluding these vendors from monetizing their 3GPP contributions), they will certainly carefully consider any future contributions to 3GPP for global cellular standards.*

This could give way to two possible scenarios: Huawei and ZTE will shift their focus away from cellular connectivity and focus on different technologies. Alternatively, Huawei and ZTE will look to work toward Chinese implementations and alliances to circumvent these restrictions. Recent announcements by Huawei about manufacturing its chipsets in Shanghai and shifting its efforts to its industry associations, such as the 5G Deterministic Networking Alliance, might be the first signs of this development.

Either way, in 2021, we will see geopolitics affecting the work of 3GPP and other standardization bodies. Therefore, the year to come will show the telecommunications industry how geopolitically-motivated restrictions toward certain vendors can unleash a negative slowdown effect on the entire industry.

Leo Gergs, Research Analyst
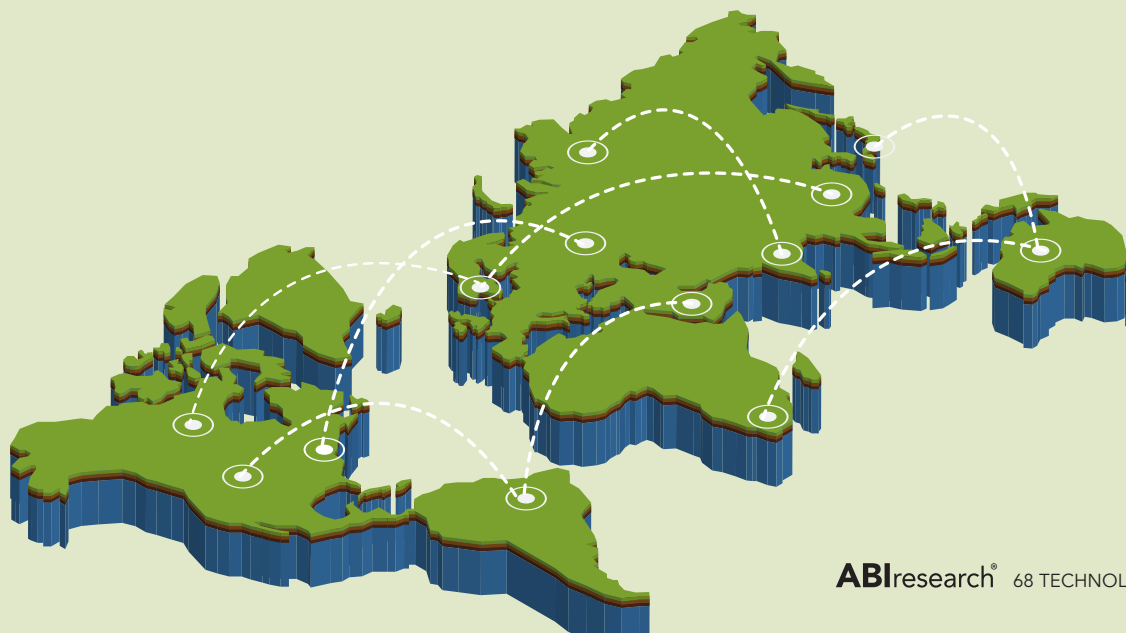
14 | **MOBILE OPERATORS WILL NOT SUCCEED IN PRIVATE CELLULAR**

Tight budgetary controls will prevent enterprises from investing large sums in network infrastructure deployment upfront, giving rise to consumption-based OPEX-intensive pricing models. In addition, requirements for network integrity, reliability, and availability demand customizable deployment options, as well as the flexible design of Service-Level Agreements (SLAs). Furthermore, in the wake of a growing number of spectrum liberalization arrangements, spectrum assets held by CSPs lose their bargaining power. In addition, the reluctance of CSPs to adapt their monetizing models to service-based OPEX models will jeopardize their enterprise ambitions even further.

Also, the changing shape of the competitive landscape will put traditional CSPs even further under attack. *On the one hand, hyperscale companies are developing E2E solutions for enterprise connectivity. On the other hand, we see more and more specialized network operators emerging and reserving spectrum assets to provide private cellular for enterprises as a service-based offering.* Considering this, ABI Research expects 2021 to be a make-or-break year for enterprise cellular business models, particularly MNOs.

Leo Gergs, Research Analyst
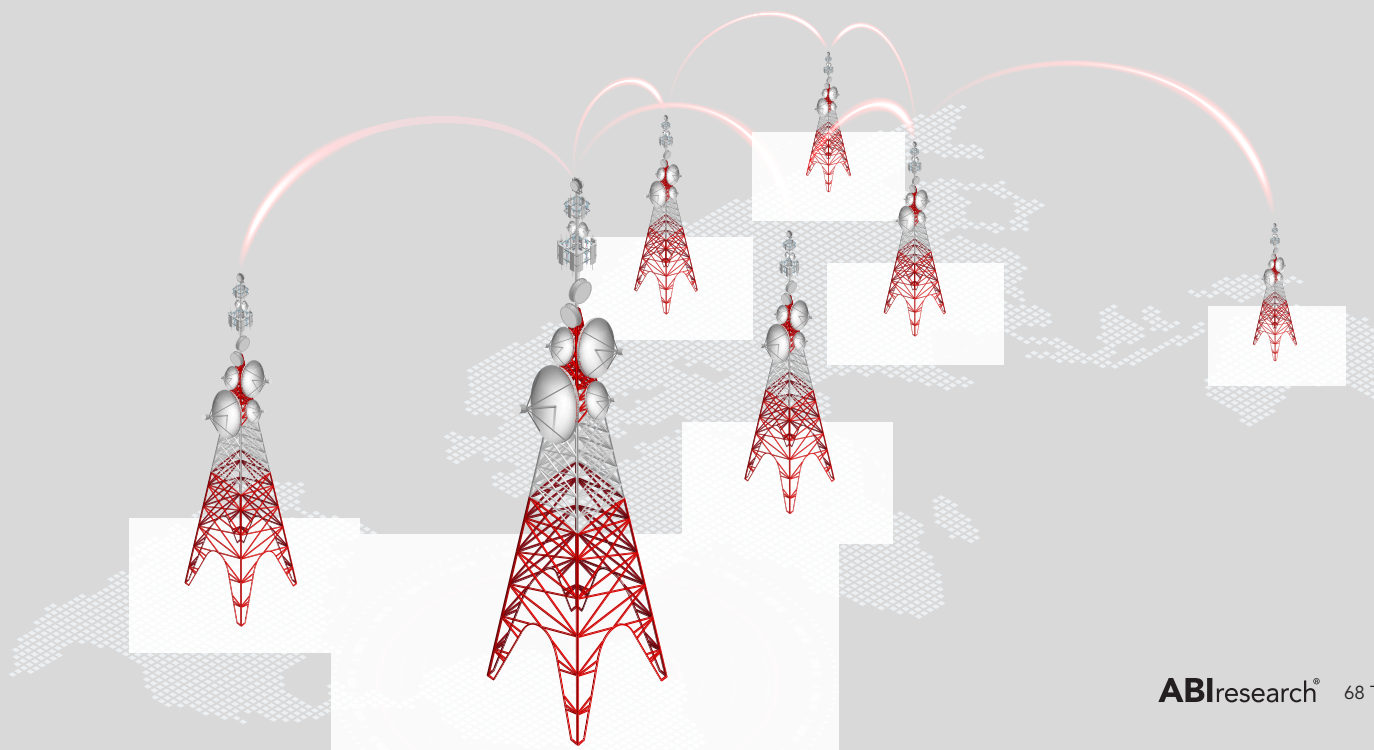
5G AND MOBILE NETWORK INFRASTRUCTURE

15 TELCO MARKET WILL CONSOLIDATE EVEN FURTHER, HYPERSCALERS WILL MOVE IN

Geopolitics and COVID-19 will cause the global market to slow down and will continue to highlight the importance of telco networks. This will translate to outstanding government support for telco operators in both Western and Eastern markets, but at a time when the telco consumer business will continue to face competitive and market-related pressure.

ABI Research expects several high-profile mergers and acquisitions to happen in 2021, especially in the open network domain. We also expect hyperscalers to start addressing private cellular and 5G networks more aggressively, which may lead to even more high-profile acquisitions, especially in the radio domain.

Dimitris Mavrakis, Senior Research Director

16 2021 WILL MARK THE BEGINNING OF OPEN NETWORKS

2020 has been special, full of eventful twists and turns, ranging from geopolitics, such as Brexit, the American elections, and the trade war between China and the United states, to the spread of the COVID-19 pandemic across the world. These events have impacted various industries and uncovered many gaps in the technology supply chain, which is based on a linear and vertically-integrated model currently dominated by Ericsson, Huawei, and Nokia.

In 2021, expect the mobile industry to start breaking up with this model. Alternatively, the mobile value chain will increasingly migrate to a more open network approach. Vendors at every node of the supply chain, from chipset suppliers and antenna vendors to system integrators, will attempt to increase their products' value and establish themselves as essential payers in the chain. This approach will lower the barriers to new entrants in the mobile supply chain, spurring innovation and competition across the entire value chain.

The emergence of the Open Radio Access Network (RAN), network cloudification, and the adoption of edge computing are the key anchors that will form the foundation of next-generation open networks.

Malik Saadi, Vice President, Strategic Technologies

17 AI BECOMES A MAINSTREAM TREND TO STREAMLINE 5G RADIO ACCESS NETWORKS

In 2020, Rakuten showed the world how Open RAN, coupled with network automation, can reduce operational costs related to network maintenance, operations, and even network optimization.

ABI Research expects many vendors to start implementing AI in the Open RAN Radio Intelligence Controller (RIC), which will ultimately prove to be more important than the open interfaces currently being developed, attracting the lion's share of MNO interest.

These open interfaces will provide the first wave of Open RAN market growth. Still, RIC and automation will be the big drivers for developing new technology, especially for brownfield operators.

Jiancao Hou, Senior Analyst

5G AND MOBILE NETWORK INFRASTRUCTURE

18 CHIPSET AND HARDWARE PLATFORM DEVELOPMENTS SPUR GROWTH FOR NEW ENTRANTS IN OPEN RAN

The latest market developments indicate significant activity in chipset and hardware platform developments. Intel, Qualcomm, Xilinx, and more chipset OEMs are releasing new products targeting all layers of 5G base stations. This has included Centralized Units (CUs), Distributed Units (DUs), and, most recently, Radio Units (RUs).

ABI Research expects that 2021 will see a plethora of new announcements by incumbents, challengers, and even new entrants in the previously locked cellular infrastructure domain. Delegating the RAN technology complexity to specialists among chipset suppliers will, no doubt, lower the barrier to entry for many new system integrators, enabling them to differentiate on software design and protocol.

This development will enrich the Open RAN value chain and provide MNOs with significantly more choice in choosing a RAN equipment vendor. This will create economies of scale for reference designs, software development platforms, and test tools for these products, which will, in turn, accelerate the Open RAN market even further.

Jiancao Hou, Senior Analyst

19 COVID-19 WILL ACCELERATE THE ADOPTION OF NEUTRAL HOST NETWORKS AND THE DEFINITION OF NEW BUSINESS MODELS

2020 has been a challenging year during which COVID-19 has forced people to start working from home. This "new normal" has shifted mobile data traffic from central locations, such as business parks, shopping centers, and touristic places, toward more residential and rural locations. This change in data traffic is likely to remain in the following years because several companies have realized operation continuity with employees working from home. However, this situation might impact the business models of MNOs, which have calculated the Return of Investment (ROI) typically based on data traffic demands in highly congregated areas.

Thus, with the traffic transition toward rural and residential areas, neutral hosts can create networks that enable cellular connectivity indoors in different multi-tenant building sizes, with collaborative work with MNOs enabling the first business models and technical definitions of the neutral host networks. Thus, MNOs will have better ROI with reduced CAPEX compared to the deployment of dedicated networks. And end users will have a better work experience from home. This may also trigger an excellent business stream for MNOs to deploy indoor systems to deliver coverage and data services to corporative users. However, a corporate business-line redesign is needed to reduce customer churn, with neutral host networks representing a good opportunity to overcome this business challenge.

Johanna Alvarado, Senior Analyst

20 INITIAL DEPLOYMENTS OF 5G DETERMINISTIC NETWORKS APPEAR IN CHINA

3GPP Release 16 has introduced deterministic networking features in the 5G NR standard, meaning that cellular networks can now provide reliable rather than best-effort networking. *Despite the R16 standard freeze in June 2020, ABI Research expects the Chinese market to accelerate implementations of these features and to deploy the first deterministic 5G network in 2021.*

This will be deployed in the manufacturing domain for a business or mission-critical application and be fostered by the Chinese 5G-Deterministic Network Alliance (5G-DNA). This will give Chinese operators and vendors significant experience in implementing these features, which will, in turn, make the Chinese market the clear leader in implementing 5G for enterprise use cases.

Jiancao Hou, Senior Analyst

21 vRAN WILL NOT ACCELERATE THE DEPLOYMENT OF C-RAN DEPLOYMENTS

Centralized-RAN (C-RAN) solutions promise great advantages for deploying new cell sites due to the potential reduction of equipment footprint, reduced energy consumption, enhanced resource pooling, and reduced CAPEX. Yet, the adoption of Virtual RAN (vRAN) will not accelerate the deployment of C-RAN configuration due to different factors, namely reduced availability of transport infrastructure (fiber) and reduced availability of edge data centers to house Virtualized Central Units (vCUs) and Virtualized Distributed Units (vDUs).

However, it is likely that with the adoption of vRAN solutions, MNOs will start to transition from fully distributed networks, where CUs and DUs are co-located at the cell site, to centralize the CU at the core edge depending on the use case scenario. For instance, for enterprise verticals with stringent low latency requirements, CU and DU will have to be co-located at the local main equipment room.

Johanna Alvarado, Senior Analyst

22 THE DEPLOYMENT OF 5G INDOORS COULD BE DELAYED DUE TO COVID-19

MNOs have started to bring 5G indoors, mainly in highly congested areas, such as stadiums, airports, and arenas. These deployments have accelerated the adoption of Distributed Radio Systems (DRSs), which can support premium features and support the frequency bands in which 5G typically operates while overcoming many of the challenges of the traditional Distributed Antenna Systems (DASs).

However, due to the pandemic, the deployment of 5G indoors may be delayed because many public venues have remained closed without spectators for several months. *Instead, MNOs are working more rapidly to densify their outdoor networks to have a greater reach to end users.*

Johanna Alvarado, Senior Analyst

5G AND MOBILE NETWORK INFRASTRUCTURE

23 | 5G WILL NOT BE ENVIRONMENTALLY FRIENDLY IN 2021

As 5G technology grows in prominence globally, its environmental benefits are touted by experts across the industry. These benefits arise from the countless opportunities that 5G is enabling and creating. With larger amounts of data now being transferred at much higher speeds, the synergy between 5G and technologies like AI and the IoT could lead to lower energy consumption and increased efficiencies in operations.

However, this may not be true in the near term. *According to ABI Research's Network Technology and Market Tracker (MD-NWMT-104), global 5G subscriptions are forecast to grow from 234 million in 2020 to 347 million in 2021 at a rate of 48.4%. This accelerated growth in 5G adoption will likely strain the environment as a growing number of consumers will be switching over to 5G devices to take advantage of the high speeds and low latency.*

The transition will potentially create large amounts of electronic waste and it is crucial that operators and manufacturers do more to encourage recycling and the use of recycled materials in their 5G operations and developments. In addition, energy consumption could increase tremendously as the higher speeds encourage more usage among consumers and applications. It is prudent that Research and Development (R&D) is directed at reducing energy consumption and carbon footprints in the telecommunications industry.

Jun Wei Ee, Research Analyst

24 | ANTENNAS SUPPORTING 5G IN LIMELIGHT, BUT ANTENNAS SUPPORTING 4G REMAINS IMPORTANT IN 2021

One of the main challenges that telecommunication operators face as they upgrade toward 5G is deploying the newly acquired spectrum bands (e.g., mid-band) onto existing cell sites. However, existing cell sites have limited physical space. Therefore, to tackle the limited site space, operators will have to adopt new multiband antennas that support the legacy frequency bands in the sub-3 GHz range, thereby making space for antennas supporting 5G.

4G will also continue to be the primary data traffic and subscription driver in the next few years and certainly in 2021. *According to ABI Research's forecasts, 4G will carry about 75% of the total mobile traffic in 2021. Some operators are refarming the older 2G/3G spectrum bands for 4G; for example, Verizon and Swisscom have plans to do so at the end of 2020.*

Operators will also have to ensure the deployment of antennas matching the respective frequencies as they phase out the older 2G and 3G spectrum bands. The 4G network plays an essential role as the main traffic driver and the support for 5G rollouts; thus 4G antennas will continue to play an important role in supporting the performance of and the user experience with the network.

Dean Tan, Research Analyst

25 **THERE WILL BE MORE CONSOLIDATION IN THE AI HARDWARE BUSINESS**

While 2020 is relatively quiet when it comes to Venture Capital (VC) investment in AI, AI has shown tremendous potential in various applications across all industries. This has led to the acquisition of Arm by NVIDIA and the potential acquisition of Xilinx by AMD.

This consolidation trend will continue in 2021, as chipset vendors are looking to diversify and expand their AI product portfolios to serve a rapidly growing cloud and edge AI market. Portfolio diversification across multiple architectures, including CPU, GPU, DSP, and hardware accelerators, drives current and future acquisitions in the computing space.

This will play a fundamental role in the transition toward fully-fledged heterogeneous computing, which will be key for handling the next-generation AI networks' heavy workloads. Also, expect acquisitions to happen in the TinyML space, where established AI chipset vendors look to expand into ultra-low-powered AI. AI hardware consolidation will likely happen in China, too, as the country is growing its expertise in the AI chipsets business by building strong domestic AI chipset players to reduce its reliance on Western technologies.

Lian Jye Su, Principal Analyst
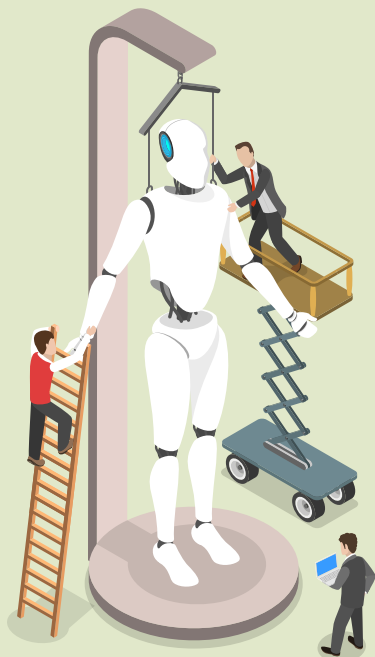
ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

26 **DISTRIBUTED COMPUTING WILL BECOME SIGNIFICANT IN 2021**

Distributed intelligence is an architecture that breaks computation workloads hosted in a centralized system into a combination of one central node and multiple end nodes. While this architecture has greatly benefited from the design and implementation of various systems, such as cloud computing clusters, warehouse robots, and smart home systems, these systems are often limited by geographical factors, connectivity options, and the processing capabilities in end nodes.

The emergence of 5G and AI is set to change these. Combining the high throughput, low latency, and massive IoT connectivity of 5G, with on-device inferencing capabilities of AI, 5G-enabled edge AI devices will have the flexibility to centralize all their workloads in the cloud or perform time-, latency-, and security-sensitive workloads at the edge. This removes data privacy, safety, and security concerns, while allowing the overall system to update and optimize itself. ***Expect major webscalers and chipset suppliers to align their products and solutions in 2021 to address demand for more distributed intelligence across both the consumer and the enterprise markets.***

Lian Jye Su, Principal Analyst

Robot Loader

27 **THERE WILL BE A LOT MORE FOCUS ON ZERO-CODE ONBOARDING FOR EDGE AI**

Edge AI deployment has been a challenge as there is a diverse range of edge AI chipsets, frameworks, and toolkits. Some players in the market are coming up with a zero- or low-code deployment platform. These platforms support zero-code web user interface-based deployment, cloud-based device monitoring, orchestration and management, alert management, and ML model performance monitoring and retraining.

Key players include Laneyes and Balena. Some players offer custom tools to compress ML models for edge AI devices, such as Edge Impulse, Nota, and SensiML. Expect more startups and system integrators to focus on new offerings targeting zero-code onboarding.

Lian Jye Su, Principal Analyst

28 | EXPLAINABLE AI NOT TAKING OFF IN 2021

Deep learning-based AI remains a black box. Although cloud AI players, such as Google, H2O, and Element AI, have offered development tools and frameworks around explainable AI, AI built based on these solutions is not mature enough for mass commercialization.

At the moment, most AI models are not designed for transparency, let alone explainability. Hence, do not expect explainable AI to become mainstream in 2021. Also, do not expect massive migration or switching either, because switching away from non-transparent deep learning models may not be an option for many companies.

Lian Jye Su, Principal Analyst
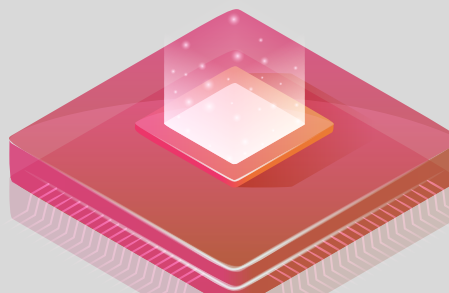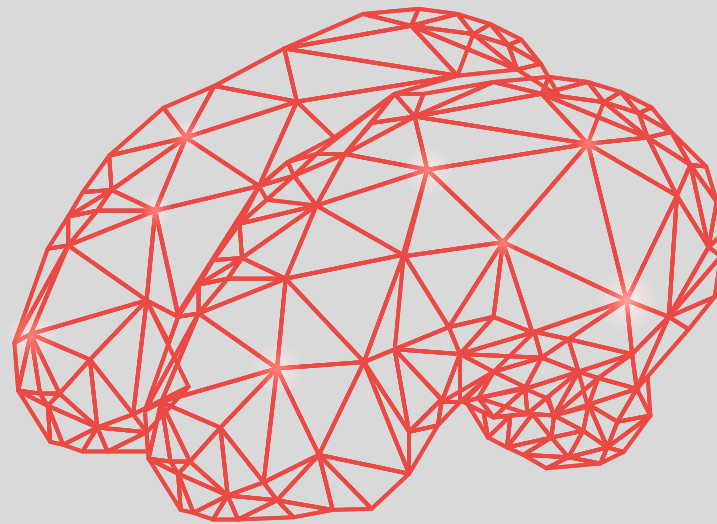
AUGMENTED AND VIRTUAL REALITY

29 **BROAD AR MARKET GROWTH OUT OF CONSUMER AND ENTERPRISE**

In the Augmented Reality (AR) enterprise market, AR remote applications, such as AR remote expertise and AR remote training, will continue to grow and lead in terms of adoption rates. *The risk of traveling and the experience from the first months of the COVID-19 outbreak will drive demand for proactive solutions that increase employee and business efficiency and ensure employee safety.*

AR software/platform providers will continue to update and expand their offerings, including more features and new strategic collaborations to support, automate, and simplify large-scale deployments while providing more data and analytics tools for proactive decisions.

Enterprise AR hardware will not shift dramatically, as current offerings well serve value use cases. However, the consumer hardware market will be more dynamic. 2021 will be an important one for AR consumer hardware. nReal will ship its first headsets to consumers, while Mad Gaze will also look to expand. Also, Facebook is expected to roll out its AR smart glasses out of its Reality Labs initiative; Google may join as well after the acquisition of North, and with pressure from Facebook and others. Although expectations for a dedicated AR product launch are targeting 2022 for the company, Apple is a wild card.

The total AR market, including content and usage on mobile devices, will be strong. Media & entertainment and retail & commerce will lead in terms of growth and adoption rates due to the establishment of "at home entertainment" and the rise of online shopping. Retailers will continually introduce AR capabilities, such as AR product preview/visualization or virtual try-on, into their online platforms to enhance online shopping experiences, maintain sales during the pandemic, and remain competitive. The increase in social media usage/spending time and the democratization of AR content creation tools (such as Spark AR or Lens Studio by Snap) will unlock opportunities for new AR content and increased spending for AR-branded content/advertising.

Moreover, AR remote assistance for customer service is an application with the potential to be established in the consumer space due to social distancing rules. 5G is not likely to have a significant impact on AR in 2021, so some of the promising AR applications that could best leverage 5G, such as outdoor navigation and location-based content experiences, are expected to show slow progress despite their initial strong potential in combination with 5G speeds.

Eric Abbruzzese, Research Director
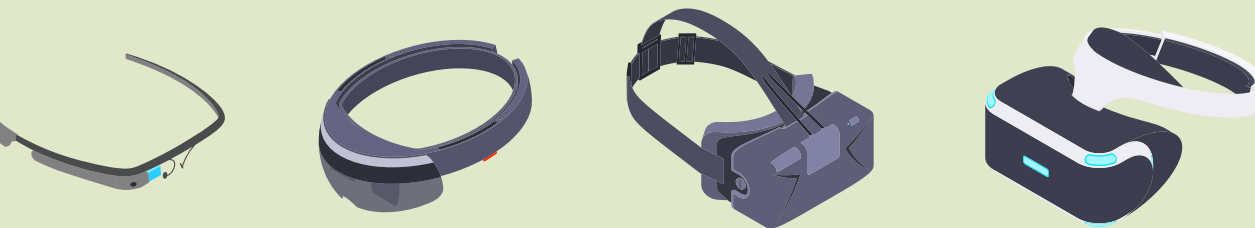
AUGMENTED AND VIRTUAL REALITY

30 VIRTUAL REALITY WILL NOT BE MAINSTREAM IN 2021

Market elements have not aligned to enable mainstream Virtual Reality (VR) adoption. Growth will be strong in 2021, but the user base will not reach levels once thought probable where VR competes for usage time with TVs, smartphones, and traditional displays. Price and availability of valuable content remain primary barriers. The Oculus Quest 2 is the best positioned VR device the market has seen so far, with a US$300 starting price and no other hardware required to use it, such as a tether to a smartphone or PC. The cost of US$300 is likely to be a sweet spot for standalone VR, but it can still be seen as expensive for a limited use item that will be outdated by next year. While smartphone-like upgrade cycles are possible and would spur growth overall, the lack of necessity for VR will limit that possibility.

As for content, gaming dominates, but there have been only a few "must-have" games for VR so far, with few AAA game developers and publishers getting involved. Early efforts in video content, especially for sports leagues, have shown promise, but never to the point of disruption. Apple's acquisition of NextVR, a content house, points to promise, but not for another 1 or 2 years, when a library of content is built, potential users are shown the value of VR content, and ultimately, those users have bought in. Social and environmental dynamics of content consumption are also a challenge; many do not have space in their homes to fully experience 6 Degrees of Freedom (DOF) VR, and in-person content sharing is limited simply due to the form factor of VR.

Therefore, the enterprise sector remains the fastest growth opportunity for now. Training and simulation in VR have shown increased training efficacy and trainee engagement. During the pandemic—and after—remote training and worker enablement through VR allow workers to remain engaged with limited workflow disruption for most. *The consumer still presents the largest potential user base and the most alignment with content in media & entertainment. Still, content creators are mostly waiting for a more approachable user base, and that user base is waiting for content. This will not happen by 2021, but the momentum is growing across both consumer and enterprise spaces.*

Eleftheria Kouri, Research Analyst

DIGITAL SECURITY

31 THE LACK OF SECURITY STANDARDIZATION WILL THREATEN THE DEVELOPMENT OF IOT SERVICES

The fervent expansion of IoT connectivity and subsequent monetization strategies have revealed cavernous security concerns fueled by the lack of proper security standardization. With each passing quarter, the ever-evolving IoT cyberthreat horizon unleashes new attack vectors, costing the world's largest markets tens of billions of dollars in damage. Traditional finance, enterprise, and government verticals are not the primary targets anymore, ;instead attacks are becoming more frequent, and more sophisticated, in areas such as:

- Connected infrastructure
- Smart healthcare
- Connected transportation
- Surveillance systems

- Industrial and processing facilities
- Monitoring devices
- Automotive telematics
- Smart cities

Driven by increased cyberthreats, IoT players often begrudgingly accept the push for specific security tools and protocols, urging security integrators to chop them down to their bare essentials to negate any operational disruption and latency.

However, this migration of IT security tools toward Operational Technology (OT) and the broader IoT ecosystem simply does not work. Even standard IT-borne tools like firewalls or Intrusion Detection and Prevention Systems (IDPSs) need to be wholly re-worked and re-trained with new AI models.

It is essential to fit each IoT market's security requirements, not to mention the mandatory addition of Transmission Control Protocol (TCP)/Internet Protocol (IP) to IoT communication protocols, Thing identity management, and gateway-level protection for lower computing power devices. This effect is exacerbated due to the lack of widely accepted accompanying security standards and regulations, except for a few much appreciated security frameworks instigated by bodies like the International Organization for Standardization (ISO) and the National Institute of Standards and Technology (NIST).

From automotive to smart cities and industrial control systems, security frameworks and architecture vary greatly, are often prone to inherently insecure communication protocols, lack security infrastructure, or are locked behind proprietary manufacturer options, adding further complexity for security operations. Like a vicious circle, the IoT security concerns do not stop there.

All compromised devices and platforms can be leveraged by cyberattackers as botnets to launch further attacks in the form of massively brewed Distributed Denial of Service (DDoS) and sent back to disrupt and destroy the defenses of other IoT markets. Standardizing and developing a fully-fledged security framework for the entire IoT is, of course, a tall order. Due to the highly fragmented, volatile, and, ironically, intertwined nature of this IP-connected ecosystem, this security unification will not happen anytime soon. However, it will be determined by painstakingly securing its key markets one by one, mending the cross-vertical integration challenges, and adopting a ROI-driven security approach moving forward.

Dimitrios Pavlakis, Industry Analyst

DIGITAL SECURITY

32 | THE BIOMETRIC PAYMENT CARD IS COMING, BUT MASS ISSUANCE WILL NOT HAPPEN IN 2021

The biometric payment cards market continues to gain significant momentum, gaining further traction from the COVID-19 pandemic, viewed as a next-generation payment card form factor suitable for a post-COVID-19 world.

The market's need and demand for Everything to Everything (E2E) contactless experiences continue to increase as people's awareness, and perception of social and physical interactions continue to shift. The biometric payment card lends itself well to this new post-COVID-19 contactless paradigm, combining Strong Consumer Authentication (SCA) with a payment process that requires no physical interaction at the Point of Sale (POS), offering a true E2E contactless payment experience, without compromise.

Now all ecosystem players are readying themselves for mass-market adoption. The full focus is on cost-down strategies, from the sensor and chipset level, to the inlay and finished card, as vendors look to reduce the Bill of Materials (BOM) and manufacturing complexities via the development of second-generation components and architectures. Every ecosystem player has a role to play in helping to significantly reduce the biometric payment card from its current ASP in the US$20 to US$30 range. Pricing continues to be the largest market inhibitor, and despite significant efforts to address this, it will not translate into mass issuance in 2021.

The next generation of biometric payment card products will likely hit the market in 2021/2022. Although this will help push the price point down to the US$13 to US$20 range (dependent on volumes), they will continue to command an ASP significantly higher than standard contactless cards. *With a pricing ratio between a contactless card and biometric payment card in the range of x5, ABI Research expects that approximately 300,000 to 1 million biometric payment cards will be delivered as of 2021.* However, 2021 will not mark the beginning of mass issuance, but rather the year that will be defined as the "soft" commercial launch milestone.

Phil Sealy, Research Director

33 | THE GLOBAL PASSPORT MARKET WILL NOT FULLY RECOVER BY 2021

Due to the ongoing COVID-19 pandemic, year-on-year growth for e-passport shipments will experience a considerable decline of -34.9% between 2019 and 2020, with passport-heavy countries, such as the United States and China, bearing the brunt of the shortfall with shipments expected to fall by up to 50% to 60%. With most borders closed and almost no international travel opportunities, the credentials' replacement rates have dropped significantly.

The volume of applications for passport replacements has fallen significantly across the globe, as the credentials (which already come with a high cost to the end-user) have been limited in their access to destinations as countries close borders and cease international travel to limit the spread of the pandemic. Citizens have clearly made a choice to defer passport renewals until they can maximize the use of their credential expiration, something that is difficult to measure given the ongoing market uncertainty originating from countries heading into second lockdowns, such as the United Kingdom.

Also, any citizens who have opted to renew their passports may see considerable delays in issuance. To reduce in-person contact and limit transmission rates, many government credential enrollment and personalization centers have seen closures, leading to significant backlogs.

As a result, while ePassport shipments will pick up moving into 2021, with a year-on-year growth of 26%, this will not be sufficient to match pre-COVID-19 issuance levels as the pandemic looks to be a continuing issue moving into the new year.

Sam Gazeley, Research Analyst

34 VACCINE FREEZER FRENZY—2021 AS THE YEAR OF COLD CHAIN

Early vaccine candidates require ultra-low temperatures, as much as -70 degrees Celsius©, or -94 degrees Fahrenheit. This is influenced by a lack of data storage specifications and shelf life for these new types of Messenger RNA (mRNA) vaccines. The containers to store and transport them are not widely available and not required for common vaccines. Constant temperature control is needed E2E from the manufacturing site to the inoculation sites. According to known criteria, people will require two vaccines from the same manufacturer within a specific time frame. That equates to more than 662 million doses in the United States and approximately 1.5 billion across the European population.

Drug companies like Pfizer and logistics giants DHL and UPS are working together on expected supply chain gaps, including logistics and freezer farms. Questions remain about the providers of these ultra-cold freezers. One such company is Cryoport, with its C3 Ultra Cold solution dry ice shipper that can keep commodities at temperatures of -60 to -90° C. These suppliers are not particularly large companies. And not many offer transportable options (versus upright freezers from ThermoFisher Scientific). In question is their ability to scale or the capabilities of their supply chain down to the raw materials.

Much of the focus, to date, has been on fulfilment centers and modal capacity for air and road. Another concern is the need to seamlessly track temperatures and provide alerts for any out-of-spec loads. This involves integrated software, sufficient compute and sensor capabilities throughout, and the cooperation of both public and private entities across multiple modes and likely competitors. The search for critical Personal Protective Equipment (PPE) and ventilators this spring unveiled dependencies on China sourcing, challenges scaling at a global level, and a lack of awareness of suppliers' suppliers. *The scale of technology, strategy, and operations excellence needed will require transparency, flexibility, and scale never seen, and will take herculean efforts beyond the actual vaccine development and approval.*

Susan Beardslee, Principal Analyst

FREIGHT TRANSPORTATION & LOGISTICS

35 NO GLOBAL RETURN TO THE "BEFORE TIMES" FOR THE SUPPLY CHAIN

When COVID-19 arrived, supply chain trends were either in the early stages of implementation or planned—for 5 years from now. Companies that were not prepared to pivot quickly to digitization, automation, and a contactless consumer scrambled to respond. Many companies became acutely aware of the complexities of their supply chains, from workforce capabilities, distribution networks, and modal restrictions down to their raw materials suppliers. Concurrently, the adoption of digital and low/no-contact behaviors shifted exponentially and rapidly, becoming ingrained this year for many.

One area receiving attention is the reconfiguration of supply chains geographically (China+1, near-shoring, etc.), which is a longer-term strategy. Investments and partnerships are proliferating from Vietnam and India to Mexico and beyond. However, beyond a sales office, many considerations remain, including regulatory, infrastructure, and employee skillsets/wages regarding the need for an extended ecosystem, which has been developed in China for the last 10 to 20 years. It is important to consider geographic diversity, which will likely reframe many supply chains over the remaining decade.

U.S. e-commerce growth is estimated to be -44% year-on-year in 2020. Consumer expectations continue regarding fast delivery, a variety of delivery options, and free shipping. These changes include continued curbside pick-up and Buy Online Pay in Store (BOPIS) options, as well as last-mile deliveries, the latter of which poses a profitability issue for retailers. Government exemptions for Automated Ground Vehicles (AGVs), including Nuro and Starship Technologies, will continue to support options for lower costs, less contact, and greater choice for consumers. Another lasting change is underway with Consumer-Packaged Goods (CPG), which have been materially reducing their SKUs to those with the highest volumes. Coca-Cola is eliminating half of the number of brands it produces. Mondelez International is reducing its line-up by 25%, with further reductions planned by both Procter & Gamble and General Mills. It remains to be seen how this will impact consumers accustomed to actual and virtual shelves with nearly unlimited variety.

Finally, even the latest mid-range Gross Domestic Product (GDP) estimates anticipate a slower return to pre-pandemic growth levels, accounting for time to bring back entire industries/verticals that were decimated. Some airlines are not expecting to return to earlier levels before 2024, and an historic number of retailers and restaurants have closed permanently. *Although goods transportation has seen a promising rebound from the spring, pinch points continue, from driver shortages (back to 2018 levels) to container shortages and carrier bankruptcies due to increasing insurance costs and lower profits. Further digitization and integration of systems will provide greater visibility, flexibility, and ROI to supply chain participants that can improve economic performance, but likely after 2021 on a broader scale.*

Susan Beardslee, Principal Analyst

INDUSTRIAL, COLLABORATIVE, AND INDUSTRIAL ROBOTICS

36 **FUNDING WILL NO LONGER BE MONOPOLIZED BY THE SELF-DRIVING CAR AND HEALTH SECTORS**

In 2019, self-driving car vendors and health robotics companies (mainly for surgical automation) represented 73% of the US$17 billion spent by venture and corporate funders. That will not be the case in 2020, and in 2021, the Venture Capital (VC) market will continue to diversify.

Commercialization of the robotics health market is happening at a feverish pace, with 5,582 Da Vinci robots installed as of 3Q 2020. Meanwhile, the Autonomous Passenger Vehicle (APV) space faces increased scrutiny after massive investment met with virtually no commercialization. Increasingly, startups in the broader field of robotics are garnering attention, with examples being Seegrid and Outrider.

Rian Whitton, Senior Analyst

ROBOTICS INVESTMENT MARKET SHARE BY INDUSTRY 2019 (%)
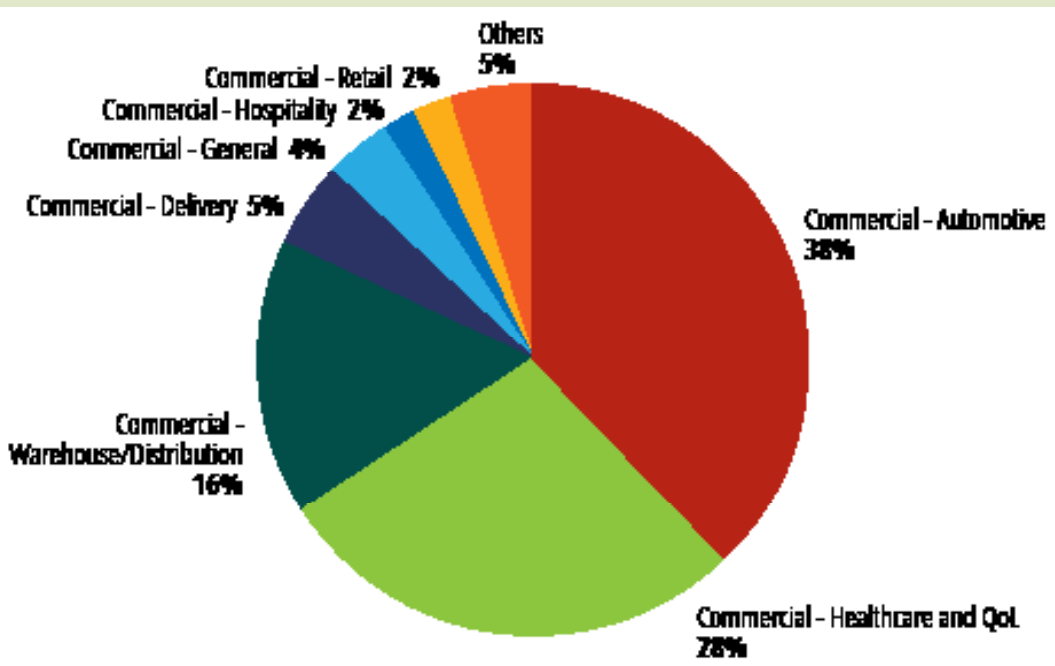
Investment Values (US$)	
Automotive	10.9 billion
Health and Quality of Life (QoL)	8.2 billion
Warehouse/Distribution	4.5 billion
Delivery	1.3 billion
Commercial (General)	1.2 billion
Retail	667 million
Hospitality	620 million
Discrete Manufacturing	620 million
Emergency Response	190 million
Agriculture	186 million
Cleaning & Maintenance	169 million
Defense	142 million
Inspection	119 million
Process Manufacturing	72 million
Construction & Demolition	72 million
Other	265 million

INDUSTRIAL, COLLABORATIVE, AND INDUSTRIAL ROBOTICS

37 | COVID-19 WILL NOT SIGNIFICANTLY DISRUPT THE ROBOTICS MARKET

The robotics industry can anticipate a significant rebound in 2021 as the negative impact of COVID-19 will slowly dissipate. As the crisis has unfolded, interest in robotics has skyrocketed, even as deployments have stalled due to installation challenges and companies withholding investments. There have been exceptions with the increased deployment of service robots and systems for certain applications, like ultra-violet disinfection for hospitals and airports.

But the recent parting of ways between Walmart and inventory tracking robot developer Bossa Nova highlights how fragile the pilot to commercialization stage is in the automation world. While the virus opened space for more testing and demonstrations, the more challenging real-world robotics applications, like last-mile delivery and outdoor scrubbers, are not at a stage of development that can meet market needs.

ABI Research predicts the industrial and collaborative robot spaces will continue their strong trajectory in 2021. But the nascent stage much of the industry finds itself in precludes the possibility of a significant acceleration in adoption due to the pandemic. Acceleration will only come with better data orchestration strategies, more operational experience, and a further supportive ecosystem from adjacent technology vendors in the cloud, cellular, and AI spaces.

Rian Whitton, Senior Analyst

38 | ROBOTICS COMPANIES WILL NOT BE ABLE TO SCALE EFFECTIVELY WITHOUT THIRD PARTIES

Robotics developers have moved up the value chain by developing service models and analytics tools to supplement their hardware revenue. Some are offering comprehensive cloud platforms that control all aspects of the robot's operation. This is potentially beneficial to the robot vendor because they can lower hardware costs and control more of the process. But considering the limited budgets and time these companies have, the significant challenges of deploying robots can divert precious resources to customer service.

Given that robots currently do not scale easily with more deployments, and require engineers to manage and maintain, roboticists need outside assistance. System integrators like Ricoh Automation are beginning to provide more customer service options. Robot vendors that build robust and widespread distributor links like Universal Robots and Mobile Industrial Robots are benefiting from more shipments.

Looking forward, other third parties like cloud service providers and computing vendors (such as AWS and NVIDIA) are building comprehensive robotics offerings for developers. While NVIDIA covers onboard processing, simulation tools, and ever-more comprehensive development platforms, AWS is building cloud computing specialized for robotics vendors. These adjacent technology vendors will become increasingly central to the robot space as the use of their hardware and services become more ubiquitous.

While in the long term, robotics vendors want to develop vertical integration and move up the value chain, this is a long-term prospect, and right now, they need third parties.

Rian Whitton, Senior Analyst

INDUSTRIAL & MANUFACTURING

39 ADDITIVE MANUFACTURING SOFTWARE INNOVATION WILL PLAY CATCH-UP

Additive Manufacturing (AM) has made considerable strides over the last decade thanks to advances in computer processing, simulation, robotics, material science, connectivity, and overall process control. This led to the broader use of the technology for applications other than rapid prototyping. Now, AM is used for everything from hearing aids and dental implant molds to low-volume, high product mix situations, such as at a service bureau or job shop. This statement mostly applies to polymer systems, but increasingly includes metal AM as well. *But what is becoming increasingly apparent as prototyping and low-volume applications graduate to mid- and eventually high-volume production is the massive gap between hardware capability and software enablement.*

Software is the glue that makes systems operate in a systemic, rather than an isolated or independent and less useful manner. Software manages the file design (Computer-Aided Design (CAD). It is responsible for structuring and communicating the toolpath (Computer-Aided Engineering (CAE)), monitoring material flow/feedstock recycling systems (Manufacturing Execution System (MES)/Enterprise Resource Planning (ERP)/Product Lifecycle Management (PLM)), and driving continuous improvement of both product and process (simulation).

AM is an ecosystem starting to open up to third-party developers, and we will see this in 2021 with broader support for AM systems in IoT platforms like Siemens MindSphere. We will also see a much greater emphasis on simulation and integration of process parameters for greater repeatability and systems management. Finally, the market will start to realize the disparity between hardware and software innovation and react with new solutions, and new programs that improve awareness, education, and integration. The reason these actions are inevitable is that production AM simply cannot happen without them.

Ryan Martin, Research Director

40 SIMULATION WILL BE THE NEEDLE FOR DIGITAL THREADS

Manufacturers and industrial firms have been focusing efforts on creating a digital thread that keeps data flowing in a continuous loop between the engineering, manufacturing, and fulfillment teams. Digital threads also need to accommodate upstream information (from suppliers, such as the availability of parts or raw materials) and downstream information from distributors, customers, and their customers, too. This can be achieved by enabling data to be shared between industrial applications (MES, ERP, PLM, Warehouse Management System (WMS), Supply Chain Management (SCM), etc.).

The year 2020 has put in stark relief the fact that firms do not operate in isolation. Think back to the first half of this year when retailers ran out of certain goods, and manufacturing plants came to a standstill due to the lack of parts. The digital threads had failed to anticipate demand surges because ML was looking at historical patterns and did not provide firms with the ability to maintain production.

Firms will now need an overview of their operations, and they will need to stress test them to build resilience. Projects will look to simulate scenarios and run what-if analysis; the analysis should cover both downstream events (in end markets or individual customers) and upstream events to simulate how to accommodate supply chain events in engineering and production departments. Digital threads will need to be more than a system of record versus a strategic tool for manufacturers and industrial firms to fully understand and accommodate changes in the operating environment so they can thrive in uncertain times.

Michael Larner, Principal Analyst

INDUSTRIAL & MANUFACTURING

41 SMART MANUFACTURING BUILDS MOMENTUM IN 2021, BUT ONLY TAKES OFF WITH 4G/5G CELLULAR

Smart manufacturing will continue to build on its momentum in 2021, but not until factory owners embrace 5G for their smart factory connectivity layer will they reap the operational benefits. Factory owners have been deploying industry 4.0 tools, such as condition-based monitoring, inventory management, and building automation using ethernet cable, but deploying wireless-enabled Industry 4.0 tools will bring smart manufacturing to its full potential. Applications like wearables (health and location/safety trackers) and AR are only possible with wireless connectivity.

Wi-Fi 6 has notable enhancements over Wi-Fi 5. However, managing the end-point density and orchestrating the signaling and data traffic could be more challenging for aggressive IoT deployments in congested factory spaces. 4G improves IoT device management up to 50,000 devices per Square Kilometer (km^2), but 5G private cellular is the real game-changer, bringing the full versatility and functionality of 5G to the smart manufacturing opportunity.

With 5G private cellular, IoT density can reach as much as a million end-points per km^2. A 5G edge server can provide enterprise applications and a subscriber database, User Plane Function (UPF), and 5G NG control plane management. Indeed, with 5G, some of these functions can be offloaded to a telco cloud if the factory owner prefers. *By the end of 2021, while 5G private cellular investment will only have notched US$53.3 million compared to US$1.52 billion for 4G, private 5G cellular's Compound Annual Growth Rate (CAGR) is 2.6X that of 4G's.*

Jake Saunders, Vice President, Asia-Pacific & Advisory Services

INDUSTRIAL & MANUFACTURING

42 | SERVITIZATION WILL NOT NECESSARILY SERVE CUSTOMER OR SUPPLIER NEEDS

Many machinery manufacturers' business models are very similar to IT hardware suppliers. The production unit provided little or no margin to build an installed base with profit margins generated by providing add-on services. Others are aping software vendors' move to pay-per-use models with Konecranes looking to give the clients weightlifting (as opposed to cranes), SKF providing rotations (rather than bearings), and aaS models with Kaeser Kompressoren now offering Air Compression-as-a-Service. Customer engagements concern the delivery of a service, rather than a product.

The move to servitization is timely as manufacturers want to have fewer people working inside the facilities to achieve social distancing, but cannot afford to neglect the machines. This scenario drives demand for such models whereby machinery suppliers remotely monitor the assets. When coupled with analytics, software can provide Maintenance-as-a-Service with technicians entering facilities only when required. Furthermore, the shift to pay-per-use models enables manufacturers to keep costs down.

But manufacturers already use technology vendors and system integrators to optimize asset performance and identify cost savings. The customer may also need to shift the financing for a piece of machinery from a CAPEX purchase to OPEX models. However, before looking at the finance models, the metrics used (rotations, weight lifted) may not necessarily resonate with the customer or be fully appreciated by finance staff, making it harder to build the business case.

The supplier is challenged with reconfiguring and managing changes to service teams that are used to predictable schedules. *Publicly traded companies will face the same challenges that legacy software vendors faced in keeping financial analysts on the side, while changing revenue streams from large upfront payments for software licenses (large regular payments for the piece of equipment over time) to smaller incremental streams from aaS models.*

Michael Larner, Principal Analyst

43 | INDUSTRIAL BLOCKCHAIN WILL NOT REVOLUTIONIZE THE MANUFACTURING SECTOR IN 2021

Industrial blockchain applications are dynamizing the broader blockchain market, which has seen global revenue fall 35% between 2018 and 2020. Notably, industrial blockchain revenue grew 131% in that same period, driven by successful pilots in food and beverage, and in transport and storage. These markets will see exponential growth over the next 24 months. However, blockchain manufacturing applications are not going to see any significant traction immediately within that industrial breakthrough.

This is largely due to the almost exclusive interest in how blockchain can successfully enable provenance, trade finance, and tracking and tracing applications, rather than in manufacturing itself. Blockchain remains a nascent technology, and those successful pilots are still in the initial stages of commercial deployment. Industrial stakeholders are keen to wait until the ROI is proven on a first application before engaging in other use cases.

Further, the actual manufacturing opportunities are not yet clear for blockchain usage. Where on the factory floor can blockchain be most effectively leveraged? Initial research and a limited number of projects have looked at how smart contracts could aid on-demand and cloud-based manufacturing, crowdsourcing additive/Three-Dimensional (3D) printing, smart diagnostics, prognostic health management, predictive maintenance, and automated Machine-to-Machine (M2M) transactions for order placement and machine servicing, etc. However, many of these applications rely on engaging in industry 4.0 development strategies, which is still a distant milestone for many factory operators. Blockchain-based manufacturing operations will remain a low priority and an underdeveloped opportunity in the near term, despite its potential and the hype around it.

Michela Menting, Research Director

44 ULTRA-WIDEBAND WILL EMERGE AS A KEY WIRELESS CONNECTIVITY TECHNOLOGY IN 2021 AS ABI RESEARCH FORECASTS 300 MILLION DEVICE SHIPMENTS

The last couple of years have laid the foundation for Ultra-Wideband (UWB) to become a mainstream wireless connectivity technology across many consumer and IoT applications over the next decade. ABI Research expects 2021 to be a critical juncture in UWB's rollout and increased adoption thanks to wider chipset availability, adoption across multiple segments, and the formation of a healthy UWB ecosystem across the entire supply chain.

In June 2020, the UWB Alliance and FiRa Consortium announced a formal liaison to help accelerate the development and adoption of UWB technology, with the former focusing on regulation, and the latter on use case specifications, interoperability, and certification programs. In September 2020, the FiRa Consortium added a further 21 members to its growing network, including Thales, Cisco Systems, and STMicroelectronics, as well as numerous adopter members across the globe.

In the chipset space, Qorvo acquired UWB pioneer Decawave in February 2020, and STMicroelectronics acquired UWB specialist BeSpoon in July. NXP recently extended its UWB portfolio by unveiling its Trimension SR040 and SR150 ICs, targeting IoT use cases, such as smart locks and Real-Time Location System (RTLS) tags, building on its existing smartphone and automotive UWB solutions. Apple has deployed its own UWB U1 chipset solutions within many devices.

While historically, the technology has been used primarily within high-accuracy RTLS applications, 2020 has propelled UWB into various new markets. To date, arguably the biggest news was Apple's decision to develop and use its own UWB technology in its iPhone 11, iPhone 12, and iPhone SE series of devices. In addition, Samsung now supports the technology in its Galaxy Note 20, while Xiaomi has also added the technology to its Mi 10 series of devices. Apple has also integrated the technology within its latest Apple Watch Series 6, alongside its HomePod Mini speaker, demonstrating the importance of the technology going forward. Xiaomi also recently demonstrated UWB leveraged within a variety of smart home devices, such as fans, lamps, and smart speakers, highlighting the growing potential of the UWB ecosystem.

Once embedded within a sizable installed base of smartphones, it is clear that new opportunities will emerge within the mobile accessory space, alongside wider consumer electronics applications. ***Though it is difficult to predict which will be the largest markets exactly, it is clear that UWB is here to stay and that a strong ecosystem of devices is emerging. The year 2021 will see this growth accelerate, growing to nearly 300 million device shipments.***

Andrew Zignani, Principal Analyst

LOCATION TECHNOLOGIES

45 **WHILE LEO SATELLITES ARE GENERATING MUCH FANFARE IN 2021, THEY WILL NOT OVERTAKE GEO OPERATORS' DOMINANCE WITHIN THE SATELLITE INDUSTRY**

The promise of ubiquitous, high-capacity, low-latency connectivity of mega-constellations has initiated a potential changing of the guard within the satellite industry. Potential disruptors like SpaceX and OneWeb are ramping up development and production of their Low Earth Orbit (LEO) solutions to offer affordable and universal connectivity solutions.

Mega constellation business models are propped up by reduced manufacturing costs from either the use of commercial off-the-shelf components in software-defined satellite systems or vertical integration (as with the case of SpaceX); lower launch costs due to smaller satellites and near-earth orbits; and E2E, consumption-based connectivity targeting untapped markets in rural regions.

There are, however, major obstacles that will hinder the ambitions of these LEO companies from coming to fruition, especially in 2021. For example:

- LEO companies must still improve commercial feasibility by overcoming the cost implications of deploying large-scale satellite fleets.

- The cost advantages of LEO deployments, such as Amazon's Kuiper (intending to launch 3,000 satellites) and SpaceX's Starlink (estimated 42,000 satellites by 2025), are neutralized as GEO/Medium Earth Orbit (MEO) deployments only require, at most, 10 satellites for global coverage.

- The need for more ground system infrastructure.

- Proper orchestration of seamless switching/hand-offs of up to thousands of beams (due to the narrower spot beam capabilities of modern high throughput satellite systems).

- The challenge of navigating the varied landing rights of different countries.

Miguel Castaneda, Industry Analyst
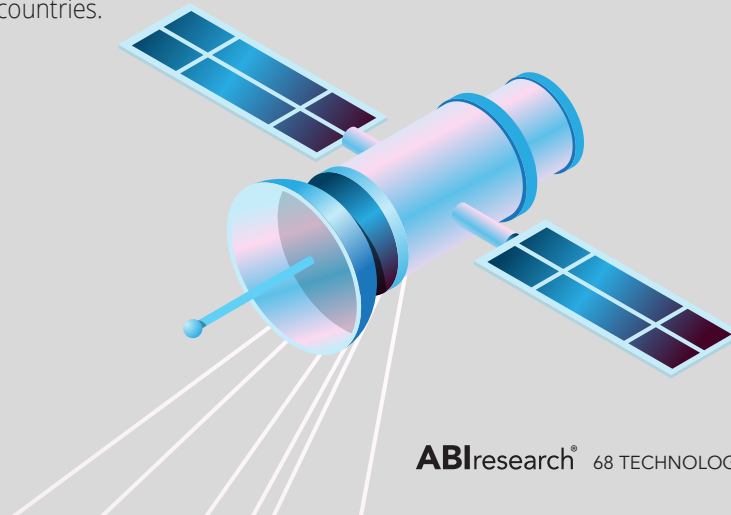
M2M, IOT, AND IOE

46 COMMERCIAL BUILDING AUTOMATION MARKET REVENUE WILL CONTRACT FURTHER IN 2021

Many global companies, including Apple, Facebook, Twitter, Pinterest, Infosys, Group PSA, Hitachi, and TCS, have announced that their Work from Home (WFH) policies will continue even after the COVID-19 pandemic ends. Office buildings account for up to 25% of commercial real estate in key regions, and this has been the most affected commercial building vertical segment during the pandemic.

In the short term, the served available market within the large buildings segment (over 100K square feet) will contract for incumbent Building Automation System (BAS) vendors, thus impacting the overall hardware and services market revenue. *Incumbent BAS solution providers will need to explore new greenfield market opportunities in the mostly underserved small and medium-sized commercial buildings segments.*

The COVID-19 pandemic has presented the commercial BAS market with an unprecedented situation to adapt its buildings to meet occupants' needs for health and safety. In 2021, while the overall market contracts, there will be an increasing need for flexible building spaces. These will drive demand for simple-yet-secure and quick-to-deploy smart building technologies that provide seamless occupant experiences and transparency, and, most importantly, address real-time health and safety needs of building occupants.

Adarsh Krishnan, Research Director
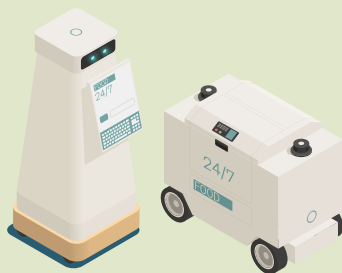
47 AS THE DUST SETTLES ON 5G TECHNOLOGY HYPE, LPWANS WILL ACCELERATE IOT CONNECTION GROWTH

As the Low-Power Wide-Area Network (LPWAN) technology global network footprint grows and the IoT solution ecosystem matures, 2021 will witness large-scale massive IoT implementations using LPWANs.

Non-cellular LPWAN technologies will grow the most next year, primarily driven by growing confidence in these technologies and enterprises' urgent need to start implementing IoT solutions following pandemic-induced slowdowns.

Among LPWAN technologies, LoRa and Sigfox will benefit from its early market entry and commercial availability of turnkey IoT solutions. In 2021, LoRa will witness the most growth in vertical IoT applications, such as smart metering and the smart home, whereas Sigfox will continue to build on its early momentum in the tracking and supply chain visibility market.

In 2020, the global footprint of cellular LPWANs dramatically increased to more than 154 networks commercially in 59 countries. However, the lack of carrier roaming agreements has hindered the acceleration of high-volume product categories, such as asset trackers, environmental sensors devices, and smart meters.

In 2021, ABI Research expects that roaming agreements from telcos will accelerate international coverage and service continuity on LTE for Machines (LTE-M) and Narrowband-IoT (NBIoT) networks to offer seamless coverage to enterprises that want to deploy connected devices in multiple markets.

Adarsh Krishnan, Research Director

48 **A NEW CATEGORY OF LOW-COST, SIMPLE, AND DISPOSABLE LPWAN ASSET TRACKERS WILL START SEEING COMMERCIAL UPTAKE IN THE MILLIONS**

One direction for asset tracking device manufacturers is to push increased intelligence and functionality to the device edge, making highly configurable devices for highly variable use cases. Another direction is to simplify the edge device to create single-use and disposable devices and make them cheap enough to be sold at high volumes for item- or parcel-level tracking. These devices have little more than a communication module, one or two sensors, and a small battery, giving a few months to a couple of years of battery life when activated.

Several LPWAN disposable trackers are already on the market, with models by CoreKinect, Sensitech, NanoThings, and Sigfox, among others. Bayer's solution with Vodafone for flexible and printable LTE-M/NB-IoT tracking labels, with an anticipated 10 million labels deployed by 2025, will help transform the market. This will mark a turning point in the asset visibility market as LPWAN connectivity, low-power location technologies, printable electronics, low sensor cost, and commercial awareness of asset tracking requirements and benefits align to enable viable smart label solutions. New challenges and opportunities, such as device kitting and logistics, will arise from this new category of trackers. The category will also transform the use of IoT tracking technology for compliance and regulatory alignment in pharmaceutical and food industries, among many others.

Tancred Taylor, Research Analyst

49

NB-IOT WILL NOT FALL BY THE WAYSIDE, DESPITE 2020 NETWORK CLOSURES

Two NB-IoT networks ceased to exist in 2020; one closed after less than a year of operation, and the other never launched. But carrier commitment to NB-IoT and the market prospects will remain undiminished in 2021. NB-IoT network rollout has led the charge for carriers to establish IoT-specific networks, with numerous international operator groups using their NB-IoT coverage as a blueprint for their Cat-M deployment plans. Both technologies' longevity is the assured part of 5G standards where they will stand together to constitute Massive Machine-Type Communication (mMTC). So, even if their rate of adoption has been slower than initially anticipated, due to the high commoditization, stubborn persistence, and generous coverage of 2G networks, their time will inevitably come.

It was NTT DOCOMO that shuttered its NB-IoT network, while it was Dish Communication that canceled its launch. Both had very different reasons for doing so. NTT entered a period of resource management in April 2020, partly in response to pressures from the COVID-19 pandemic. Few commercial connections had gone live on its NB-IoT network during its brief period of operation, so it was a natural candidate to be cut.

Meanwhile, Dish had simply missed its opportunity, having announced its NB-IoT network in 2017 before any incumbent U.S. carrier supported the technology. Since then, T-Mobile, AT&T, Verizon, and Sprint all launched NB-IoT. Unable to compete and with slower NB-IoT growth than 2017's hype suggested, it made sense for Dish to buy Boost Mobile and channel its spectrum resources into the consumer market instead.

The big challenge for NB-IoT as a technology is breaking out of the Chinese market, where 96% of NB-IoT modules are made and 65% are consumed. One path may be via standards-based operational integration with complementary communication technologies like satellite for backhaul, as evidenced by Sony Semiconductor Israel's partnership with Skylo Technologies, and MediaTek's field trial with Inmarsat in August. A further barrier has been NB-IoT roaming support from carriers. Although NB-IoT is best suited for connecting stationary objects, devices may be shipped to different countries for activation. The problem lies not in the standards, but in incompatibilities in the billing systems and reconciliation agreements between carriers for such low data rate connections.

Jamie Moss, Research Director

M2M, IOT, AND IOE

50 **WESTERN INCUMBENTS WILL NOT RECAPTURE THE IOT MODULE MARKET**

Cellular IoT module vendors from China exerted a new level of worldwide influence at the end of 2019. Quectel became the leader in terms of shipments in 2018, but was still heavily reliant on a late surge in 2G module shipments. European and North American module vendors had always been dominant when it came to revenue, but that changed in 2019 when Quectel surpassed them. 2G shipments are still an important part of Quectel's business, but 4G is where the revenue lies, and 4G jumped to a massive 55% of its total shipments, giving them a 17% market share of 4G IoT module revenue globally. In a market that consists of more than 50 vendors, where NB-IoT and LTE are the target sweet spots, at the high-volume and high-value end, respectively, that was an impressive achievement.

This might not be considered a problem if this performance was an aberration or if Quectel's only focus was its domestic market. But since its market entrance in 2010, Quectel has been heavily focused on international business, which currently constitutes 40% of its turnover.

More vendors from China are following suit, with Fibocom, at 60% of its business being international, leading the way. Such vendors have also leaned heavily on their Original Device Manufacturer (ODM) capabilities, building their modules into white-labeled hardware, sold to carriers and IoT service providers in Europe and North America. Fibocom has even developed an industry association to do so: the Fibocom International Alliance. And in just a few years, Neoway has become a major supplier of On-Board Diagnostics II (OBD2) dongles for aftermarket telematics.

The picture may seem bleak for the western incumbents that worked hard to pioneer the market, but they are still dominant where it matters as they own the trust of device OEMs worldwide. They are known for high quality, customer service, and product innovation, not just in hardware design, but also in software features and value-added service integration.

They have known for years that commoditization in the module hardware-only space was inevitable and have a head start in developing subscription-based business models. Their experience also makes them ripe for acquisition. Thales acquired Gemalto in 2019 for US$5.43 billion, its Identity, IoT & Cybersecurity division was worth 46% of Gemalto's turnover the year before, and its IoT module constituted a quarter of that.

Jamie Moss, Research Director

51 A SEAMLESS NETWORK BETWEEN TECHNOLOGIES: CLOSE TO HAPPENING, BUT NOT CLOSE ENOUGH

The increase in satellite connectivity for the IoT has seen satellite vendors keen to partner with the main MNOs to enable a seamless connection globally. Satellite connectivity is better suited for use cases marketed in industries located in the most rural areas, where terrestrial network infrastructure is minimal or non-existent. Satellite providers do not wish to compete against MNOs, but rather work with to ensure they meet their connectivity goal.

Reports of new satellites being launched into orbit lead to the assumption that a complete satellite network will be up and running within the next year; however, this is not the case. Even with satellite providers having launched large numbers of satellites, such as Space-X having launched 713 Starlink satellites into orbit, there are still several launches planned to take place this year alone to complete their network. These launches are for one specific network alone, with several other providers, such as Lacuna Space and Astrocast, awaiting launches of their first satellites to take place. Delayed launches due to the COVID-19 pandemic has created challenges for manufacturing satellites and other launch requirements due to restrictions that have been put in place to protect the engineers working on said projects. Because launches have been delayed, they are unable to complete the manufacturing process.

Ultimately, the overall goal is to deliver a global network that can be used by devices that offer the ability to connect to both terrestrial networks and satellite networks as and when a specific type of connection is required. This will not happen until complete networks are in place and key partnerships between terrestrial network providers, such as MNOs and satellite providers, are in place and secure.

Harriet Sumnall, Research Analyst

52 CHINA WILL NOT REGAIN ITS SUPPLY CHAIN PROMINENCE

While this statement may be a risky bet, even when COVID-19 is behind us, China will not regain its influence on the global supply chain. The question is to what extent, but the wheels of change cannot be stopped as enterprises seek to diversify their supply chains for three reasons. First, there will be another pandemic. *As the world warms and Earth's population grows, pandemics are simply more likely. But where they will break out and how they will spread is unknown.* Second, onshoring or producing locally is a theme resonating across many countries. This is not just a politically driven theme. It is a recognition that the economic fallout from trade wars and pandemics, climate change, etc. is out of the enterprise's control. But, preparing for these uncertainties is. Uncertainty preparation is not cheap or the most efficient, but, producing locally is cost effective and more controllable under these circumstances. In addition, many countries are factoring in the national security benefits of producing locally.

Finally, and probably most importantly, the technologies and toolsets to technically and economically diversify away from China are now possible. New LPWA devices and networks, cloud location services, blockchain, and the IoT supply chain, in general, are now advanced enough to offer asset tracking and monitoring solutions that satisfy enterprise ROI requirements. This is critical as enterprises need tools and technologies to lower the risk of supply chain diversification. These technologies and toolsets will only improve over time, providing scalability and flexibility in solution development for greater asset visibility and trust in new suppliers and processes.

Dan Shey, Vice President, Enabling Platforms

M2M, IOT, AND IOE

53 | AWS AND MICROSOFT AZURE WILL NOT LOSE THEIR DOMINANCE IN THE IOT MARKET

The end of 2020 is a great pivotal point on how far AWS and Azure came with their dominance in the cloud domain, as well as cloud-enabled IoT technologies. Both vendors use opportunities to create global data centers for the global manufacturing enterprises in their local clusters, to keep all the collected data closer to the source. In addition to multi-billion contracts in the data center business, AWS and Azure leverage their scaling and processing capabilities for IoT applications.

Both vendors have created marketplaces that are exceeding the abilities of others to compete with them (e.g., IBM Marketplace). By leveraging third-party solutions via marketplaces, the vendors commit to open standards and protocols, including proprietary, open-source, and developer ecosystems in multi-cloud and multi-platform, hybrid environments. The environment is already filled with a wide range of vertical and application-specific solutions that enabled AWS/Azure to be a leader in the IoT core Platform-as-a-Service (PaaS) market, currently rapidly penetrating the industrial cloud (see ABI Research's *SI/VAR and Partner Program IoT Ecosystem Market Data* (MD-SVIT-109).

The industrial customers are alleviated by much more flexible options to avoid vendor lock-in with an industrial platform versus adopting a hybrid cloud to satisfy their analytics needs and simplify data strategies. For more detail, see ABI Research's report *IoT Analytics and Data Management Services: Strategies of Major Cloud Supplier*s (AN-5268).

Kateryna Dubrova, Research Analyst

54 | IOT VENDORS WILL NOT STOP RELYING ON OPEN SOURCE FOR IOT PROJECTS

While big IoT data explosion is unavoidable, the competitive landscape is tightening between top vendors racing to provide sophisticated E2E IoT solutions. Meanwhile, the other ultimate driver for IoT technology is an open-source offering, which can be used by the developer's community and is increasing in usage by top cloud vendors, as well as trending SaaS players.

One of the most successful open-source IoT communities is the Apache Project. The success and significant demand for its technologies (NiFi, Spark, Storm, Flink, Cassandra, etc.) are driven by cost concerns about proprietary technology development, alongside the cost for its scalability. Hence, open-source technologies could further enable interoperability and ease integrating the other products without extra investment. *The market dynamic of 2020 showcased that many enterprises start their IoT journey and digital transformation process with open source, most popular with data engine and integration tools enabled by Apache Kafka.* Such dynamic and in-depth research confirms that enterprises will not stop widely using existing open-source offerings, nor will the community of developers abandon open-source toolkits, favoring only proprietary tech.

However, it is important to stress that proprietary IoT technology is losing its popularity to open source; proprietary and open source synergy is a new "must-have." Several existing combinations of proprietary technologies and open-source solutions are offered across the IoT market, with StreamAnalytix and Oracle Complex Event Processing running on Spark Streaming. In contrast, Confluent, AWS, and Azure offer their data management services on proprietary engines, as well as Apache Kafka. For more details, see ABI Research's report *Business Intelligence 2.0: IoT Stream Processing, Analytics, and Data Management Services* (AN-5295).

Kateryna Dubrova, Research Analyst

SMART CITIES AND SMART SPACES

55 **DIGITAL TWINS WILL BECOME KEY URBAN ASSET MANAGEMENT TOOLS FOR MANY CITIES IN 2021**

With digital twins having made their appearance in cities a few years ago, mainly in the form of pilots showcasing limited feature sets, their more widespread deployments as transversal governance tools are imminent. This is not in the least driven by COVID-19 requirements to achieve increased resilience levels and optimized asset and demand-response resource management. Additionally, real-time 3D models of a city's built environment allow scenario analysis through the simulation of the potential impact of natural disasters like flooding, adopting generative design principles for new city developments to optimize energy savings and solar capacity, and saving costs by operating cities more efficiently and effectively.

Vendors like Dassault Systèmes and Engie subsidiary Siradel have extended urban digital twins to open platforms and even marketplaces, allowing both new govtech ecosystems of third-party developers to emerge and opening access to key metrics and dashboards to the citizens themselves, increasing their overall involvement and helping gain the approval of city government decisions and policies. The role of digital twins as the ultimate urban decision and management tool will start to be fully understood, driving deployments and new use cases in 2021.

Dominique Bonte, Vice President, Verticals/End Markets

SMART CITIES AND SMART SPACES

56 | **DESPITE THE EDGE CLOUD HAVING BECOME ONE OF THE MOST DEBATED TECHNOLOGY TOPICS IN 2020, IT WILL HAVE LITTLE OR NO IMPACT ON SMART CITIES IN 2021**

In partnership with cloud giants like AWS, IBM, and Microsoft, the entire telco community is gearing up to offer low-latency, cloud-native analytics capabilities at the edge of, but within cellular networks, powered by 5G connectivity. This is mainly driven by the critical need to unlock new telco monetization mechanisms to justify and recoup the high costs of 5G network deployments. Similarly, cloud players are keen to extend their reach and leverage their capabilities in the distributed cloud paradigm.

However, while there is clear potential for low-latency edge cloud use cases, such as safety and security operations, including real-time hazard alerts and closed-loop emergency response modes, road intersection remote traffic management, and the operation and remote control of autonomous assets like drones, robots, and driverless vehicles, the awareness about this new technology with both city governments and Information Technology Services (ITS) providers remains very low. Additionally, installing granular server capacity at the 5G network edge will take time, both in terms of 5G network deployments and integrating cloud technology within the cellular network infrastructure.

In the meantime, the use of analytics at the device/end-point edge in the form of smart AI-based traffic monitoring and surveillance cameras, adaptive traffic lights, smart streetlight platforms, and other types of high-compute local sensor data processing will remain the default technology innovation and transformation strategy in urban environments in terms of leveraging actionable local intelligence to address urban challenges related to congestion, safety, and overall resource management.

Dominique Bonte, Vice President, Verticals/End Markets

SMART HOME

57 **THE SMART HOME MARKET IN 2021 WILL NO LONGER BE A HAVEN FOR SMART HOME VENDORS WITHOUT DELIVERABLE AND REALIZED PATHWAYS TO PROFITABLE SERVICE DELIVERY**

The title is true unless, of course, the provider has the deepest of pockets. For many OEMs and service providers, the smart home has meant a strategy geared to quickly winning hardware sales and potential subscription services further out. However, the ongoing cost of supporting a smart home device funded solely by a low-cost purchase price years ago will weigh down smart home players. In leading markets, consumers are adding to their smart home systems as much as they are starting on their first purchases.

Increasingly, while existing devices may remain useful, they will not have the capacity to be upgraded to the latest benefits that new devices will support, such as connectivity, sensing, security, and more. *Vendors will be facing a choice between the cost of upgrading or integrating aging equipment or expecting the consumer to re-purchase devices, potentially losing that customer to a rival offering.* At the same time, deep-pocketed players, such as Amazon, Apple, and Amazon, while continuing to funnel huge investments into their smart home efforts, will continue to drive consumer expectations of free and very low-cost services. These players will continue to do so as they leverage smart home devices to drive their wider businesses' value and revenue.

Jonathan Collins, Research Director

SMART HOME

58 **DESPITE CLOUD CONNECTIVITY UNDERPINNING AND DRIVING SMART HOME ADOPTION AND APPEAL FOR YEARS, 2021 WILL NOT SEE CLOUD CONNECTIVITY REMAIN UNCHALLENGED**

Instead, smart home OEMs and system providers will increasingly embed greater on-device processing to enable edge processing, allowing them to augment offerings and limit some of the cost and service longevity limitations of lower-capability and cloud-hungry devices. Key features, such as an on-device image or sound analysis using onboard AI/ML, will reduce the impact of cloud dependence and reduce demands on the home network. Further driving investment in edge processing will be the potential for faster system response times and improved data security and privacy as less data need to leave the home.

A range of new low-power, lower-cost edge computing capable products from Amberella, NXP, STMicro, Silicon Labs, and others all target the smart home as a key market, while startups like Perceive are focused on the smart home and AI with their first product. With both Amazon and Google pushing their voice control front-ends increasingly as smart home gateway-capable devices, the era of cloud connectivity domination will not continue unchallenged in 2021.

Jonathan Collins, Research Director

**59 THE FIRST CONSUMER eSIM DEPLOYMENTS SHOULD REACH THE AUTOMOTIVE MARKET IN 2021, DRIVEN BY PREMIUM OEMS**

Today, premium OEMs deploy an M2M Embedded Subscriber Identity Module (eSIM) for telematics and, to some extent, infotainment services. In this deployment model, remote management of global operations and profiles is executed by the server-side under the OEM's full control (push model). Concerning infotainment connectivity only, there has been an increasing trend toward adopting a pull model (consumer eSIM) where the consumer is responsible for the profile subscription management for end-user-driven interactions with infotainment apps.

The consumer eSIM provides drivers with the opportunity to add their cars to their existing data contract. The benefits include affordable prices, choosing which functionalities they want available in their vehicles, and making or receiving calls in the car using their current phone number seamlessly. On the other hand, OEMs benefit from not being responsible for the subscription management and the billing after the free trial period, which would translate into lower costs. OEMs could also promise MNOs to sell and upsell on private data plans as leverage to bargain for cheaper deals on telematics.

On the downside, the implementation of a second modem inside the car is capital-intensive. Also, OEMs would have to be willing to lose control of the vehicle's infotainment experience for companies like Google and Apple to create even more integrated experiences among cars, smartphones, and other IoT devices.

Although the ecosystem within carriers is still in development, as eSIM is not supported by all carriers globally, the first consumer eSIM should reach the market in 2021, driven by a premium OEM deployment. While a handful of carmakers plan to implement two in-vehicle communication channels by the end of 2021, consumer eSIM adoption will only gain traction in the automotive industry by 2024.

Maite Bezerra, Research Analyst
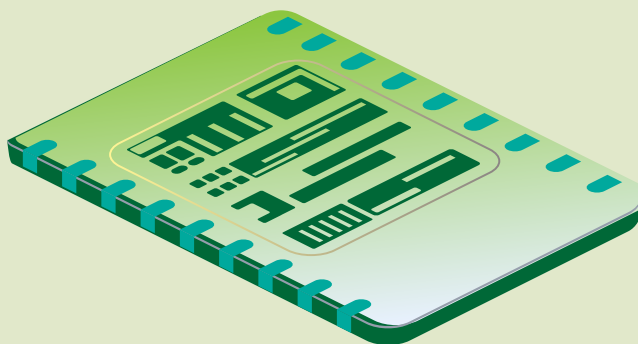
60. DESPITE LOW NEW VEHICLES SALES CAUSE BY COVID-19, C-V2X SHOULD GO INTO PRODUCTION IN 2021

After Volkswagen (VW) launched the Golf equipped with 802.11p/Dedicated Short-Range Communication (DSRC) in late 2019, 2021 seems to be the year of Cellular Vehicle-to-Everything (C-V2X). The Federal Communications Commission (FCC) proposed a C-V2X mandate in November 2019 and has recently announced its intention to transitioning the upper 30 megahertz of the 5.9 GHz band from DSRC to C-V2X. This is expected to have a significant impact on the deployment of C-V2X in the United States. For instance, since the first announcement, Audi, VDOT, Qualcomm, Tech Transportation Institute (VTTI), and Commsignia have been developing together C-V2X technologies that can be readily introduced to roadways using the 5.9 GHz wireless communications band. Moreover, Audi expects to complete a C-V2X project that involves two applications that improve safety in school zones and around school buses by 2021.

Meanwhile, C-V2X developments in China are progressing at high speed since the country demonstrated a clear preference for the protocol. In 2019, Ford announced the deployment of C-V2X in Ford vehicles in China in 2021 and all new vehicle models in the United States from 2022. Despite the COVID-19 effect on the automotive industry, Ford recently began final testing of Vehicle-to-Infrastructure (V2I) communication equipment in Changsha, in Hunan province, ahead of the 2021 launch. The tests are conducted on a 100 km motorway and public roads on a 100 km^2 area. A few applications will be made available to a small group of owners this year to collect feedback for production next year.

While interoperability between different 3GPP releases was a major concern regarding C-V2X adoption, Autotalks, a V2X chipset provider, has demonstrated interoperability among chipsets, software, security, and systems in the IMT-2020 C-V2X New Four Layers event in China. The company's solution is the first to support C-V2X based on 3GPP release 14 and 15 specifications with embedded cybersecurity functionality. Moreover, it met all Chinese configuration, throughput, performance, and security requirements.

In conclusion, real-life deployments of C-V2X are expected to occur in China in 2021, a trend that should be followed by the United States considering the FCC's recent support of the technology.

Maite Bezerra, Research Analyst

SMART MOBILITY AND AUTOMOTIVE
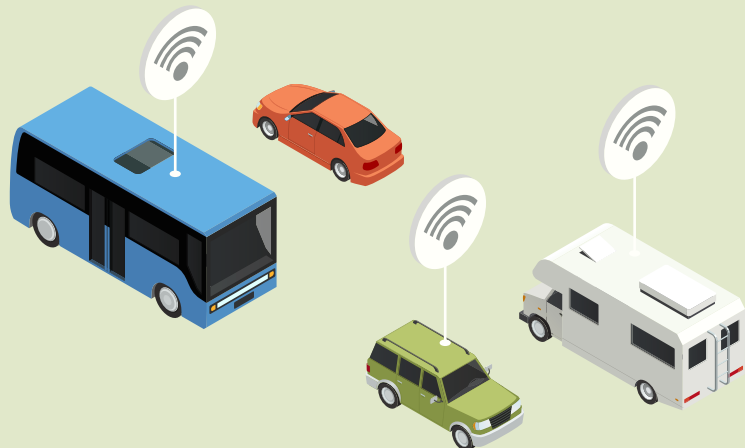
61 MICRO-MOBILITY WILL CONTINUE TO SIGNIFICANTLY EXPAND

Micro-mobility will continue to grow as a market, with the use of shared vehicles, such as electric bikes, scooters, and standard push bikes, having increased even during the COVID-19 pandemic. In the last half of 2020, while there have been a variety of different countries in lockdowns, the use of micro-mobility has not slowed down. As the world becomes more COVID-19-aware, Mobility-as-a-Service operators have been putting extra measures in place to ensure that cleanliness standards have been increased and regulated so that their services can continue.

Some service operators originally halted their services as the world hit the pandemic's peak; however, several have managed to continue running with extra measures in place. As lockdown measures were eased, micro-mobility vehicles were picked up again, with the use being more than just the last-mile additions to commuters' journeys. Reports have seen users opting to use the scooters and bikes at different times than in the past, with people now using them for recreational purposes, as well as just for that last hurdle of their day-to-day commute.

Pre-COVID-19, ridership was starting to significantly expand, especially as many major cities are looking at methods to become greener, which initially came to a halt as the pandemic started its course; however, New York City has seen its ridership increase beyond the peak seen in 2019. Not only are there new reasons to use these vehicles, allowing the market to continue to blossom, but cities are also becoming more lenient with the vehicles they allow. New York is now allowing electric scooter fleets to join the electric bikes already available, and the United Kingdom has now legalized the use of shared electric scooters. These factors contribute to the growth of a market that many would assume would have been affected more directly by the pandemic.

Harriet Sumnall, Research Analyst

62 ELECTRIC VEHICLES WILL BEGIN THEIR SLOW ENTRY INTO THE AUTOMOTIVE MAINSTREAM

2021 will kickstart a decade of growing Electric Vehicle (EV) adoption, which will see EV sales move from a rounding error of total new vehicle shipments to over a quarter of new vehicles shipping in 2030. This transition from niche to mainstream will be built on the introduction of low-cost EV models that satisfy the typical mileage requirements at an acceptable price point.

Models slated to be introduced to market over late 2020/2021 include the Koda Enyaq iV, delivering a 316-mile range with a starting price of €33,800 and the SEAT Cupra el-Born delivering a 310-mile range. Both models demonstrate the spread of VW's modular MEB EV-specific platform throughout VW's brands. Although EVs still command a cost premium over Internal Combustion Engine (ICE) equivalents, high-volume models, such as those based on the MEB platform, the Nissan Leaf, Hyundai IONIQ electric, and the Tesla Model 3, will be key to making EVs a viable option for the typical consumer.

As EV owners shift from the legacy of environmentally conscious, enthusiastic technology first adopters to more typical automotive consumers, OEMs will need to develop more innovative approaches to the life cycle management of EVs. Smart charging technologies, support for occasional Direct Current (DC) fast charging, and battery management will be critical in supporting mainstream consumers in their transition from ICEs to EV ownership.

James Hodgson, Principal Analyst

SMART MOBILITY AND AUTOMOTIVE

63 **NEW VEHICLE SHIPMENTS WILL NOT SNAP BACK TO BUSINESS AS USUAL**

The first half of 2020 saw the market for new vehicles implode, contracting by around 70%. COVID-19 and the measures taken to contain the spread of the virus dealt a double blow to the already faltering automotive market, disrupting supply chains and depriving the industry of the bricks-and-mortar retail environment on which it heavily relies. Many OEMs reported a return to growth in 3Q 2020 as offset demand from 1H 2020 manifested in a summer period that saw many governments lift restrictions and allow auto dealerships to reopen.

Moving into 2021, however, the automotive industry should not expect a return to the new vehicle sales volumes of recent years. The market size is expected to remain subdued until 2024 given the prospect of repeated lockdowns, long-term remote working, and a bleak macroeconomic outlook. At the same time, a boom in used vehicle sales will further cannibalize the precarious new vehicle market. This will give greater urgency to develop new business models that will enable OEMs to monetize their brand and vehicles without requiring ever-higher model shipments, such as subscription-based approaches that mirror the smartphone experience. A renewed emphasis on life cycle management will open up revenue opportunities that are increasingly tied to the fleet of an OEM's models already on the road, rather than the number of new vehicles shipping.

The drop off in new vehicle sales is already manifesting in a drop in Requests for Proposals (RFPs), and a request from industry bodies to push back the rollout of new technologies, such as the European Automobile Manufacturers' Association's (ACEA) application to the European New Car Assessment Programme (NCAP) to delay the rollout of testing protocols for certain new active safety technologies. As a result, many innovative technology developers are looking to the aftermarket and retrofit space to account for the OEM interest drop.

James Hodgson, Principal Analyst

64 INTERACTIVE VIDEO WILL GROW TO DIFFERENTIATE AND TAP INTO SOCIAL BENEFITS

Interactive video is not new, but 2021 will stand out as an inflection point for this aspect of the video and entertainment market. The COVID-19 pandemic altered consumers' perception of video and Internet services. In some cases, these digital channels were the best connections available to friends and family members. This applies to real-time video communications, and features like virtual living rooms to view streaming media, which once may have been viewed as a novelty that suddenly became then new weekly hangout. Social media has also changed how content is consumed and shared.

All of these interactive features require coordination between users and, ultimately, very low latencies, bringing attention to technologies like WebRTC and SRT to enable the appropriate latency and interaction capability for video. *The content landscape continues to evolve, and video is increasingly becoming pervasive as a means of entertainment and communication, which will ultimately impact and force change in video workflows.*

Michael Inouye, Principal Analyst

65 CLOUD GAMING WILL PICK UP MOMENTUM

Cloud gaming entered a renaissance period in late 2019 when Google launched Stadia; while the market did not evaporate following past failures, a new broader cycle had started. In 2021, the cloud gaming market will pick up momentum. Microsoft xCloud entered beta in 2019 and launched to Xbox Game Pass Ultimate to subscribers in September 2020. More recently, Amazon and Facebook (stemming from an acquisition of PlayGiga) entered the cloud gaming market, offering early access for Amazon Luna and free-to-play cloud games in Facebook Gaming, respectively. Most critical is the activity from the cloud providers, which also includes cloud gaming efforts in China from Alibaba and Tencent.

The year 2021 is still about momentum, though, not seismic shifts in consumer behavior. Launches are still limited and geographically constrained, and significant work is needed to address business models, content availability, and quality of services. The demand for next-generation consoles has well outstripped the available supply during the launch window, and even NVIDIA's new GeForce RTX 30 Series GPUs have similarly seen stockouts, which are strong indicators that high-end and traditional gaming still has plenty of life left. Cloud gaming will, however, expand the gaming market to new users and, in time, as in other markets, will see a shift in compute from embedded solutions to the cloud and data centers. The year 2021 will prove to be a critical one that keeps that momentum moving forward.

Michael Inouye, Principal Analyst

VIDEO AND CLOUD SERVICES

66 **COMPANIES WILL NOT MAINTAIN SILOS AND WALLS AROUND SOCIAL, VIDEO, AND INTERNET SERVICES**

While silos around social media, video, and broader Internet marketing will not entirely collapse in 2021, there will be a significant shift away from viewing these areas as fully distinct distribution channels and market opportunities. *Advertisers and marketers are already extending campaigns across platforms, and many of the ad tech solutions seek to help with cross-platform/channel attribution and campaign management.*

Similarly, video platform providers offer solutions to help customers distribute content across media channels, including streaming media and social networks. Once devoted to specialties like social networking, marketing teams are coalescing into coordinated networks, if not multi-disciplinary teams.

These activities and consumer opt-in are becoming increasingly important as brands and advertisers adapt to privacy regulations like the General Data Protection Regulation (GDPR) and the California Consumer Privacy Act (CCPA), along with the declining use of third-party cookies. Making connections to other services like social networking allows marketers to provide more targeted ads and receive opt-in from consumers, which are two essential ingredients for digital advertising, be it search, video, or display.

Michael Inouye, Principal Analyst

67 **WI-FI 6E HAS SHOWCASED VALUE, BUT WILL BE LIMITED IN 2021**

Ever-increasing connected device density and the growing use of bandwidth-intensive applications have always driven the demand for high-efficiency Wi-Fi networks. COVID-19 has accelerated demand, as live streaming for work, education, and healthcare use cases spiked during the pandemic. Similarly, in-home entertainment use cases, such as video streaming and cloud gaming, significantly increased, forcing many homes to upgrade their Wi-Fi Customer Premises Equipment (CPE) to manage bandwidth demand.

High demand for better Wi-Fi will only grow over time as the use of high-bandwidth, low-latency applications, such as AR/VR, gaming, and 4K streaming, increase. Wi-Fi 6E, an extended Wi-Fi 6 with 6 GHz spectrum, will help meet this demand. The 6 GHz band in Wi-Fi 6E offers 1200 MHz of additional bandwidth to support larger bandwidth.

- While chipset makers Qualcomm and Celeno announced chipsets supporting Wi-Fi 6E in early 2020, and the first Wi-Fi router from ASUS is expected to be available at the end of 2020, Wi-Fi 6E adoption in residential broadband use cases will be very limited in 2021 due to two core factors:

- The 6 GHz spectrum band is not allocated for Wi-Fi use in every market yet. So far, the United States, the United Kingdom, and South Korea have released 6 GHz for unlicensed Wi-Fi use, while regulators in many other markets are still exploring 6 GHz's potential and the possibility of releasing it for Wi-Fi.

Chipset availability is limited, leading to less competition and high costs, resulting in limited CPE development. Besides, broadband service providers have only recently started upgrading their CPE with Wi-Fi 6. This means that it will take some time for service providers before rolling out Wi-Fi 6E CPE to their customers.

As a result, ABI Research expects that Wi-Fi 6E adoption will be very limited in the residential broadband market in 2021, while Wi-Fi 6 will gain significant market shares in 2021, representing 17% of residential Wi-Fi CPE market.

Khin Sandi Lynn, Industry Analyst

WI-FI, BLUETOOTH, AND WIRELESS CONNECTIVITY

68 **60 GHZ WI-FI WILL STRUGGLE IN CONSUMER DEVICE MARKETS, INSTEAD TAKING OFF IN FIXED WIRELESS ACCESS**

The consumer device market has seen limited interest in the use of 60 GHz Wi-Fi,. Companies like ASUS added the technology to previous smartphones but ultimately decided to remove it, suggesting that it was not widely used and may have caused battery drain on these devices.

While it's therefore unlikely that consumer devices with 60 GHz Wi-Fi in 2021 will ship in large numbers, players within the 60 GHz Wi-Fi market, such as Peraso, Qualcomm, Cambium Networks, Blu Wireless, Radwin, and Facebook, are now focusing their efforts on offering the unlicensed technology for fixed wireless access, backhaul, and mesh networking. It will see significant growth, particularly with the move from 802.11ad to 802.11ay. Here, the technology offers fiber-like speeds of up to 7 Gigabits per Second (Gbps), multi-gigabit performance, and low-latency line-of-sight connections on an uncongested spectrum in home and enterprise settings without the high cost, licensing, and slow deployment associated with fiber.

The technology has the added ability to reach areas where fiber cannot and provide easy-to-deploy updates, which has often been a challenge. The above companies are particularly interested in the technology now. The numbers of people working from home have increased incredibly, putting a large burden on home networks and residential broadband. In addition, unlicensed 60 GHz is currently a much lower cost solution than what cellular alternatives can provide.

However, companies within this market must be aware of the challenges of offering 60 GHz solutions, which include:

- The lack of chipsets, devices, and networks currently available, which is also leading to a lack of awareness.

- Regulators often focus more on the lower bands for Wi-Fi, which puts off further movement in the higher bands.

- The 60 GHz band provides direct links and focused beams, which can create complexity for tracking users and signals.

- The technical complexity of developing solutions in the 60 GHz band.

- A lack of interoperability.

As the technology continues to develop, these challenges will present less of a concern for companies offering 60 GHz solutions as the awareness grows, regulations and interoperability options develop, and the technical complexity decreases, allowing the technology to see great strength in the fixed wireless access market.

Stephanie Tomsett, Research Analyst

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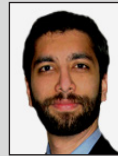
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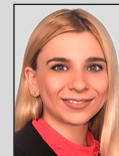
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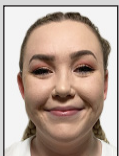
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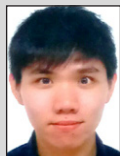
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