

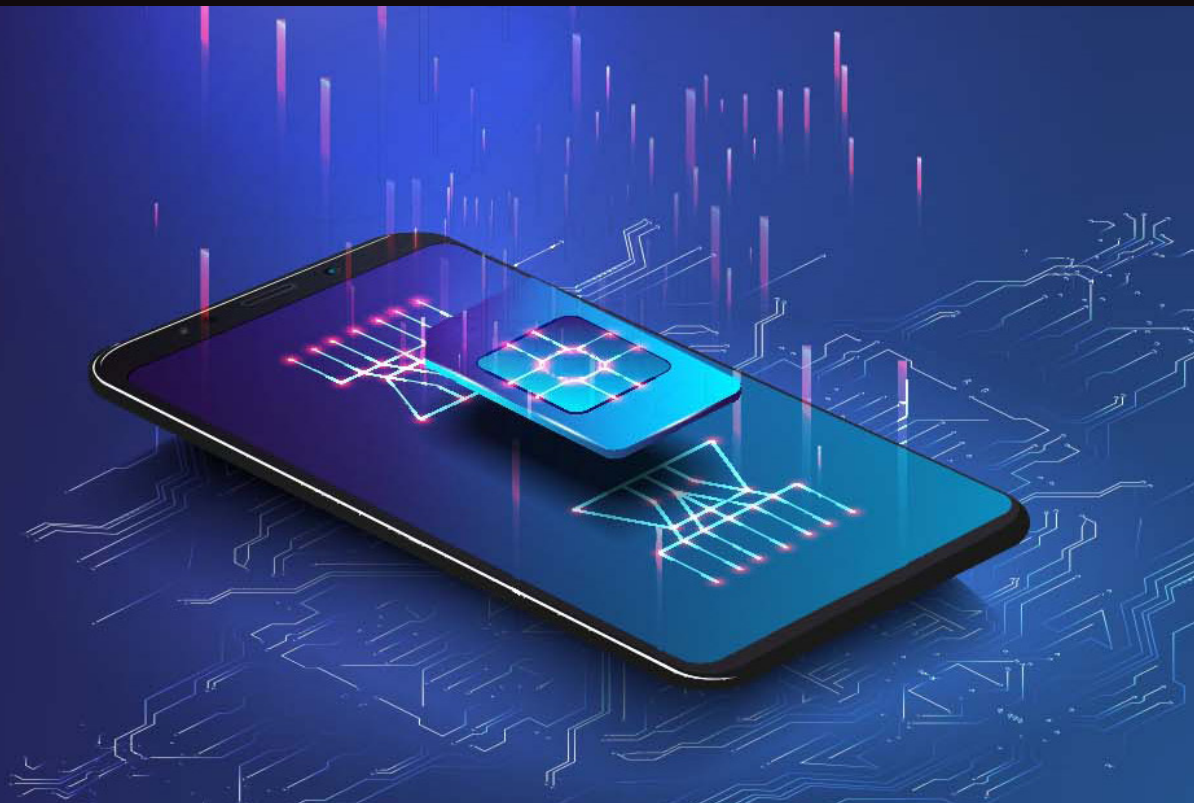
2022 EMERGING TECHNOLOGY TRENDS

MARKET AND LEGAL INSIGHTS FOR INNOVATORS



MOBILE WIRELESS TECHNOLOGY

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Smartphones are rapidly evolving to incorporate AI, GPS, biometrics, and other technologies to enable the development of new products and services, while also shaping the future direction of wireless innovation.

SECTOR OVERVIEW

What Is Mobile Wireless Technology?

Mobile wireless technology permits communication between persons, devices, or information systems in different locations by relying on radio spectrum rather than end-to-end landline connections between end users. It includes telecommunications, computing, Internet of Things (IoT), and networking technologies. Today, it is used to make consumer and commercial devices “smart” and is being deployed by business, government, and consumers to support a variety of use cases. The global rollout of fifth generation (5G) network technology is providing greater bandwidth and speed with lower latency, features that will enhance mobile performance and enable innovative applications and services. And the wireless industry is already at the beginning stages of preparing for 6G network technology, which will usher in unforeseen wireless innovations.

Associated Sectors

- Cloud Computing
- Infrastructure/Construction
- Information Services
- Healthcare
- Retail
- Finance
- Transportation
- Artificial Intelligence

Why Is It Important?

Mobile wireless technology, especially 5G mobile networks, is an essential part of the [Fourth Industrial Revolution](#), which

fuses the digital, biological, and physical dimensions of human life with developments in artificial intelligence (AI), cloud computing, robotics, and IoT. The term 5G refers to wireless technology that achieves certain high levels of speed and bandwidth and low latency (the response time for data to move from one point to another), enabling a broad range of innovative applications and services. AI and cloud technology can go farther on a 5G network. Innovation is moving rapidly, and some contours of the 6G future are already visible on the horizon.

Recent Technological Developments

The most significant developments regarding advanced wireless technologies include the millimeter wave spectrum (mmWave) and visible light communication, multiple-antenna technology (called “massive MIMO”), dense small-cell networks, network slicing, cloud-based wireless network management services, and AI for spectrum sharing.

Over the next [decade](#), technical changes could include quantum computing, decentralized networks via handheld devices, over-the-air charging, and reflective surfaces facilitating one-terabyte-per-second transfer rates. However, development and deployment of 5G are ongoing, and it is [too early](#) to tell for certain what the next generation of mobile wireless technologies will look like.

MOBILE WIRELESS TECHNOLOGY

ENABLING SCIENCE AND TECHNOLOGY

Unlocking the Spectrum: mmWave and Terahertz Spectral Bands

Millimeter wave spectrum (mmWave) sits between microwave and infrared waves and can be used for certain high-speed wireless services under certain conditions. This band is relatively uncongested, and the wavelength is shorter, meaning it can transfer greater quantities of data in less time, although it is more vulnerable to obstructions. While the technology currently operates in gigahertz frequencies, it will be extended into terahertz frequencies in the future. Terahertz usage has been proposed by the Federal Communications Commission (FCC) and is expected to be operational by 2030.

Unlocking the Spectrum: Visible Light Communication, or Light Fidelity

The visible light range of the electromagnetic spectrum is being considered to increase bandwidth, raise transfer rates, lower latency, and heighten security. Visible light communication (VLC) systems are also called light fidelity (LiFi) systems. The technology allows providers to use existing lighting infrastructure (high-speed light-emitting diodes and photodetectors) for communication. Visible light is on the terahertz spectrum and allows for greater bandwidth and faster data transmission speeds. It provides an extra layer of security because visible light cannot travel through opaque objects. This is especially useful in aircraft, medical equipment, and military zones, where security is paramount. Moreover, VLC operates on non-licensed frequencies, which is advantageous with respect to its implementation. Finally, terahertz frequencies are non-ionizing and generally considered safer than those purportedly cancer-causing ionizing frequencies higher on the spectrum, beginning with ultraviolet light. In summer 2021, the FCC determined that wireless communication technologies do not cause cancer. However, advocacy groups maintain that the FCC failed to adequately explain why its guidelines protect against the harmful effects of radiation unrelated to cancer and negative effects on sleep, memory, learning, perception, and motor abilities, and prenatal and child health.

Massive MIMO

MIMO stands for multiple-input and multiple-output. It is a method for multiplying transmission and receiving capacity through multiple radio antennas. Massive MIMO uses hundreds or thousands of antennas to support channel capacity, which increases with the number of antennas. The technology could deliver improvements in multiplexing, reduced interference, lower latency times, and higher efficiencies. It can also better mitigate intentional signal jamming, which enhances security.

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Ultra-Dense Small-Cell Networks

High-frequency bands like mmWave and terahertz spectrum have a large path loss due to atmospheric absorption and vulnerability to physical obstructions such as walls, tunnels, and trees. Operation at these frequencies therefore requires the careful placement of ultra-dense small-cell networks. In the initial years of 5G, these small cells will coexist with 4G technology. The former will cater to high-capacity users, while the latter will ensure better reliability and in-building penetration.

Wireless Time-Sensitive Networking

The Institute of Electrical and Electronic Engineers created protocols for time-sensitive networking, that is, connectivity enabled through “guaranteed packet transport with bounded

MOBILE WIRELESS TECHNOLOGY

ENABLING SCIENCE AND TECHNOLOGY (CONT'D)

latency, low packet delay variation, and low packet loss.” According to [Intel](#), achieving time-sensitive networking over wireless “has been met with skepticism” by the industry, but this is an area of ongoing research and development.

Network Slicing

[Network slicing](#) allows several virtualized networks to exist on a single physical network infrastructure. This decreases energy costs and increases [efficiency](#) because each process receives only the physical resources it needs. Resources are allocated to each service dynamically based on usage, allowing the services to [operate](#) on the same physical infrastructure.

Artificial Intelligence

AI is an essential technological component of next generation wireless systems. Simultaneous support for many devices is and will continue to be a priority in the design of 5G and 6G networks. Massive MIMO technology requires AI to model channels, manage mobility, and optimize resource allocation. Predictive analytics and scenario adaptation are central to these networks, which makes continued developments in AI processes like machine learning and deep learning an indispensable enabling technology for growth.

MOBILE WIRELESS TECHNOLOGY

SECTOR AND INDUSTRY SIGNALS

Broadband | Bipartisan Infrastructure Investment and Jobs Act

The \$1 trillion proposed Bipartisan Infrastructure Investment and Jobs Act includes \$65 billion to expand broadband internet access for millions of Americans who remain unconnected. It is expected to boost competition in areas where providers have not offered sufficient coverage. The funds will be distributed to states, and local businesses may bid on contracts. The time to complete projects will vary, but longer horizons and knowledge that the funds are available will help businesses plan. The improvements themselves will enable businesses in underserved areas to compete online across the country and increase digital equity by facilitating remote work, education, and healthcare.

Telecoms Roll Out 5G Millimeter Wave Spectrum

Some U.S. consumers currently have access to 5G technology either on the low-band spectrum, or on mmWave spectrum. AT&T offers mmWave through its 5G+ service, and Verizon

is rolling out mmWave technology as well. Qualcomm claims to have achieved a “world’s first” 5G mmWave data connection for 200MHz carrier bandwidth.

New Prospects in 5G Technology After FCC’s C-Band Spectrum Auction

The FCC’s auction of C-band frequencies in January 2021 raised \$80.9 billion. This mid-band spectrum has less vulnerability to obstructions than high-band mmWave. The C-band will complement 5G deployments, especially by applying it to the next generation of wireless time-sensitive networks.

United States Partners with South Korea to Develop 6G

In the spring of 2021, the presidents of the United States and South Korea released a joint statement declaring that the two countries would collaborate to develop 6G technologies, especially in the fields of open radio access network and

AI IS AN ESSENTIAL TECHNOLOGICAL COMPONENT OF NEXT GENERATION WIRELESS SYSTEMS. SIMULTANEOUS SUPPORT FOR MANY DEVICES IS AND WILL CONTINUE TO BE A PRIORITY IN THE DESIGN OF 5G AND 6G NETWORKS.



MOBILE WIRELESS TECHNOLOGY

SECTOR AND INDUSTRY SIGNALS (CONT'D)

quantum technology. Collaboration in the private sector began in 2020, when Samsung joined the [Next G Alliance](#), whose members include prominent U.S. firms like Microsoft, Google, Apple, and Cisco. China's Huawei was not invited, but it did set up a research and development center for 6G in Canada the year before. Critically, the United States aims to become the leader in quantum cryptography communication, a technology capable of neutralizing existing internet security systems. Business competition and national security concerns—including the impact of quantum computing on current cryptographic methods—appear to be [driving](#) this cooperation with South Korea.

Meanwhile, China launched an experimental [6G satellite](#) alongside 12 other orbital communications devices in late 2020. The satellite [uses](#) terahertz frequencies that could transmit data at speeds several times that of prevailing technology. It will also monitor crop disasters and help to prevent forest fires. Because the telecommunications industry is still years away from agreeing on 6G specifications, the trial satellite might not reflect the final standards.

LG Transfers Data Over 100 Meters on Terahertz Frequency, 6G Milestone

In the summer of 2021, LG successfully [transmitted](#) data over 100 meters outdoors using the terahertz frequency for the first time. Before August, the chief obstacle to successful communication was the band's short range and power loss during transmission. The achievement was made possible by a new power amplifier developed by LG, Fraunhofer HHI, and the Fraunhofer Institute for Applied Solid State Physics. The company also successfully demonstrated adaptive beamforming technology, which modifies the direction of the signal based on changes to the channel and receiver position.

Advances in Smartphone Technology Driving New Wireless Services and Innovation

Smartphones are rapidly evolving to incorporate AI, GPS, biometrics, and other technologies to enable the development

of new products and services, while also shaping the future direction of wireless innovation. AI-based services, such as Google Assistant, are ubiquitous and continue to evolve, while uses of GPS technology go beyond ride sharing and navigation services to mobile apps that can deliver customized and targeted support services. AI and GPS are being deployed for augmented reality services and games like Pokémon GO, which has surpassed [one billion downloads](#). Smartphones are increasingly being synched with wearable and home devices as well. Uses range from healthcare to air conditioning and dynamic LED lighting. They are also being linked to smart cars (see below). Electric bike and scooter services, such as Lime, use the technology to make finding and renting vehicles easier. Biometrics are being used for device access and online banking, while real-time payment technologies have revolutionized business-customer relations.

Smart Cars, Autonomous Vehicles, and the Future of Mobility

Smart cars and autonomous vehicles can gather and process data in real time. Advances in wireless technology are enabling new services and will eventually provide the foundation for the mobility sector. Information collected from the road helps prevent accidents and smooth the flow of traffic, while on the horizon 3D technology will allow users to control parts of their car like windows, air conditioning, and entertainment systems using gestures. Smartwatches are already being synched to cars, allowing users to lock or unlock doors, turn headlights on or off, and beep horns. Synching to smart devices also allows users to locate their vehicle or call roadside assistance. Beyond improvements for user-friendliness, the capabilities of smart cars and autonomous vehicles are growing at a rate that is transforming the transportation sector. More information is available in the Robotics & Autonomous Systems section of this report.

MOBILE WIRELESS TECHNOLOGY

IMPACT

Economic

New wireless technologies will deliver substantial economic benefits—the deployment of 5G technology alone is expected to contribute between \$400 and \$500 billion to the U.S. gross domestic product (GDP) directly and create up to a million jobs by 2030, representing merely 30% of the total value potential of the technology's implementation, according to Boston Consulting Group (BCG).

Building out broadband internet access is a pillar of the Biden administration's [infrastructure investment](#) initiative. Federal funding can facilitate a faster and more widely distributed build-out nationally, creating new economic opportunities for underserved areas and advancing access to greater health and educational resources.

The indirect economic impact of further developments in wireless technology is [expected](#) to be wide-ranging and affect almost every sector of the economy as the technology is adopted and used to solve productivity problems. BCG estimates

that the indirect benefits attributable to the introduction of 5G technology could create 3.6 million jobs by 2030 and add up to \$1.2 trillion to U.S. GDP, representing 70% of the total value potential of the technology.

Social

Ongoing [developments](#) in mobile wireless technology have far-reaching social implications. Terahertz frequencies, edge computing, satellites, and the cloud are likely to affect online education, remote work, precision agriculture, transportation, and smart [implants](#). For example, online education and remote work are being powered by mobile hotspots, improved bandwidth, and cloud computing. These same technologies are transforming the agricultural sector, where wireless, edge computing, and satellite technology make possible real-time data streaming and precision agriculture. These developments help to increase crop production, manage water scarcity, and reduce waste by more tightly integrating supply chains.



THE \$1 TRILLION BIPARTISAN INFRASTRUCTURE INVESTMENT AND JOBS ACT INCLUDES \$65 BILLION TO EXPAND BROADBAND INTERNET ACCESS FOR MILLIONS OF AMERICANS WHO REMAIN UNCONNECTED.

MOBILE WIRELESS TECHNOLOGY

IMPACT (CONT'D)

Environmental

Some cities are deploying cloud, IoT, edge computing and wireless technologies to improve transportation and reduce emissions. One city in Portugal set up a cloud-based command center that improved municipal services and reduced energy costs. It was most successful in waste management, where it cut operational costs by 40% and energy costs by 20%. Many other cities can deploy similar infrastructure, to improve the safety and efficiency of their services while reducing their carbon footprint. It's unnecessary to use the fastest wireless networks to create "smart cities," but lower latencies can be useful for devices that rely on real-time data, particularly emergency shut offs.

The industry is seeking ways to mitigate environmental challenges associated with the rollout of new wireless technology, including greater levels of e-waste, higher energy consumption, and the increased demand for materials sourced through intensive mining. Finally, study is ongoing regarding how greater use of the electromagnetic spectrum might affect animals that use the earth's magnetic field to navigate in space, such as bees and birds.

Policy

Beyond the economic investments in the federal government's infrastructure plan, the development and deployment of

advanced wireless technologies have triggered national security and trade policy responses from the U.S. government and internationally. The U.S. Secure 5G and Beyond Act of 2020 requires the development of a national strategy to protect next-generation wireless technologies and infrastructure. The National Telecommunications and Information Administration has been tasked with developing the Implementation Plan for the National Strategy to Secure 5G. It identified four lines of effort: (1) facilitating the rollout of 5G in the United States; (2) identifying and addressing cybersecurity risks related to 5G infrastructure; (3) assessing and addressing risks to U.S. economic and national security as 5G infrastructure is deployed globally; and (4) encouraging the responsible development and distribution of secure infrastructure.

Government leaders in the United States are also looking beyond 5G. The U.S. Office of Naval Research, the U.S. Air Force Office of Scientific Research, and the U.S. Army Research Office are helping Princeton University researchers unlock the terahertz band, which the U.S. Department of Defense has identified as a "critical strategical technology" that could aid military communication, improve virtual and augmented reality for troops, and facilitate the deployment of autonomous vehicles. The United States is also partnering in wireless with world leaders, including South Korea, to develop technologies to contain China's growing influence.

MOBILE WIRELESS TECHNOLOGY

LEGAL IMPLICATIONS

OUTLOOK

Cybersecurity | SolarWinds Hack Highlights Vulnerability of US Software Supply Chain

The 2020 cyberattack on [SolarWinds](#) was a wake-up call for U.S. Cyber Command and the broader cybersecurity industry. The successful breach of a company that provides infrastructure management software affected thousands of its clients, including the Pentagon and the U.S. Department of Homeland Security, among others. The code gave hackers a back door into client systems, allowing them to install malware. The extent of the breach is unknown, and its resolution could take [years](#). The event highlighted the increased risks associated with converging technologies and an extended [software supply chain](#), and brought to the forefront the importance of vendor security management.

Cybersecurity | Executive Order on Cybersecurity Signals More Uniform Approach

In May 2021, President Biden issued an [Executive Order on Improving the Nation's Cybersecurity](#). The EO comes in response to increasingly sophisticated cyberattacks that threaten both private and public sectors. It identifies the prevention, detection, assessment, and remediation of cyberattacks as a top priority for the nation's security and prosperity. The move [signals](#) that the administration seeks to strengthen—and standardize—cybersecurity protections across the government and intends to move away from agency-specific policies in favor of a uniform approach with expanded participation from industry.

Specifically, the order aims to (1) remove barriers to sharing threat information; (2) modernize federal government cybersecurity; (3) enhance software supply chain security; (4) establish a cyber safety review board; (5) standardize the federal response to cybersecurity vulnerabilities and incidents; (6) improve the detection of vulnerabilities and incidents in federal government networks; (7) improve federal investigative

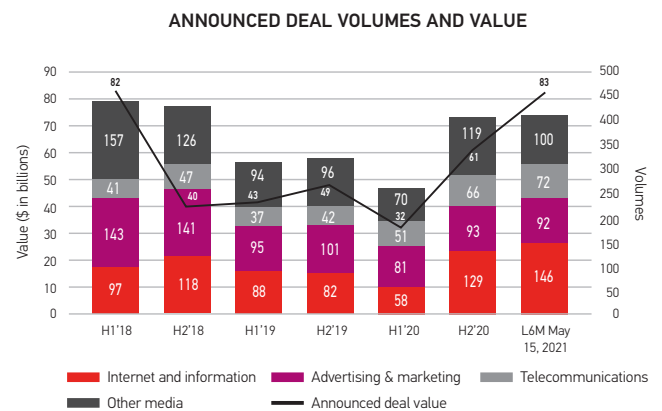
and remediation capabilities; and (8) require the Secretary of Defense to adopt National Security Systems requirements equivalent to or exceeding those set out in the EO.

Cybersecurity | Senators Introduce Cyber Incident Notification Act

A bipartisan group of senators introduced the [Cyber Incident Notification Act of 2021](#). The bill would require critical infrastructure operators, government agencies, and contractors to report cybersecurity breaches to the Cybersecurity and Infrastructure Security Agency within 24 hours of detection. The legislation comes in response to the SolarWinds and Colonial Pipeline hacks that underscored the importance of information sharing to national security.

M&A | Dealmaking Set to Return to Pre-Pandemic Levels, but Long-Term Trends Show Decline

From one perspective, dealmaking in media and telecommunications began to recover in H2 2020, and momentum continued in H1 2021. [Globally](#), there have been around 410 deals and \$83 billion of announced deal value in H1 2021.

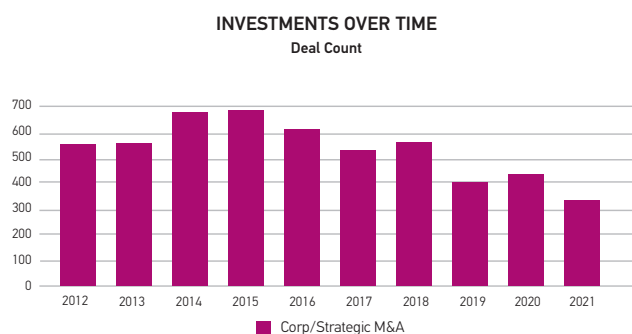


Source: PwC Analysis

MOBILE WIRELESS TECHNOLOGY

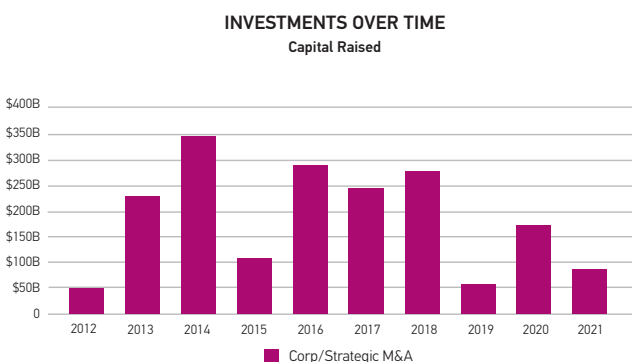
LEGAL IMPLICATIONS (CONT'D)

From another perspective, PitchBook data reveals a long-term trend of declining M&A in the Communications and Networking vertical. The following chart shows dealmaking in 2021 on track to reach 2020 levels, but M&A activity has declined almost continuously since 2015:



Source: PitchBook Companies & Deals Search (Accessed on September 30, 2021)

In terms of capital raised, the sector has seen a lot of variation over the same period, but there is a general downward trend since 2014:



Source: PitchBook Companies & Deals Search (Accessed on September 30, 2021)

One explanation for the significant variation in deal value is the impact of megadeals. The media and telecommunications sector produced several megadeals in recent years, and the trend appears to be continuing.

As noted below, however, future deals may face increased scrutiny from the [FCC](#) and the Federal Trade Commission (FTC) as the Biden administration prioritizes national security and antitrust considerations—potentially slowing or restricting M&A approvals.

Antitrust and Consumer Protection | New Executive Order Targets Big Broadband Providers

In July 2021, President Biden issued his [Executive Order on Promoting Competition in the American Economy](#), targeting broadband service and calling for additional protections for subscribers of broadband services by restricting anticompetitive practices in the industry. The order encourages the FCC and FTC to consider rulemakings that would carry out these objectives:

1. Reviving protections for net neutrality, preventing companies from slowing internet content
2. Preventing the undue concentration of spectrum license holdings
3. Supporting the deployment of 5G Open Radio Access Network protocols and software
4. Prohibiting unfair early termination fees for subscription contracts
5. Requiring providers to furnish a consumer label with reliable information about their services
6. Requiring providers to report broadband price and subscription rates to the FCC
7. Preventing landlords and service providers from hindering tenants from changing providers
8. Preventing consumer device manufacturers from interfering with consumers' "right to repair" their own devices

Agency rulemakings can take a year or more to finalize and may evolve along the way. They are also subject to court review. It is unclear whether all these initiatives will become final regulations.

MOBILE WIRELESS TECHNOLOGY

LEGAL IMPLICATIONS (CONT'D)

Antitrust | FTC's Defeated Suit Against Qualcomm Highlights Importance of National Security

A federal appeals court threw out an antitrust verdict against Qualcomm in 2020. The FTC had sued the chip manufacturer in 2017 for monopolistic pricing, denying licenses to its competitors, and blocking them from selling to Apple. Two years later, a federal judge found Qualcomm's behavior to conflict with the Sherman Antitrust Act and directed the firm to renegotiate license deals with its customers. The case was finally settled in Qualcomm's favor in summer 2020, but the reasons for its divisiveness warrant consideration. While the FTC and companies like Apple and Huawei supported the original ruling, the U.S. Department of Justice and telecom firms like Ericsson opposed it. Many of Qualcomm's supporters raised concerns about the ruling's national security implications. The company is the country's leading source of telecommunications chips, which enable drones, smart munitions, and the command of troops, among other military functions.

M&A | Committee on Foreign Investment in the United States and National Security

Apple, Microsoft, Amazon, Alphabet, and Facebook are among the top six publicly traded firms worldwide by market cap and are critically important to the United States and its place in the world. The ninth is China's Tencent. U.S. policymakers have raised concerns over the future of the country's technological leadership, especially as Chinese investment in U.S. high-tech companies continues to grow. In 2020, amendments to the process followed by the Committee on Foreign Investment in the United States (CFIUS) were finalized and went into effect. The updated process upholds the president's authority to prohibit or delay foreign mergers and acquisitions that threaten national security. Some changes include increasing the time allowed for government officials to review investment declarations, analyzing the potential impact of real estate transactions close to property critical to national security, evaluating noncontrolling investment in critical

technology and infrastructure businesses, and discriminating among foreign investors by country of origin and transactions tied to certain countries.

The United States also seeks to counter China's influence through infrastructure investments abroad, including telecommunications. The federal government recently dedicated \$60 billion for that purpose. The program is led by the International Development Finance Corporation (DFC). Beyond ports and other strategic assets, the DFC seeks to encourage private-sector investment abroad by both American firms and those of its allies in cell networks.

M&A | Team Telecom, National Security, and Foreign Investment in the United States

Team Telecom is a committee of executive branch agencies responsible for, among other things, assessing the national security implications of transactions involving foreign investment in American telecommunications firms. In 2020, its review process was streamlined, and for the first time, reviews must occur within FCC-mandated time frames. Standard mitigation occurs within these time frames and involves investors who are regular participants in the telecom market, while nonstandard mitigation requires additional time and involves a unique risk profile. Team Telecom will continue to review existing FCC authorizations and recommend revoking them where appropriate. The establishment of review time frames and input from CFIUS is expected to improve alignment between Team Telecom and the U.S. intelligence community.

Regulatory | FCC Rejects Dish's Attempt to Deny C-Band Licenses to T-Mobile and Verizon

In July 2021, the FCC denied Dish Network's bid to prevent its mobile wireless carrier competitors T-Mobile and Verizon from acquiring C-band licenses. According to the FCC, the licenses won by the companies do not exceed spectrum-aggregation limitations. The agency determined that the expansion of 5G services into this band would not significantly shrink the

MOBILE WIRELESS TECHNOLOGY

LEGAL IMPLICATIONS (CONT'D)

number of wireless businesses or consumers in local markets, nor would it lead to a single carrier controlling more than one-third of the spectrum allocated in the United States for commercial wireless use. The move puts an end to around three years of pushback against the spectrum auction.

LITIGATION DEVELOPMENTS

Self-Regulatory Process | Telcos Occasionally Solve Disputes Through BBB National Programs

BBB National Programs delivers self-regulatory and dispute resolution forums, several of which relate to advertising. The National Advertising Division (NAD) reviews national advertising in all media, and the National Advertising Review Board (NARB) is its appellate body. A review of NAD/NARB decisions shows U.S. telecommunications companies occasionally resort to the self-regulatory process. Over the last year, disputes have primarily centered on 5G rollout claims, network reliability claims and network speed claims. Complaints are typically filed by competitors, over the truthfulness of claims related to their rivals' networks, or on the truthfulness of claims disparaging their own networks.

PATENT TRENDS AND OUTLOOK

Chinese State Strengthens Protections for Patent Holders Amid Telecommunications Boom

China's economy stabilized over the last year and picked up steam, especially in 5G telecommunications investment. Complementing these developments in the economy, the Chinese state has initiated several legislative actions aimed at regulating foreign investment in the country. In October 2020, China passed its highly anticipated fourth amendment to the Patent Law of the People's Republic of China, which took effect on June 1, 2021. The amendment involves over two dozen articles affecting rights and procedures regarding the acquisition and protection of patents. The amendment seeks to strengthen Chinese patent law, augmenting the rights of applicants and patent holders, including a wider scope and term for patents and greater compensation for infringement. The amendment is designed to better defend the interests of patent applicants and holders.

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ABOUT US

Technology Transactions & Privacy | Mobile Wireless Technology

With one of the leading groups in the industry, our Technology Transactions & Privacy attorneys possess decades of experience with laws and regulations critical to the communications sector. We maintain productive relationships with key federal agencies including the Federal Communications Commission and Federal Trade Commission, handling traditional proceedings, as well as developing and implementing innovative legal and public policy strategies. Our clients include wireless telecom companies, disruptive connected device manufacturers, and leading and emerging technology companies for whom we serve as product counsel.

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MARKET AND LEGAL INSIGHTS FOR INNOVATORS

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