



How Licensed Spectrum Fuels U.S. Competitiveness

**MORE LICENSED, FULL-POWER SPECTRUM FOR COMMERCIAL
5G USE WILL HELP U.S. FIRMS COMPETE ON THE GLOBAL STAGE**

Table of Contents

Executive Summary 3

Competitiveness Defined 4

The Wireless Industry's Role in Advancing U.S. Competitiveness 4

The Wireless Industry Advances U.S. Competitiveness Directly 6

Wireless Innovation Fuels U.S. Competitiveness Throughout the Economy 8

Rivals Are Seeking to Gain the 5G Competitiveness Edge 14

How Spectrum Policy Can Advance U.S. Competitiveness 16

Conclusion 18

Executive Summary

The wireless industry is a force multiplier for U.S. economic competitiveness. By providing advanced connectivity, wireless fuels innovation and productivity throughout our economy—boosting domestic economic growth and enhancing industries' abilities to compete globally. Licensed spectrum is the critical limiting input to continual improvements to our nation's wireless services, meaning more licensed, full-power commercial spectrum will allow the wireless industry to continue its outsized role in strengthening the U.S. economy and securing America's future prosperity.

Licensed spectrum has a long history of powering innovation and productivity gains throughout the economy. The mobile revolution enabled by 4G LTE networks demonstrates the tremendous opportunity for wireless networks to fuel American competitiveness.

Advanced 5G platforms are poised to make U.S. firms even more competitive, provided that those networks have sufficient spectrum.

Other countries see this opportunity and are making significantly more spectrum available for 5G, jeopardizing the future competitive advantage of U.S. firms.

To ensure continued wireless-enabled productivity gains throughout the U.S. economy, more licensed, full-power, mid-band spectrum must be made available for commercial use.

As CTIA detailed last year in its report, "The State of 5G: Evaluating Progress and Charting the Path Forward," 5G is here, and it is off to a great start. 5G networks have been widely deployed and are available throughout the United States. Today, the wireless industry adds \$825 billion in GDP annually and nearly 4.5 million jobs to the American economy.¹

But the best is yet to come—the most advanced applications that can take advantage of the full capabilities of 5G networks, like precision robotics or advanced manufacturing guided by digital twins, require significant R&D and integration with existing production processes. As these use cases continue to come online, 5G will drive advances in productivity that make U.S. firms more effective, ultimately driving down costs for consumers, growing jobs, and enhancing American prosperity. 5G networks themselves also continue to evolve and improve—operators are transitioning to more advanced 5G networks as they are developed and deploying recent 5G updates designed for specific use-cases.²

U.S. economic competitiveness takes on added salience when considering our rivalry with autocratic nations like Russia and China. China in particular is aggressively directing its state-owned firms and national champions to integrate 5G technology over licensed spectrum into key strategic sectors like manufacturing in an effort to boost its economic competitiveness. It is critical the United States has the policies in place to counter this threat. Unfortunately, as of this writing, this is not the case. Congress has allowed the FCC's auction authority to lapse for the first time in its over 30-year history and the country is without a clear pipeline of additional mid-band spectrum for licensed use.

Cutting-edge wireless connectivity grows our economy and makes key sectors more competitive. Without additional spectrum, U.S. networks will inevitably lag those deployed in other nations, giving our competitors the advantage in developing the wireless innovations of tomorrow. By making more full-power, licensed mid-band spectrum available for the commercial sector in the U.S., policymakers can ensure the wireless industry has the tools to continue serving America's innovators and advancing U.S. competitiveness.

Competitiveness Defined

The concept of competitiveness gets at the ability of a nation's economic actors to succeed on the global stage and how well one country's firms can compete internationally to provide traded goods and services.

One key component of a nation's competitiveness is its productivity level.⁴ Growing productivity means a nation's economy can produce more output with fewer inputs—which, in the long run, drives economic growth and rising income levels. Another interrelated factor is innovation.⁵ New technologies power continual improvement in the production of goods or provision of services, and also allow for disruptive leaps forward that can develop whole new markets. This type of dynamic innovation is typical of the wireless sector and the industries it enables.

Innovation and productivity are the key considerations establishing a nation's competitiveness.⁶ Another dimension of competitiveness is the focus on a nation's traded sectors. Competitiveness is concerned with how gains from international trade flow among countries. While wireless supports productivity and innovation throughout the economy, this paper primarily examines its impact on export-focused sectors. The productivity of traded sectors takes on particular importance when considering our economic rivalry with other countries.

The Wireless Industry's Role in Advancing U.S. Competitiveness

Connectivity, combined with the accessible software development and monetization platforms within smartphone operating environments, drove an explosion of innovation over the last decade. The 4G mobile revolution enabled breakthroughs like ridesharing and other dynamic, demand-driven use cases. 5G, with its enhanced capabilities, offers faster, more responsive connectivity that can be tailored to specific applications. These capabilities only deepen 5G's promise for both sustainable and dynamic innovation. Bottom-up entrepreneurship like that enabled by wireless networks has long been a cornerstone of the American success story and is a key factor in the competitive edge enjoyed to date.

Unfortunately, U.S. wireless providers face a looming spectrum crunch, without enough licensed mid-band spectrum to keep up with anticipated user demand. Researchers estimate that by 2027, U.S. operators will need an additional 400 megahertz of full-power licensed mid-band spectrum, even accounting for

optimistic growth in infrastructure, spectral efficiency, and Wi-Fi offload.⁷ This deficit swells to nearly 1500 megahertz by 2032.⁸

Policies to support 5G and wireless connectivity generally have long enjoyed bipartisan support, and for good reason—wireless is a force multiplier for economic growth, enabling innovation across industrial sectors. As Boston Consulting Group, in studying the role 5G plays in amplifying the U.S. economy, summarized, 5G will “deliver significant socioeconomic benefits through higher productivity, improved cost competitiveness, and better health and safety.”⁹

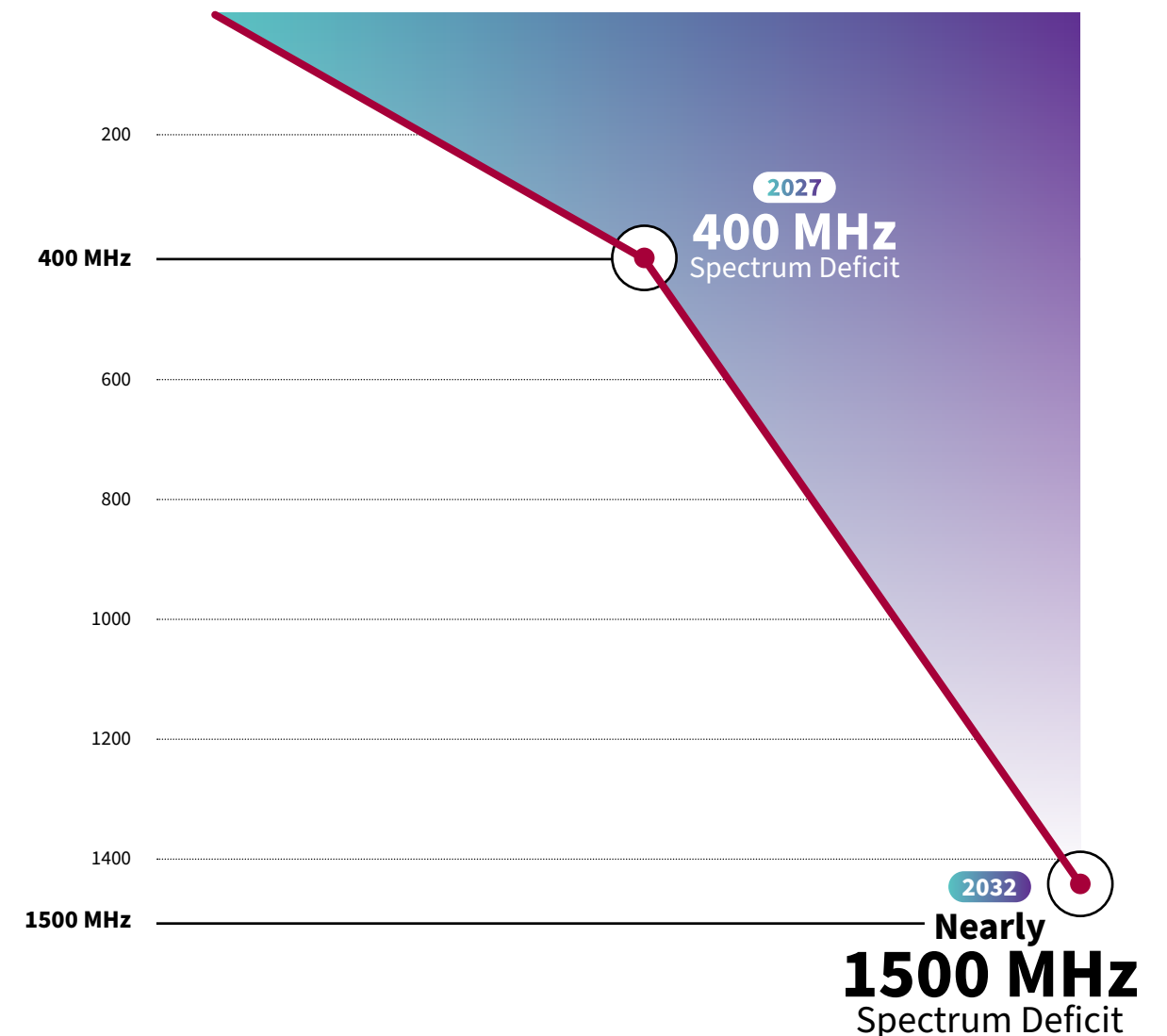
The wireless industry advances U.S. competitiveness both directly and indirectly. In other words, wireless connectivity is a critical innovation-enhancing input that boosts productivity across several key traded sectors, while constitutive parts of the wireless industry, like equipment, components, chips, devices, and software, are also themselves exported around the world.



“History makes clear that countries with the best communications have the highest economic growth, and a distinct competitive advantage. 5G will play a major part in continuing our nation's leadership.”

SENATOR (THEN REP.) MARSHA BLACKBURN (R-TN)³

GROWING SPECTRUM DEFICIT



The Wireless Industry Advances U.S. Competitiveness Directly

Today, many of America's most successful firms depend in part on wireless connectivity, particularly for the firms that participate in the wireless ecosystem. Various firms supply everything from physical layer components for networking equipment, devices like handsets and tablets, mobile operating systems and software, various chips, as well as foundational intellectual property underlying wireless communications. All of these technologies support and benefit from each other, driving the success of the wireless sector. Many of these components are themselves traded internationally, bringing economic growth back to American soil.

At the center of the U.S. wireless ecosystem are the 5G providers who source a wide range of inputs to build and operate networks, offering service to consumers and enterprises.

These world-leading investments generate a tremendous economic impact. Researchers estimate the wireless industry contributes over \$825 billion to the U.S. GDP every year and nearly 4.5 million jobs to the American economy.¹¹ This analysis only considers the direct impact of the wireless industry value chain and adjacent markets. It does not take into account the contributions made by other sectors that also depend on and use wireless services, which could well represent hundreds of billions in additional gross output and GDP, as well as millions of jobs.

Wireless is a big demand driver for high-performance semiconductors. Chips have received significant attention for their role in U.S. competitiveness. Communications equipment and devices are the top driver of global semiconductor sales, a significant portion of which are attributable to consumer smartphones.¹² U.S. companies like Qualcomm are leaders in high-performance baseband chips that power wireless communications. A healthy U.S. 5G ecosystem makes for a stronger U.S. semiconductor industry.

Similarly, smartphones and the software that run them are a huge American success story, in no small part thanks to the early lead the United States held in robust 4G LTE networks. U.S. firms enjoy over 25 percent of global handset market share and dominate smartphone operating systems worldwide.¹³

The United States is also a significant player in development of the intellectual property underlying wireless communications. With this IP, U.S. firms are major contributors to wireless communications standards, which are then used around the world.¹⁴

Strong 5G and 6G networks with sufficient spectrum will be key to the continuing success of U.S. firms in adjacent markets similar to that during the 4G era. Researchers estimate the global 5G value chain, including network operators, providers of underlying technology and components, device and equipment manufacturers, and 5G application developers, will contribute \$3.6 trillion in economic output by 2035.¹⁵ The downstream effects will be substantially larger at \$13.2 trillion.¹⁶

Policymakers should seek to ensure the U.S. 5G ecosystem has the needed resources such that those economic gains flow to the United States. Thankfully there is an effective policy lever to secure the performance and influence of domestic 5G networks relative to the rest of the world—making additional spectrum available for commercial use. Licensing spectrum lets loose the highly competitive wireless industry to wring as much output as possible from limited airwaves, amplifying the U.S. wireless value chain and its downstream impact throughout the economy.



“While many new technologies will be important for the future economy—artificial intelligence (AI), robotics, cloud computing, Open Radio Access Networks (ORAN), and biotechnology will create the future economy, all of these will depend on digitalization, beginning with 5G wireless networks. This makes progress in 5G networks a strategic issue for the United States.”

JAMES LEWIS

Center for Strategic and International Studies (CSIS)¹⁷



\$54B

Average annual investment (2020-2022) in U.S. economy of the five publicly-traded mobile providers¹⁰



\$591B

Total capex of largest five wireless providers (2011-2022)

Wireless Innovation Fuels U.S. Competitiveness Throughout the Economy

The wireless industry is a tremendous engine of innovation, advancing productivity and making key sectors more competitive on the global stage. The advanced capabilities of 5G (especially in the enterprise space) promise a deepening integration of wireless networks with production processes throughout the economy, enabling a flywheel of innovation that will boost productivity and growth. With the growing digitization of economic production over recent decades, the connectivity that enables the flow of large amounts of information has an outsized role in advancing cutting-edge innovation.

A significant component of this economic potential comes from efficiency-driving insights from Internet of Things (IoT) deployments. As Boston Consulting Group explains, “5G-enabled IoT use cases, such as connected vehicles, smart cities, and Industry 4.0, could fundamentally transform industries and drive U.S. competitive advantage in the 2020s.”¹⁸ More spectrum will ensure 5G networks have the capacity to support a deeper integration of IoT sensors and devices to further enhance use cases across industries.

Several other efficiency-enhancing technologies depend on 5G’s ability to aggregate data and provide integrated computation at the edge of the network, allowing for real-time feedback systems with little delay. For example, high-quality augmented reality depends on AI-driven models to make sense of camera inputs and dynamically integrate its display with the user’s field of view. 5G allows for this interaction to occur in real-time, enhancing the AR experience. 5G also allows for easy management of far-flung systems onto a single platform, helping to streamline distributed supply chains—warehouse logistics compiled by 5G can be integrated with a smart factory across town (or across the world), for example.

5G enables flexible aggregation of actionable data, driving breakthroughs in education, healthcare, transportation, and beyond. These gains take on particular importance when considering traded sectors, where if U.S. firms do not win export deals, another country’s firm will. Making more full-power, mid-band spectrum available for commercial licenses will help secure our nation’s competitive edge.



“U.S. competitiveness depends on the nation’s ability to provide leading wireless communications networks and innovative applications and uses that enhance consumers’ lives and improve business efficiencies.”

BOSTON CONSULTING GROUP¹⁹



“To have a global, enterprise-wide view, we need a single communication pipe that is everywhere. That is where the power of 5G comes in... 5G allows us to make little things in the buildings, the facilities, and in the supply chain act like a system of systems. It gives us much [more] lower granular level of insights than we can achieve today.”

USMAN SHUJA
Honeywell Chief Commercial Officer²⁰



\$825B
contributed to U.S. GDP annually

MANUFACTURING, MACHINERY, AND EQUIPMENT

The U.S. has long been a manufacturing powerhouse, but twin challenges have seen the U.S. lose ground over recent decades: other countries’ use of innovative technologies to increase productivity, as well as highly competitive production in other nations with lower costs of doing business. China, for example, is now the world’s leading exporter of goods, with the United States as the top purchaser.²¹ Increasing U.S. manufacturing productivity—squeezing more from each dollar invested—is essential to making American manufacturing more globally competitive, and how to do this is a key consideration for policymakers who are looking to encourage manufacturers to produce more goods in America.

Wireless networks are helping these efforts by connecting all elements of the manufacturing process, making production lines more responsive to demand and allowing manufacturers to start and stop production quickly, scale it up or down, and use machinery and factory space more efficiently and safely.

The Manufacturing Institute surveyed manufacturing leaders on the impact of 5G on their business, finding manufacturers believe 5G can help lower costs by an estimated average of 38%, while increasing machine productivity by an estimated 42% and workforce productivity by 41%. Bottom line, 5G will have a significant impact on profitability and productivity industry wide.²² This productivity impact comes from many 5G applications, such as smart factory connectivity, real-time insights from digital twins, and enhanced training and maintenance capabilities.



4.5M
American jobs enabled by
the wireless industry

Connecting systems and equipment across a factory provides immense amounts of data that manufacturers can use to continually assess the health of equipment and schedule proactive maintenance, understand energy and water consumption to identify areas ripe for savings, improve training and employee safety, and power autonomous vehicles across the factory floor. Such wide-scale information processing is part of the Industry 4.0 movement, and wireless networks are well-suited to provide the needed connectivity to make this possible, including through the creation of private networks that meet the specific needs of the plant or manufacturer.

In North Carolina, fiber-optic company Corning and Verizon worked together to create a 5G-powered, connected factory environment that takes advantage of edge-computing capabilities to process data quickly at the source. For example, “during the fiber-optic cable production process, cameras capture images of the cable as it is created and spooled; those images are transmitted via Verizon’s 5G network to computers that analyze the images to detect anomalies that can indicate a defect.”²³ 5G is helping make significant gains in this process: “Previously—before the capabilities enabled by 5G—it would take valuable time to identify and verify any anomalies so that action could be taken. Those images can now be analyzed and classified in real time. The machine learning algorithm can then provide an automatic notification to workers if a defect is detected.”²⁴



“5G’s capabilities can enable a number of digital twins use cases that depend on the efficient and reliable movement of vast quantities of data. 5G could amplify the business case for digital twins.”

STL PARTNERS²⁵

What’s more, wireless firms themselves are participating in returning manufacturing capacity to the United States, with key wireless vendors investing in U.S. manufacturing plants.²⁶ In Lewisville, Texas, Ericsson’s USA 5G Smart Factory is exploring the future of manufacturing for 5G radios and other network elements.²⁷ This 5G-connected production facility is demonstrating capabilities like digital materials tracking, automated plant procedures, and environmental monitoring. The Smart Factory’s autonomous mobile robots carry heavy radios across the manufacturing facility, receiving their instructions via 5G connectivity. This is both an efficient process and one that improves worker safety.

A skilled and effective workforce improves manufacturing productivity. Wireless networks can help connect staff to external experts or technical guidance through augmented reality (AR) applications that overlay specific instructions onto equipment. AR can also help train new staff through realistic and reactive scenarios.

For example, Seattle-based Taqtile is leveraging 5G’s advanced capabilities in its Manifest software—a cutting-edge AR and mixed reality work-instruction platform designed to transform frontline and deskless work, including in the manufacturing industry. AR headsets equipped with Manifest software can enable manufacturing workers to remotely perform machine maintenance, virtually view service checklists and more. 5G powers the fast responses necessary for a realistic experience.

A digital twin is an accurate, virtualized model of a process, equipment, or product. Creating a digital twin allows a manufacturer to run tests that assess the impacts of changes on their processes, equipment, and products in realistic conditions, without having to reorient their factory or waste resources. 5G networks powered by licensed spectrum provide the high throughput needed to manage the large number of sensors and immense amounts of data digital twins require, along with the low latency to process and react to inputs to the digital twin system in real time, which is essential for mimicking realistic responses.

AGRICULTURE

U.S. agricultural competitiveness is a complex topic, impacted by international trade agreements, exchange rates and monetary policy, weather, conflict, and more. Research finds the U.S. “has historically been one of the largest exporters of agricultural crops in terms of volume and value. In recent decades, increased competition from countries, such as Argentina and Brazil, have threatened the current U.S. standing in the global arena.”²⁸

Wireless networks can make the agriculture industry more productive, which can help the nation’s agricultural competitiveness. 5G’s fast speeds, high capacity and low latency enable precise applications of water and fertilizer, which saves money and resources. For example, startup company Trellis is helping family farmers grow more with less water. Using 5G-powered soil sensors, farmers can more accurately irrigate their crops. Trellis helped one Georgia farmer save 7 inches of rainwater over the course of a season—equal to nearly 38 million gallons of water for an average 200-acre farm.

5G can also connect sensors that provide information about equipment and maintenance needs, and help farmers collect, process, and react to data in just minutes, saving them precious time and trips to and from the fields. 5G connected drones can inspect crops and identify potential nutrient deficiencies. 5G networks, powered by licensed spectrum, offer wide-area coverage, making wireless key to providing connectivity over large swaths of low-density farmland. Other network types, like those built on CBRS or unlicensed spectrum allocations, can’t provide this kind of wide-area coverage.



20%

5G will help the U.S. meet 20% of its emission-reduction goals by 2025



“As 5G technology becomes increasingly pervasive ... the life science industry will increasingly invest in this technology... to explore newer terrain, such as telepathology, smart factories, intelligent supply chain, and digital twins. The promise of widely available high-bandwidth, high-reliability edge computing and expansive network capability that 5G has to offer is a game changer for pharma, biotechs, and medical device companies,”

DR. NIMITA LIMAYE
Research VP, Life Sciences R&D
Strategy and Technology at IDC.²⁹



“Many of our partners are planning to implement 5G on their manufacturing sites and see a great potential in having this technology in place. It will help the companies to become more competitive and profitable.”

THOMAS BERGS
Managing Director of the Fraunhofer
Institute for Production Technology

PHARMACEUTICALS, HEALTHCARE, AND LIFE SCIENCES

Life sciences and pharmaceuticals are a key traded sector poised to benefit from 5G. According to medical researchers, the “development of fifth generation wireless networks,” along with the attendant ecosystem of AI, machine learning, and connected IoT devices, “have created an extraordinary opportunity to create an integrated ecosystem for new opportunities in healthcare and other industries... [that] could potentially address some of the most urgent challenges facing health service providers and policy makers, including universal, equitable, sustainable healthcare service.”³⁰

These gains are seen through a wide range of applications, such as telemedicine, wireless hospital equipment, and enhanced diagnostics. The physical production of pharmaceuticals and medical devices are benefiting from many of the same advances being incorporated in the manufacturing environment. But 5G can also help with one of the most costly and challenging aspects of drug development—clinical trials.

According to the pharmaceutical industry, it takes 10-15 years and costs \$2.6 billion on average to develop one successful new medicine, with only 12 percent of new drugs entering clinical trials receiving FDA approval.³¹ Connected digital technology is helping to streamline this process through decentralized clinical trials (DCTs). 5G allows for safe, accurate, and expedient collection of medical data with a lower burden on participants. 5G-connected DCTs can increase participation rates and significantly lower costs of clinical trials, helping U.S. firms develop more successful drugs that can improve lives around the world.³²

TRANSPORTATION

The U.S. is the world’s third-biggest vehicle exporter and the second-largest auto manufacturer—successful positions, but both with room to grow.³³ 5G connectivity can help auto manufacturers by giving the increasingly technical, data-driven process of assembling vehicles a competitive edge.

Iconic U.S. automaker Ford partnered with AT&T to bring 5G connectivity to their historic Rouge industrial complex in Dearborn, Michigan. 5G’s ultra-fast speeds enable production-line workers to scan trucks, send information, and check equipment or materials in real time, saving time and better managing inventory and equipment.

The U.S. aviation industry is yet another key exported sector seeing unique 5G applications. The complex aerodynamics and extreme precision required for jet engine development present some of the most demanding scenarios for advanced manufacturing. Here, high-performance digital twins enabled by 5G can really shine.

For example, German engineers at the Fraunhofer Institute for Production Technology, a leading European organization for applied research, are working to integrate digital twins in production of jet engine components, and point to 5G as the only available wireless technology that provides the performance necessary for their aerospace production use case.³⁴ The researchers estimate that introducing 5G-enabled technology to the manufacturing of key engine components could create annual savings of about €27 million for a single factory and up to €360 million globally.³⁵ Policymakers should ensure that U.S. 5G networks have the resources they need to enable this type of innovation here at home.

5G can also lower costs and improve performance of the maintenance and inspection of aircraft after they have been manufactured, making for a more compelling product. For example, aircraft manufacturers are developing a 5G-connected system that integrates inspection drones and augmented reality goggles to allow technicians to inspect and maintain aircraft more effectively.³⁶

5G AND THE SCIENTIFIC ENTERPRISE

5G is also being adopted to support basic research efforts. By helping advance scientific breakthroughs, 5G can chart a path for the innovations of tomorrow. By connecting far-flung data collection sensors or making laboratories more flexible and productive, 5G presents a wide range of opportunities to make the U.S. scientific enterprise even more fruitful.

The U.S. Department of Energy (DOE), for example, is excited by “[t]he rapid commercial deployment of 5G [which] opens the opportunity to rethink and reinvent DOE’s scientific infrastructure and experimentation.”³⁷ In its wide-ranging report, “5G-Enabled Energy Innovation,” DOE points to opportunities “from intelligent sensor networks at unprecedented scales to a digital continuum of cyberinfrastructure spanning low-power sensors, high-performance computing embedded within and at the edge of the network, and DOE’s large-scale user instrument and computing facilities.”³⁸



“5G has the potential to impact all areas of science research and could revolutionize our nation’s science infrastructure.”

U.S. DEPT. OF ENERGY,
Argonne National Laboratory³⁹

Rivals Are Seeking to Gain the 5G Competitiveness Edge

National competitiveness has taken on increased importance in recent years with intensified economic rivalry with China. In telecommunications policy, the Chinese support national champion Huawei in the global market for telecommunications equipment, and due to U.S. security concerns with Huawei and other Chinese equipment, there are ongoing efforts by U.S. policymakers to shore up a healthy supply chain of trusted vendors to provide alternatives. Similar stories are unfolding across other industries, with policymakers examining appropriate steps to facilitate market-oriented competition with Chinese firms and others around the world.

Our nation's edge in critical emerging technologies increasingly intertwines our economic competitiveness with national security.⁴⁰ In its "National Defense Strategy," the DoD recognized the elevated role of innovation from the private sector in its new strategic posture.⁴¹ As DoD explains, there is a tight coupling of commercial innovation and national security, meaning "[t]he United States' technological edge has long been a foundation of our military advantage."⁴² 5G and the broader wireless ecosystem also advance our economic growth and global competitiveness, which in turn strengthen our long-term national security.

Research from the Center for Strategic and International Studies (CSIS) has explored the specific link between 5G-fueled innovation and the economic success that underpins our national security. A vibrant 5G ecosystem allows wireless innovations to be developed here first, strengthening our economic advantage and giving us a head start in integrating emerging technologies into defense systems.

As CSIS's James A. Lewis, SVP, Pritzker Chair, and Director of the Strategic Technologies Program explains: "Staying on the technological edge creates the income and innovations needed for a strong economy and for national security."⁴³

The idea of wireless as a platform for economic growth is not new. In the 4G era, the development of the on-demand economy and expansion of large U.S. tech firms was fueled by a robust mobile platform that enabled transactions and conversations to take place on the go. U.S. companies and the U.S. economy were the overwhelming beneficiaries of the financial gains made during this tech era, and other nations took note.

Europe, which went from wireless leader to laggard in a few short years, provides a cautionary tale. Despite leading in 3G, EU nations trailed significantly in the transition to 4G, in part because of difficulty making spectrum available for those new networks.⁴⁴



"Economic competitiveness is national security, and making sure we have enough spectrum available for private sector innovation and 5G expansion is national security."

GINA RAIMONDO
U.S. Secretary of Commerce⁴⁵



"The Chinese government has been actively mobilizing to contest global leadership in next-generation 5G technologies and accumulate geopolitical power by doing so. Left unchecked, China and others will be able to leverage its spectrum position to dictate technology choices, equipment options, and innovation throughout the world..."

**RET. U.S. NAVY ADMIRAL MIKE ROGERS
& RET. LIEUTENANT GENERAL AND
U.S. ARMY CIO BRUCE CRAWFORD⁴⁶**

Today, nine of the top 10 and 18 of the top 20 largest internet firms are based either in the United States or China (and none are in Europe).⁴⁷ Europe continues to lag in 5G deployment, with EU policymakers voicing concern that its slow 5G roll-out will limit adoption of technologies like artificial intelligence.⁴⁸

China seeks to develop the winning 5G platform and the industries that will be propelled by 5G's high capacity, low latency, and flexibility. CSIS warns of China's ambitions "to shape twenty-first century technologies and to establish a dominant position in global networks."⁴⁹ The researchers worry that "[t]his dominance could enable military and strategic superiority. If China leads the 5G era, its state-supported 'national champion' tech companies will play a dominant role, and in that scenario, there are no weapons systems, technology bans, or mitigation strategies that could defend U.S. and allied security interests."⁵⁰

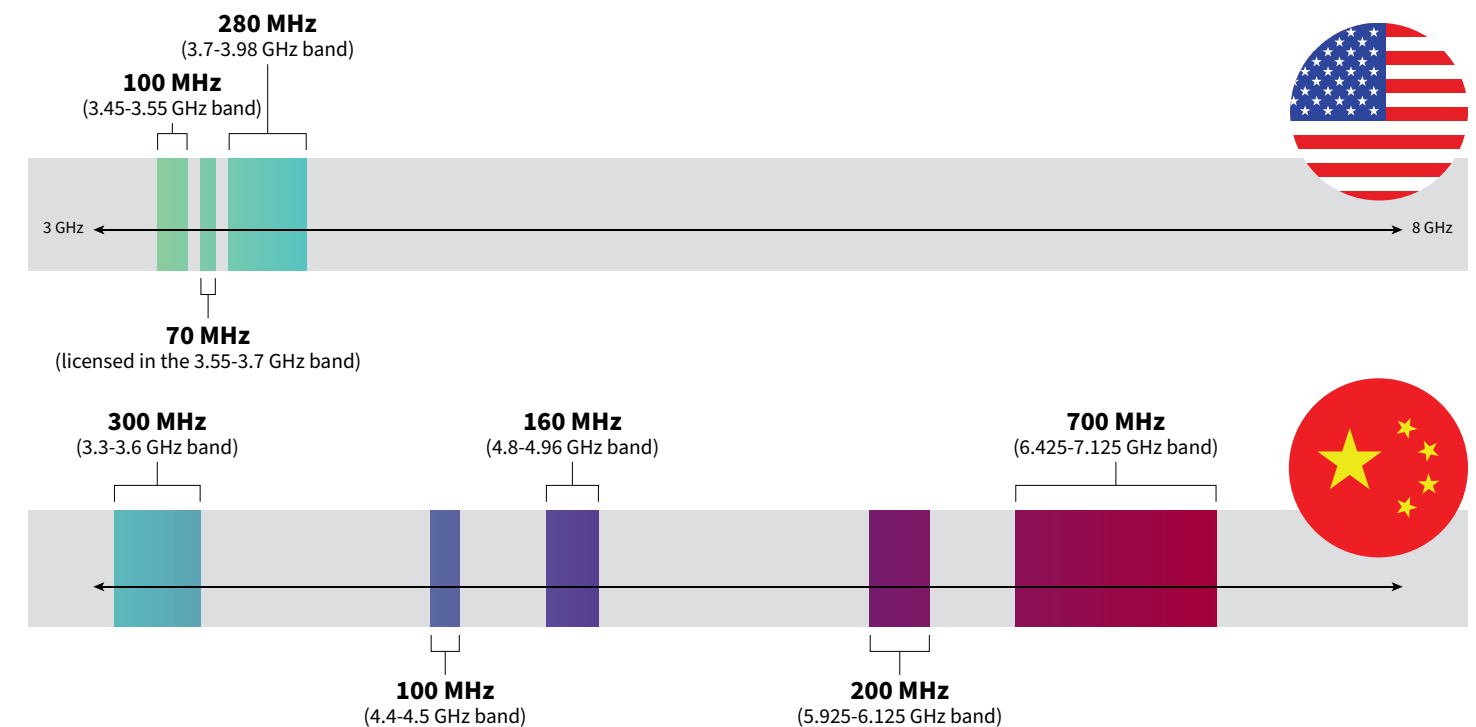
China is a strong challenger to U.S. technological and economic leadership. As discussed, China is pushing the global adoption of its wireless equipment companies, like Huawei. Timothy Bonds, RAND Corporation Senior Fellow elaborates on the risk to the U.S. of nations widely adopting the technology: "If China succeeds in making essentially a captured market in those [BRICS and Belt and Road Initiative] nations, ... there's a chance that the U.S. ultimately could be frozen out of 90% of the world's markets. At that point, it will be hard for U.S. companies, or even western companies, to be able to compete at scale..."⁵¹

The United States' global competitiveness going forward will rely on a thriving wireless industry, which starts with thoughtful spectrum policy. Unfortunately, China is allocating significantly more spectrum for 5G, giving it a potential edge.⁵² Indeed, China has already allocated 1460 megahertz of mid-band spectrum for 5G, 3.2 times more than the United States, and China made clear at the recent World Radiocommunication Conference (WRC) that they aren't stopping there. Researchers estimate that China may dedicate up to a total of 1660 megahertz of mid-band spectrum for 5G in the coming years.⁵³

As CSIS warns, "the United States lags far behind the rest of the world in allocations of the spectrum needed for 5G. This undercuts its advantages in the competition for technology leadership, global influence, and national security."⁵⁴ More full-power, mid-band spectrum for wide-area commercial 5G networks will be key to securing U.S. competitiveness through our rivalry with China.

Without a real pipeline of full-power, licensed mid-band spectrum, the U.S. is at a significant strategic disadvantage when it comes to developing cutting-edge wireless-enabled technologies. In order to maintain our competitive advantage over rival nations like China, policymakers should rely on tried-and-true auctions to identify those entities best positioned to generate the greatest value out of the limited frequencies available.

AMERICA NEEDS TO ALLOCATE MORE LICENSED MID-BAND FOR 5G

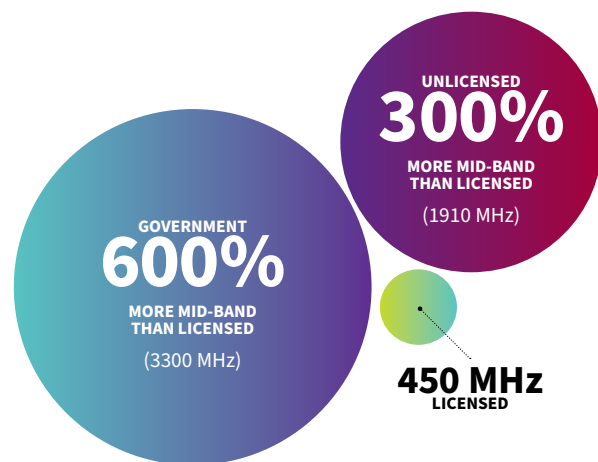




“Reliable access to spectrum is essential to innovation here in the U.S., to economic progress, to competitiveness, and, of course, national security.”

LAEL BRAINARD
White House NEC Director⁵⁵

U.S MID-BAND ACCESS IS OUT OF BALANCE



How Spectrum Policy Can Advance U.S. Competitiveness

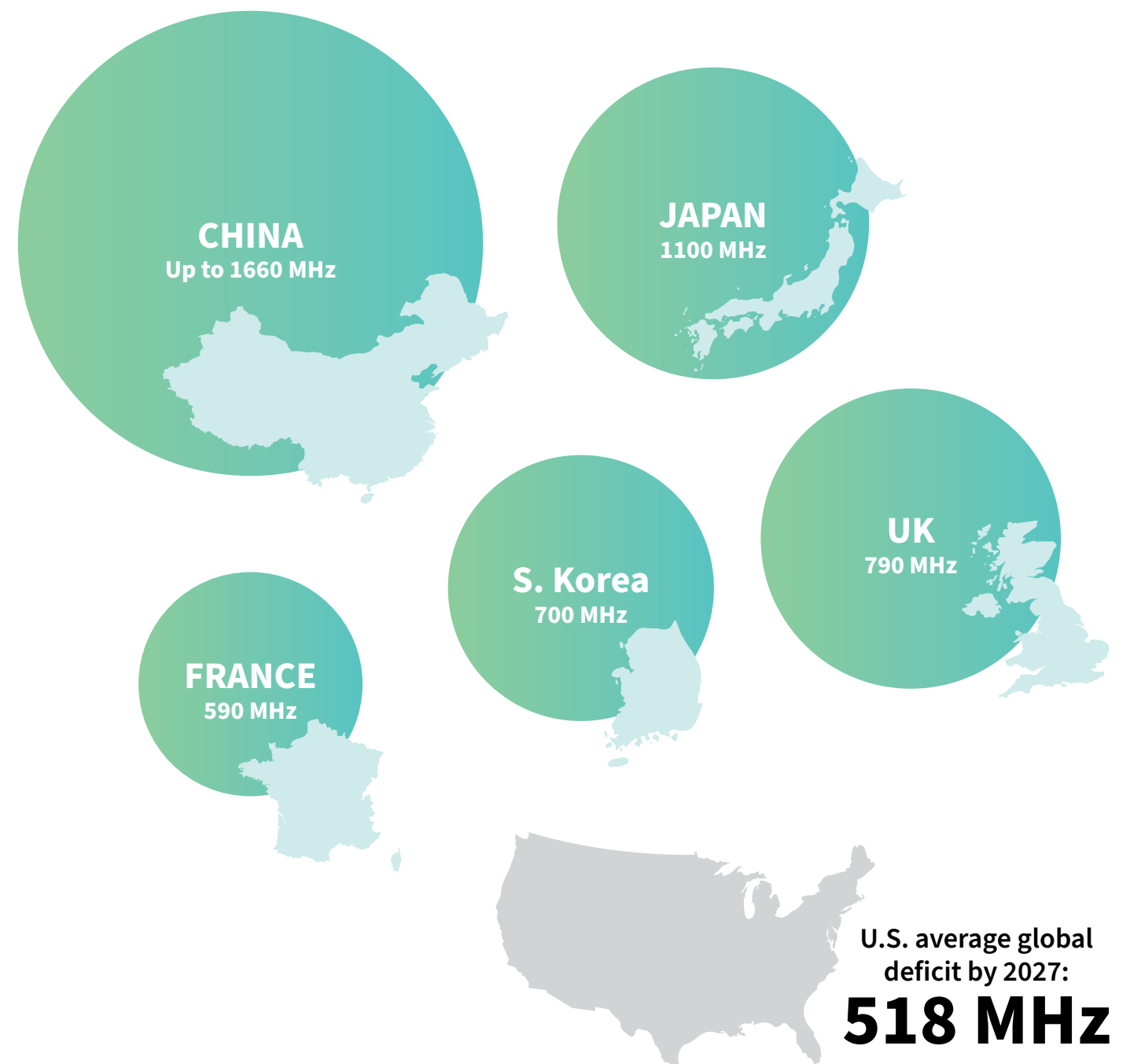
The United States can best secure its wireless leadership by licensing key internationally recognized 5G spectrum bands and leading in the adoption of additional mid-band spectrum that is under global consideration. When the President’s National Security Telecommunications Advisory Committee was asked to develop insights to improve U.S. competitiveness and maintain leadership in next-generation wireless telecommunications, its first recommendation was to make more spectrum available. The advisory committee explained, “[s]pectrum is critical to the wireless industry. There can be no growth in the U.S. wireless marketplace without additional spectrum made available for commercial wireless use.”⁵⁶

Unfortunately, the United States lacks a meaningful pipeline of mid-band spectrum for commercial use, let alone a pipeline of licensed spectrum sufficient to maintain the national security and economic advantages that have emanated from the United States’ global leadership in wireless services. Unlike both our allies and geopolitical rivals, who are making more and more licensed spectrum available for 5G, the United States has no future auctions planned today. Licensed spectrum, which is auctioned and tradeable, allows market forces to channel limited airwaves to their most productive use. Unlicensed spectrum, on the other hand, sees government define an open commons for low-power, local area uses like Wi-Fi or Bluetooth.

Any modern nation’s communications system will rely on a healthy combination of both licensed and unlicensed spectrum, but today the U.S. has a considerable imbalance between these two spectrum allocation models, with far more unlicensed mid-band than licensed.⁵⁷ Moreover, the U.S. faces a significant shortfall of licensed mid-band spectrum compared to other nations, while we lead the world with the most unlicensed spectrum available.⁵⁸

For example, Japan currently allocates 1100 megahertz of mid-band licensed spectrum for 5G. China had allocated 460 megahertz for 5G by 2022, a number that has since increased to 1460 megahertz, with China considering making up to 1660 megahertz available by 2027. South Korea allocates 380 megahertz today and is estimated to assign another 700 megahertz by 2027. As a result, the United States, with its 450 megahertz of mid-band spectrum, currently lags its peers by an average of 198 megahertz in mid-band mobile licensed access, a deficit that, by 2027, could rise to 518 megahertz absent immediate action.

GLOBAL RIVALS ARE MAKING MORE MID-BAND AVAILABLE



With 5G data traffic expected to triple by 2027 and no additional spectrum to support that growth, U.S. wireless networks may face eventual limitations that lead companies to look to other nations for the cutting-edge networks they need to innovate. We risk ceding control over this key engine of innovation and economic growth to other countries, including our adversaries. The wireless industry is hard at work with the resources it has—since 2018, providers have invested over \$160B in network infrastructure, including a record \$39B in 2022. But without more spectrum, there is little operators can do to keep pace with mobile ecosystems developing abroad.

Spectrum harmonization plays a crucial role in determining the success of a nation's wireless sector.⁵⁹ When specific spectrum bands are identified for the same use across borders and around the world, it enables economies of scale and simplification of components, and also reduces expenses throughout the entire wireless value chain, lowering the cost of services and devices for end-users. Allocating harmonized spectrum maximizes downstream growth and innovation, with first-mover advantages for those allocating these frequencies in developing new markets and technological ecosystems. Failing to follow global 5G allocations will cost billions in lost innovation and productivity and result in higher network costs.

THE SPECTRUM HARMONIZATION LANDSCAPE



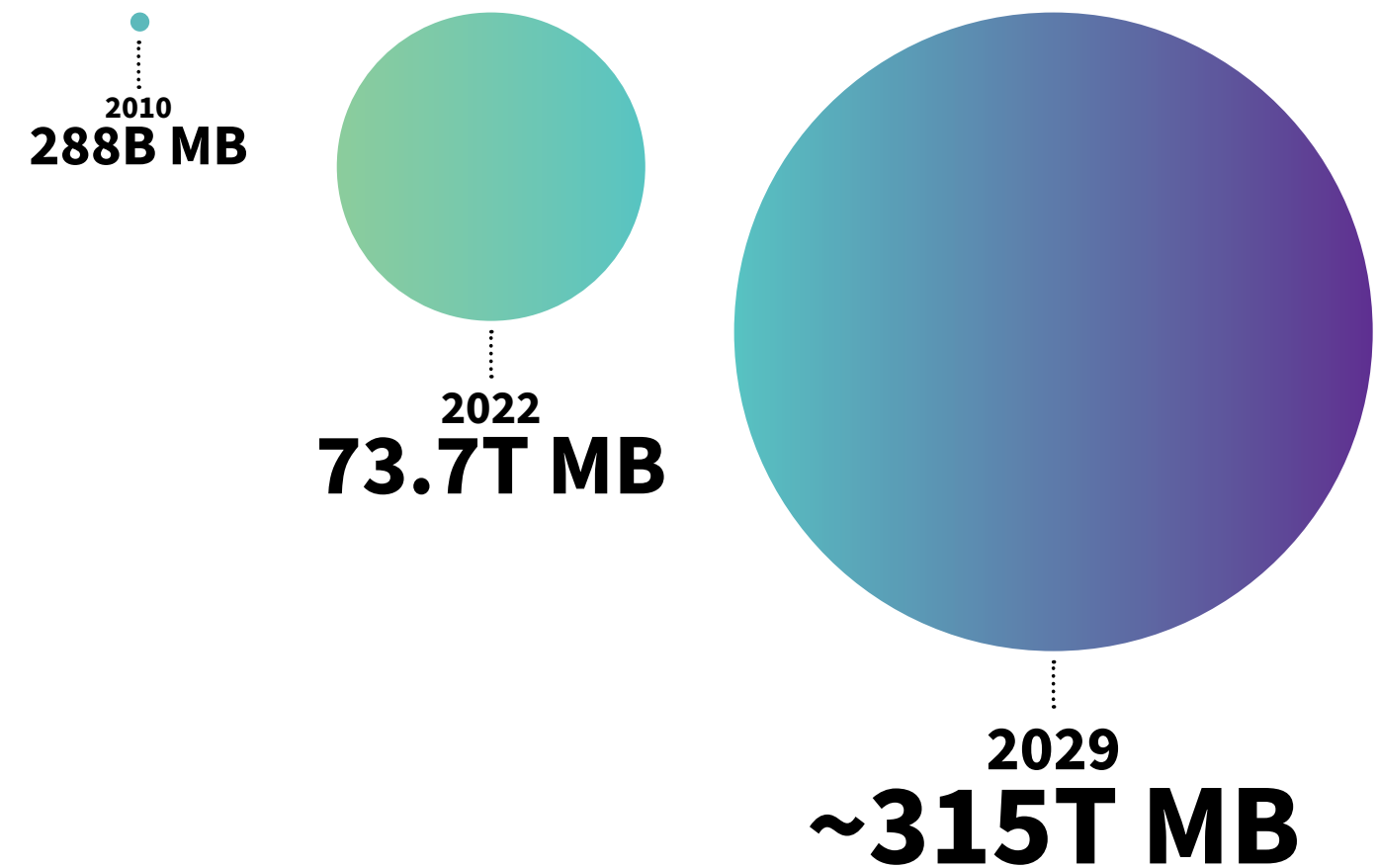
Allocating additional spectrum for 5G in key harmonized bands and leading the future harmonization of bands identified for international study, will help create added economies of scale for 5G devices and components. This in turn lowers costs for consumers and expands markets for U.S. companies. Aligning U.S. 5G spectrum with those in other countries also unlocks larger markets for trusted vendors competing with Chinese firms.

After examining global trends in allocations, agreements struck at the WRC-23, and standardization efforts at 3GPP, Accenture identified four bands the international community is rapidly coalescing on to support their 5G networks.⁶⁰ In the United States, two of these bands—the lower 3 GHz and 7/8 GHz—provide the greatest opportunity to better align with, and ideally lead, 5G harmonization efforts underway.

Conclusion

To maintain our 5G leadership, meet exploding demand, and build the foundation for future innovation and growth, policymakers must move quickly to license suitable sections of the lower 3 GHz and 7/8 GHz bands for full-power 5G networks. In doing so, the U.S. can avoid isolating itself from the global 5G ecosystem and continue its longstanding leadership in developing wireless technology and leveraging the productivity gains from wireless to advance American competitiveness.

AMERICANS WILL USE 4X MORE 5G DATA BY 2027



1 <https://www.ctia.org/news/the-importance-of-licensed-spectrum-and-wireless-telecommunications-to-the-american-economy>.

2 For example, 5G RedCap allows for simplified, low-cost IoT sensors. These devices are designed with simplicity in mind, using streamlined communications protocols that help make for cheaper devices with a longer battery life, though at the cost of communication speed and latency. See <https://www.ericsson.com/en/reports-and-papers/white-papers/redcap-expanding-the-5g-device-ecosystem-for-consumers-and-industries>.

3 <https://www.congress.gov/event/115th-congress/house-event/106636/text>

4 The World Economic Forum (WEF), which measures competitiveness among countries, focuses on productivity as core to a nation's level of competitiveness. The WEF defines competitiveness as "the set of institutions, policies, and factors that determine the level of productivity of a country." <https://www.weforum.org/agenda/2016/09/what-is-competitiveness/>

5 Historically, technological innovation has played a crucial role in economic growth. Academics estimate that growth in capital and labor explain less than half of productivity growth—the rest is thanks to innovation. See e.g., https://eml.berkeley.edu/~bhhall/papers/BHH11_Innovation_Productivity_NEPR.pdf.

6 There are other nuances to consider. For instance, the role of natural resources exploitation and strength of a nation's currency complicate the analysis of national competitiveness. See Robert D. Atkinson, "Competitiveness, Innovation and Productivity: Clearing Up The Confusion," ITIF (August 2013), <https://www2.itif.org/2013-competitiveness-innovation-productivity-clearing-up-confusion.pdf>.

7 <https://www.ctia.org/news/how-much-licensed-spectrum-is-needed-to-meet-future-demands-for-network-capacity>

8 Ibid.

9 https://api.ctia.org/wp-content/uploads/2021/01/5G-Promises-Massive-Job-and-GDP-Growth-in-the-US_Feb-2021.pdf

10 <https://www.ctia.org/news/wireless-investment-and-economic-benefits> The five publicly-traded mobile carriers—AT&T, Dish, Verizon, T-Mobile, and UScellular—have invested an average of \$54 billion in capex per year (2020-2022). \$54B is second highest industry total based on PPI's 2023 Investment Heroes report (tech industry is first). Biggest five wireless providers' capital expenditures from 2011-2022 total \$591 billion, second to the capital expenditures of the "Big 5" tech companies at \$611 billion, based on PPI Investment Heroes data, as covered in the report, "Wireless Investment and Economic Benefits."

11 <https://www.ctia.org/news/the-importance-of-licensed-spectrum-and-wireless-telecommunications-to-the-american-economy>.

12 Ibid.

13 <https://www.idc.com/getdoc.jsp?containerId=prUS51776424;https://www.counterpointresearch.com/insights/global-smartphone-os-market-share/>.

14 For discussion, see, e.g., <https://www.wisefharbor.com/wp-content/uploads/2016/12/Mallinson-FINAL.pdf>.

15 https://www.qualcomm.com/content/dam/qcomm-martech/dm-assets/documents/the_ihs_5g_economy_-_2019.pdf.

16 Ibid.

17 <https://www.csis.org/analysis/spectrum-allocation-contest-china>

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36 <https://breakingdefense.com/2023/06/boeing-sees-5g-drone-inspectors-and-augmented-reality-training-key-to-future-aircraft-maintenance/>.

37 https://science.osti.gov/-/media/ascr/pdf/programdocuments/docs/2020/5G_Workshop_Report_2020.pdf.

38 Ibid.

39 <https://www.energy.gov/science/articles/how-5g-may-boost-science-research>

40 As the Department of Defense (DoD) has explained, "Inter-state strategic competition, not terrorism, is now the primary concern in U.S. national security." <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>

41 <https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF>.

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43 <https://www.csis.org/analysis/spectrum-allocation-contest-china>

44 In 2013, then European Commission Vice President Neelie Kroes complained that three out of every four people living in the EU couldn't access 4G/LTE mobile connections in their hometowns, and virtually no rural area had 4G, whereas in the United States over 90% of people had 4G access. She pointed to challenges making spectrum available at the member-state level https://ec.europa.eu/commission/presscorner/detail/en/IP_13_742; for additional discussion, see <https://www2.itif.org/2015-eu-spectrum-policy.pdf>.

45 <https://www.commerce.senate.gov/2023/10/chips-and-science-implementation-and-oversight>.

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47 <https://hbr.org/2018/05/18-of-the-top-20-tech-companies-are-in-the-western-u-s-and-eastern-china-can-anywhere-else-catch-up>; while Europe is home to a handful of large, successful tech firms like ASML in the Netherlands, SAP in Germany, and Schneider Electric in France, Spotify (Sweden) is likely its only large consumer-facing web company today.

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59 <https://www.ctia.org/news/advancing-u-s-wireless-excellence-the-case-for-global-spectrum-harmonization>.

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