



The State of 5G

Evaluating Progress and Charting the Path Forward

July 2023

U.S. networks are leading the way in 5G, with record wireless investment delivering nationwide deployment faster than any previous generation. Expectations are high for 5G, and the wireless industry is on pace to deliver our connected future ahead of schedule.

The state of 5G is strong.

Each successive generation of wireless technology brings new tools and opportunities to improve our connected world. 5G has arrived, and it is off to a great start. The United States leads the world in deploying 5G, with more 5G availability than any other country. 5G's faster speeds and more responsive networks are driving strong consumer and enterprise adoption. The wireless industry is delivering 5G ahead of schedule, investing record, world-leading amounts of capital to deploy 5G faster than any previous generation of wireless. Analysts expect 5G will ultimately add \$1.5 trillion to America's economy and contribute at least 4.5 million new jobs.

5G wireless networks, built on a foundation of full-power, licensed spectrum, offer the most reliable and secure wireless connectivity available, making it the ideal platform for the industries of the future. 5G's first big impact is in home broadband, where 5G is America's fastest growing home internet service, bringing real competition to cable.

With new 5G applications, demand is rapidly increasing—mobile traffic doubled last year compared to the year before, and Ericsson predicted that between 2020 and 2027 consumers will nearly quintuple their mobile data use per year. Estimates indicate we will need 400 megahertz of additional mid-band spectrum to meet projected demand in 5 years, and nearly 1500 megahertz in 10 years. Today, however, there are no planned spectrum auctions in the pipeline.

5G is off to a tremendous start, and our 5G platform will become more transformative each year as network capabilities grow and the 5G innovation ecosystem takes off. Still, more must be done to ensure 5G can reach its potential. Decisive action to re-establish the FCC's auction authority and identify a pipeline of exclusively licensed, full-power mid-band spectrum is sorely needed to secure the future of America's competitiveness and national security.

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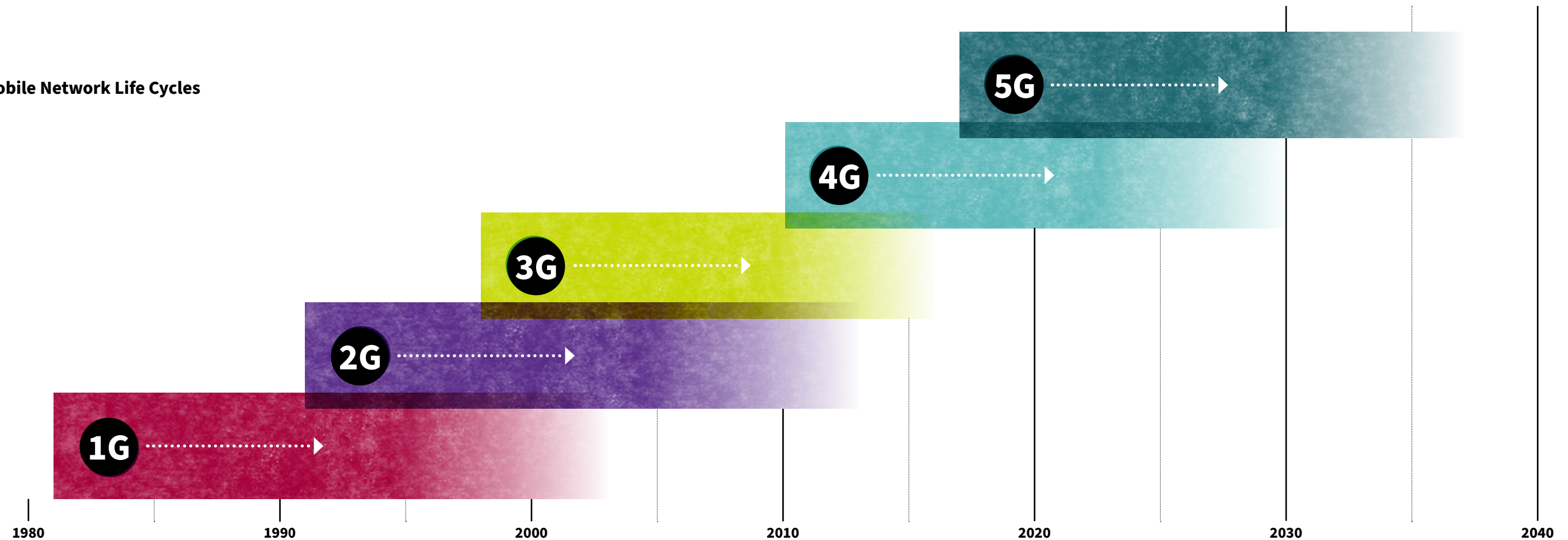
The Promise of 5G

Each wireless generation delivered better service and new capabilities to consumers and businesses. The first wireless networks let us communicate on the go, but only by voice, and service was spotty. The advent of 2G brought digital technology to wireless, 3G paved the way for the initial mobile internet, and 4G enabled true mobile broadband, unleashing the app economy and inspiring other industries to harness the power of wireless.

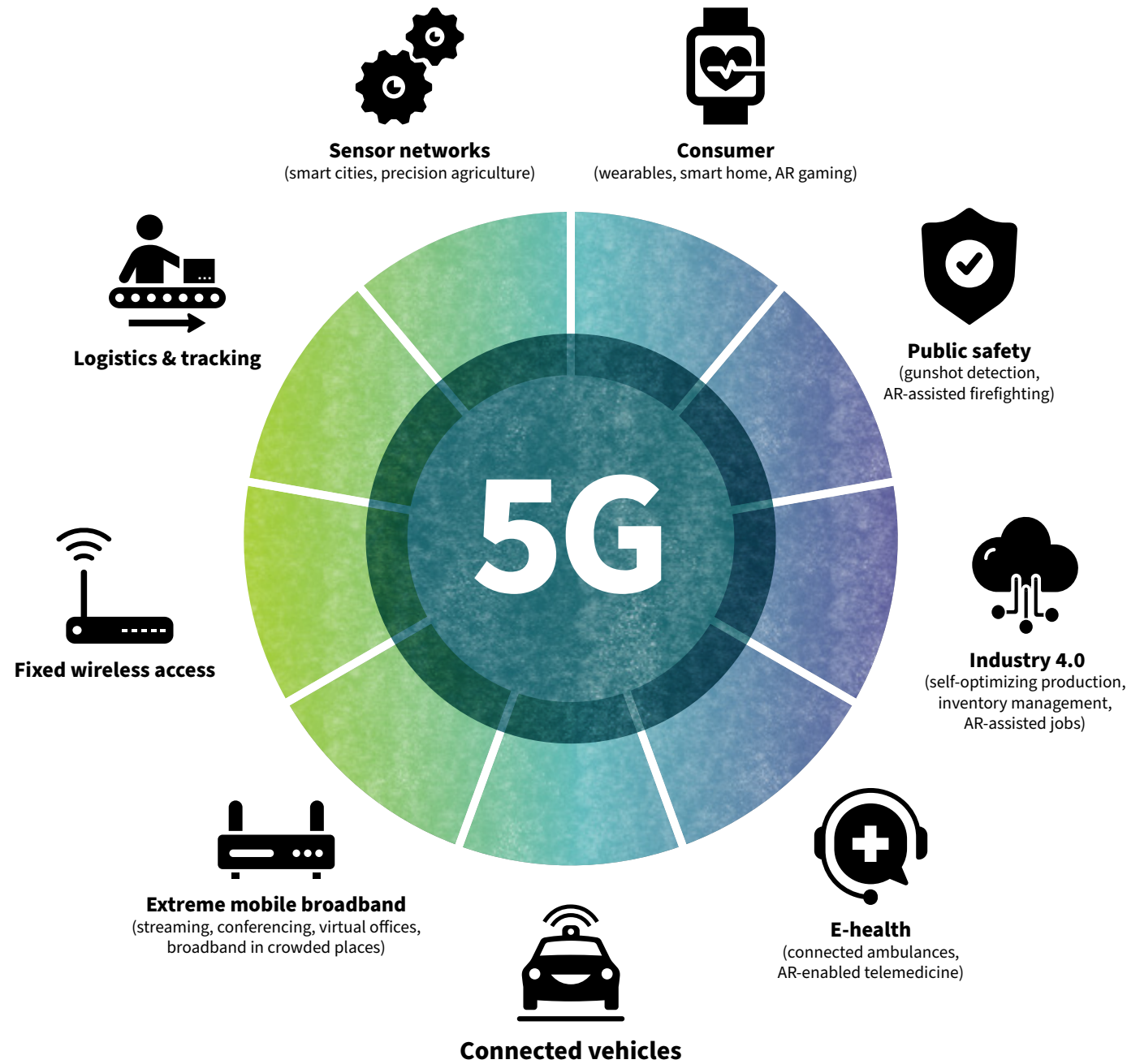
5G will be much faster than 4G, with speeds up to 100x faster. 5G is reducing latency, or the delay that occurs when data is transmitted across distances. Low latency is especially important for machine-to-machine communications that require precise timing. 5G is expected to be 5 times more responsive than 4G. 5G technology will also be able to handle 100 times the number of connected devices, enabling dense deployments of connected devices and powering smart cities. As discussed below, we are already seeing a great jump in these capabilities.

The real hallmark of 5G is its flexibility. **While 4G was designed to do one thing well—bring internet access to mobile phones—5G can dynamically adapt to provide optimized connectivity to a wide variety of different use cases.** For example, if embedded sensors for smart agriculture need to extend battery life as much as possible, the 5G network can simplify communications, reducing the need for processing on the sensor itself.

North American Mobile Network Life Cycles



Use Cases Will Drive the 5G Economy



5G'S ENORMOUS EXPECTED IMPACT

The flexible and powerful capabilities of 5G networks promise to enable wireless connectivity that is more deeply integrated into economic and social systems, making 5G a real engine for innovation. 5G has transformative potential in several key sectors of our economy, including healthcare, transportation, education, manufacturing, energy, agriculture, public safety, and more.

5G will spur massive economic growth across the United States, with BCG estimating an addition of approximately 4.5 million jobs and an increase of about \$1.5 trillion in U.S. GDP over the 5G decade.¹ By powering innovative healthcare applications and making organizations more efficient, Deloitte projects 5G technology will save \$305 billion in healthcare costs every year.² 5G technology will also support important safety features of connected cars, enable massive IoT deployments, and enhance detailed supply chain analytics to improve logistics and optimize fleet management. Analysts estimate that wireless-powered smart city solutions will add \$1.8 trillion to the U.S. economy and deliver \$160 billion in benefits and savings through efficiencies like lower energy use and reduced congestion.³

Advanced manufacturing is critical to our nation's competitiveness, economic growth, and quality of life. Drone commerce is expected to add more than \$80 billion to the economy and create 100,000 new jobs as 5G helps unlock this technology's full commercial potential.⁴ We are seeing significant investment in new uses cases and applications that take advantage of 5G's advanced capabilities, thanks to its rapid deployment.

Delivering Ahead of Schedule

The United States has made remarkable achievements with 5G deployment. Compared to the launch of 4G, providers are delivering broader coverage at a faster pace, and consumers are adopting 5G devices more quickly. Across several network performance metrics, 5G is delivering ahead of schedule. While we are still in the early stages of what will be a decade-long 5G investment cycle, U.S. wireless providers have already built a strong 5G platform for innovation, job creation, and economic growth that will continue to grow in the years to come.

DEPLOYMENT

5G deployment is moving at a faster pace than 4G. **The first 5G network achieved nationwide coverage twice as fast compared to 4G,⁵ and the three major providers were able to provide nationwide networks 1.5 times faster than with 4G.⁶**

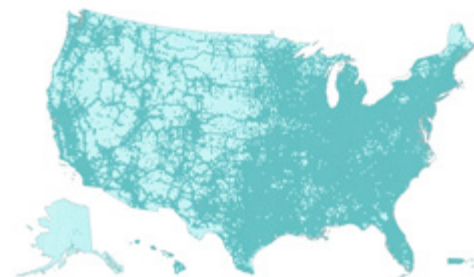
5G networks across the United States already cover over 325 million people, giving us the world's most available 5G networks. Ookla puts the United States as the world leader in availability, with over 54 percent of connections from 5G-capable handsets connecting to a 5G network most of the time.⁷ This puts us ahead of South Korea by almost 20 points, a truly remarkable feat.⁸ We're at nearly double the 5G availability of China, which is at 27.3 percent.⁹

This quick initial deployment underscores the wireless industry's commitment to global leadership, which only continues as networks expand and densify. As discussed further below, 5G works best with a mix of different types of spectrum, and operators do not yet have access to an optimal blend of frequencies. While the base-line initial platform of 5G has been quickly deployed at a wide scale, 5G networks will need to keep getting better to meet America's wireless needs.

Faster Nationwide Deployment

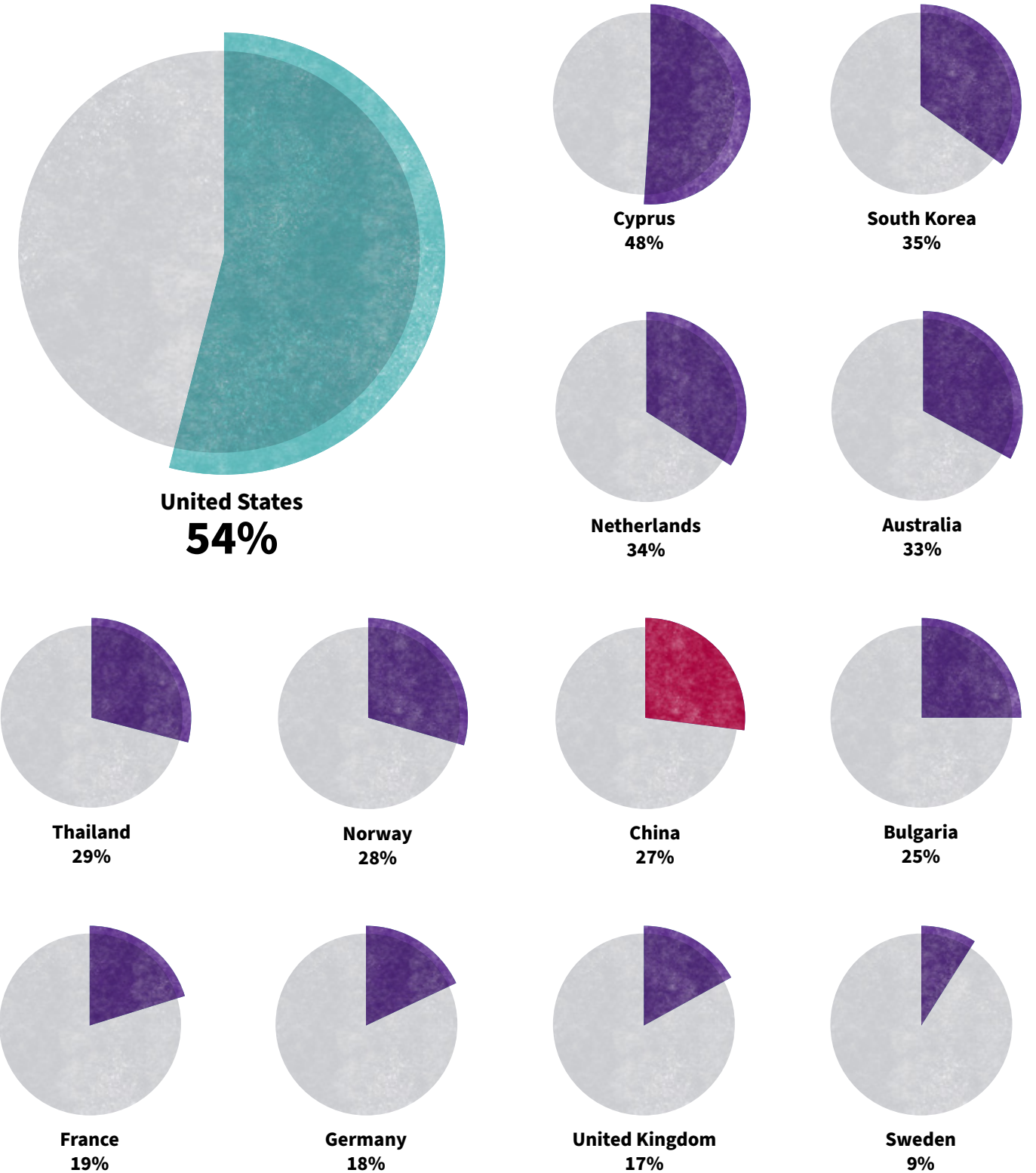


4G
24 months after first launch



5G
22 months after first launch

5G Availability in Select Markets



Ookla's availability metric measures the percent of connections from a 5G capable handset connecting to 5G networks most of the time. It is thus a measure of both adoption and deployment. China figures are from personal communication.

CONSUMER ADOPTION

Consumers are also adopting 5G quickly. Comparing 5G's adoption to 4G, we find that two years after the nation's first large-scale 5G deployment, the U.S. had 50 million people subscribed to 5G versus 38.6 million subscriptions two years after the first large-scale 4G launch.¹⁰ Looking at market penetration at the same two-year mark, almost 15 percent of Americans have subscribed to 5G, compared to about 12 percent two years after 4G's first large-scale launch.¹¹

Today, over one in three American adults have an active 5G device—a quickly growing contingent: **The number of 5G devices in the United States grew over 500 percent between 2020 and 2021 to 85 million.**¹²

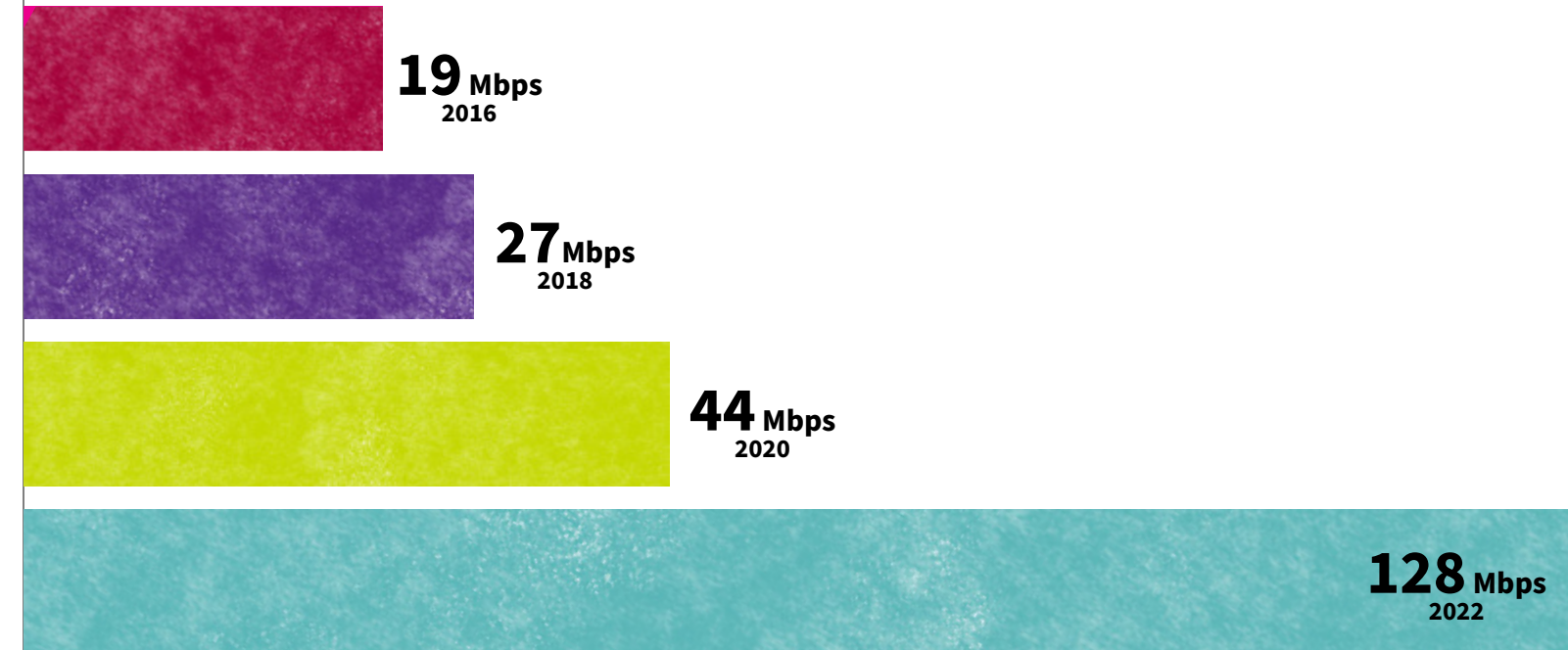
NETWORK PERFORMANCE

5G is already showing marked improvement over earlier generations of wireless across several performance criteria. Wireless network speed (or data throughput) is one of the most important factors affecting user experience, especially for data-hungry applications like streaming video. Again compared to the 4G era, 5G is bringing bigger improvements faster than we saw before. Eighteen months after the launch of 4G, average download speeds were only about 3 times faster than the previous generation. Over a similar timeframe, 5G speeds were more than 16 times faster than 4G speeds. That means 5G's rate of speed increase is over 5 times faster than 4G's.¹³ Speeds on 5G networks are now routinely over 100 Mbps, and continually getting faster.

Latency is another important performance metric, measuring the time delay as information transfers across the network. Low latency is critical to having a responsive network, and for some applications, such as 5G-enabled driverless cars, precision robotics, or high-quality augmented reality, it really matters. Here again, 5G is already bringing measurable improvements in overall responsiveness. According to real-world Ookla measurements, only about 15 percent of 4G connections have a latency of under 20 milliseconds, whereas more than 80 percent of high-band 5G connections are faster than 20 ms.¹⁴ That makes for a roughly 5 times improvement over 4G latency, helping empower more real-time applications.

Spectrum plays a critical role in determining 5G network performance. Electromagnetic spectrum—the invisible radio waves by which mobile data travels through the air—has different properties depending on its frequency and wavelength. 5G works best when it has a mix of different types of spectrum to be able to optimize connectivity for different use cases.

Wireless Speeds Keep Getting Better



Median download speed

For policy discussions, spectrum can be broken down into low, mid and high bands.



Low-band spectrum (spectrum below 3 GHz) can cover wide areas with a single cell tower and can propagate well through foliage and around buildings. Low-band provides crucial foundational coverage.



High-band spectrum (spectrum above 24 GHz) provides extremely high-speed connections by using what the industry calls mmWave technology—relying on the tiny wavelengths of this high-frequency spectrum, measured in millimeters. While high-band spectrum provides great performance, it does not propagate very far and is easily blocked by obstructions.



Mid-band spectrum (focused on spectrum between 3 and 8.5 GHz) provides a happy medium: it can leverage advances in technology to provide high capacity, and still provides relatively good coverage. Other nations have done a better job of making mid-band spectrum available for 5G services. Frequencies above 8.5 GHz, while still useful, are more similar to high-band.

Historic Investment Fueled Unprecedented Deployment

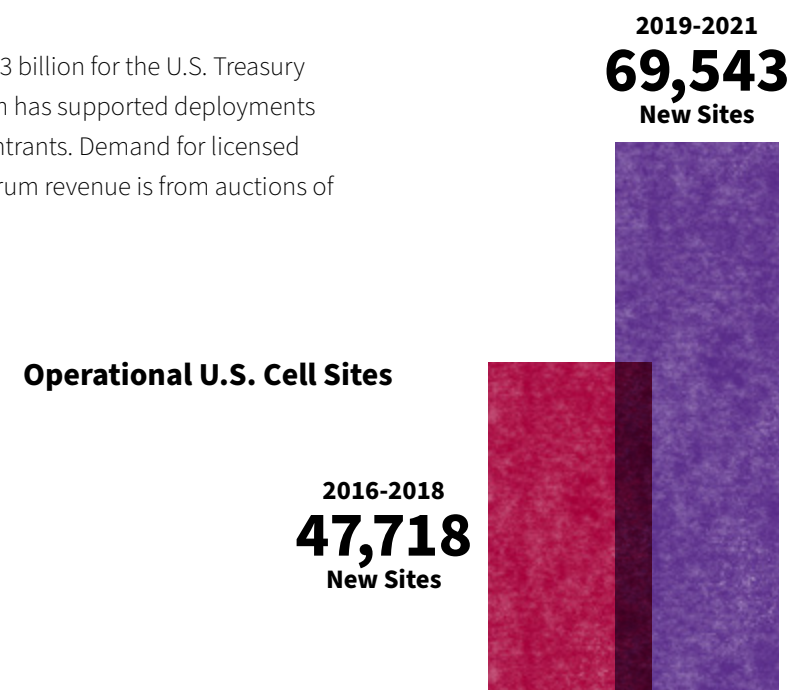
The initial success of 5G deployments is thanks to tremendous investment by the wireless industry—providers are investing an estimated \$275 billion into network infrastructure to build out 5G and enhance network coverage, security, and capabilities.¹⁵ Fierce competition has driven nationwide providers to pour billions into designing and deploying networks they anticipate will best win over customers and enable new use cases. **A record \$35 billion was invested by providers in 2021, and since 2018, the year 5G launched, providers have already invested over \$121 billion.**¹⁶

To further contextualize this extraordinary investment, the United States is just 4 percent of the world’s population, but we invest 19 percent of the world’s total wireless capital.¹⁷ Looking at 5G investment on a per capita basis, in 2020, the U.S. wireless industry invested 4.5 times more than Chinese counterparts.¹⁸

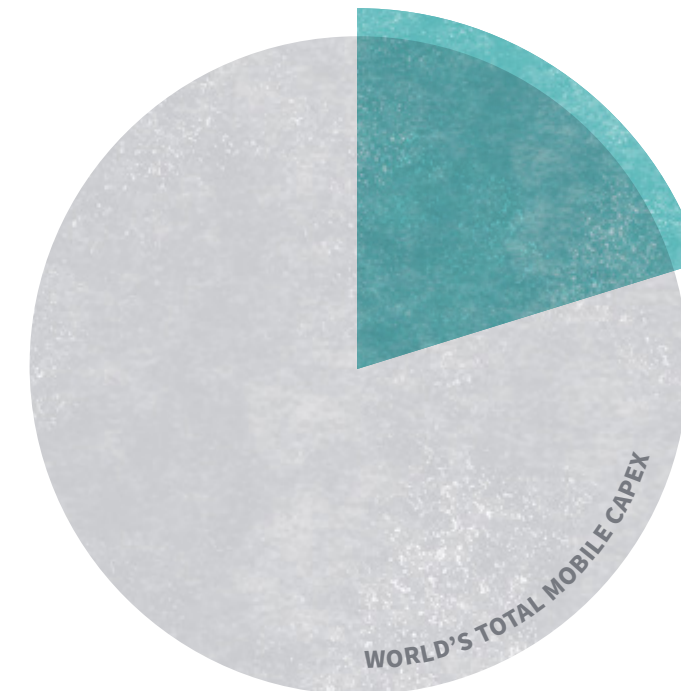
5G investment has driven efforts to expand and densify networks to support innovative services. By the end of 2021, there were 418,887 operational cell sites across the nation, and that doesn’t account for all the new 5G base stations added to existing cell sites.¹⁹ **Federal and state siting reforms encouraged the rapid deployment of 5G, with 62 percent of cell sites built from 2016 to 2021 coming after reforms were made.**

Operators also invest heavily in spectrum—the lifeblood of wireless networks. The Federal Communications Commission (FCC) auctions licenses that provide rights to use particular airwaves without interference from others. The wireless industry competes vigorously in these auctions to gain the resources needed to build ever-better performing networks.

Over the years, these auctions have raised over \$233 billion for the U.S. Treasury and policymakers’ priorities.²⁰ In turn, this spectrum has supported deployments by national operators, regional carriers, and new entrants. Demand for licensed spectrum is growing rapidly: About half of all spectrum revenue is from auctions of 5G spectrum in the last four years alone.



U.S. Invests More Than Its Peers



Driving Secure, Innovative Access for All

5G is connecting more Americans in more ways than ever before. As a result of strong competition driving record investment, the United States has networks covering more than 325 million people and counting. Consumers have embraced the technology, leading the number of 5G-connected smartphones and other 5G devices to grow exponentially year-after-year.

With the growth in wireless innovations, applications, and connections, mobile data use has consistently increased year-over-year—and it leapt to 53.4 trillion megabytes (MBs) in 2021.²¹ That means U.S. networks are supporting more data traffic in one year than all of 2010 through 2017 combined. Wireless data traffic will only keep climbing—**Ericsson predicted between 2020 and 2027 consumers will nearly quintuple their mobile data use, to 240 trillion MBs per year.**²²

Americans continue to add wireless connections, driven by growth in data-only devices—the medical sensors, smartwatches, hotspots, and more that run on wireless data. These devices make up an increasing share of overall connections every year—42 percent of the nation’s 499 million wireless connections today.²³

FIXED WIRELESS ACCESS

Beyond mobile, 5G is also being leveraged to deliver broadband to the home. 5G home broadband—also called 5G Fixed Wireless Access, or FWA—is a new home broadband option, bringing increased competition to the fixed broadband market.

Early FWA offerings are the fastest growing broadband connection in the nation. Last year, 5G home was the connection of choice for 90 percent of new broadband subscribers, and it accounted for virtually all broadband growth in the fourth quarter of 2022.²⁴

5G home broadband downstream speeds easily support the typical American household’s needs, including multiple users actively engaged online—a family can comfortably stream a 4K movie, hold an HD group call with coworkers, participate in an HD math class, participate in a telehealth visit, Skype with friends, and stream YouTube videos simultaneously on one 5G home network with capacity to spare.

5G home broadband is already available to millions of Americans, and top providers have already signed up over four million subscribers.²⁵ The number of homes FWA will reach is predicted to jump 16 times from 2021 to 2025.²⁶ However, operators are only able to offer FWA where they have sufficient capacity in the network to be able to guarantee reliable quality of service. Recent research from Econ One indicates that if operators had sufficient additional spectrum capacity, consumers could save over \$8 billion per year thanks to FWA competition.²⁷ The scale of FWA and its competitive impact on the home broadband market ultimately depends on sufficient spectrum being made available for 5G.

WIRELESS HELPS CLOSE THE DIGITAL DIVIDE

Wireless has historically proven a key tool in building digital equity, and 5G goes even further in helping bridge the digital divide. As the on-ramp of choice for many of those without a home broadband connection, mobile helps drive connectivity, choice, and digital literacy within historically underrepresented groups like communities of color, low-income households, and rural populations.

The wireless industry is proud of the flexible service options that deliver consistently better value for varying consumer preferences and budgets. **Unlimited plans are 43 percent cheaper and connections are 117 times faster than in 2010.**²⁸ This long track record of declining prices helps explain why wireless is the only broadband connection for over a quarter of low-income households.²⁹

Wireless has long been the most widely used broadband technology. In 2021, Pew Research estimated that while 77 percent of adults in the United States have a home broadband connection, 85 percent own a smartphone.³⁰ For about 15 percent of Americans, their wireless device is their only broadband connection.³¹ Demographic disparities in smartphone adoption have all but disappeared: 85 percent of African Americans and 83 percent of Latinos own smartphones today, compared with 85 percent of white Americans.³²

For rural populations, smartphone ownership grew by nine percentage points from 2019 to 2021—80 percent of rural residents now own a smartphone compared to 84 percent of suburban and 89 percent of urban populations.³³

5G home broadband offerings are also providing more options for high-speed home internet in unserved and underserved communities. 5G home can be deployed quickly and easily without the need for additional last-mile infrastructure. Accenture projects that nearly half of rural U.S. households could be served with high-speed broadband over 5G-powered fixed wireless.³⁴ 5G home cuts down on expenses in the infrastructure-intensive last-mile of the network, contributing to greater competition and more affordable pricing for home broadband. It serves as a very cost-effective tool to bridge broadband access and adoption gaps—the question is whether there is sufficient spectrum to provide the capacity demanded by this service. More licensed spectrum is key to meeting the demand for ubiquitous FWA coverage.

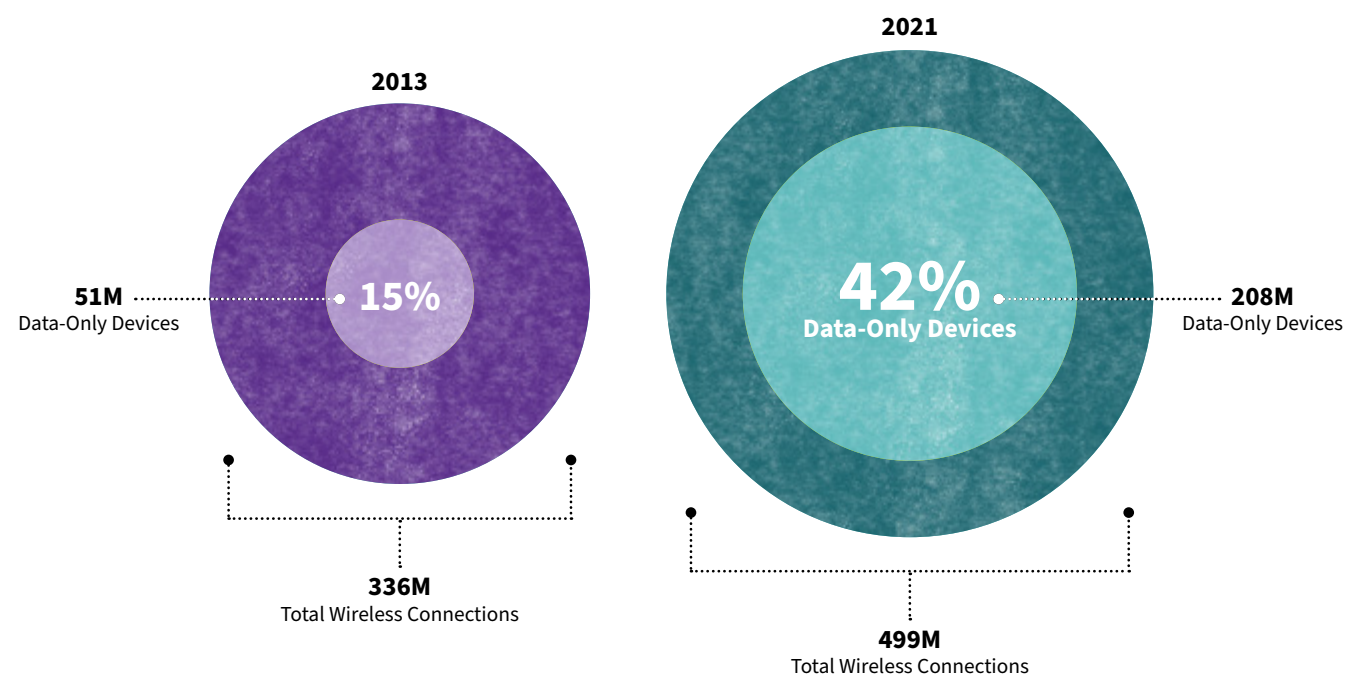
Enabling Innovation Throughout the Economy

5G's enhanced speed and capacity, combined with its flexibility to support many different use cases, is driving efficiency across a wide variety of economic sectors. While everyone is most familiar with the smartphones we interact with every day, large-scale machine-to-machine connections promise to drive tremendous productivity gains. These IoT devices that generally only use wireless data (and not voice service) make up an increasing share of overall connections every year. In 2021, data-only devices represented about 42 percent of all wireless connections, increasing from 190 million to 208 million since 2020.³⁵

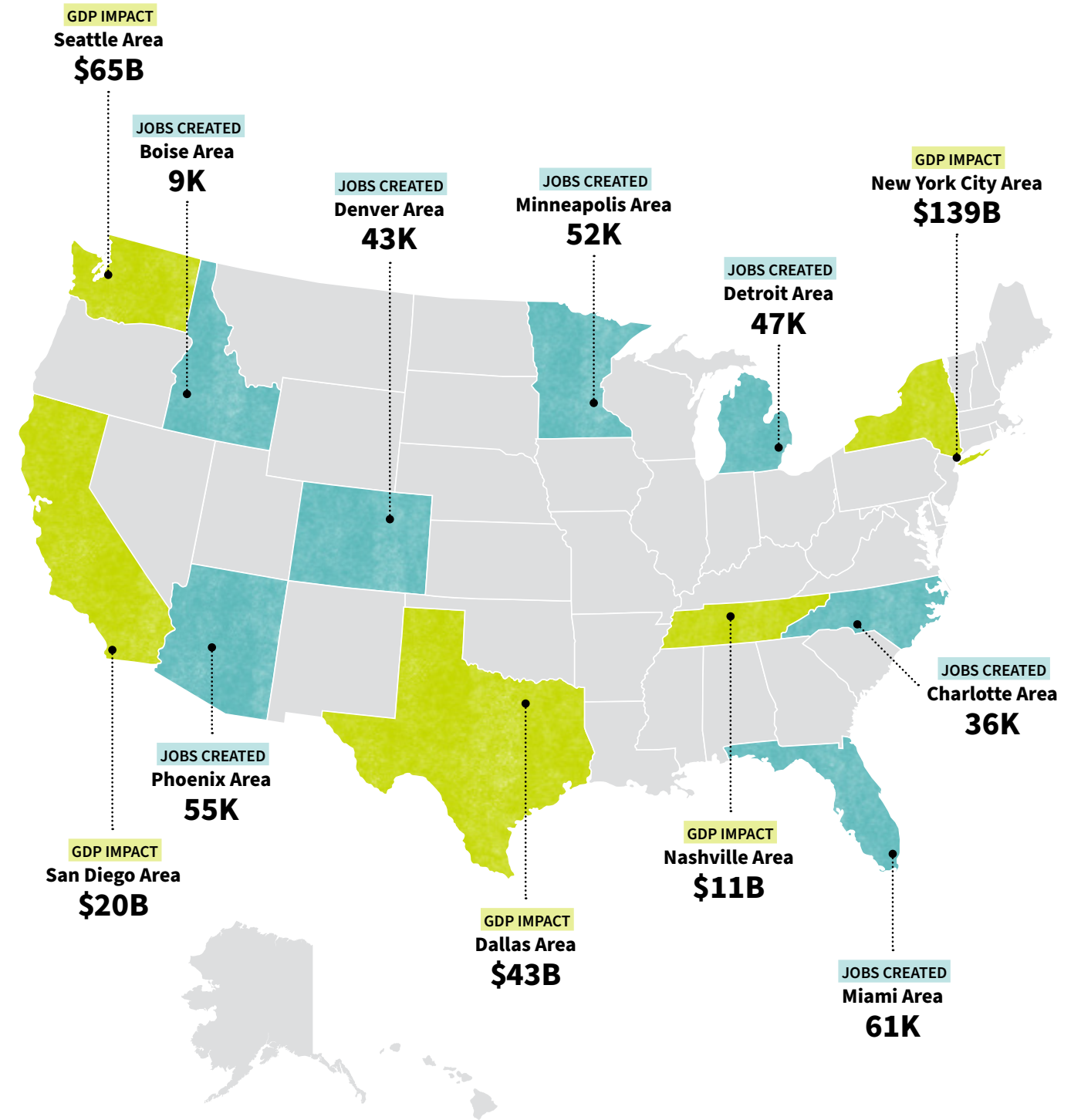
5G-powered connected devices are enabling new innovations such as remote patient monitoring, efficient smart energy grids, immersive, virtual reality learning experiences, and connected cars that reduce congestion and increase safety. Thanks to significant wireless industry investment, 5G will create \$1.5 trillion in economic growth and 4.5 million new jobs in the U.S. this decade.³⁶

These are the jobs and technologies that will help us address our country's biggest challenges, like educational inequities, access to health care, and climate change. According to Accenture, **5G use cases across just five industries—transportation, energy, manufacturing, agriculture, and living/working/health—can help the United States meet 20 percent of its climate change goals by 2025.**³⁷

Continued Growth of Data Only Devices

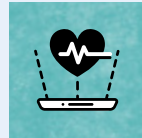


This 5G-powered transformation of our economy is happening in both big cities and smaller communities. This means tens of thousands of new jobs in places like Nashville and Charlotte, and tens of billions in GDP growth in places like Kansas City and Seattle.



Driving Innovation Across Industry Sectors

New services and applications built on the secure and reliable 5G platform are already transforming communities and industries across America's economy. The wireless industry is hard at work, partnering with a wide variety of entities to develop next generation technology across industry sectors, as CTIA explored in its recent "5G Innovators" report.³⁸ A few highlights provide a snapshot of the innovations 5G is enabling throughout the economy.

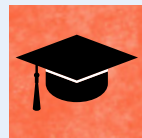


Healthcare

5G is redefining what's possible in healthcare, making organizations more efficient, complex procedures more precise and life-enhancing care available in real time, from anywhere. By transforming traditional 2D imaging data into near real-time 3D holographic visualizations, doctors can visualize a patient's anatomy, enhancing surgical practices and the precision of care.



Verizon is helping improve the future of veteran care through 5G-enabled hospitals. Partnering with the VA Palo Alto Health System, which is the first 5G-connected veteran's hospital in the U.S., Verizon is exploring how 5G-connected virtual and augmented reality solutions can be used to enhance surgical navigation systems and medical training to advance veteran care throughout the U.S.

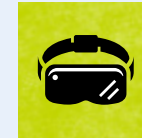
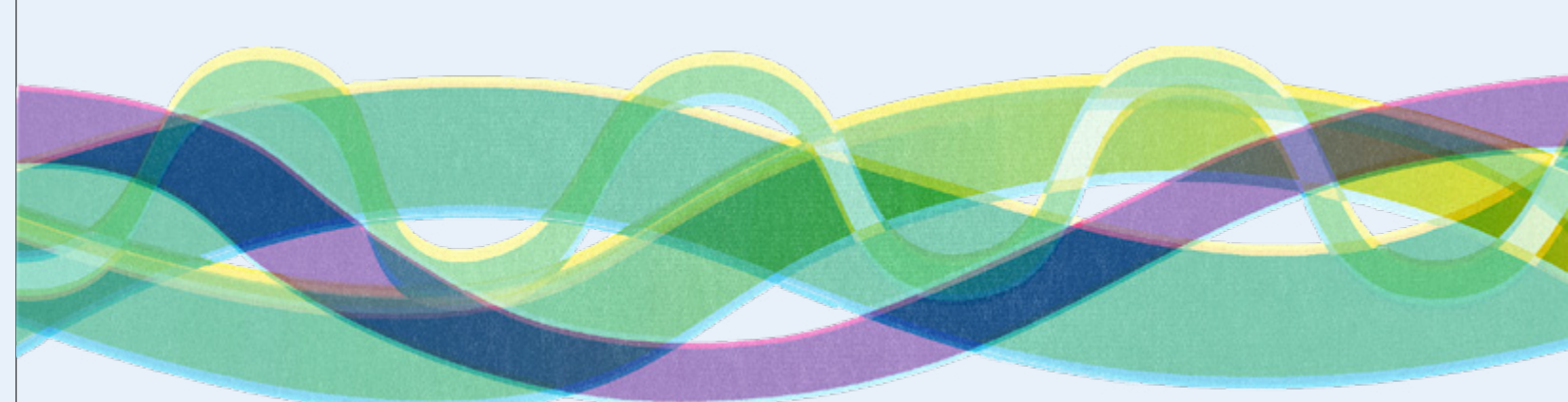


Education

Now more than ever, education is essential to build thriving communities and fostering equitable opportunities. 5G is helping America's teachers and students stay ahead of the curve, increasing engagement, leveraging real-time data, and sparking imaginations.



AT&T is connecting students with 5G-enabled immersive, interactive learning experiences. AT&T has partnered with Boddle to develop 5G immersive technologies, like augmented reality, to bring math lessons to life for students and create rich, interactive learning experiences that help remove barriers to quality education.



Manufacturing

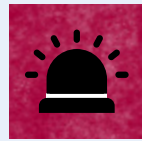
Advanced manufacturing is critical to our nation's competitiveness, economic growth, and quality of life. 5G is helping U.S. factories springboard into the future of safety, sustainability, and innovation, thanks to AR and VR training, advanced robotics, and real-time information sharing. Augmented reality (AR) headsets can be a game-changer for frontline workers, enabling them to remotely perform tasks like cell site upgrades and machine maintenance, virtually view service checklists and more. 5G powers the fast responses necessary for a realistic experience.



Ericsson is unlocking the potential for 5G-connected Industry 4.0. The USA 5G Smart Factory is a full-scale production facility for 5G radios and other network elements, which is exploring fast, secure wireless connectivity to enable innovations and processes that optimize efficiency and increase production, such as: augmented reality for remote support, digital materials tracking, automated plant procedures, environmental monitoring, and other use cases.



Samsung is leveraging 5G to streamline advanced manufacturing and develop industrial use cases at the company's state-of-the-art semiconductor manufacturing facility in Austin, Texas. 5G is enabling real-time communication among millions of sensors, devices and systems within the manufacturing facility to bring next-generation innovations into daily operations. For example, augmented reality applications are improving factory efficiency and performance through more immersive training, and 4K live video and IoT sensor data are supporting factory automation to improve equipment monitoring and preventative maintenance procedures.



Public Safety

When it comes to keeping people safe, knowledge is power and speed is everything. 5G delivers both, exponentially increasing first responders' access to video and data and accelerating their ability to respond. For example, firefighters need to find people quickly while protecting their own safety, often in zero-visibility environments. Augmented reality, powered by 5G, can be projected directly onto fire-fighting face-shields, providing needed information within view. 5G's low latency and ability to support enhanced edge-compute capabilities enables safer, more efficient tactical response.

T-Mobile

T-Mobile is connecting emergency responders to 5G-enabled AI solutions to speed up detection and response times for wildfires. T-Mobile partnered with Pano AI to create 5G-connected, AI-powered cameras that identify the first signs of wildfires. This technology provides emergency crews with immediate, actionable intelligence, allowing them to respond quickly and effectively before the fire has a chance to grow out of control.



Smart Cities, Buildings and Energy

The cities of the future will be smart cities: growing and thriving while offering residents and visitors a convenient, enjoyable and safe place to work and play. 5G is the engine of smart cities innovation, connecting people, data and new ideas in creative ways.

intel.

Intel is building smart city solutions that are helping communities everywhere deliver smarter services, safer streets, and a healthier, more sustainable environment for every resident. 5G is enabling an ecosystem of next-generation technologies, including sensors, cameras, and edge computing, that can provide near real-time awareness of issues requiring attention. Data collected and analyzed from these 5G-enabled devices can be used to optimize city operations, improve basic services, enhance public safety, increase sustainability, and inform planning and policy making. These devices can also be used to enhance public experiences and optimize operational efficiency at local sports stadiums, theme parks, and resorts or improve parking and safety on university campuses.

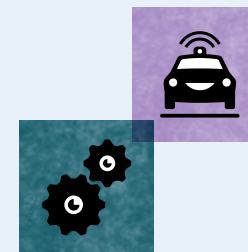


Connecting Rural America with Fixed Wireless Access

5G is powering fixed wireless home broadband, with significant early growth. This technology holds special promise for rural and small-town America. FWA, used as last mile infrastructure, will connect more people with reliable and affordable internet options.

uscellular

UScellular is rolling out FWA with antennas specially designed for rural access. The high cost and complications of connecting remote and hard-to-reach areas has made for a persistent digital divide. FWA has the potential to bridge this gap with practical, timely, and lower-cost infrastructure.



Transportation and Logistics

5G can help vehicles use the information around them to operate more efficiently with awareness of other cars, infrastructure, and pedestrians around them. Innovators nationwide are using 5G to redefine how people and products get from one place to another.

Qualcomm

Qualcomm is helping drive 5G innovation for next-generation connected cars and mobility solutions. Partnering with companies like Volvo and Ford, Qualcomm is demonstrating how 5G is enabling a diverse ecosystem of C2VX technologies that can securely connect cars to the cloud, each other, and the environment while supporting next-level intelligence for enhanced in-vehicle experiences, new connected-car services, higher levels of safety, and autonomy.

NOKIA

Nokia is improving the efficiency of our global supply chain by enabling the digital transformation of shipping and warehousing operations. 5G is enabling previously unseen applications for remote machine control and robotics, increasing speed, safety and efficiency across a range of environments. 5G makes it possible for human operators to remotely steer drones, cranes, and other large equipment with precision and ease through complex settings from the production facility to seaports and rail transfer stations to warehouses.

Providing the Most Secure and Reliable Wireless Networks

Providing a safe and secure wireless experience is critical. Security has improved with each generation of wireless, and the wireless industry continues to build innovative security features into our nation's networks. **5G wireless networks built on licensed spectrum combine security features within hardware, software, and virtualization technologies, making it the most secure wireless communication technology available.** 5G was designed with security in mind from the ground up and includes several new protections.

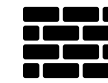
5G networks include multiple layers of encryption protocols and network management capabilities to minimize the potential for large-scale security breaches. New capabilities incorporated into 5G networks, such as network functions virtualization, give operators unprecedented visibility into operations to more quickly identify problematic behavior, and enable more enhanced, targeted forms of security.

5G network defenses include a mix of technologies, techniques, and principles that guide how providers secure their networks. For example, 5G networks have adopted a Zero Trust architecture. Traditional security models generally relied on a "single perimeter defense" or "castle-and-moat" model, granting users broad access to the network after a single authentication. A Zero Trust model instead requires continuous authentication of users, applications, and devices as they access different parts of a network and corresponding network functions.

5G networks also encrypt data exchanged on them from end to end, and at multiple layers of the network. Some types of encryption and security include IPsec tunnels, transport layer security, identifier encryption, and support for virtual private networks.

LICENSED SPECTRUM MAKES 5G MORE SECURE

5G networks are built using licensed spectrum. Exclusive-use, licensed spectrum provides reliability, lack of interference, and no third-party management. It is a secure and reliable platform for 5G because it:



Limits Interference: Licensed spectrum conveys rights to a sole license holder, meaning networks built with licensed spectrum are protected by law and managed by the licensee to limit interference and deliver secure, reliable communications.



Is a Secure Architecture: Networks built with licensed spectrum are more controlled and resilient, with fewer potential points of attack, thanks to their ability to avoid middlemen, shared databases, or the need to accommodate multiple stakeholders.



Requires Device Security: Smartphones, tablets, and laptops connected to licensed networks must adhere to standards and pass rigorous certification testing, increasing the overall security of the network.



Incentivizes Security Investment: License holders have spent \$233 billion to acquire the rights to use their spectrum. The significance of the investment and the rights that come with it incentivize continued investment in network reliability and security. America's wireless providers have invested over \$121 billion in networks since 2018, the year 5G launched.

Licensed spectrum is a key input into building secure communications networks that support a safe internet experience. As discussed below, more licensed spectrum is needed to help secure our connected future. Key tranches of mid-band spectrum are ideal for enhancing 5G's capacity and responsiveness, providing the secure 5G experience promised by 3GPP standards.

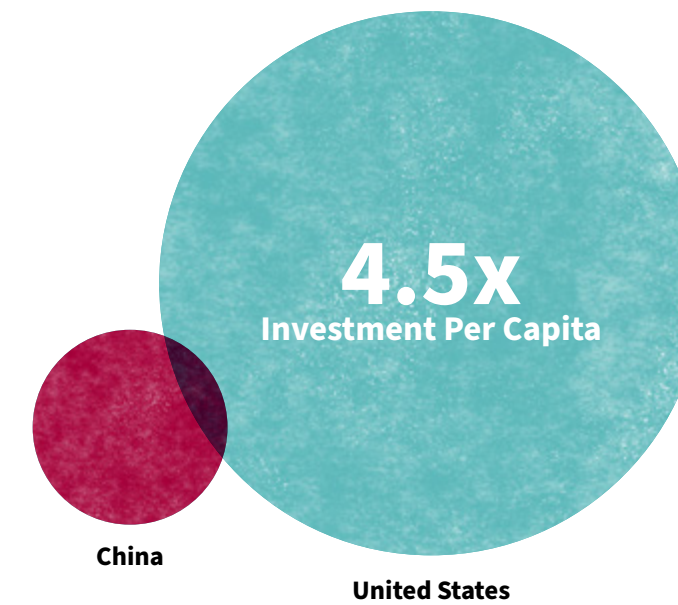
Maintaining Competitiveness and National Security

Our world-leading 5G networks are a force multiplier for productivity gains throughout the U.S. economy and key to the United States gaining a comparative advantage in the industries of the future. Being the hub for advanced manufacturing and precision robotics, mobile augmented reality applications, and dense smart city deployments, for example, will be a tremendous boon to U.S. economic success. So much more than entertaining videos on our smartphones, 5G is the connective tissue supporting the innovations that will make or break economies through the 21st century. We're off to a great start, but it is critical we maintain the economic benefits and first-mover advantages in many 5G-enabled innovations.

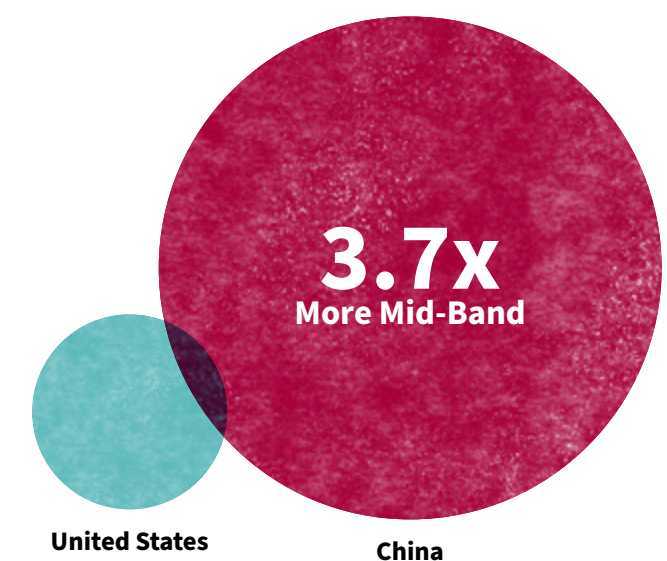
Nowhere is 5G's support in achieving leadership in the industries of the future more important than in our rivalry with China. The wireless industry is hard at work to ensure our 5G platform is the best in the world with the limited spectrum resources available today. The U.S. was the first mover on 5G deployment, with the first U.S. deployments 13 months before China.³⁹ The U.S. was also first to a nationwide network, with three competing networks before China had one.⁴⁰ Looking at key markers of 5G success, the U.S. is expected to maintain its lead—by 2028, 5G will be about 91 percent of U.S. wireless connections. China will see 5G permeate society at a lower rate of roughly 80 percent.⁴¹ This is in no small part thanks to strong investment in the United States providing a compelling 5G platform: **U.S. operators invest roughly 4.5 times more than their Chinese counterparts on a per-capita basis.**⁴²

But China is accelerating its 5G-led digital transformation, making vast amounts of mid-band spectrum available for commercial use. China has already assigned nearly twice the mid-band to wireless operators than the United States, including part of key lower 3 GHz and 4 GHz bands. And what's more, China is considering making the entire 6 GHz band available for commercial wireless (unlike the United States, which allocated this band to unlicensed). Together, this would result in 1660 megahertz of 5G mid-band spectrum in China—3.7 times the mid-band spectrum available to U.S. wireless operators today.⁴³ Making additional mid-band licensed spectrum available for commercial use would augment the capacity of U.S. networks and help ensure China does not leap-frog U.S. network performance.

U.S. Operators Out Invest Chinese Counterparts



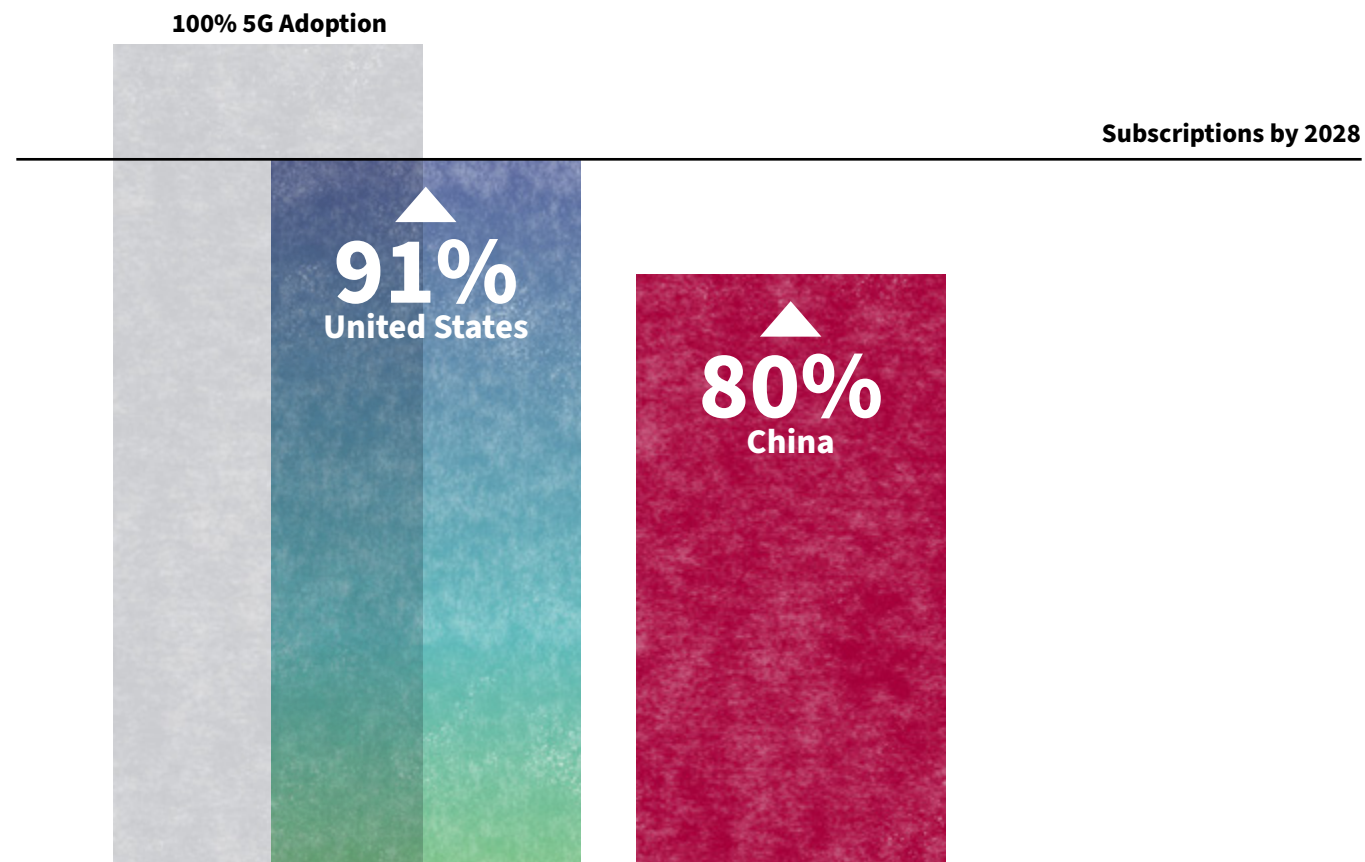
Chinese Regulators Allocating More Mid-band For 5G



Spectrum policy also plays an important role in shaping the market for wireless equipment. Strong 5G demand in the United States means the purchasing sway of our sizeable market has an outsized effect in shaping the wireless equipment market, allowing policy to support the companies and ideals we believe in. Policymakers rightly spent the last several years encouraging other nations to use trusted equipment from suppliers like Ericsson, Nokia, Samsung, and Cisco, rather than providers that present security risks given their close ties to the Chinese government. So far, this effort has largely focused on export controls of semiconductors and related advanced technology.

The key role of spectrum policy in driving economies of scale in communications equipment presents another critical vector to ensure a healthy supply chain of trusted equipment. While Huawei's share of equipment revenue has fallen from 2020 levels, the company remains the largest global telecom equipment provider, indicating a narrow focus on chips may not be sufficient to ensure a healthy supply chain of trusted equipment. The United States should align its spectrum policy with globally harmonized bands for 5G and ensure U.S. consumers benefit from lower-cost networks built with equipment produced at scale for the entire world and avoid driving up costs by requiring special equipment designed just for the U.S. market.

U.S. Driving Faster 5G Adoption



5G IS STRENGTHENING OUR NATIONAL SECURITY

The economic implications of productivity gains from 5G-related innovations are profound, especially as the emerging technologies 5G supports and enables are anticipated to play an important role in defense and security industries. 5G fuels advances across both the defense industry and broader commercial sectors, with synergistic gains to our economic and national security.

Several 5G applications are under development to buttress our national security directly. U.S. military operations are actively experimenting with 5G, including for a variety of logistics applications, VR/AR for military training and machine maintenance, real-time surveillance, and cutting-edge robotics, for example.

Operators are developing in several compelling defense use cases currently under development: AT&T supported 5G-enabled demonstrations of smart warehouse solutions at Naval Base Coronado in San Diego.⁴⁴ T-Mobile partnered with Oceus to bring advanced 5G solutions tailored to government needs, including defense applications in AR/VR, maintenance and logistics, training, and active operations.⁴⁵ Verizon has partnered with Lockheed Martin to develop so-called "5G.MIL" applications, integrating military and enterprise networks that leverage existing telecommunications infrastructure.⁴⁶ 5G security is highly customizable and segmentable to support the particular needs of national security applications.

Auctioning spectrum raises billions that DoD can use to upgrade to new, technologically efficient systems that are more appropriate for the battlefield of the 21st century. The Spectrum Relocation Fund provides a tried and true mechanism that can provide the funding and the catalyst to help government users upgrade systems. The hard work of repacking a federal band for more efficient use can help government users more effectively achieve their critical missions, while also making additional spectrum available to fuel 5G networks, helping secure our country and economic future.

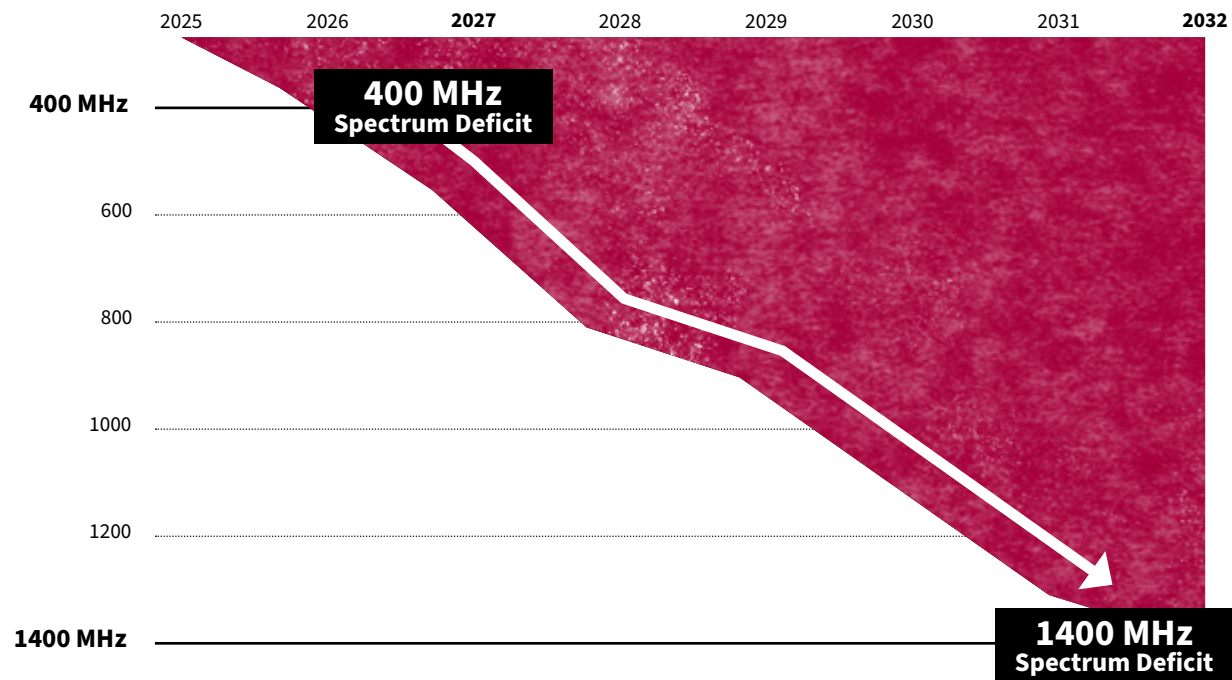
As the Center for Strategic and International Studies recently explained, "[telecommunications regulatory governance is therefore a powerful strategic security lever that the United States and its allies should wield to advance free-market democracy...the United States can help guide and enable free-market democracies by ensuring the 5G platform reaches its full potential to help solve the challenges of the twenty-first century."⁴⁷

More Must Be Done to Secure Our 5G Future

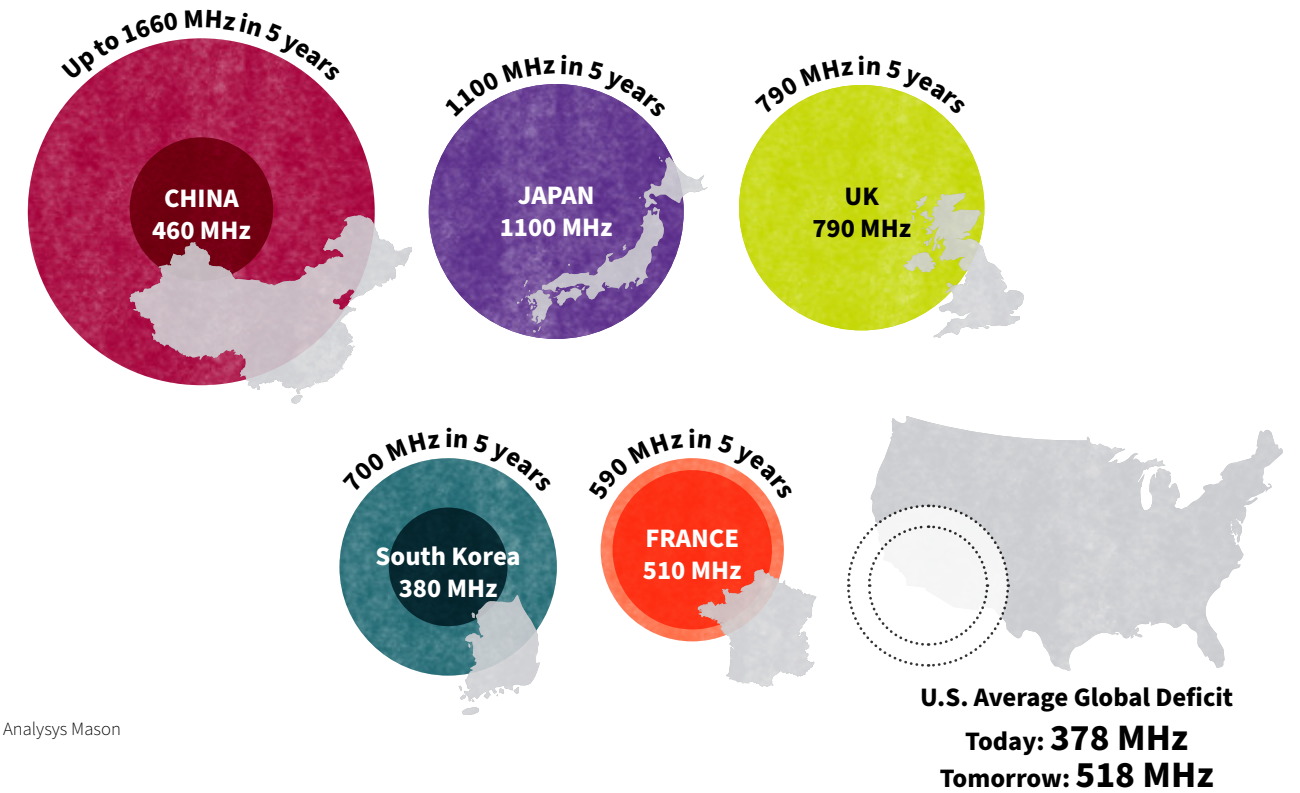
5G is at an inflection point: While initial deployments have achieved a solid footing, attention now turns to the scaling-up of applications and ensuring capacity is available to meet growing demand. Licensed, exclusive-use spectrum is the lifeblood of mobile communications—in order for 5G to reach its true potential, more spectrum is sorely needed.

A new study from The Brattle Group finds that even optimistic improvements in technological efficiency and added cellular infrastructure will not be nearly enough to meet projected demand. Additional spectrum is the only realistic option for the wireless industry to be able to provide needed capacity. **The Brattle Group’s analysis indicated that the United States needs at least an additional 400 megahertz of full-power, licensed, mid-band spectrum in five years, and nearly 1500 megahertz by 2032.**⁴⁸

Growing Spectrum Deficit



Global Rivals Have Significantly More Mid-Band



Source: Analysys Mason

Mid-band spectrum is particularly important to achieve the capacity needed to meet demand and allow 5G to reach its full potential. Mid-band spectrum is especially well suited to allow operators to augment network capacity—it has relatively strong propagation compared to higher frequencies, but it can also utilize recent advances in antenna technology to boost capacity.

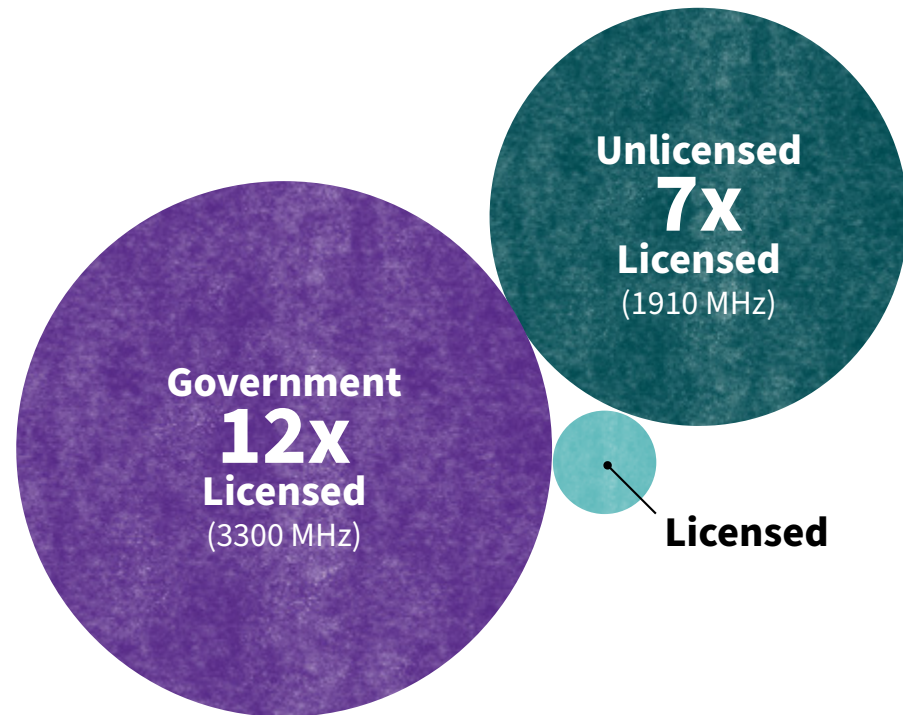
Other countries have recognized the need to make more full-power licensed mid-band spectrum available and are quickly allocating resources to unlock additional capacity for 5G networks. **Examining spectrum allocations of global peers, Analysys Mason concluded that the United States is behind by an average of 378 megahertz of mid-band spectrum today.**⁴⁹ This gap is projected to grow to an estimated 518 megahertz in five years.

Without additional spectrum, U.S. innovation ecosystems that depend on high-capacity wireless service will be at a disadvantage compared to those in other nations. The impacts will be profound and wide-ranging—the potential future of wireless abundance will be curtailed. The historic trend of lower per-unit prices may slow or stall, networks will become congested, and particularly data-intensive applications may not gain hold in the United States.

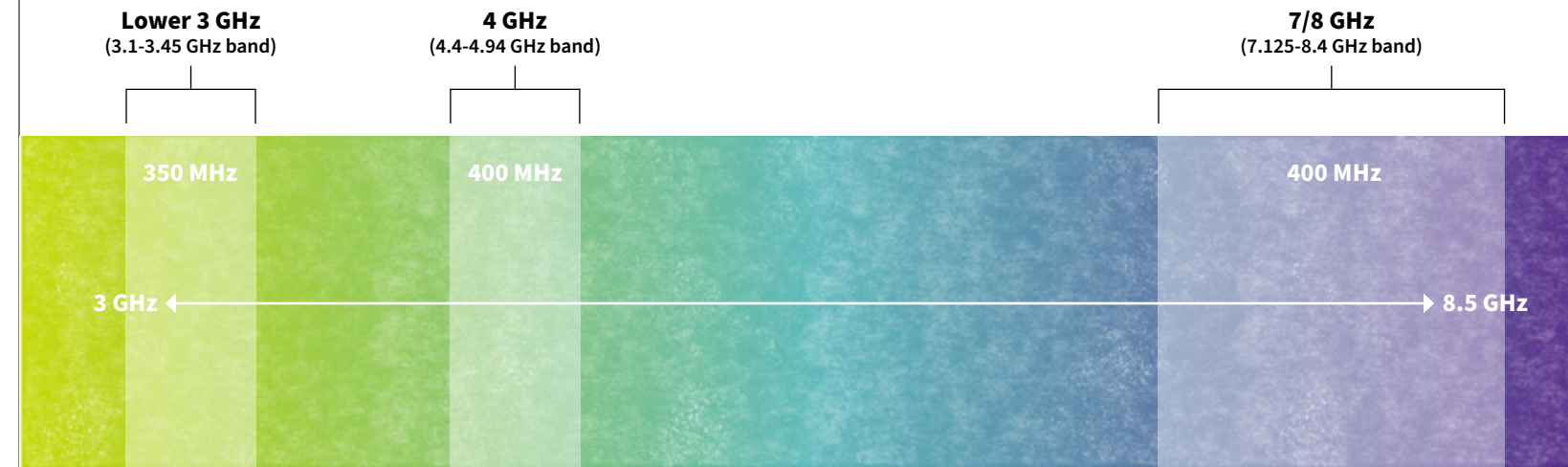
5G home broadband has significant momentum in the market, but this service requires more spectrum to scale up to its potential as a nationwide home broadband competitor. Today operators only offer this service in areas with sufficient capacity to provide reliable quality of service. Without more spectrum, the opportunity for FWA to scale and meet demand for a home broadband alternative to cable will likely be foregone.

A balanced spectrum policy calls for additional full-power, mid-band spectrum to be allocated for commercial wireless use. **The U.S. wireless industry has very little lower mid-band spectrum, with unlicensed operations in this range having access to 7 times more spectrum than licensed users.**⁵⁰ The variety of government users have access to much more, over 12 times the amount available for commercial wireless.

U.S. Mid-Band Spectrum Access Is Out of Balance



America Needs More Mid-Band for 5G



Unfortunately, the United States is without a concrete plan to reallocate any spectrum bands for 5G today. Even worse, the FCC's auction authority was allowed to lapse for the first time in its 30-year history. Action is urgently needed to set spectrum policy back on track and ensure operators have the necessary resources to meet demand and secure our economic competitiveness.

Research from Accenture identified the lower 3 GHz band, as well as spectrum in the 4 GHz and 7-8 GHz ranges as offering the greatest opportunity, considering the characteristics of these bands and existing global allocations that can provide greater economies of scale in equipment.⁵¹

Time is of the essence for U.S. spectrum policy. Telecommunications stakeholders around the world are gearing up for November's 2023 World Radio Conference, where an arm of the United Nations will coordinate key bands for international spectrum harmonization. Deviating from the rest of the world on the spectrum up for discussion at the WRC will further empower China to set the global spectrum agenda and hand Huawei an advantage in creating lower-cost equipment for the rest of the world.

Over the next decade, we should aim to make 1500 megahertz of mid-band spectrum available for full-power, licensed, commercial use to meet demand and secure our competitiveness. The upcoming WRC offers an important opportunity to align the spectrum needs of 5G and 6G globally. In November, delegations from around the world will consider new mobile allocations for 1490 megahertz of spectrum in various bands between 4.8 GHz to 10.5 GHz. Supporting these proposals, both at WRC and through domestic policies, would set us up for continued success in the wireless innovations ahead.

The Best of 5G Is Yet to Come

Fueled by its enhanced capabilities, 5G has incredible potential to power innovations that help address societal challenges. From developments in augmented reality and holograms, to advanced precision robotics or real-time haptic feedback, 5G provides the connectivity ecosystem that will bring new technologies to life.

The app stores of the 4G era ushered in an explosion of innovation. For the first time, the basics of mobile e-commerce were all brought together within well-supported development environments, with 4G networks providing the capabilities for connected applications. 5G is different. The most transformative 5G applications are not just about software running on traditional smartphones—many of the cutting-edge use cases require development of new hardware or integration with complex machinery. More development is required, and it will be some time before innovators deliver applications that fully leverage the 5G opportunity.

INNOVATORS ARE HARD AT WORK CREATING OUR 5G FUTURE

5G is already having a big impact across industries, but we are just scratching the surface of what we'll see in the years to come. All across the country, thanks to America's early 5G lead, innovators and entrepreneurs are hard at work creating the future. Here are some of their stories.



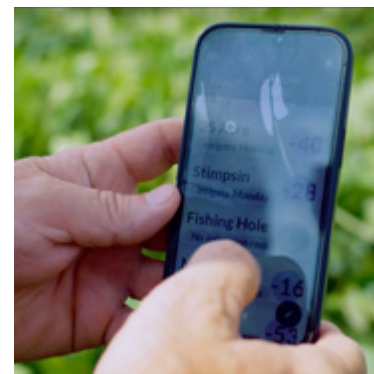
5G is what we need to completely optimize farming.

Peter Knezevich, CEO, Trellis

AGRICULTURE

PETER KNEZEVICH • CEO TRELLIS

Peter and his team at Trellis are using 5G to connect soil sensors to an AI-based platform that collects moisture levels directly from the field and combines that information with historical crop and weather data from that farm to help farmers decide the best time to irrigate. In the past, farmers would water their fields when they thought the soil was dry. With 5G, farmers—like Jon Carroll, a 4th generation Arkansas farmer—can receive data directly from their fields to their smartphones and make informed decisions about when to apply more water. By better managing field conditions and water use throughout the growing season, family farmers can potentially save millions of gallons of water every year without negatively impacting yields or their bottom lines. 5G will allow applications, like Trellis, to optimize precision agriculture and help strengthen the future of America's family farms.



TRANSPORTATION

ANAND NANDAKUMAR • CEO HALO.CAR

Anand and his team at Halo.Car are driving the future of transportation with 5G connectivity and their all-electric, remote-piloted cars available on demand through the Halo.Car app. In order to make any sizeable impact on reducing the carbon footprint of the transportation sector, Anand realized his solution had to make electric vehicles more accessible to all and replace the need for personal car ownership. For Halo.Car's remote-piloted technology to work safely and effectively, there needs to be a fast, reliable connection that can handle the massive amount of data generated from multiple cameras and sensors on the vehicle. That's where 5G comes in. With 5G, Halo.Car's on-demand approach to vehicle access transforms the current car ownership model to a more economical and sustainable solution: a smaller number of electric vehicles being used by multiple people multiple times throughout the day. More 5G deployment is key to expanding Halo.Car's model to more cities across the country and connecting more transportation use cases that will help make our roads safer, improve traffic and reduce emissions.



5G is key to making electric, remote-piloted vehicles accessible everywhere.

**Anand Nandakumar,
Founder and CEO of Halo.Car**

EDUCATION

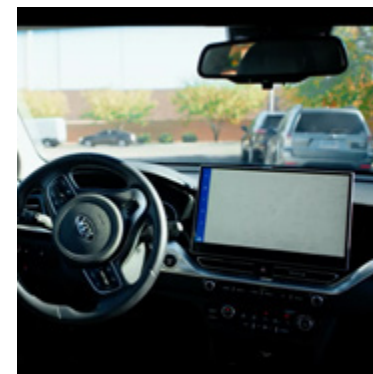
KAI FRAIZER • FOUNDER & CEO KaiXR

Kai is using 5G to connect students at under-resourced schools with immersive, virtual reality field trip experiences. As an educator in Title I schools, Kai saw firsthand how her students didn't have access to new technology or educational opportunities outside of the classroom, and she wanted to find a way to connect her students to those learning experiences. With 5G and virtual reality technology, KaiXR brings more than 100 field trips to students through a mobile-based platform. These virtual field trips have expanded students' horizons as they learn about new ideas, places, and careers. 5G can help close the digital divide by connecting more kids and addressing inequities in education with new technology, like KaiXR.



5G is needed to connect more kids to life-changing educational experiences.

Kai Fraizer, Founder & CEO, Kai XR



PUBLIC SAFETY

**SONIA KASTNER • CEO
PANO AI**

Sonia and her team at Pano AI are leveraging 5G connectivity in remote, mountain-top areas of the Pacific Northwest to help firefighters pinpoint, detect, and monitor wildfires. The firefighting community is facing a mounting threat of faster spreading and more dangerous wildfires than ever before, yet the tools they are working with have not kept up. Sonia saw an opportunity to upgrade firefighters' tools using modern technology, like 5G and AI. Pano AI is deploying a network of cameras that collect high-resolution, 360-degree video of the surrounding landscape and uploaded that data instantly to the cloud via the 5G network. That data is run through an AI-based platform that can detect the threat of smoke and provide real-time, actionable intelligence to the firefighting community and other stakeholders involved in emergency response. More 5G deployment will allow Pano AI to go deeper into the forest and into more remote communities to help mitigate the threat of wildfires and provide critical information that can speed up emergency response times.



We need 5G technology to harness the power of rich camera data with low latency, reliability and consistency.

Sonia Kastner, CEO, Pano AI

SMART CITIES

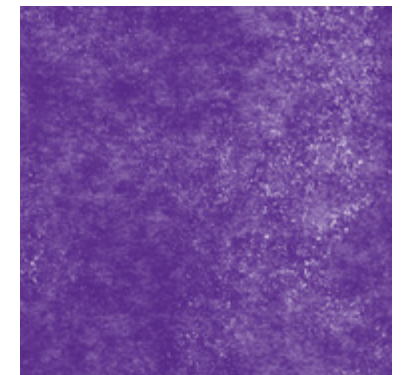
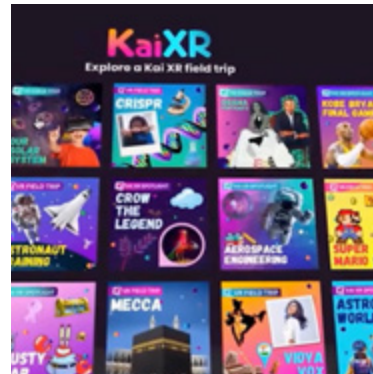
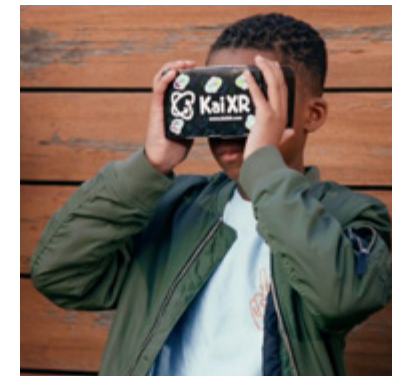
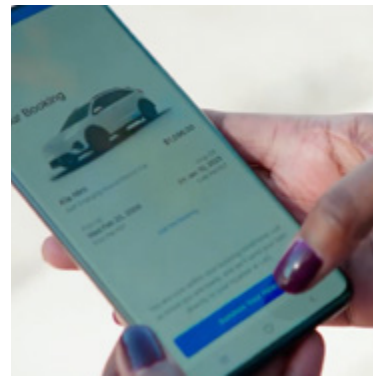
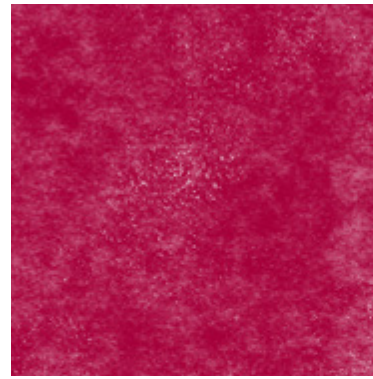
**BRIAN JOHNSON • CITY MANAGER
PEACHTREE CORNERS, GEORGIA**

Brian is using the 5G network to build the smart city of the future in Peachtree Corners, Georgia. Technology Parkway in the heart of Peachtree Corners is a living laboratory for companies to deploy smart city innovation—such as autonomous shuttles, IoT connected infrastructure, and camera-as-a-sensor technology—in a real-world environment. Brian recognized early on that 5G connectivity needed to be the foundation for making the “City Street of the Future” a reality because it provides the speed, latency, and reliability to connect an ecosystem of smart city innovation with the flexibility to move and evolve with the pace of the community. All of the 5G-connected infrastructure, cameras, and sensors in Peachtree Corners generate a massive amount of data that the city is able to use to inform municipal projects and resource allocation, making the community smarter, safer, and more vibrant. Peachtree Corners is showing other cities what is possible with more 5G connectivity to grow smart city innovation, connect people and create thriving communities across the country.



5G is a major factor in growing the economy, creating jobs and making our community more vibrant.

Brian Johnson, City Manager,
Peachtree Corners, GA



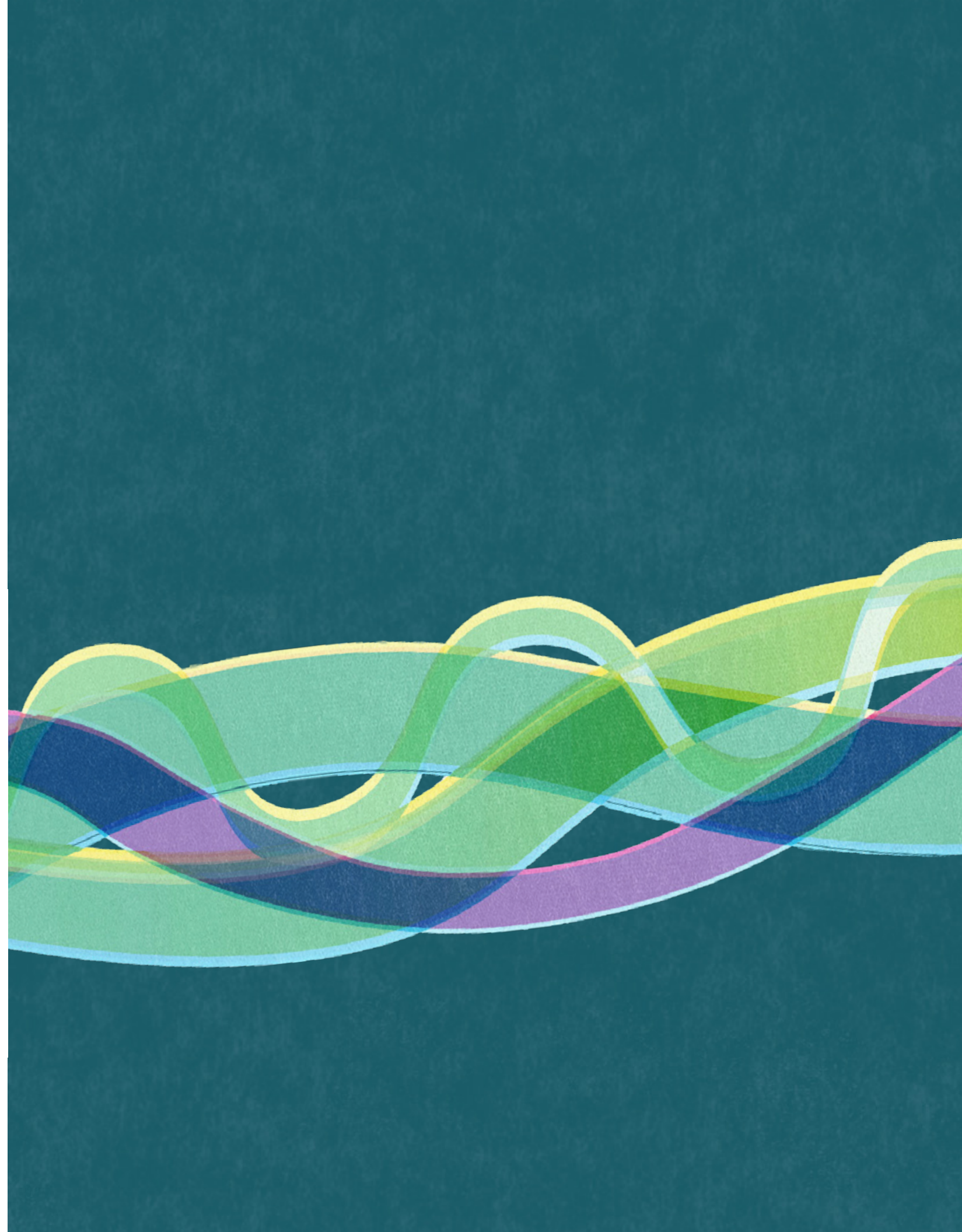
Conclusion

5G has arrived, with faster-than-ever wireless networks blanketing the country. These networks are already powering new innovations throughout the economy, and the 5G platform will become more powerful and transformative each year as network capabilities grow and the 5G innovation ecosystem takes off.

Spectrum is the key to maintaining our 5G leadership, but unfortunately today there is no established pipeline for additional 5G spectrum and, what's worse, Congress allowed FCC auction authority to expire for the first time in its 30-year history.

We need to restore FCC auction authority with a pipeline of full-power, licensed, mid-band spectrum, with the goal of making available at least 1,500 megahertz for commercial use. The bands with the greatest promise for addressing this challenge are lower 3 GHz, 4 GHz, and 7/8 GHz. As in the past, this can be done while protecting and advancing the federal mission, particularly of DoD, and ensuring that America leads the global wireless race and sets the agenda for the next iteration of our digital future.

Additional full-power, licensed, mid-band spectrum is the fuel we need to meet ever-growing 5G demand, help close the digital divide, and protect our economic and national security with the most reliable, resilient, and secure wireless available.



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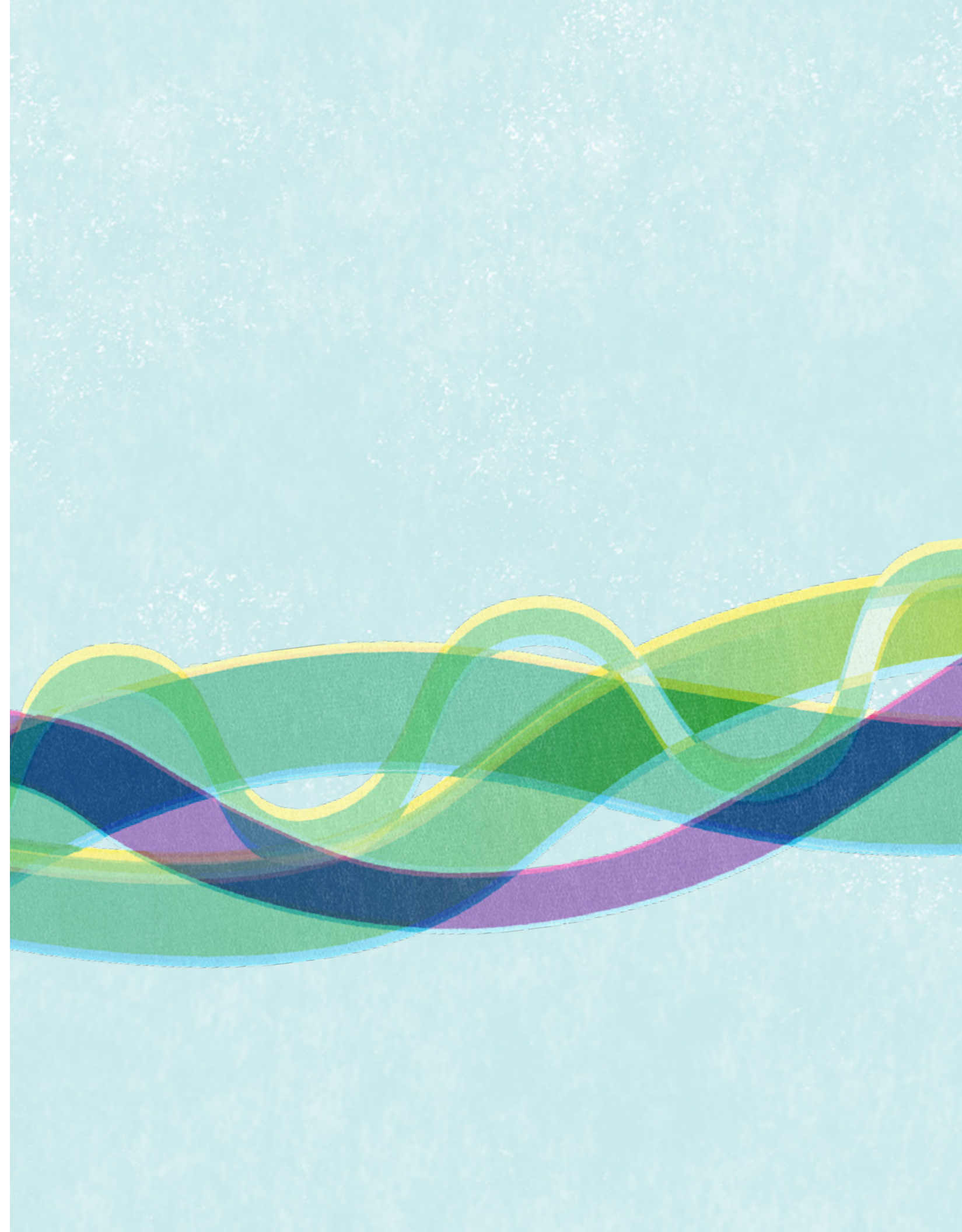
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