ctia™

A National Spectrum Strategy to Lead in 5G

The growth in the availability of mobile wireless broadband connectivity over the past decade has reshaped the American experience—the way Americans work, learn, shop, run businesses, transport their families and goods across the Nation, farm, conduct financial transactions...and interact with one another."

– President Trump

Introduction

5G wireless promises to transform the way we live and work. From new smartphone uses, automated vehicles, and the Internet of Things to remote healthcare, augmented and virtual reality, industrial automation and more, the innovations of the future will be built on 5G. And 5G requires an influx of more spectrum to support Americans' mobile needs and our global wireless leadership.

With smart government policies focused on free market spectrum auctions, the U.S. won the race to 4G, growing our economy and spurring American innovation and leadership of the technologies that defined the decade, such as smartphones, apps, and mobile services.

Recognizing 5G's potential, and that "the real advances will be made by innovators across America using spectrum in unforeseen ways," the Trump Administration is engaged in an ambitious project to develop a National Spectrum Strategy that gives "industry more freedom to innovate" and "reach the full potential that 5G offers."[1]

This document lays out a strategy to help fulfill the Administration's bold vision with a three-point plan of action:

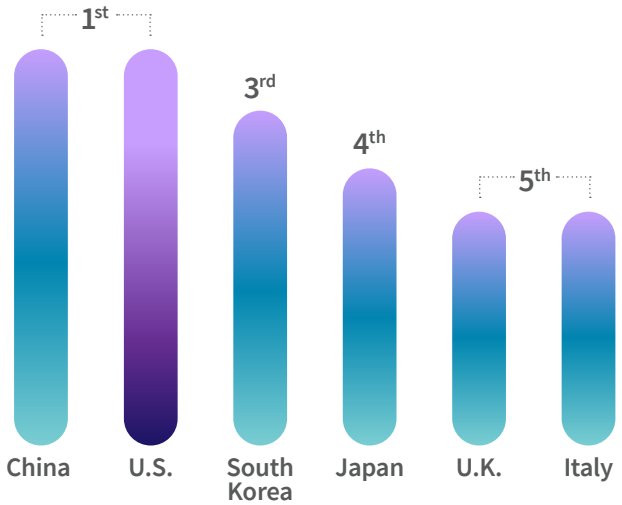
1. **Creating a five-year schedule of auctions that puts more high-, mid- and low-band spectrum in the hands of America's wireless industry.**
2. **Recommitting federal spectrum policy to proven free market approaches that harness the power of competition to enhance our nation's economic and national security.**
3. **Modernizing government policies and procedures to ensure optimal use of spectrum.**

This plan will unleash a significant spectrum stimulus that will create jobs, grow our economy, and help America lead the industries of the future.

01. The 5G Challenge

A year ago, China and South Korea were leading the 5G race, with the U.S. close behind.[2] This year, America is now tied for first with China in 5G readiness.[3]

Global 5G Readiness—2019

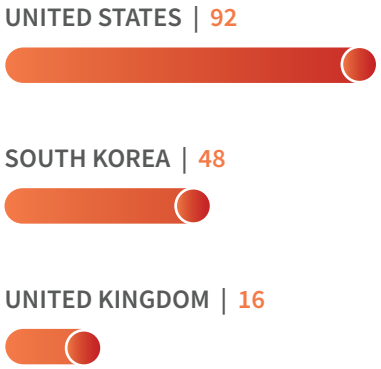


This improvement is thanks to significant investment by America's wireless industry and to policymakers' quick action and visionary leadership, which is empowering America's commercial wireless industry to challenge each other to build the world's biggest, most robust, and most secure 5G networks.

By the end of 2019, America will have almost double the number of 5G deployments compared to its next highest rival, with 5G networks launching from Harrison County, Mississippi and Indianapolis, Indiana to Phoenix, Arizona and Nashville, Tennessee.[5]

5G Deployments

(by the end of 2019)



Key Policymaker Actions

During this Administration, policymakers have taken key steps to jump start our 5G efforts. Under FCC Chairman Pai's 5G FAST plan, the agency took key actions to make spectrum available for 5G. When 2018 began, no spectrum auctions were scheduled. Today, the FCC has auctioned the 28 GHz band; is currently conducting the 24 GHz auction; and will auction additional bands later this year.

Congress also enacted the Spectrum Pipeline Act—requiring NTIA to identify spectrum for reallocation—and the MOBILE NOW Act, which requires the auctioning of 100 megahertz of spectrum below 6 GHz for licensed use. The Administration also took an important step forward in directing the Commerce Department to review the 3.45-3.55 GHz band with an eye toward reallocating that spectrum for wireless.

But the work is far from done. While America ranks strongly in the majority of 5G-readiness metrics, China and many other countries are ahead in making critical mid-band spectrum available for 5G and Chinese wireless operators are conducting hundreds of large-scale 5G trials across the country, thanks to a significant wireless infrastructure advantage. Rectifying the mid-band spectrum deficit should be central to the Administration's efforts, and a renewed commitment to free market solutions will help secure our long-term 5G leadership.

Other countries are making

4x

more mid-band spectrum available than the U.S. by the end of 2020.

02. A Spectrum Stimulus

Today, America's wireless industry supports over 4.7 million jobs and contributes $475 billion annually to the economy.[6] The contributions of America's wireless industry make it equivalent in size to the 24th largest economy in the world.[7]

This tremendous success story is the result of decades of policies that enabled the competitive wireless industry to develop licensed spectrum into innovative products and services that deliver value throughout America's economy. The U.S. wireless industry competes to build the best networks, devices, and service offerings—and Americans benefit.

Benefits of Making 5G Spectrum Available

$391B
Boost to the U.S. Economy

1.8M
New Jobs

Looking ahead, substantial economic benefits will come from freeing key low-, mid- and high-band spectrum at regular intervals in the coming years. Reallocating this additional spectrum for commercial use by the U.S. wireless industry will add nearly $400 billion to the U.S. economy and create over 1.8 million new jobs.[8] The full economic impact will be even greater as U.S. entrepreneurs leverage the new 5G platform to lead the world in tomorrow's advancements across health care, transportation, robotics, and other key economic sectors.

03. A Strategy to Lead the Industries of the Future

The National Spectrum Strategy is a unique opportunity for the Trump Administration to provide a comprehensive national vision for continued wireless leadership, and to help build the commercial platform necessary to help fuel American innovation and lead the industries of the future.[9] Given the global focus on 5G, the U.S. needs a clear action plan, built on proven approaches, comprised of the following three steps:

1. A Five-Year Schedule of Spectrum Auctions

The most critical element of the National Spectrum Strategy is the creation of a long-overdue auction schedule of the low-, mid-, and high-band spectrum necessary to fuel the full range of 5G deployments and innovations.

The good news is the Administration and the FCC have already identified each of the key bands needed for our 5G future. It is now about executing on a clearly defined schedule over the next five years to provide the U.S. wireless industry with certainty that providers will have the spectrum they need to compete globally, as well as a timetable to allow effective network planning and design.

The need for planning goes beyond the national and regional wireless operators, and requires close collaboration with network equipment vendors and device and handset manufacturers. The entire U.S. ecosystem needs to know when bands will be available so networks and devices are ready to support U.S. consumers as soon as practicable. The FCC should auction these bands by 2024:

Low-band

Low-band spectrum was the foundation of the first generations of wireless and America's global wireless leadership. Low-band spectrum

3 Types of 5G Spectrum

Low-Band

COVERAGE | HIGH

CAPACITY | LOW

Mid-Band

COVERAGE | MODERATE

CAPACITY | MODERATE

High-Band

COVERAGE | LOW

CAPACITY | HIGH

5G and Education

Columbia University is developing a 5G-enabled experience that exposes students to inaccessible realms such as atoms and particles, planets and stars, black holes and galaxies.

5G and Entertainment

Disney's StudioLab is using 5G to develop interactive theater programming, location-based entertainment, and real-time AR and VR consumer experiences.

can travel long distances and reach indoors, and is widely used by government agencies. To fully leverage the promise of 5G technologies, providers need a mix of spectrum bands, and low-band is key to provide a base coverage level and reach more suburban and rural communities. The most recent low-band auction was the 600 MHz auction in 2017.[10]

Reallocating additional low-band spectrum—the 1.3 GHz and 1.7 GHz bands—can help the U.S. win the 5G race and help federal agencies upgrade to modern, more efficient systems. Congress has already directed that at least 30 megahertz of low-band spectrum be auctioned for licensed use by 2024,[11] and the National Spectrum Strategy should announce at least 100 megahertz of low-band spectrum be auctioned by 2024.

The 1.3 GHz band would provide 50 megahertz of spectrum for next-generation wireless services, and the proceeds of that auction will help the FAA and other incumbent users modernize radar and related systems. The 1.7 GHz band is 50 megahertz directly adjacent to the AWS-3 spectrum that was auctioned in 2015, and offers great synergies with existing wireless offerings. There is good understanding by both commercial and government users of the affected government systems, which will help facilitate a smooth transition.

Mid-band

Mid-band spectrum is a key building block for 5G, thanks to its ability to travel far and offer high capacity for mobile traffic. The global emphasis on mid-band airwaves—Japan, South Korea, Spain, and the UK have already brought mid-band spectrum to market—underscores the importance of policymakers acting quickly to free up hundreds of megahertz of mid-band spectrum.

Policymakers are appropriately focused on spectrum from 3.45 to 4.2 GHz, which is globally harmonized for 5G services, and is where our rival nations are moving forward aggressively to expand access to wireless operators.

3.45 GHz— In 2018, NTIA identified this band for potential 5G use. Under the Spectrum Pipeline Act, the current users of this band—who operate military radar systems—are conducting analysis to determine how best commercial wireless can share this spectrum without impacting agency operations.[12] The FCC has also already ceased authorizing new users of this band to help facilitate a future transition,[13] and the National Spectrum Strategy should set a date certain for a future spectrum auction.

3.5 GHz— The FCC finalized rules for the licensed portion of this spectrum band in October 2018[14] and should schedule an auction by the end of 2019. While only 70 megahertz, this represents the best opportunity to provide mid-band access in the very near term.

3.7 GHz— This 500-megahertz band is the key to U.S. mid-band policy and should be the Administration's primary spectrum initiative this year. The FCC is examining how to reallocate the band for 5G.[15] Other countries are unleashing hundreds of megahertz of this spectrum band for 5G services, and the FCC should move quickly to release hundreds of megahertz for the U.S. as soon as possible.

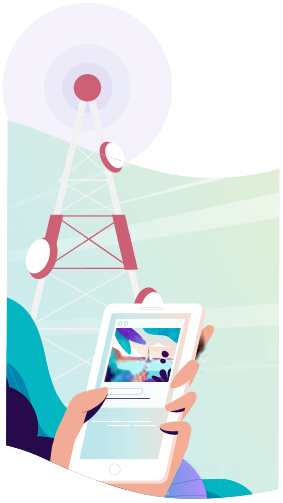
Acting on the 3.7 GHz band will also create new opportunities for both unlicensed and licensed operations in the 6 GHz band—which is the uplink to the downlink satellite bands at 3.7 GHz—while protecting key incumbent users.

High-band

High-band spectrum refers to frequencies above 24 GHz, and is also known as millimeter wave spectrum. A few years ago, high-band spectrum was considered unusable for mobile wireless service, but thanks to significant R&D efforts, high-band spectrum will be key to unlocking 5G's faster data rates, densified connections, and reduced latency. High-band spectrum will be important for high-capacity and data-intensive 5G applications.

The Administration should support the bands already set for auction, help drive action on additional bands identified for future mobile use, and advocate aggressively in support of mobile use of these bands globally. As a leader in high-band spectrum, the U.S. needs to ensure there is a global ecosystem around the bands U.S. operators are already investing in today.

24, 26, and 28 GHz—The FCC has already completed the 28 GHz auction and began the 24 GHz auction in March.[16] Adding the 26 GHz band has support domestically and internationally and will create a nearly 4 gigahertz contiguous block of spectrum. This would create significant economies of scale that would speed deployment, reduce costs for consumers, and advance U.S. leadership in global spectrum policy.



Mid-Band

Making 400 MHz of mid-band spectrum available for commercial 5G networks will add $274 billion to the U.S. economy and create 1.3 million new jobs.

$505B

The economic value of licensed spectrum in the hands of wireless providers today[20]

29, 31, and 32 GHz—Allowing mobile broadband in these bands will leverage economies of scale, enable efficient spectrum use, and is consistent with FCC rules.[17]

37, 39 and 42 GHz—The FCC acted in December 2018 to set the auction rules for 37 and 39 GHz, creating a significant swath of important high-band spectrum to be auctioned by the end of 2019.[18] The Administration should fully support following through with those auctions, and ensuring mobile use around the globe. A single radio chip can leverage the 42 GHz band as well as the 37 and 39 GHz bands, and the Administration should support global use of this entire spectrum block.

47 and 50 GHz—The 47 GHz band is teed up for auction in 2019 and adding the 50 GHz band will create a nearly contiguous block of spectrum for future 5G services.[19]

2. Recommitting to Free Market Spectrum Principles

The first large-scale commercial 5G deployments are happening here, in America, far ahead of schedule—and ahead of any other country, thanks to an embrace of free market policies that unleashed the competitive energy of America's wireless industry. The National Spectrum Strategy should build on this foundation with forward-looking policies that encourage industry investment and free market competition, and that harnesses the creative power of America's innovators and entrepreneurs.

With respect to the five-year schedule as well as longer term spectrum planning, the National Spectrum Strategy should identify enough additional licensed spectrum to ensure that terrestrial wireless services—and 5G in particular—have access to sufficient spectrum. To do so, the Administration should promote a flexible approach that lets spectrum auction winners determine the service offerings that best serve the interest of U.S. consumers. This proven approach—reliant upon licensed spectrum—has been critical to U.S. global wireless leadership, and policymakers should avoid dictating business terms (i.e., retail versus wholesale networks) or technology choices.

Balancing Spectrum Uses

Traditional wireless spectrum allocations trail other licensed services in availability, and the amount of unlicensed spectrum greatly exceeds licensed in the mid- and high-bands. This underscores the need for a clear plan to support additional mobile services.

Satellite allocations cover nearly 30 GHz of spectrum compared to only 6.5 GHz for mobile flexible use. Similarly, in the mid- and high-bands, unlicensed spectrum predominates. Today in the U-NII mid-band, there is 580 MHz dedicated to unlicensed use, compared to only 70 MHz for licensed in the mid-bands. There is a comparable disparity in high-band where more than twice the amount of spectrum is available for unlicensed (14 GHz) as mobile flexible use (5.5 GHz).[21]

A set of fundamental spectrum policies has driven U.S. wireless leadership: exclusive use licenses, flexible use rights, reliance on market forces to ensure spectrum is put to its highest and best use, globally harmonized spectrum, prioritizing cleared spectrum, and investment-friendly technical rules.

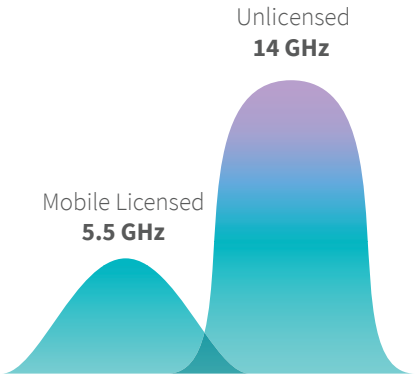
Exclusive Use Licensing

Exclusive-use licensing policies have long been the cornerstone of the U.S.'s successful wireless strategy—and exclusive licenses form the backbone of our mobile networks today. Exclusive-use licenses provide more certainty and predictability to licensees that their investments will be protected against harmful interference, and that they can fully use the spectrum they hold, resulting in more intense and efficient utilization. In addition, exclusive-use licensing helps ensure the security capabilities of the overall wireless network infrastructure. The spectrum needed for 5G networks require an equivalent bundle of rights so wireless providers leverage the airwaves to the fullest and have the flexibility to deploy what consumers and the marketplace demand.

Flexible Use Rights

U.S. wireless providers can deploy any technology consistent with technical rules, in contrast to mandating specific technologies for specific frequencies as has often been done elsewhere in the world. Flexible rights

A Balanced Approach



There is more than twice as much unlicensed spectrum (14 GHz) in high-band than mobile licensed (5.5 GHz).

Security

5G network defenses include the use of standards-based encryption algorithms, new and advanced authentication mechanisms, data encoding, anti-spamming software to protect against unwanted and illegal calls and messages, strict controls for physical and IT access, and customized security updates. Such network security protections will extend to the growing cellular-capable IoT market.

The National Spectrum Strategy should encourage the U.S. government to continue to work with the wireless industry on security strategies—drawing on market-oriented risk management principles, industry-government leadership models, and the work of CSRIC and NIST—to promote 5G security.

apply to both technological choice and wireless service business models. By permitting licensees to offer mobile, fixed, or portable services with the technologies that help meet whatever the market demands, flexible-use rights have fostered investment and innovation because they empower licensees to differentiate themselves by offering one service or a mix of services. The results are greater consumer choice, intensified competition, increased opportunities for innovation, and spectrum that is put to its highest and best use.

Market-Based Spectrum Policies

Secondary market transactions of spectrum licenses, the auction of new spectrum licenses, and the use of incentive auctions to repurpose spectrum provide strong incentives for licensees to make efficient use of spectrum.[22] Market-based spectrum policies have raised over $114 billion in auction proceeds for the U.S. Treasury, and provided incentives for U.S. wireless providers to make private investments of almost $300 billion over the past ten years. In the MOBILE NOW Act, Congress also recognized the value of market-based spectrum policies in closing the digital divide.[23]

Emphasize Globally Harmonized Spectrum

Harmonization enables device and equipment vendors to design wireless products and services that can operate in multiple countries, thereby generating substantial economies of scope and scale that help to minimize costs and thereby increase demand. The government should focus on encouraging harmonization of spectrum bands,[24] while retaining America's flexibility to lead on key 5G spectrum bands.[25]

Prioritization of Cleared Spectrum

Reassigning spectrum for exclusively licensed use is key and the National Spectrum Strategy should reaffirm this is the optimal approach. There are however circumstances where incumbent operations pose challenges to reallocating for exclusive-use licensed purposes, and a sharing framework will be the best means to repurpose spectrum. In that event, the sharing regime should provide spectrum licensees with sufficient rights to warrant the investment necessary to deploy robust, next-generation networks.[26]

Investment Friendly Technical Rules

The National Spectrum Strategy should also endorse the core technical characteristics needed to support 5G. Firstly, large blocks of spectrum will allow for wide channelization that enables key 5G attributes: speeds up to 100 times faster than 4G networks and single-digit latency.[27] Both mid- and high-band spectrum can accommodate the wide bandwidths necessary to facilitate faster connections and lower latency.[28]

Mid-band and high-band spectrum blocks for 5G should have 100-megahertz channel sizes as a minimum goal whenever practical.[29] Similarly, blocks of contiguous spectrum enable faster data rates, lower latency, and improved spectral efficiency (allowing more capacity in the same amount of spectrum).[30] Contiguous spectrum for 5G should be prioritized to the extent possible, and candidate bands adjacent to existing commercially allocated bands should be prioritized.

5G networks can support a much greater number of transmitters within antenna arrays in base stations and devices. While a 4G antenna may have up to eight transmitters, 5G antennas may be driven by up to 128 transmitters—known as Multiple Input Multiple Output (or massive MIMO) antenna arrays—that work together to deliver faster speeds and increased spectral efficiency. Spectrum bands identified for 5G will help support massive MIMO.

Siting

To handle growing mobile data demands and unlock new 5G applications, wireless providers will also need to install hundreds of thousands of small cells—small antennas the size of backpacks—in the next few years.

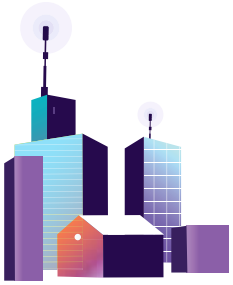
In order to speed deployment of this new infrastructure, the FCC acted in 2018 to modernize the thirty-year old infrastructure siting rules designed for 200-foot cell towers. The FCC exempted small cells from federal historic and environmental reviews and streamlined those processes for all wireless siting deployments, clarified that moratoria—express, de facto, temporary, or permanent—on siting requests are prohibited, and adopted guardrails for state and local reviews of small cell projects.

5G and Healthcare

Rush University Medical Center is creating the first 5G-enabled hospital, enabling telemedicine, smart scheduling, and enhanced patient care through artificial intelligence and augmented reality.

5G and Agriculture

John Deere is developing 5G analytics and automation tools for farmers that will improve yields and reduce the use of herbicides.



5G and Smart Cities

Greenville, SC is building a 5G smart city ecosystem enabling connected vehicles, autonomous drones and other smart machines to operate in real time and enhance city life.

Other countries are moving aggressively to deploy the infrastructure needed for 5G. For instance, a recent study showed China with more than 14 wireless cell sites per 10,000 people, compared to 4.7 in the United States, and more than 5 sites per every 10 square miles, compared to 0.4 in the U.S.[31]

The National Spectrum Strategy should build on this historic achievement by supporting continued reforms that encourage all levels of government to clear barriers to 5G deployment—primarily timely and affordable access to government lands (particularly federal lands), buildings, and facilities, and to public rights-of-way.[32]

3. Modernizing Government Policies and Procedures

Smart spectrum policy is good government policy and the National Spectrum Strategy should articulate a vision for modernizing the government's approach to managing this resource in a way that both benefits government operations, and encourages private sector development. Government agencies have national security and operational needs for spectrum, and the National Spectrum Strategy should seek to ensure the federal government uses its substantial spectrum holdings in an efficient and forward-thinking manner.

Re-purposing government-held spectrum for commercial services can also generate billions of dollars that go right back to the agencies that freed up that spectrum, allowing them to invest in modern, more efficient wireless systems and technologies. This has helped the Department of Defense in the past, and promises even more significant benefits across the federal government in the future.

Providing Incentives for Win-Win Scenarios

This process—where federal agencies identify and work to relocate often mission-critical spectrum uses in order for the FCC to auction the spectrum and generate funding for government agencies to upgrade their wireless systems—only works well when agencies are incentivized to act.

CASE STUDY:

How the Spectrum Auctions and the SRF Helped the Dept. of Defense

The 2015 AWS-3 auction generated $3.5 billion—including $500 million from the SRF alone—for the DoD allowing the deployment of new equipment, better capabilities, and increased readiness.

As Maj. General Robert E. Wheeler (USAF Ret.) noted, "[T]he military's capabilities and systems are greatly improved as a direct result of proceeds of the last two auctions of spectrum reallocated for commercial use."

The good news is that the Commercial Spectrum Enhancement Act (CSEA) of 2004 created a notable incentive—the Spectrum Relocation Fund (SRF)—that allowed agencies to receive funding from spectrum auctions to cover their relocation costs and explore future spectrum-related R&D.

As 5G increases the need for commercial spectrum, policymakers should focus on CSEA-eligible bands—like the 1.3 GHz, 1.7 GHz, and 3.45 GHz bands—for auctions and make targeted enhancements to the SRF to further incentivize federal agencies, while providing improved equipment and cybersecurity protections. The National Spectrum Strategy should modernize the government's approach to spectrum planning, management and use in the following ways:

Enhancing Federal Spectrum Transparency— Spectrum is a "valuable, finite resource"[33] that must be used efficiently and effectively. To that end, the National Spectrum Strategy should promote transparency and collaboration between federal agencies and the commercial sector—like the call in the Presidential Memorandum for federal agencies to review current frequency assignments and quantify spectrum use.[34]

Smart SRF Enhancements— Since its creation in 2004, the SRF has greatly improved the incentives for federal agencies to actively participate in

> **We are actively identifying and studying additional spectrum bands that could be made available for commercial uses. We're also supporting national and international efforts to harmonize spectrum and set technology standards. And we're working with industry to help remove obstacles to deploying the network infrastructure that's needed for 5G to flourish."**
>
> – NTIA Administrator David Redl

spectrum reallocation efforts, and the National Spectrum Strategy should seek opportunities to further enhance that successful program. The National Spectrum Strategy should support use of the SRF for exploring technology advancements that could facilitate the transition of federal spectrum for commercial use.

Specifically, making the SRF R&D review process more flexible, using SRF funds to develop a standardized national information repository on federal spectrum use, and creating an automated enforcement mechanism to allow federal agencies to rapidly identify and eliminate interference issues would serve the goals of the SRF: allowing for more effective use of federal spectrum resources and making spectrum available for our 5G future.

Advancing Spectrum Management and Use— The National Spectrum Strategy should advance spectrum management and innovative spectrum use through research, development, testing, and evaluation. Additional funding for the support agencies that manage the overall process—NTIA, OMB and the FCC—would likewise pay great dividends.

Policymakers should promote initiatives—like video compression technology and secure, automated capabilities that can assess spectrum use and expedite coordinated spectrum usage among federal and commercial users—that can lead to spectrum clearing and development of spectrum-sharing tools. The National Spectrum Strategy should commit to study with industry the 3.5 GHz experiment in spectrum sharing three years after widespread deployment of commercial services in the band in order to assess whether that three-tier sharing mechanism could—or should—be used for future spectrum bands.

Boosting 5G Equipment Authorization Processes— The FCC's ability to conduct prompt and comprehensive equipment authorization of new devices is a critical gating factor to achieving the immense promise of 5G. The National Spectrum Strategy should ensure that the FCC has the resources necessary to advance and streamline its current equipment and device application and approval processes.

About the Research

This paper draws on original research from Analysys Mason, Analysis Group, and The Brattle Group.

Analysys Mason

Analysys Mason compared 5G spectrum and infrastructure policies proposed in markets worldwide to advance 5G technology and facilitate successful network deployment, and to prepare a readiness comparison between markets.

Analysis Group

Analysis Group conducted a series of analyses of the economic impact of low-, mid-, and high-band spectrum, if such spectrum was made available for 5G services.

The Brattle Group

The Brattle Group updated their analysis of the estimated value of licensed spectrum in the hands of wireless providers today.

Endnotes

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13. Public Notice, Temporary Freeze On Non-Federal Applications In The 3100-3550 MHz Band, WT Docket No. 19-39 (Feb. 22, 2019), https://docs.fcc.gov/public/attachments/DA-19-105A1.pdf.
14. The 3.5 GHz band refers to the 3550 to 3700 MHz frequencies. See Promoting Investment in the 3550-3700 MHz Band, Report and Order, 33 FCC Rcd 10598 (2018).
15. The 3.7 GHz band refers to the 3700 to 4200 MHz frequencies. See Expanding Flexible Use of the 3.7 to 4.2 GHz Band, Report and Order and Notice of Proposed Rulemaking, 33 FCC Rcd 6915 (2018).
16. The 24, 26, and 28 GHz bands refer to frequencies of 24.25 to 24.45 GHz and 24.75 to 25.25 GHz, 25.25 to 27.5 GHz, and 27.5 to 28.35 GHz, respectively. See Public Notice, Auctions of Upper Microwave Flexible Use Licenses For Next-Generation Wireless Services (Apr. 17, 2018), https://docs.fcc.gov/public/attachments/FCC-18-43A1.pdf; see also Public Notice, Auction of 28 GHz Upper Microwave Flexible Use Service Licenses For Next-Generation Wireless Services Closes, Gross Winning Bid Amounts Announced For Auction 101 (Jan. 31, 2019), https://docs.fcc.gov/public/attachments/DA-19-23A1.pdf.
17. The 29, 31 and 32 GHz bands refer to frequencies of 29.1 to 29.25 GHz, 31 to 31.3 GHz, and 31.8 to 33.4 GHz, respectively. The Commission previously declined to adopt service rules for the 29 and 31 GHz bands that allow mobile, terrestrial use. Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, et al., Notice of Proposed Rulemaking, 30 FCC Rcd 11878, 11902 ¶ 70 (2015). The Commission previously proposed allocating the 32 GHz band for exclusive, licensed use. Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, et al., Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration, and Memorandum Opinion and Order, 32 FCC Rcd 10988 (2017).
18. The 37, 39 and 42 GHz bands refer to frequencies of 37.6 to 38.6 GHz, 38.6 to 40 GHz, and 42.0-42.5 GHz, respectively. See Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, Fourth Report and Order, GN Docket No. 14-177, FCC-18-180, at ¶ 2 (2018).
19. The 47 and 50 GHz bands refer to frequencies of 47.2 to 50.2 GHz and 50.4 to 52.6 GHz, respectively. See Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, Fourth Report and Order, GN Docket No. 14-177, FCC-18-180 (2018).
20. Coleman Bazelon & Paroma Sanyal, Mobile Broadband Spectrum: A Revaluation in a 5G World, THE BRATTLE GROUP (April 2019).
21. Unlicensed is a key component in meeting consumer demand, and the U.S. Government must maintain a keen eye as to the ongoing balance between licensed and unlicensed spectrum. The FCC historically allocated more low-band spectrum to licensed services, recognizing its vital role in mobile network deployments and facilitating broad coverage, but in the mid- and high-bands, unlicensed spectrum dominates. For instance, 5.5 gigahertz has been committed

to flexible-use licensing in high-band spectrum, while nearly three times that amount – 14 gigahertz – is reserved for unlicensed. See Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd 8014, 8096 ¶ 239 (2016); see also Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, Second Report and Order, Second Further Notice of Proposed Rulemaking, Order on Reconsideration and Memorandum Opinion and Order, 32 FCC Rcd 10988 (2017).

22. FCC Chairman Ajit Pai has noted that auctions "have facilitated the explosion of wireless services that have created millions of U.S. jobs and improved the American people's lives in countless ways." See Ajit Pai, FCC Chairman, Remarks at the Hudson Institute: The Importance of Economic Analysis at the FCC, at 2 (Apr. 5, 2017), https://docs.fcc.gov/public/attachments/DOC344248A1.pdf.
23. MOBILE NOW Act as incorporated in the Consolidated Appropriations Act, 2018, Pub. L. No. 115-141, 132 Stat. 348, Division P, Title VI, (2018).
24. Through allocations, identifications, and development of interference protection criteria, the Administration should ensure that its positions reinforce our 5G leadership and do not undermine access to critical bands identified for 5G in the U.S.
25. For instance, the United States must continue to chart a path for leadership in terrestrial, flexible-use spectrum, and that path can sometimes diverge from those other nations choose.
26. For spectrum sharing to be successful, arrangements must ensure the utility of the band for commercial use and any sharing conditions should be clear prior to auctioning the spectrum. Some sharing mechanisms have proven successful. For example, geographic sharing has been used successfully for years. Coordination zones are preferable to exclusion zones, and should be minimized and based on real-world interference analysis. AWS-3 spectrum is an example of a successful sharing model between federal and commercial interests. Individual government uses were defined and sharing criteria developed in coordination with the commercial industry. With this sharing framework in place, the FCC held the AWS-3 auction – netting more than $41 billion for the U.S. Treasury and the funding of key national priorities. See FCC, Auction 97: Advanced Wireless Services (AWS-3), https://www.fcc.gov/auction/97/factsheet.
27. See Comments of CTIA, Expanding Flexible Use of the 3.7 to 4.2 GHz Band, et al., GN Docket No. 18-122, at 9 (filed Oct. 29, 2018).
28. See id. at 9.
29. We recognize that the FCC may not immediately allocate 100-megahertz channels, notably in the mid-band spectrum. Other countries have recognized this physical and technological reality and are focusing on the availability of 100-megahertz channels for 5G. See Comments of Nokia, Expanding Flexible Use of the 3.7 to 4.2 GHz Band, et al., GN Docket No. 18-122, at 4-5 (filed May 31, 2018) (noting that China, South Korea, and Japan have prioritized providing 100 megahertz of spectrum per operator in the mid-band spectrum range).

30. While carrier aggregation technology has allowed for the aggregation of non-contiguous spectrum blocks, use of this method introduces latency and signaling overhead (especially as more providers and/or spectrum is added). See White Paper, Wireless Technology Evolution, Transition from 4G to 5G, 5G AMERICAS, at 192-93 (Oct. 2018), http://www.5gamericas.org/files/8015/4024/0611/3GPP_Rel_14-16_10.22-final_for_upload.pdf.
31. Deloitte, 5G: The chance to lead for a decade (2018), https://www2.deloitte.com/content/dam/Deloitte/us/Documents/technology-media-telecommunications/us-tmt-5g-deployment-imperative.pdf.
32. See, e.g., American Broadband Initiatives Milestones Report, NTIA, at 14--19 (Feb. 2019), https://www.ntia.doc.gov/files/ntia/publications/american_broadband_initiative_milestones_report.pdf.
33. See David Redl, NTIA Assistant Secretary for Communications and Information, Testimony Before the U.S. Senate Commerce, Science, and Transportation Committee (June 13, 2018), https://www.ntia.doc.gov/speechtestimony/2018/testimony-assistant-secretary-redl-senate-commerce-science-and-transportation.
34. Presidential Memorandum on Developing a Sustainable Spectrum Strategy for America's Future, Sect. 1 (issued Oct. 25, 2018), https://www.whitehouse.gov/presidential-actions/presidential-memorandum-developing-sustainable-spectrum-strategy-americas-future/

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