

**House Committee on Energy and Commerce  
Subcommittee on Communications and Technology  
“5G and Beyond: Exploring the Next Wireless Frontier”**

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Chairman Doyle, Ranking Member Latta, and Members of the Subcommittee, thank you for inviting me today to provide a global perspective on policies to enable the deployment of 5G, next-generation Wi-Fi, and 6G. I serve as Global Executive Director of Product and Digital Infrastructure Policy at Intel Corporation. In this role, I am responsible for Intel’s policy efforts related to digital infrastructure, including 5G, 6G, and Wi-Fi connectivity; Artificial Intelligence (AI); autonomous vehicles; and Internet of Things (IoT). My responsibilities also include representing Intel in certain global forums, including the World Radiocommunication Conferences (WRC) and the International Telecommunications Union (ITU). I currently chair the Federal Communication Commission’s (FCC) WRC-23 Advisory Committee Informal Working Group for terrestrial services and serve as a member of the Department of State’s International Digital Economy and Telecommunication Advisory Committee. I also serve on the Board of Directors for the Open RAN Policy Coalition and the US Telecom Training Institute and am a member of the Global mobile Suppliers Association (GSA) Spectrum Group management team.

**I. Executive Summary**

Given the tremendous growth in adoption of wireless technologies fueled by innovation in many existing and emerging applications, it is imperative to replenish the spectrum pipeline for mobile broadband technologies for both near-term and long-term deployment needs. For example, extended mid-band spectrum ranges, below 3.45 GHz and within 7.125 GHz to ~15 GHz, and high bands, including spectrum above 95 GHz, should be explored to support the capacity, speed, and latency requirements of new and emerging applications. Making new spectrum bands available for use in a timely manner is crucial to establishing a U.S. leadership role in wireless. Given the lengthy process involved in making spectrum available for commercial use, the U.S. must move quickly to consider which bands can be studied to ensure U.S. leadership in next generation deployments. Further, with the FCC’s auction authority set to expire this year, extension of the FCC’s spectrum auction authority will be important to ensure the spectrum pipeline can continue to flow to enable future U.S. broadband deployment efforts. Finally, Intel looks forward to partnering with the federal government through the CHIPS Act programs to enhance domestic semiconductor R&D and manufacturing.

## II. Background

Intel Corporation is one of the world's largest semiconductor manufacturers, employing over 110,000 people globally, with approximately half in the United States. Intel's headquarters are in Santa Clara, California, with innovation hubs in Oregon, Arizona, California, New Mexico, and Texas. As an integrated device manufacturer (IDM), Intel both designs and manufactures products within its own leading-edge manufacturing and advanced packaging network. In 2021, Intel invested \$18.7 billion in capital expenditures and \$15.2 billion in R&D,<sup>1</sup> ranking sixth among publicly-traded U.S. companies in individual R&D investment.<sup>2</sup>

Intel is making unprecedented new investments in U.S. semiconductor manufacturing capacity. In the past year, Intel announced \$43.5 billion in investments for the construction of new semiconductor fabrication facilities in Arizona and Ohio<sup>3</sup> and for the manufacturing of advanced semiconductor packaging technologies in New Mexico.<sup>4</sup> These announcements demonstrate Intel's ongoing commitment to leadership investments in manufacturing and R&D in the United States.

Intel is one of only three semiconductor manufacturers in the world manufacturing semiconductors using advanced nodes and the only one with R&D anchored in the United States. Intel's processors, memory, storage, and other products power much of the world's computing capability. Intel semiconductor products are foundational to personal computing, cloud computing, AI, IoT, autonomous vehicles, quantum computing, high-performance computing – and most important for today's hearing – 5G and Wi-Fi.

One of Intel's roles as a leader in 5G is to supply high-volume and high-quality products to telecom equipment manufacturers. 5G runs on Intel: through our Network Edge Group, we are a leading silicon provider for 5G infrastructure. Intel also ignited the wireless revolution by integrating Wi-Fi™ into laptops in 2003. Since 2016, Intel has been the market leader of Wi-Fi and Bluetooth solutions for the Personal Computer (PC) market through our Client Computing Group. Intel also holds leading positions in major standards and industry organizations, spearheading the development of wireless technologies. Intel employees hold leadership positions in 3GPP, IEEE, and ATIS Next G Alliance, as well as Working Groups in the ITU,

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<sup>1</sup> Intel Corporation Annual 10-K for Fiscal Year Ending December 25, 2021, available at <https://www.intc.com/filings-reports/all-sec-filings/content/0000050863-22-000007/0000050863-22-000007.pdf>.

<sup>2</sup> Intel's Impacts on the US Economy," Report Issued April 2021, using data for FY 2019, available at <https://www.intel.com/content/www/us/en/newsroom/news/us-economic-impact-study.html?wapkw=economic%20impact#gs.tptln6>.

<sup>3</sup> Intel Press Releases available at <https://www.intc.com/news-events/press-releases/detail/1501/intel-breaks-ground-on-two-new-leading-edge-chip-factories>; <https://www.intel.com/content/www/us/en/newsroom/news/intel-announces-next-us-site-landmark-investment-ohio.html>.

<sup>4</sup> Intel to Invest \$3.5 Billion to Expand New Mexico Manufacturing Operations, Press Release available at <https://www.intel.com/content/www/us/en/newsroom/news/new-mexico-manufacturing.html>.

including WRC preparatory efforts. In short, Intel is active through the wireless technology life cycle, from helping drive the development of wireless standards, to powering the network from the core to the edge, enabling access on laptops and IoT devices, and driving transformation in 5G networks, Artificial Intelligence, autonomous vehicles and data centers.

### **III. Spectrum Pipeline Considerations**

Given the tremendous growth in adoption of wireless technologies fueled by innovation in many existing and emerging applications, it is imperative to replenish the spectrum pipeline for mobile broadband technologies, for both near-term and long-term deployment needs. Future needs will include spectrum in low bands (with excellent propagation characteristics for wider coverage areas), high bands (with potentially wider channel bandwidths for higher data rates), and mid bands (which combine favorable propagation and potential for wider channel bandwidths). As FCC Chairwoman Jessica Rosenworcel recently stated at Mobile World Congress, for “6G we need to start planning now to identify spectrum in the 7-15 GHz range that can support faster speeds and wider coverage.”<sup>5</sup> Considering the importance of providing varied spectrum for 5G and beyond, we should not forget the need for additional spectrum in the extended mid-band ranges both below 3.45 GHz and above 7.125 GHz. In particular, spectrum bands up to around 15 GHz should be considered to identify sufficient spectrum bands to support new and emerging applications while protecting incumbent services. In the context of very high bands, studies in the ITU may open up possibilities for larger, contiguous bandwidths for future terrestrial applications.<sup>6</sup> Replenishing the spectrum pipeline requires not just deciding which bands will be studied, but also ensuring the timely results of studies, and making spectrum available for commercial use. For instance, progress on the 37-37.6GHz band, which was set aside for “coordinated co-primary shared access between Federal and non-Federal users” years ago, could be beneficial.

Intel has a long history of supporting spectrum allocations for use by both licensed (*e.g.*, 5G) and unlicensed (*e.g.*, Wi-Fi) technologies. As a leading technology company, Intel takes a technical approach to evaluating potential spectrum use by existing and future technologies to determine which technologies we believe would be most appropriate for a given band and maximize spectrum efficiency. For example, we consider the characteristics of incumbent services with respect to the potential for sharing or clearing spectrum within geographic areas; wide-area exclusively licensed operations generally require clearing/relocating incumbents from the spectrum (often over large geographies), while licensed-shared or unlicensed operations could be more appropriate when clearing incumbents is not possible or suboptimal. We also consider the proximity of the spectrum band to other spectrum ranges already used by the same technology,

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<sup>5</sup> <https://www.fcc.gov/document/chairwoman-rosenworcel-remarks-mobile-world-congress-2022>

<sup>6</sup> Consideration of Sharing and Adjacent Band Compatibility Between Passive and Active Services above 71 GHz, <https://www.itu.int/oth/R0A060000A1/en>

which impacts the ease of incorporating it into existing devices. Another important consideration we take into account is the amount of spectrum needed, as increasingly wider channel bandwidths are utilized to support ever-increasing data throughput requirements. As we look to the future, it is important to recognize that a range of spectrum characteristics will likely be needed; some emerging applications require significant bandwidth but over a short range (*e.g.*, precision positioning or sensing), while other applications (*e.g.*, wide area mobile broadband) require larger coverage areas.

#### **IV. Global Spectrum Policy Perspectives on Spectrum Pipeline**

Other countries also recognize the pivotal role broadband technologies play in connecting members of our society and forming an increasingly foundational role in our economies. The U.S. benefitted from being the first nation with widespread 4G coverage, which led to innovations developed in the U.S. that many of us use every day on our smartphones, such as ordering rides, buying groceries, checking in for flights, reading books, and watching shows. 5G, in addition to enhancing the mobile broadband capabilities of 4G, is expected to enable similar types of benefits for businesses and consumers in many different industries, such as industrial IoT in manufacturing, mining, agriculture, healthcare, and more. The importance of broadband has become increasingly apparent over time, especially during the pandemic and to underserved communities, leading to numerous countries/markets competing to ensure they can benefit from a leading role in deployments. Making new spectrum bands available for use in a timely manner is crucial to establishing a leadership role in wireless.

During my career at Intel, I have seen incredible technology advances, including in areas that facilitate more efficient use of spectrum and coexistence such as advancements in radio design, modulation and coding, antennas, etc. However, consumer demand for higher data rates and other broadband applications has also led to the need for wider channels and larger spectrum blocks.

For the majority of my two decades at Intel, I have been actively involved in international spectrum policy deliberations at the regional, national, and global levels. In addition to serving on many U.S. delegations to ITU meetings over the past decade, I also participated in multiple WRCs, including as the Spokesperson for the Americas Region (CITEL) on an Agenda Item considering spectrum access for unlicensed technologies in 5 GHz during WRC-19.

Every three to four years, the WRC reviews and, if necessary, revises the Radio Regulations, the international treaty governing the use of radio frequency spectrum. In the context of wireless technology, it should be noted that the ITU (the United Nations specialized agency for ICTs) Radiocommunication Sector generally focuses more on policy (*e.g.*, “WRC preparations, the development of Recommendations” and “Reports”) related to spectrum sharing studies, band

plans, technologies, *etc.*, while 3GPP, IEEE, O-RAN Alliance, and Wi-Fi Alliance are industry-led efforts focused on technology standards development.

These international deliberations traditionally focused on the goal of “harmonization” of the use of spectrum bands across different geographies and bands to facilitate global roaming, economies of scale, and reduced device complexity. In the past, different products needed to be developed for even minor differences in spectrum bands. Today, however, consumers and businesses can also benefit from harmonization of “tuning range” solutions covering adjacent or nearly-adjacent bands in which equipment can be reconfigured to operate over multiple bands within the same tuning range. While tuning range harmonization has practical limits due to technology capabilities, it has improved the harmonization prospects in many key bands.

The dynamics of international spectrum policy decision-making processes are increasingly interconnected to U.S. domestic processes. For example, the FCC’s decision to open the 6 GHz band for unlicensed use has been transformative to Wi-Fi technology around the world. In the two years since the FCC decision, over 60 countries have followed FCC’s lead to open 6 GHz spectrum to Wi-Fi. At the 2015 WRC (“WRC-15”), the U.S. was able to secure an allocation to the Mobile Service in ~600 MHz (low band), which was crucial to enabling the FCC’s successful \$20 billion incentive auction to repurpose broadcast spectrum for mobile broadband use. Similarly, WRC-15 also adopted provisions for the Americas region to enable the 3.4-3.6 GHz (mid-band) to be utilized for mobile broadband. During WRC-19, deliberations included topics such as unlicensed (*e.g.*, Wi-Fi) and licensed (*e.g.*, 5G) broadband technologies; in addition to changes in 5 GHz regulations, much of the U.S. high-band spectrum was also identified for harmonized use by mobile broadband technologies. WRC-23 will also address key frequency bands for broadband technologies.

Technical work has already begun on the next generation of technologies including “Advanced 5G”, “6G”, “Wi-Fi 7,” and “Wi-Fi 8”. Innovation in radiocommunication technologies goes through a well-known development and investment cycle, from research to prototypes, trials, and finally commercialization of products, which could take several years. Research and development of new generations of technologies in turn relies on the availability of associated components such as radios, filters, *etc.* Technology developers need to know which frequency ranges to design for; therefore, early indications of which spectrum bands might be available, followed by early availability of spectrum, facilitates technology leadership. It is important that regulations are put in place in a timely manner, so spectrum availability intercepts the product cycle at the appropriate time.

In summary, given the lengthy process involved in making spectrum available for commercial use, consideration of spectrum bands which could be studied is urgently needed if the U.S. wants to ensure it has a leadership position on next generation deployments. For example, now is the

time to make progress on which low, mid (*e.g.*, within 7-15 GHz), and high bands (*e.g.*, including new spectrum ranges above 95 GHz) might be available for use by both early 6G deployments as well as the next generations of unlicensed technologies. Alternately, if the U.S. does not make timely progress of identifying potential spectrum bands and subsequently making spectrum available, then the U.S. will not be in a position to take a leadership role in helping define which spectrum ranges will be utilized; it is crucial to intercept the development and investment cycles to ensure timely commercialization of products for the U.S. market.

## **V. Importance of U.S. Interagency Coordination**

Spectrum is an important resource, relied upon by many different services and applications. With many competing demands for spectrum, developing technical regulations is a lengthy and often contentious process. While the FCC is responsible for managing commercial (or non-Federal) spectrum access, the National Telecommunications and Information Administration (NTIA) within the Department of Commerce is responsible for managing Federal spectrum use. In the context of developing U.S. positions on international spectrum issues, the FCC and NTIA likewise are responsible for representing non-Federal and Federal spectrum use, respectively. NTIA must be empowered to represent the various Federal agencies' views both domestically and internationally to ensure that the domestic preparatory process can function as intended. The development of WRC positions impacts both federal and commercial users of spectrum. Deliberations of these positions should have balanced representation of both federal and commercial interests. When balanced, the process can work well; otherwise, issues can arise. The recent joint announcement from FCC Chairwoman Jessica Rosenworcel and Assistant Secretary Alan Davidson that the agencies will increase their spectrum coordination efforts is a positive step forward.

## **VI. FCC's Spectrum Auction Authority**

The FCC has been a world leader in spectrum auctions, starting with Congressional action in 1993 giving the FCC authority to use competitive bidding systems. These auctions fueled innovation leading to significant economic growth and technology leadership for the United States. Other countries have also closely followed U.S. activities, including innovations such as the incentive auction of the 600 MHz band, leading to improvements in other markets as well. With the FCC's auction authority set to expire this year, extension of the FCC's spectrum auction authority will be important for continued U.S. broadband deployment efforts. Congress can also use this opportunity to identify spectrum bands that could be utilized for broadband deployment and can consider directing future auction revenue could fund public interest priorities.

## **VII. CHIPS for America Act**

In addition to the steps outlined above, critical to maintaining the goal of U.S. leadership in connected technologies is a secure supply of semiconductors across many nodes. Semiconductors are fundamental to U.S. technology development, our economy, and national security. They represent the fourth largest U.S. export sector, and the pandemic only accelerated the adoption of digital infrastructure powered by semiconductors. Recent supply chain disruptions due to COVID-19 and widespread chip shortages illustrate the risks to our economy and the danger of losing our ability to make advanced chips in the United States.

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Despite the critical nature of semiconductors, America lost significant share of semiconductor production to Asia over the last 30 years. For decades, countries in Asia have provided substantial incentives to build domestic semiconductor champions, driving a decrease in U.S. share of global chip manufacturing and creating a 30 percent cost disadvantage for chipmaking in the U.S. Since 1990, that share dropped from 37 percent to 12 percent, and it is projected to erode further to 9 percent by 2030.

Federal investment is urgently needed to reverse this erosion by leveling the playing field for America's semiconductor industry. Over one year ago, thanks in great part to the leadership of Congresswoman Matsui, Congress took a critical step by authorizing new semiconductor manufacturing and R&D programs through the *CHIPS for America Act*. The House and Senate separately approved \$52 billion in appropriations for the so-called *CHIPS Act*, but now Congress must finish the job by conferencing the bills containing *CHIPS Act* funding as soon as possible. We thank the Members of this committee for your support for this initiative. Intel is doing its part to invest in American leadership, and we look forward to partnering with the federal government through the *CHIPS Act* programs to enhance domestic semiconductor R&D and manufacturing.

## **VIII. Conclusion**

Identifying additional low, mid, and high band spectrum to study and quickly make available for commercial use is essential to ensuring U.S. leadership in the next generations of licensed and

unlicensed wireless technologies. Thank you for holding a hearing on this important topic, and we look forward to working with the Committee, the FCC, and other federal agencies to ensure the spectrum pipeline continues to flow to support U.S. broadband development and deployment.