

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554**

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))
In the Matter of))
))
Expanding Flexible Use in Mid-Band))
Spectrum between 3.7 and 24 GHz))
))
_____)

GN Docket No. 17-183

COMMENTS OF ALL POINTS BROADBAND, AMPLEX INTERNET, APPLE, BLAZE BROADBAND, BROADCOM, CAMBIUM NETWORKS, CISCO SYSTEMS, CYPRESS SEMICONDUCTOR, DELL, EXTREME NETWORKS, FACEBOOK, FIRE2WIRE, GOOGLE, HEWLETT-PACKARD ENTERPRISE, HP, INTEL, JOINK, MEDIATEK, METALINK TECHNOLOGIES, MICROSOFT, NEW WAVE NET, PIXIUS COMMUNICATIONS, QUALCOMM, RISE BROADBAND, RUCKUS, A UNIT OF BROCADE, SNAPPY INTERNET, SONY ELECTRONICS, WESTERN BROADBAND, WIRELESS INTERNET SERVICE PROVIDER ASSOCIATION, WISPER ISP

October 2, 2017

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INTRODUCTION AND SUMMARY

Our diverse companies—spanning the consumer equipment, internet media, software, cloud services, semiconductor, enterprise and service provider broadband, and rural connectivity industries—all agree that Part 15 access to the 5925–7125 MHz band (the “6 GHz band”) is essential to meeting demand for the next generation of wireless broadband services. By opening this entire band to unlicensed radio local access network operations, the Commission will allow us to bring consumers faster service, lower latency, and more pervasive coverage, and allow the nation to reap the economic and public safety benefits that are associated with unlicensed technologies.¹

Commission rules already allow other types of Part 15 operations in this band. But the existing rules make broadband operations impossible.² By adopting updated technical and use rules that permit Wi-Fi™ and other unlicensed services and support investment in the 6 GHz band, U.S. consumers will gain access to the wide gigabit-capable channels needed for next-generation services, and the Commission will both address the increasing congestion consumers

¹ Raul Katz, Telecom Advisory Servs., LLC, *Assessment of the Future of Economic Value of Unlicensed Spectrum in the United States* 39–40 & tbl. 19 (2014), <http://dynamicspectrumalliance.org/assets/Katz-Future-Value-Unlicensed-Spectrum-final-version-1.pdf>; Lisa Plummer Savas, *Smart City Networks Keeps Houston Connected in Hurricane Harvey Aftermath*, TSNN (Sept. 8, 2017), <http://www.tsnn.com/news/smart-city-networks-keeps-houston-connected-hurricane-harvey-aftermath> (weather event safety); Linda Poon, *What Makes a Smart City Truly Smart*, CityLab (Sept. 5, 2017), <https://www.citylab.com/solutions/2017/09/kansas-city-smart-city-bob-bennett-technology/538563/> (economic development); Gabi Maspons, *Miami-Dade Getting Hundreds of Touch-Screen Internet Kiosks*, MiamiToday (Aug. 22, 2017), <http://www.miamitodaynews.com/2017/08/22/miami-dade-getting-hundreds-touch-screen-internet-kiosks/> (crime prevention); *Mt. Vernon School Buses Going High-Tech with Wi-Fi, Tracking Program*, 13 WTHR (Jan. 23, 2017, 5:36 PM), <http://www.wthr.com/article/mt-vernon-school-buses-going-high-tech-with-wi-fi-tracking-program> (school bus travel safety).

² 47 C.F.R. § 15.209. While we recognize that the Notice of Inquiry seeks comment on other mid-band spectrum, these comments focus exclusively on the 6 GHz band.

are now experiencing as existing unlicensed bands strain under the pressure of exploding Wi-Fi demand and advance innovative new uses of unlicensed technologies.

All of our companies and organizations therefore strongly support the Commission's inquiry into expanding access to mid-band spectrum for a range of wireless broadband services, including improved internet connectivity, the Internet of Things ("IoT"), and ultra-low latency applications. This Notice of Inquiry presents an important opportunity to address the nation's clear need for additional unlicensed frequencies. As a next step, the Commission should expeditiously issue a Notice of Proposed Rulemaking ("NPRM") to develop service and technical rules that permit unlicensed broadband operations across the entire 6 GHz band.³

The timing of this proceeding could not be better. In anticipation of regulatory action by the US and other nations, the IEEE 802.11ax Task Group recently voted to extend coverage to the 6 GHz band.⁴ This action will extend 802.11ax from 5 GHz into new gigabit-enabled channels. This means that as manufacturers move to take advantage of new 6 GHz channels, their technology will employ 802.11ax, which will deliver orders of magnitude more capacity and efficiency than prior generations of Wi-Fi.⁵ Moreover, the path to rapid consumer adoption for this new technology in the 6 GHz band is no different than that of IEEE 802.11ac in the 5 GHz band. Importantly, at the global level, ETSI has initiated a System Reference Document

³ *Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, Notice of Inquiry, FCC No. 17-104, 32 FCC Rcd. 6373 (2017).

⁴ See Rich Kennedy, Abstract, *IEEE P802.11 Wireless LANs: P802.11ax PAR Modification* (July 12, 2017), <https://mentor.ieee.org/802.11/dcn/17/11-17-0913-02-00ax-par-modification-to-support-6-ghz-band.docx>.

⁵ IEEE 802.11ax is capable of delivering at least 4X capacity in dense environments relative to 802.11ac. See Adrian Stephens et al., Intel Corp., Current Topics in 802.11: Overview, High Efficiency and Reduced Power Consumption, slides at 24 (Mar. 13, 2017). While .11ax will operate in the 5 GHz band, it will do so with the limited channels available there.

addressing unlicensed use of these frequencies. This will enable a significant market opportunity in the U.S. and Europe, with U.S. industries poised to lead the evolution to 6 GHz on a worldwide basis. Furthermore, 3GPP is moving forward with studying and creating a version of 5G optimized for unlicensed/shared spectrum, 5G NR SS.

The technology manufacturers signing this filing are committed to delivering 6 GHz-capable products and services to the market in a timely manner given regulatory rules that support investment. Moreover, the Commission and industry have recognized a shortage of unlicensed spectrum, with unlicensed spectrum shortfalls expected to be over 500 hundred megahertz by 2025.⁶ Wi-Fi consumers are experiencing this shortage directly. But although congestion is mounting, consumers, industries, and the public sector will rely even more heavily on Wi-Fi in the future to power an entirely new range of use cases.⁷ These unlicensed bands are

⁶ See, e.g., *Expanding Flexible Use in Mid-band Spectrum Between 3.7 and 24 GHz*, FCC No. 17-104, 32 FCC Rcd. 6373 (2017) (statement of Commissioner Mignon L. Clyburn) (“There is no question that the demand for wireless broadband services is increasing at a very fast clip.”); Steve Methley & William Webb, Quotient Assocs. Ltd., *Wi-Fi Spectrum Needs Study 29* (Feb. 2017) (“[B]etween 500 MHz and 1 GHz of new spectrum will be needed in 2025 to satisfy the anticipated busy hour.”); Commissioner Michael O’Rielly, *A Mid-Band Spectrum Win in the Making*, FCC Blog (July 10, 2017, 2:30 PM), <https://www.fcc.gov/news-events/blog/2017/07/10/mid-band-spectrum-win-making> (“Study after study has shown that the U.S. is going to need multiple gigahertz of licensed and unlicensed spectrum just to keep up with current growth patterns.”); Chairman Ajit Pai, *Bridging the Digital Divide*, FCC Blog (July 13, 2017, 2:25 PM), <https://www.fcc.gov/news-events/blog/2017/07/13/bridging-digital-divide> (“Increasingly, meeting the connectivity needs of all Americans—no matter where you live—means freeing up spectrum to meet the growing demand for wireless broadband.”); Commissioner Jessica Rosenworcel, *Bringing the Connected Future to All Americans, May 11, 2012–January 3, 2017*, FCC Blog (Dec. 30, 2016, 5:30 PM), <https://www.fcc.gov/news-events/blog/2016/12/30/bringing-connected-future-all-americans-may-11-2012-%E2%80%93-january-3-2017> (“Moreover, as any wireless user can attest to, the airwaves used for Wi-Fi today are getting crowded—putting a premium on identifying additional spectrum for unlicensed growth.”).

⁷ See Cisco, *Enterprise Best Practices for iOS Devices on Cisco Wireless LAN 4* (Nov. 2016), https://www.cisco.com/c/dam/en/us/td/docs/wireless/controller/technotes/8-3/Enterprise_Best_Practices_for_Apple_Devices_on_Cisco_Wireless_LAN.pdf (“As per established enterprise best practices, and both Cisco and Apple's joint recommendation, the

also used to provide fixed broadband services to rural areas, for Bluetooth, and to support IoT. The 6 GHz band presents an important opportunity to help address this growing challenge.

Unlicensed broadband operations are especially well suited to operating in the 6 GHz band, while protecting its incumbents from harmful interference. Wi-Fi use has proven to provide protection for existing users in other bands via Part 15 rules and mitigations. Unlike hypothetical new licensed use in this band, adding unlicensed broadband use would allow incumbent services to grow and manage their networks in the future without imposing any new coordination obligations or other limits on licensees—while substantially increasing the overall use and value of the band, due to its proximity to the widely used 5 GHz unlicensed bands.

In addition to seeking comment on mechanisms for protecting incumbents, however, the Commission’s NPRM should also ensure that any rules the Commission adopts for 6 GHz unlicensed operation promote maximum utilization of the band and provide a clear path to rapid adoption. The Commission should limit regulation to what is truly needed to protect incumbents at a given frequency, and as described below, should seek comment on adopting different technical rules in different sub-bands, resulting in greater overall utilization and investment.

Rules that vary across well-defined contiguous portions of the 6 GHz range would be far preferable to imposing strict least-common-denominator limitations across the entire band. The Commission should not propose rules that cover the entire band if they are only needed to protect particular incumbents that only exist in a portion of the band. The Commission should also work to adopt technical rules that are compatible with those in the nearby U-NII-1 or U-NII-3 band to the greatest possible extent. Although total consistency may not be possible or desirable,

use of the 2.4 GHz band is not considered as best suiting the needs for business and/or mission critical enterprise applications.”).

compatibility between 6 GHz and U-NII-1 or U-NII-3 rules will speed adoption by reducing cost for manufacturers and consumers alike.

Finally, the Commission should advance effective interference protections for incumbents and improve spectral efficiency by requiring licensees to confirm the accuracy of their licensing information, and should remove entries for transmitters that are no longer in service. This maintenance will be necessary under any set of rules that seeks to improve spectrum utilization by opening the 6 GHz band to wireless broadband.

I. PERMITTING UNLICENSED OPERATIONS IN THE 6 GHz BAND IS CRITICAL TO MEETING GROWING DEMAND FOR WI-FI, DRIVING INNOVATION AND INVESTMENT, AND PRESERVING U.S. LEADERSHIP.

Today, just 540 MHz of channelized spectrum—the 2.4 GHz and 5 GHz unlicensed bands used for Wi-Fi—carry more internet data than any other wireless technology or service, with usage expected to continue increasing at a rapid pace.⁸

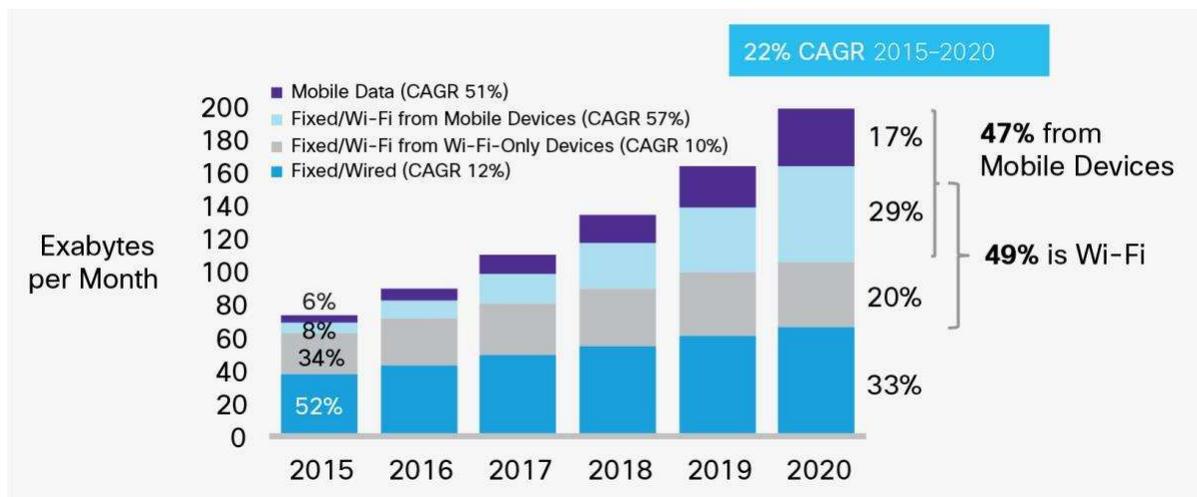


Figure 1: IP Traffic By Access Technology
Cisco Visual Networking Index

⁸ Cisco, Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016–2021, 21–22 & fig. 23 (2017), <https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.pdf>.

This intensive use contributes substantially to the nation’s economy. Unlicensed technologies are expected to contribute \$547 billion in economic value and nearly \$50 billion to the GDP, in 2017 alone.⁹

Policy and industry leaders now recognize, however, that the limited amount of spectrum available for unlicensed use is not adequate to meet today’s demand for broadband internet access. Quotient Associates conducted an important analysis of the Wi-Fi spectrum landscape earlier this year. Its results are concerning for the future of wireless broadband. Despite the fact that unlicensed technologies are the dominant mechanism for consumer and business broadband access, Quotient found that the United States faces an unlicensed “spectrum shortfall” of between 540 and 1,588 MHz by 2025.¹⁰

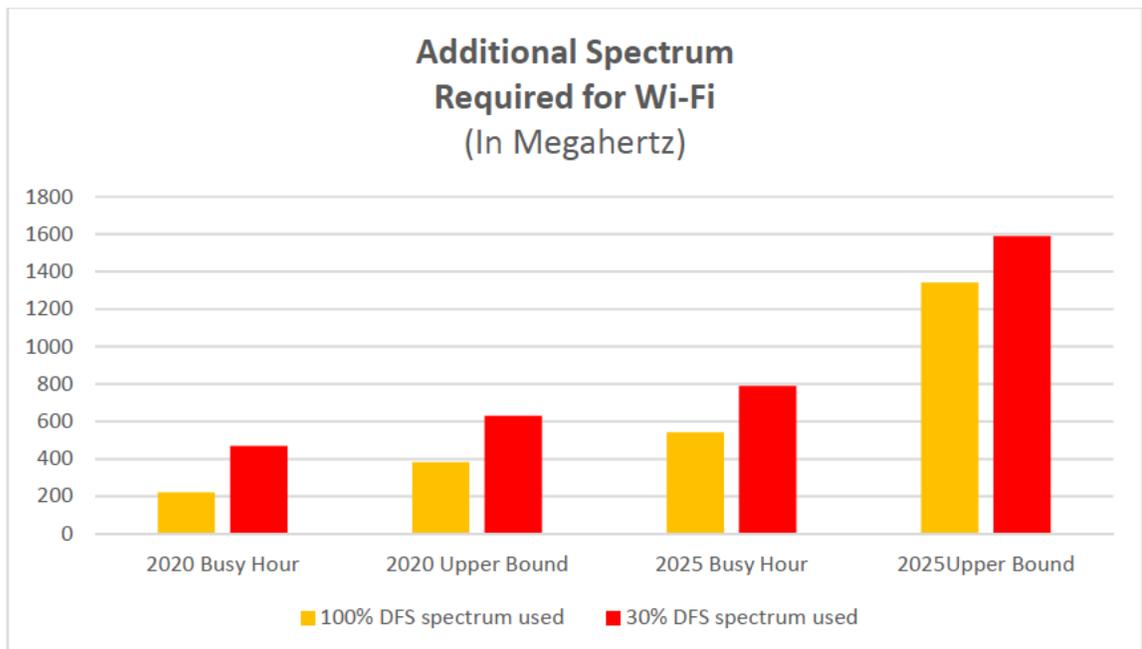


Figure 2: Wi-Fi spectrum gap analysis based on Quotient Associates’ Figure-6-3 and Table 6-3¹¹

⁹ Katz, *supra* note 1, at 4.

¹⁰ Methley & Webb, *supra* note 6, at 26.

¹¹ Note that the Quotient results include analysis of spectrum needs if 100 percent of spectrum can be used for Wi-Fi in the U-NII-2A and 2C bands, where FCC rules impose Dynamic

As this chart makes clear, even the conservative lower end of these results presents the Commission with the extraordinary challenge of designating a minimum of 540 MHz of unlicensed spectrum by 2025 just to maintain the quality of the Wi-Fi experience consumers and businesses have today—and that assumes 100 percent use of even the portions of the 5 GHz band which require Dynamic Frequency Selection (“DFS”) sensing technology to avoid governmental radars. The authors found that, if novel applications emerge that require additional spectrum resources (which our companies and associations believe is already occurring), and use of the DFS bands remains lower than less regulated bands (as is reasonable to expect), the need for additional spectrum will become even more pronounced. In this case, the Commission would need to identify more than 1,500 MHz by 2025.

Another important study, conducted by Qualcomm, confirms these results using a different methodology. Qualcomm’s *Quantification of 5 GHz Unlicensed Band Spectrum Needs* concludes that “[t]o enable future WLAN-type application and usage scenarios, regulators should plan for around 1280 MHz of unlicensed spectrum centered around the 5 GHz band for use by unlicensed technologies.”¹² These two studies substantiate our companies’ collective experiences with marketplace and technical realities: the country cannot meet the multiple challenges that rising demand from consumers, businesses, and the public sector produce without opening the 6 GHz band to Wi-Fi.

Frequency Selection (“DFS”). Because Wi-Fi operations near government systems must cease transmission, 100 percent use across the country cannot occur, making these results useful in providing a lower bound but not an expected real-world outcome. *See* Section III below for additional discussion of DFS.

¹² Rolf de Vegt et al., Qualcomm Techs., Inc., *A Quantification of 5 GHz Unlicensed Band Spectrum Needs 5* (2017).

Unfortunately, recent news makes the challenge of identifying adequate unlicensed spectrum even more difficult without near-term action on 6 GHz. In late 2016, based on consultations with the National Telecommunications and Information Administration (“NTIA”), the Commission announced that it would terminate its effort to open the U-NII-2B band to unlicensed technologies, and as a result, a well-placed 160 MHz of spectrum will remain entirely unavailable to consumers for the foreseeable future.¹³ Furthermore, regulatory restrictions and limited bandwidth in existing unlicensed bands will not be able to reliably support the gigabit speeds that consumers will soon expect. The 2.4 GHz band is already saturated in some locations,¹⁴ with demand continuing to increase, meaning that today’s workhorse bands for unlicensed usage are located in 5 GHz spectrum. Although these bands have played a crucial role in meeting consumers’ ever-growing appetite for broadband capacity, many portions of the broader 5 GHz band are subject to restrictions that limit their use. Furthermore, the 5 GHz band provides insufficient spectrum for wider bandwidth channels (*e.g.*, 80 or 160 MHz) to meet demand in dense environments today and to meet growing consumer demand in the future, thus undermining the provision of gigabit services at the very moment when our entire economy is digitizing.¹⁵ Finally, while the Commission’s decision to open new spectrum to unlicensed technologies in the 64-71 GHz range is a forward-looking and important step, these millimeter

¹³ See *The Commission Seeks to Update and Refresh the Record in the “Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band” Proceeding*, Public Notice, FCC No. 16-68, 31 FCC Rcd. 6130, 6131–32 (2016) (noting that the U-NII-2B range would be addressed in a future phase of the proceeding, which has not occurred). Note that while the U-NII-2 band spans 120 MHz, the 20 MHz channel just above and below it are also precluded from unlicensed use as long as U-NII-2 is unavailable, for a total of 160 MHz.

¹⁴ See Cisco, *supra* note 7, at 4.

¹⁵ Prashnant Ganghi et al., *Which Industries Are the Most Digital (And Why?)*, Harvard Bus. Rev. (Apr. 1, 2016), <https://hbr.org/2016/04/a-chart-that-shows-which-industries-are-the-most-digital-and-why>.

band frequencies have limited propagation and penetration characteristics that make them inadequate as a substitute for mid-band frequencies.

It is therefore critical that the Commission act swiftly to expand opportunities for unlicensed use in the 6 GHz band. The fact that just 540 MHz of existing 2.4 GHz and 5 GHz channelized spectrum is a platform for so much economic value is a testament to the rapid pace of innovation of unlicensed technologies. Unlicensed technologies are also a critical part of a successful transition to the 5G era. As the GSM Association's *The 5G Era: Age of Boundless Connectivity and Intelligent Automation* makes clear, “[f]uture networks will rely on a combination of mainstream and alternative technologies, and use both licensed and unlicensed spectrum, across different spectrum bands.”¹⁶ But GSMA also warns that “[s]pectrum will remain a critical but scarce resource in the 5G era. This applies to both the licensed and unlicensed bands that will play a key role in delivering the 5G era vision.”¹⁷

Unlicensed spectrum lowers barriers to entry, expands consumer connectivity, and allows more enterprises to take advantage of new business processes, thereby driving innovation and investment across the economy. By opening the 6 GHz band to unlicensed use, the Commission can support these advances. Doing so sooner rather than later will compound the benefits of innovation by providing industry stakeholders regulatory certainty before completion of the next generation of wireless standards. The next generation of Wi-Fi, called IEEE 802.11ax, is currently under development, and could seamlessly support 6 GHz operations. If the Commission acts promptly, and makes clear that 6 GHz spectrum will be available for

¹⁶ Emeka Obiodu & Mark Giles, *The 5G Era: Age of Boundless Connectivity and Intelligent Automation*, GSM Association 10, GSMA (2017), <https://www.gsmaintelligence.com/research/?file=0efdd9e7b6eb1c4ad9aa5d4c0c971e62&download>.

¹⁷ *Id.* at 13.

unlicensed use under reasonable technical rules, 6 GHz standards work can continue to incorporate the band into the IEEE 802.11ax standard in the near term, providing an accelerated path to widespread consumer adoption.

II. UNLICENSED SERVICES ARE IDEAL FOR ALLOWING GREATLY EXPANDED USE OF THE 6 GHz BAND, WHILE PROTECTING EXISTING USERS.

Unlicensed services have an extensive track record of sharing with a wide range of incumbent users, and the rich toolkit of mitigation measures included in the Commission's Part 15 rules serve as a solid base of potential protection measures so that existing users and their operations will be protected as they continue to grow and change. Commission rules permit other types of Part 15 operations in the 6 GHz band today, at extremely low power or with an Ultra-Wideband device.¹⁸ But the Commission's technical regulations make unlicensed broadband investment and operation impractical. Improving the technical parameters that govern unlicensed operations so that they support expanded service will bring consumers an enhanced experience with the next generation of Wi-Fi and other unlicensed operations while drawing from the well-understood Part 15 rules, which prohibit unlicensed devices from causing harmful interference to licensed incumbent services.

With the exception of the 6425-6525 and 6875-7125 MHz bands, the most significant uses of the 6 GHz bands are for point-to-point links in the Fixed Service ("FS") and Fixed Satellite Service ("FSS") Earth station uplinks. The Commission has allocated the 6425-6525 MHz band exclusively for mobile BAS, CARS, LTTS, and OFS. The 6875-7125 MHz band hosts a smaller number of mobile BAS and CARS users.

¹⁸ See 47 C.F.R. § 15.209.

The FS and FSS uplink incumbents present, in virtually every respect, simpler coordination and interference prevention challenges than other bands where the Commission has already authorized unlicensed devices. For example, in the 6 GHz band, FS operations are outdoor, largely high power, highly directional, utilize fixed transmitters, and have known emissions characteristics. This pairs well with Wi-Fi operations, which are mostly indoor, and operate at lower EIRP. The 3.5 GHz Citizen Broadband Radio Service (“CBRS”) band, where the Commission has already approved sharing, by contrast, presented challenges of sharing spectrum with fixed licensees as well as fixed-satellite Earth station downlinks and military radar systems. Additionally, in U-NII-1, one of the most heavily used Wi-Fi bands, the Commission approved unlicensed sharing with Mobile Satellite Service feeder links. As these examples illustrate, there are many techniques available to allow unlicensed devices to share with 6 GHz incumbents without posing a risk of harmful interference.

The NPRM should seek comment on a range of options to allow unlicensed broadband use while protecting incumbents. The optimal solution, however, may be to employ different combinations of coexistence techniques in different 6 GHz sub-bands. This will allow unlicensed operations to provide the required protection for each incumbent without inappropriately over-regulating operations in one sub-band by employing sharing techniques needed only to protect incumbents in a different sub-band. For example, mobile licensees operating between 6425-6525 MHz and 6875-7125 MHz may require protections that are completely unnecessary for the fixed point-to-point links below and between those frequencies. The Commission should bear in mind that applying least-common-denominator sharing techniques in sub-bands where they are not needed would significantly impact the efficiency of use and reduce the economic utility of this spectrum. The goal in promoting greater intensity of use should be to make rules that provide

robust protection for incumbents, allowing new deployments by these licensees, without unnecessarily restricting unlicensed use by going beyond the rules necessary to address real-world interference risks. Protection of licensed incumbent services is required, but the Commission's rules for doing so should be optimized in order to maximize economic and spectral efficiency.

To accomplish this goal, the NPRM should propose to establish multiple 6 GHz sub-bands. This approach would allow the Commission to ensure that the technical rules and interference protections for each segment of the band are appropriate to incumbent operation in the relevant frequencies. For example, the NPRM could propose four sub-bands that reflect different incumbent environments:

- U-NII-5: 5925-6425 MHz
- U-NII-6: 6425-6525 MHz
- U-NII-7: 6525-6875 MHz
- U-NII-8: 6875-7125 MHz

This structure would empower the Commission to robustly protect the different incumbent environment in each range according to the particular interference needs of the relevant incumbents. Adopting one set of rules for the entire band, on the other hand, could be counterproductive, over- and/or under-protect existing services, and undermine efficient investment and spectrum use.

Unlicensed broadband operations would also be an ideal complement to existing services in the band because unlicensed operations could neither prevent incumbents from expanding their operations, nor impose additional restrictions on new deployments. Incumbent use of the 6 GHz band is active and dynamic, with links being added, removed, or altered on a regular basis. However, due to the large number of licensed incumbents in the band, coordination of a new fixed link for an established incumbent, for example, is often a significant challenge. This is

especially acute in urban areas where licensees tend to be concentrated. Each licensee in the band is, of course, entitled to protection from harmful interference and must be coordinated with other licensees before new operations are permitted.¹⁹ Therefore, the addition of an entirely new class of licensees in the band would further increase the burdens faced by existing 6 GHz service licensees.

Unlicensed services, by contrast, would impose no new coordination burdens on licensees. Unlicensed operations, unlike licensed wireless services, would be required to protect licensees' current *and future* operations in the band. Thus, new licensees could begin operations, and existing licensees could alter or expand their networks, without coordination with unlicensed users. Unlicensed users are required to avoid harmful interference to these new operations, and unlicensed operations must accept any harmful interference received from new licensees.²⁰

If the Commission were to authorize a new *licensed* service in the 6 GHz band, the new licensee's authorization to operate would be limited depending on the density of incumbents and the types of incumbent operations. Each of these factors, furthermore, would vary by frequency, location, and time, meaning that a licensee would have difficulty planning its use of the band. This uncertainty would likely make the band less valuable for mobile licensees, limiting the amount they would be willing to invest compared to more opportunistic unlicensed operations, which require less fixed infrastructure and eliminate the need for license fees.

In addition, the variety of incumbents in these bands, and the likelihood that they will change over time, will pose a serious challenge to auctioning any portion of this spectrum to mobile wireless licensees. Because incumbent usage varies by location and frequency, it would

¹⁹ See, e.g., *id.* § 101.103.

²⁰ See *id.* § 15.5.

likely not be possible to auction fungible spectrum blocks, either in pairs or individually, in this band. Further, if Commission rules permitted licensees in existing 6 GHz services to continue applying for new licenses and modifying existing ones, which is necessary given the importance of FS operations in that band, uncertainty about future impairments of a new type of licensed service would likely suppress auction revenue significantly. In fact, the coordination contour that applies to a single prospective Part 101 licensee could extend 200 miles from the transmitting end of the transmitter, and 125 miles in radius around the transmitter.²¹ This means that the coverage and/or quality of service of any new licensed service would be significantly undermined throughout the country where there could be new Part 101 licensees, and the need to protect a new mobile licensed service would undermine growth and change of current FS licensees' operations. An unlicensed designation allows the Commission and incumbents to avoid these problems, and would result in efficient and intensive use of the band.

III. UNLICENSED DESIGNATIONS BEST SUPPORT INNOVATION AND GROWTH WHEN THE COMMISSION ADOPTS PRO-INVESTMENT RULES AND PROVIDES LARGE BLOCKS OF CONTIGUOUS FREQUENCIES.

The Commission's unlicensed bands have been tremendously successful in fostering innovation and maximizing spectral efficiency. In addition to traditional Wi-Fi—which itself carries roughly half of all data on the internet²²—the opportunities for innovation in unlicensed spectrum have given rise to a whole host of other technologies. These include fixed broadband operations that enable millions of American consumers to connect to the internet; Bluetooth,

²¹ See Chris Hardy & Greg Macey, Comsearch, Recent Regulatory Changes Affecting the Broadcast Auxiliary Spectrum, What You Need to Know 9 & fig. 7 (2003), <http://www.sbe3.net/auxhardypaper.pdf>.

²² Cisco, *supra* note 8, at 21–22 & fig. 23.

itself a ubiquitous technology for short-range wireless connections; and IEEE 802.15.4, an industry standard protocol for narrowband transmissions supporting the IoT.²³ In just the last three years, new protocols such as SigFoxTM and LoRaTM have also emerged, supporting additional investment. Most recently, the Commission's designation of unlicensed frequencies in the millimeter bands has produced innovation and new consumer benefits. Consumers can now purchase products based on IEEE 802.11ad, and businesses seeking point-to-point bridging now have a range of new entrants. Furthermore, Facebook's Project Terragraph is working to redefine urban wireless connectivity, addressing both capital and operating expenses through gigabit capable consumer backhaul solutions.

History makes clear, however, that the size of available frequency ranges (especially in contiguous bands), adequate permitted power levels, and pro-investment Commission rules play a leading role in determining the relative real-world utilization and value of a given unlicensed band. In fact, a ranking of unlicensed bands in order of efficiency and economic value closely mirrors the results of ranking those bands by the operational freedom allowed by Commission rules.

The 2.4 GHz band, for instance, is the original home of both Wi-Fi and Bluetooth. In fact, the 2.4 GHz band was the *only* Wi-Fi band in general use for more than a decade, during which time Wi-Fi exploded in popularity and became the mainstay of broadband internet connectivity that it is today. It is no coincidence that this band is also characterized by attractive power limits—4 W E.I.R.P.²⁴—and an absence of regulations that restrict the permissible locations of unlicensed operations or impose other operational limitations.

²³ 802.15.4 operates in both the 900 MHz and 2.4 GHz bands, and has given rise to Zigbee, Thread, and WirelessHART (ISA100).

²⁴ See 47 C.F.R. § 15.407.

As the 2.4 GHz band has become saturated—its primary limitation is that it is less than 100 MHz wide—unlicensed use has grown rapidly in the 5 GHz band. While this new usage has grown throughout the usable portions of the 5 GHz bands, it has been most dramatic in U-NII-1 and UNII-3, which are regulated least. Like the 2.4 GHz band, U-NII-3 permits unlicensed operations at up to 4 W E.I.R.P.²⁵ without restrictions on location of use or other burdensome limitations, and higher power for outdoor point-to-point uses. The transition to wider 40 MHz channels introduced with IEEE 802.11n in 2006 was only possible in 5 GHz, which introduced speeds up to 600 Mbps. This 11X speed increase over the 54 Mbps in previous Wi-Fi generations was a principal driver in the explosion of Wi-Fi adoption by consumers and enterprises. While the current generation of IEEE 802.11ac can deliver multi-gigabit performance in 80 MHz channels, the fact is that there are only two such channels that are not encumbered by DFS requirements in the U.S., and a total of just six channels overall. Because modern managed deployments require a minimum of nine channels to achieve spatial reuse,²⁶ most enterprise and service provider deployments artificially restrict channel bandwidth to 40 MHz due to the lack of adequate gigabit class channels in the US.

U-NII-1, on the other hand, used to be subject to significantly more complex regulatory requirements. Until 2014, the Commission permitted only indoor operations in U-NII-1, and all operations were subject to highly restrictive power limits, significantly limiting the band's use.²⁷

²⁵ *See id.*

²⁶ *See* Aruba Networks, Very High Density 802.11ac Networks Engineering & Configuration Guide 38 (2015), http://www.arubanetworks.com/assets/vrd/Aruba_VHD_VRD_Engineering_Configuration_Guide.pdf.

²⁷ *See Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, First Report and Order, FCC No. 14-30, 29 FCC Rcd. ¶¶ 22-24 (2014).

Recent reforms that increased power levels and removed the indoor-only restriction has spurred dramatic growth in unlicensed U-NII-1 utilization, with rules that promote investment while protecting incumbent satellite operations.

The Commission regulates other unlicensed bands more heavily, imposing complex rules that reduce predictability and limit operations, or has not designated enough spectrum for unlicensed use. As a consequence, these bands have not produced the level of investment and consumer benefit seen in the 2.4 GHz, non-DFS U-NII-3, and U-NII-1 bands. For example, the Wi-Fi and fixed wireless broadband industries have made good use of the U-NII-2A and 2C bands, but the DFS regulations²⁸ that govern these bands come with a cost and have rendered the U-NII-2A and 2C bands unusable for many applications. Because existing rules require mobile devices to listen for beacon signals instead of permitting them to actively probe channel availability, they must sometimes wait up to 100 milliseconds before selecting a channel and transmitting. This degree of latency can be incompatible with mission-critical voice deployments used in hospitals and other clinical settings, video streaming, Wi-Fi calling, and other voice applications, because handover latencies must be less than 50 milliseconds to be inaudible to humans.²⁹ Moreover, by increasing the cost and complexity of access points, DFS rules preclude a number of other innovative uses, including LTE tethering, and peer-to-peer networking. The DFS regulations in the U-NII-2A and 2C bands also severely limit the use of this spectrum in wide-area fixed wireless deployments. The mandatory shutdown when a DFS event is detected³⁰

²⁸ See Unlicensed National Information Infrastructure (U-NII) Devices in the 5GHz Band, 79 Fed. Reg. 24,569 (May 1, 2014).

²⁹ See Cisco, *supra* note 7.

³⁰ See 47 C.F.R. § 15.407(h).

causes significant disruption to multiple consumers in a service provider environment due to the significant number of DFS events, the vast majority of which are erroneous.

The same principles will apply to unlicensed 6 GHz operations. Adopting regulations that greatly restrict unlicensed operations or reduce the amount of spectrum available could make the difference between another blockbuster unlicensed band and one suitable only for more specialized uses. This is why it is so important for the Commission to ensure that any regulations that it ultimately adopts are narrowly tailored to the true interference protection needs of incumbent services that actually operate at a given frequency. While experience has shown that unlicensed use can flourish even when faced with significant sharing restrictions, these restrictions come at the cost of more intensive and efficient spectrum use.

IV. THE COMMISSION SHOULD ADOPT TECHNICAL RULES CONSISTENT WITH THOSE IN THE 5 GHz BAND IN ORDER TO MAXIMIZE UTILITY AND PROMOTE ECONOMIES OF SCALE.

The Commission can also support intensive 6 GHz unlicensed use and investment by ensuring maximum compatibility between 6 GHz unlicensed rules and those in the nearby 5 GHz band. The best strategy for maximizing 6 GHz use will likely be to ensure that semiconductor makers can support 6 GHz operations using the same chips that power 5 GHz services and applications, including Wi-Fi. This would greatly increase economies of scale and facilitate use of the same standards, such as the forthcoming IEEE 802.11ax, across the two bands.

Where possible, the Commission should adopt 6 GHz rules that are compatible with the existing U-NII-1 and -3 rules. U-NII-1 and -3 power levels, as discussed above, have promoted extremely rapid adoption by chipmakers, vendors, and consumers, facilitating high throughputs—which would increase further still if the Commission were to make more contiguous spectrum available. The U-NII-1 and -3 rules also allow users significant flexibility in

antenna gain to allow long-range connections for wireless connectivity and other fixed distribution networks.

The rapid growth in Wi-Fi utilization in recent years depended on forward-looking Commission efforts to harmonize rules across unlicensed bands, and to increase the availability of larger channels. Although Commission rules across the core 5 GHz unlicensed bands are not identical, they are sufficiently compatible that most devices now ship with a single chip that supports multiple unlicensed bands. This greatly reduces the cost of devices by eliminating the need for multiple chips in the same device. The Commission should strive to replicate that success in the 6 GHz band so long as it ensures that its rules do not preclude these economies of scale for unlicensed devices.

V. THE COMMISSION SHOULD REQUIRE CORRECT AND COMPLETE LICENSE INFORMATION FROM 6 GHz LICENSEES.

The Commission currently maintains comprehensive databases of virtually all 6 GHz licensees including the locations of their transmitters and receivers, and their technical characteristics. This will serve as a valuable resource in ensuring unlicensed operations protect licensed services. However, to ensure that this is effective and efficient, the Commission should make certain that the data in these databases are accurate. Accurate data are needed to ensure both that incumbents are protected and that spectrum is not wasted due to unnecessary restrictions arising from incorrect technical information. In fact, accurate and complete license information regarding existing licensees will almost certainly be crucial for *any* Commission decision to increase utilization of the band.

For fixed point-to-point facilities, the Commission's existing rules provide limited assurances that license information will be accurate. The rules require licensees to construct and

bring their systems into operation no later than eighteen months after their licenses are granted or face automatic license cancellation.³¹ Thus, the Commission's database should be largely free of any erroneous information where an operator obtained a license but never brought it into service.

The Commission should also take steps to ensure that the technical data listed for a given license are accurate. Clearly, it is essential that the Commission's licensed records correctly reflect basic characteristics such as transmitter and receiver locations, antenna heights, and power levels. It is also critical, however, that the Commission's records correctly indicate the antenna class in use at each transmitter and receiver. Antennas used in the fixed point-to-point services may vary significantly in their gain contours, which would, in turn, significantly affect their susceptibility to interference and their ability to cause interference to others. The fact that the Commission's Universal Licensing System ("ULS") database already includes information about antenna characteristics could be very helpful in designing an effective sharing approach. But accurate information is required to enable much more enhanced spectrum utilization.

The Commission has multiple tools at its disposal to ensure that 6 GHz license data is accurate and up-to-date. Notably, licensees are already required to notify the Commission of any technical change to their operations that would likely be material to their coexistence with unlicensed uses.³² Thus, any Commission effort to "clean up" licensee registration data would serve the same basic purpose as the Commission's existing rules, without the need for enforcement actions or other drastic measures to correct what were likely innocent oversights.

The most straightforward way for the Commission to safeguard the accuracy of 6 GHz licensee data would be to ask licensees that have incomplete or inaccurate license information in

³¹ See *id.* § 101.63(a), (c).

³² See *id.* §§ 1.947, 1.929.

ULS to modify, through a simple electronic filing, the locations and operational parameters of their 6 GHz operations, and, where necessary, to re-coordinate facilities where circumstances dictate. This is similar to, but significantly less burdensome than, measures the Commission has taken in other bands to safeguard accurate registration data and thereby facilitate sharing between incumbent licensees and new entrants into the band. In the 3.5 GHz band, for example, the Commission adopted an annual filing requirement for FSS earth stations to verify that each earth station remains in operation and that its operational parameters had not changed.³³ Licensees with accurate license information in ULS would not be required to make any filing with the FCC or re-coordinate facilities, and such facilities would be deemed to be accurate.

³³ See *Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Report and Order and Second Further Notice of Proposed Rulemaking, FCC No. 15-47, 30 FCC Rcd. 3959 ¶ 290 (2015).

CONCLUSION

The Commission's Notice of Inquiry is an important and timely opportunity to significantly improve spectrum utilization, promote innovation, improve consumer access to broadband services, and advance U.S. leadership on spectrum policy. Amending the existing Part 15 rules in the 6 GHz band to permit higher-power, more flexible unlicensed use, with robust protection for incumbents' current and future operations, would advance these goals—driving rapid consumer adoption, maximizing economies of scale, and supporting forthcoming unlicensed wireless standards. The Commission should therefore expeditiously issue a Notice of Proposed Rulemaking to seek comment on the means to facilitate unlicensed operations throughout the 6 GHz band while protecting incumbents.

Respectfully submitted:

All Points Broadband
Amplex Electric, Inc., dba Amplex Internet
Apple Inc.
Blaze Broadband
Broadcom Limited
Cambium Networks, LTD
Cisco Systems, Inc.
Computer Office Solutions Inc., dba Snappy
Internet
Cypress Semiconductor Corporation
Dell Inc.
Electronic Corporate Pages, Inc., dba Western
Broadband
Extreme Networks, Inc.
Facebook, Inc.
Google
Hewlett-Packard Enterprise
HP Inc.
Intel Corporation
Interwest Management Services Inc., dba
Fire2Wire
JAB Wireless, Inc., dba Rise Broadband

Joink, LLC
MediaTek Inc.
MetaLINK Technologies, Inc.
Microsoft Corporation
New Wave Net Corp.
Pixius Communications, LLC
QUALCOMM Incorporated
Ruckus, a business unit of Brocade
Communications Systems, Inc.
Sony Electronics, Inc.
Wireless Internet Service Provider Association
Wisper ISP, Inc.

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