Testimony of

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Facilitating the 21st Century Wireless Economy

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Chairwoman Blackburn, Ranking Member Doyle, and members of the Committee, thank you for inviting me to provide Ruckus Wireless' perspectives on the central role wireless technologies play in the 21st century economy, the spectrum policies that can most effectively meet market demands, and the MOBILE NOW Act.

The United States is a global leader in the development and commercial utilization of wireless technologies, including Wi-Fi, LTE, and satellite-based services. Wireless innovation and investment has resulted in economic growth for a broad range of US industries, produced amazing new opportunities for American workers and citizens, and made immense direct and indirect contributions to our Gross Domestic Product. We at Ruckus are therefore encouraged that the Subcommittee is working to determine what will be required to sustain America's wireless leadership, and to enact policies that best position our nation as we move forward. This hearing is a critical part of that process, and I am honored to appear before you.

Overview of Ruckus Wireless

Ruckus is a leading supplier of wireless infrastructure solutions, providing products and services to both enterprise and service provider customers. Our products support wireless growth in a wide variety of markets, with noted leadership in connected cities, hospitality, education, healthcare, and high density public venues. You may have utilized our Wi-Fi networks at locations such as Hardin Hospital in Savannah, TN, Pittsburgh City Hall, with LinkNYC public kiosks in the Bronx, the San Jose airport and

convention center, or within Charter Communications' dense deployments across the nation in great cities like Austin, Tampa Bay, and my home city of Durham, NC.

Ruckus is ranked #1 in the Service Provider Wi-Fi market[1] and #3 in the Enterprise Wireless LAN market[2]. While our success until now has been based on Wi-Fi technologies, Ruckus is also a leader in the development of LTE systems utilizing the 3.5 gigahertz Citizens Broadband Radio Service ("CBRS") spectrum. OpenG™ is our solution for in-building cellular coverage, combining multi-operator LTE access points with the openly available CBRS spectrum. This technology enables Ruckus to provide public and private LTE services with the costs and deployment simplicity associated with Wi-Fi.

Ruckus supports a balanced spectrum policy which makes adequate licensed, unlicensed, and coordinated shared spectrum available for investors and consumers. All of these spectrum types will be needed to meet our country's growing wireless needs. I'll focus on unlicensed and coordinated shared spectrum today because of their central importance to Ruckus and its customers—and because my good friends at CTIA will ably discuss licensed spectrum.

Wi-Fi's Vital Role in the US Economy

When the 2.4 gigahertz band was first made available for permissive, unlicensed usage

1 Dell'Oro Group, Service Provider Wi-Fi Market, Calendar Year 2016.

2 Dell'Oro Group, Enterprise Wi-Fi Market, Calendar Year 2016.

in the United States in 1985, no one would have predicted that what was then thought of as a 'junk band' would provide the starting point for the most popular wireless technology in the world today. Wi-Fi is now the default wireless broadband network, and primary Internet connection, for Americans in their homes, at the office, staying in a hotel, flying on a commercial aircraft, and when traveling internationally. To put this in perspective, Cisco reported in its Visual Networking Index (VNI) that 8400 Petabytes of traffic was transmitted over Wi-Fi per month in the US during 2015. This is 16.8 times the amount of traffic (504 Petabytes) that was transmitted over cellular and includes all manner of Wi-Fi connected devices such as laptops, smartphones, tablets, gaming consoles, consumer IoT devices, and the many other Wi-Fi connected devices. And Wi-Fi has also become critical to the cellular industry. Cisco reported that globally 60% of the wireless data from mobile devices with both cellular and Wi-Fi connectivity was carried over Wi-Fi, and 40% over cellular, during 2016. Cisco further predicts that the percentage of traffic from these dual-mode devices carried by Wi-Fi will grow to 63% by 2021.[3] We're not sure 'Wi-Fi offload' is the correct description when Wi-Fi is in fact the *majority* service, but in any event, we're glad to help carry the load.

In another statement of Wi-Fi's mass-market appeal and future outlook, ABI Research predicted last year that 20 billion Wi-Fi chipsets would ship between 2016 and 2021.[4]

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[3] Cisco, Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016–2021 White Paper (updated March 28, 2017), http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html.

[4] ABI Research, ABI Research Anticipates More than 20 Billion Cumulative Wi-Fi Chipset Shipments by 2021 While Increased Use of 5GHz Spectrum Raises Coexistence Issues with

And Wi-Fi is just one of many wireless technologies that utilize these bands. The total annual US economic activity associated with unlicensed spectrum was valued at $222 billion in 2013, and is estimated to have increased to $547 billion today, with a corresponding $50 billion annual contribution to Gross Domestic Product.[5]

It is clear that Wi-Fi operating in unlicensed spectrum is critical to our country's economic success—for large industries, small businesses, and individual consumers.

Our evolving industry will require additional spectrum resources

There is a great amount of transformation going on across the wireless landscape. Traditional distinctions in many areas of both wireless technology and business models have blurred over the last few years, and this trend towards convergence is expected to continue. Our evolving industry will require more, and more diverse, spectrum resources. I'll explain why.

First, Wi-Fi and cellular are benefiting from one another. The overall demand for wireless connectivity is resulting in greater utilization of both Wi-Fi and LTE networks. New mobile devices with larger screens and improved graphics processing, are connected to ever faster LTE and Wi-Fi networks, with Wi-Fi being the default

LTE-U (May 3, 2016), https://www.abiresearch.com/press/abi-research-anticipates-more-20-billion-cumulativ/.

[5] Telecom Advisory Services, Assessment of the Economic Value of Unlicensed Spectrum in the United States (Feb. 2014), http://www.wififorward.org/wp-content/uploads/2014/01/Value-of-Unlicensed-Spectrum-to-the-US-Economy-Full-Report.pdf.

connection in the home and office, and LTE being default when out and about. The old story about these technologies supplanting each other has been replaced with a new reality of cellular and Wi-Fi advancing in parallel with new features and capabilities, and indeed learning a few things from each other. A few examples of this technical convergence include:

a) Wi-Fi is optimized for small cells, and now cellular network technologies, including LTE and the forthcoming 5G NR (New Radio) will be as well. Dense, small cell deployments have long been an essential characteristic of lower power Wi-Fi.
b) LTE is being enhanced to support a multi-operator capability, the ability to support multiple different network operators and their subscribers over a single radio operating in a single shared frequency range. Wi-Fi has always been an inherently neutral technology.
c) LTE is now being adapted to operate in non-exclusive spectrum, with LTE-LAA and MulteFire alongside Wi-Fi in unlicensed spectrum, and TD-LTE in the GAA Tier of the 3.5 GHz band. Wi-Fi has always operated in a shared access mode.
d) Conversely, Wi-Fi is becoming more spectrally efficient, with the adoption of techniques such as Orthogonal Frequency-Division Multiple Access (OFDMA) in the next major revision of the 802.11 Wi-Fi specifications. LTE was engineered from its inception with spectral efficiency in mind.
e) In the future, Wi-Fi clients will consume less power, with the next specification including mechanisms to significantly prolong battery life on mobile devices.

> Cellular technologies, including LTE and 5G NR, have long placed a priority on mobile devices consuming the least possible power.

The implication of these developments is that our country needs both licensed cellular technologies and unlicensed Wi-Fi to meet the demands of the 21st Century Wireless Economy—cellular and Wi-Fi technologies are benefiting from one another, and remarkable technological advances are being made across the wireless landscape.

Second, distinctions between Licensed and Unlicensed Spectrum are blurring. – Traditionally, there have been clear alignments between the existing spectrum frameworks, namely licensed or unlicensed, and the technologies that could utilize them. For example, 3G cellular technologies were only used in fully licensed spectrum, while Wi-Fi was only deployed in unlicensed spectrum. Now, however, we have technologies such as LTE-U, LTE-LAA, and LTE-LWA that combine both licensed and unlicensed spectrum to deliver a single service and a related technology, MulteFire, which will operate fully in unlicensed spectrum. And we have flexible spectrum frameworks such as the Citizens Broadband Radio Service (CBRS) that combine the characteristics of both licensed and unlicensed uses.

Policy Considerations for the 21st Century Wireless Economy

Against the backdrop of this wireless transformation, Ruckus strongly believes that Congress and regulators will need a broad range of spectrum designation and

management options in their policy 'toolkits'. These tools should emphasize flexibility, in recognition of policymakers' limited ability to predict which use of spectrum will be most valuable in the future. Investors and innovators will certainly need additional spectrum for networks using the traditional licensed and unlicensed access models. However, given spectrum scarcity and the need to share with incumbents, we also need newer models that support a flexible distribution of spectrum resources between exclusive and permissive uses. These modern frameworks rely on market forces instead of static, one-time government judgments about the "best" use of the spectrum. This market feedback can then be an input into an ongoing, dynamic rebalancing of the spectrum between exclusive and permissive use. This flexibility is critical to innovators and investors, as the pace of change in wireless technology and business models will only continue to accelerate.

Ruckus offers the following recommendations, with a focus on unlicensed and new dynamic models, trusting that others will adequately address the needs of the exclusively licensed model.

1. Augment Unlicensed Spectrum Resources

First, Ruckus recommends that Congress and the FCC augment current unlicensed spectrum resources. The latest generation of Wi-Fi, the 802.11ac specification, makes use of larger channel bandwidths, in conjunction with more efficient modulation and coding techniques, to produce over-the-air performance that can reach multiple gigabits per second (Gbps). Investors need the type of performance made available by these

wider channels as they deploy next generation broadband services such as Fiber-to-the-Home (FTTH) and cable DOCSIS 3.1. These fixed broadband services can easily deliver 1 Gbps or greater performance to a home or business. However, the final connection to the end user will be made over a Wi-Fi network within that home or office building. In many cases we are now seeing that the lack of these large channels in our core unlicensed bands means that the local Wi-Fi network is the limiting factor in the end user experience.

Additionally, new LTE technologies will soon make the core unlicensed bands even more congested. Earlier this year, the Commission approved the first LTE-U devices. LTE-U is a non-standard technology that utilizes the unlicensed 5 gigahertz band to boost the performance of an LTE service that is “anchored” in licensed band spectrum. Other, standardized technologies that accomplish this same licensed LTE performance augmentation by opportunistically accessing the unlicensed 5 gigahertz band have been developed by 3GPP and are expected to be deployed in the near future. These standardized variants include LTE-LAA and LTE-LWA. Finally, a ‘standalone’ version of unlicensed LTE, known as MulteFire, is being developed that would operate entirely within the unlicensed 5 gigahertz band. I am not here today to discuss how well these technologies will, or will not, coexist with Wi-Fi, but simply to point out that they will utilize the same unlicensed spectrum resources as Wi-Fi.

Furthermore, the emergence of Internet of Things (IoT) will put additional pressure on unlicensed bands. The vast majority of these devices will be connecting over unlicensed

spectrum. Ericsson, in its November 2016 Mobility Report, stated that over 92% of the 5.6 billion IoT devices in 2016 were connected using unlicensed technologies, and predicted that in 2022 over 88% of the 18.1 billion IoT devices will be connected using unlicensed technologies.[6] These unlicensed technologies include Wi-Fi, Bluetooth, ZigBee, Sigfox, LoRa, and Ingenu.

All of this adds up to a looming challenge. A Quotient Associates report was issued in February that modeled the amount of traffic that will need to be carried by Wi-Fi in the years 2020 and 2025, and the amount of unlicensed spectrum that would be required[7]. For the United States, the report forecasts a gap of from 220 to 628 megahertz of unlicensed spectrum by 2020, and a gap of from 540 to 1588 megahertz of unlicensed spectrum by 2025. The report also points out that while millimeter wave spectrum can certainly be utilized for many valuable applications, it does not meet the needs fulfilled by mid-band spectrum, such as multi-room coverage in a home, coverage for an office building, outdoor Wi-Fi hotspots, and other use cases. Unfortunately, the reality is that there have been no designations of additional mid-band unlicensed spectrum since 2002. And while there was great hope for use of the 5350-5470 MHz band, last year NTIA and the FCC decided that they would not open the band for unlicensed use. The work of Congress and the Commission to broaden the use of the 5150-5250 MHz band was very much appreciated and new outdoor and higher power deployments have

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6 Ericsson, Ericsson Mobility Report (Nov. 2016), https://www.ericsson.com/assets/local/mobility-report/documents/2016/ericsson-mobility-report-november-2016.pdf.

7 Quotient Associates, Wi-Fi Spectrum Needs Study (Feb. 2017).

resulted, however, it has not changed the fundamental outlook for the amount of mid-band unlicensed spectrum available indoors, where the demand is greatest.

Given the sharply increasing demands for unlicensed spectrum from Wi-Fi, LTE, and IoT, and the specific gap noted just to meet our nation's future Wi-Fi needs, we strongly recommend expeditious action to identify additional mid-band spectrum that can be designated for unlicensed use, including spectrum where unlicensed operation would require mitigations to protect incumbent government or commercial services. We believe the 5925 to 7250 megahertz range is one of the best candidate bands due to the characteristics of the incumbent services in the band, its proximity to the existing unlicensed bands between 5150 and 5825 megahertz, the potential amount of spectrum that could be made available, and the existing Part 15 designation by the Commission, as well as a mobile allocation by the ITU. We also note that European authorities have already initiated studies on the regulatory and technical feasibility of an unlicensed designation in the 5925 to 6425 megahertz range. Because of these unique qualities of the spectrum in 5925 to 7250 megahertz, we believe equipment and services could be rapidly deployed. And the FCC has an active proceeding considering opening the U-NII-4 portion of this frequency range for commercial broadband. We recommend that Congress support these important efforts.

We also support the designation of additional spectrum above 10 gigahertz for unlicensed use, because very high bandwidth, short range services such as wireless

virtual reality and augmented reality are especially suited to millimeter wave unlicensed spectrum.

In summary, as Commissioner Michael O'Rielly has noted, *"What I love about unlicensed is that you don't know what you're going to get out of it."* Indeed, unlicensed spectrum continues to be the incubator for all types of new services and provides fertile ground for America's best minds to innovate, invest, and develop. Additional designations of large and contiguous portions of unlicensed spectrum will ensure that the American economy continues to enjoy the incredible contributions made by Wi-Fi, as well as from other existing and emerging unlicensed technologies.

2. Advance Coordinated Shared Spectrum

Second, Ruckus recommends that Congress and the FCC make use of a powerful new spectrum management tool to produce more value for the economy: Coordinated Shared Spectrum, or CSS. CSS is a general term used to describe dynamic spectrum management frameworks that move beyond the static designation paradigm to free more value. CSS frameworks differ from unlicensed frameworks in that there is a coordination requirement to access the spectrum, whereas unlicensed access does not require coordination. They differ from licensed frameworks in that the spectrum managed by CSS can be shared by a multitude of users with similar or different use cases – and can accommodate both exclusive and permissive uses, whereas licensed frameworks allocate spectrum for exclusive use only.

The leading example of CSS is the CBRS framework, as currently applied to the 3.5 gigahertz band in the US. An indication of CBRS' flexibility and wide appeal is the enthusiastic response it has received across the various wireless markets, including industries traditionally based on licensed spectrum and those traditionally aligned with unlicensed spectrum. Industry organizations such as the Wireless Innovation Forum (WInnForum)[8] and the CBRS Alliance[9] have formed to commercialize the band, with WInnForum developing the foundational specifications applicable to all wireless technologies while the CBRS Alliance focuses on the optimization of LTE services for the CBRS band. Both of these organizations have a diverse set of members, representing the cellular, cable, enterprise, and other sectors of the economy. For example, the CBRS Alliance was only launched eight months ago with six founding members; Ruckus, Google (Access Technologies), Federated Wireless, Intel, Nokia, and Qualcomm; and has now grown to forty-two members including all four national mobile operators, the nation's two largest cable providers, cellular infrastructure vendors, enterprise networking vendors, neutral-host systems providers, and more. That such a variety of industries all see significant potential in a single shared band, and are working together to commercialize the band, is unprecedented.

In cases where CSS frameworks are applied to bands identified for cellular technologies, such as CBRS in 3.5 gigahertz, a frequency range globally identified for LTE services, the opportunity for permissive use unlocks new deployment options and

8 http://www.wirelessinnovation.org/.

9 https://www.cbrsalliance.org/.

business models. We believe this will be key to meeting the challenges of both in-building and rural coverage, by allowing private and public entities such as businesses, hoteliers, hospitals, municipalities, and niche service providers to deploy and operate their own LTE networks without having to acquire rights to exclusive, licensed spectrum. These networks can be used to meet the communications needs of the deploying entity, and may also be made available to the established cellular operators via a neutral-host relationship. Another expected use case is CBRS permissive access for industrial IoT services, providing a more consistent and predictable spectrum environment than unlicensed spectrum can provide, without the barriers to entry of a traditional licensed approach.

The broad, cross-industry appeal of CBRS, coupled with its potential to address coverage challenges that have not been successfully addressed by the traditional cellular model, has not escaped the attention of other nations. As examples, recent spectrum policy consultations from Ofcom in the United Kingdom and the Australian Communications and Media Authority referred to the three-tier structure of CBRS and sought industry input on whether similar flexibility and permissive use options should be incorporated into their frameworks.

We recommend that Congress and the FCC maintain the CSS framework in place in the 3.5 GHz band today, and consider expanding it in other bands, joining traditional licensed and unlicensed designations as a powerful new tool.

With regards to CBRS in 3.5 GHz, the Commission has recently indicated that they plan a review of some provisions of the Report and Order and Order on Reconsideration (Second Order). As indicated previously, there has been a tremendous industry response to the opportunities encompassed in the current CBRS rules, with very substantial investments made, and we expect industry's efforts to culminate in deployments in the second half of this year as the Commission completes the authorization of the Spectrum Access System (SAS) and Environmental Sensing Capability (ESC) administrators and begins certifying equipment for Part 96 operation. It is critical that any restructuring of the CBRS rules be done in a manner that does not negate industry's efforts nor delay the commercial availability of the band. Major changes would upset expectations and undermine investment. Additionally, as noted earlier, the multi-stakeholder organizations working diligently to commercialize CBRS represent an array of different wireless industry sectors; cellular, cable, enterprise, and more - the Commission should ensure during its review that is it not preferring one group over others, or reducing the existing value propositions for any of these various industry sectors.

3. Support the MOBILE NOW Act.

Third, Ruckus recommends that the Subcommittee support the MOBILE NOW bill. The bill includes the important commitment to add 500 new megahertz of spectrum below 6 GHz. We would welcome, and make good use of, the additional unlicensed spectrum below 6000 megahertz that is called for in this section. But we respectfully ask that the Subcommittee consider a more balanced approach to licensed versus unlicensed

spectrum. In a worst-case scenario, the bill would require the FCC to designate only 100 megahertz for unlicensed. This would vastly under-resource Wi-Fi, the most popular wireless broadband technology in the country, leaving the rapidly increasing unlicensed spectrum gap identified by Quotient Associates mostly unaddressed. It would not meet even half of the lowest estimated gap for 2020.

More broadly, Ruckus strongly supports MOBILE NOW's requirement that the government study shared commercial use of the 3100 to 3550 megahertz and 3700 to 4200 megahertz frequency ranges. We note that several of the *Subsection (c)* requirements, such as incumbent protection and the combination of licensed (exclusive use) and unlicensed (permissive use), are characteristics of CSS frameworks. Given this, and the proximity to the CBRS framework in the 3550 to 3700 megahertz range, we would recommend that the Commission and affected Federal agencies study the efficacy of a CBRS type framework.

Ruckus also supports MOBILE NOW's specifically unlicensed sections. We applaud the bill's requirement for GAO to assess the existing access to affordable wireless services for all of our nation's citizens, any barriers preventing such access, and strategies for removing those barriers (Section 15). Ruckus is proud to be the technology partner to many initiatives to connect the unconnected, both in the US and abroad. Our Wi-Fi systems are being used from the streets of New York[10] to towns in South Africa[11] to

[10] Gizmodo, Inside the Tech Behind New York's Monstrously Fast Gigabit Wifi (Feb. 9, 2016), http://gizmodo.com/inside-the-tech-behind-new-yorks-monstrously-fast-gigab-1757905695.

[11] http://www.projectisizwe.org/.

provide free and affordable access to people who would not otherwise be able to take advantage of the educational and economic opportunities that are required in the 21st century economy. We look forward to the report, and its recommendations. Furthermore, we support MOBILE NOW's clear statement of the Unlicensed Spectrum Policy of the United States (Section 17), and call for a National Plan for Unlicensed Spectrum (Section 18).

Conclusion

Thank you again for the opportunity to testify today. At Ruckus, we are committed to investing and innovating to make our nation's wireless infrastructure stronger and better. This Subcommittee can help us, and businesses like us, meet the needs of our nation's 21st century wireless economy by pushing for additional unlicensed spectrum resources, advancing the use of Coordinated Shared Spectrum frameworks, and adopting the MOBILE NOW bill.