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VIA ELECTRONIC FILING

Ms. Marlene Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Reply to Comments in ET Docket No. 15-105: Office of Engineering and Technology and Wireless Telecommunications Bureau Seek Information on Current Trends in LTE-U and LAA Technology

Dear Ms. Dortch:

Broadcom Corporation (“Broadcom”) submits these reply comments to the Federal Communications Commission (“FCC” or “Commission”) in ET Docket No. 15-105.¹

In our initial comments, we expressed concern that unlicensed LTE (both LTE-U and LAA) could create harmful interference with Wi-Fi when operating in the same bands.²

After reviewing the comments submitted to this docket, we continue to be concerned. In fact, the record reflects significant confusion and does not clarify how unlicensed LTE devices will coexist with existing unlicensed technologies such as Wi-Fi. For example, some members of the LTE-U Forum claim that the devices incorporate listen-before-talk; others do not mention this feature. In addition, answers to simple questions such as the extent of coordination between 3GPP, LTE-U Forum, IEEE, and Wi-Fi Alliance illustrate a major difference in views on how to define coordination and whether it has been adequate.³

¹ When Broadcom refers to LTE-U in this filing, we are referring to the technology being contemplated by the LTE-U Forum. When we refer to License Assisted Access or LAA in this filing, we are referring to the feature that has been a study item that was recently approved by the 3GPP as a Release 13 work item. When we refer to unlicensed LTE in this filing, we are referring to any LTE that operates using unlicensed spectrum, including, for example, LTE-U and LAA.

² See Comments of Broadcom Corporation, ET Docket No. 15-105 (filed June 11, 2015) (“Broadcom Comments”).

³ Compare, e.g., Letter from Paul Nikolich, Chairman, IEEE 802 LAN/MAN Standards Committee, to Marlene H. Dortch, Secretary, Fed. Commc’ns Comm’n, at 1, ET Docket No. 15-105 (filed June 8, 2015) (“[t]here has been no coordination between IEEE 802 and any standards body associated with LTE-U” and “[t]here has been no coordination between 3GPP and IEEE 802 on LAA.”), and Comments of the Wi-Fi Alliance at 8-9, ET Docket No. 15-105 (filed June 11, 2015) (“3GPP member companies will agree on sharing mechanisms and a definition of ‘fairness’ without requiring agreement from stakeholders outside of 3GPP membership” and “To our knowledge, the LTE-U specification does not detail an access methodology, and this closed approach prevents the development of even a common understanding of the issue within the larger stakeholder community.”), with Comments of Qualcomm Incorporated at 15, ET Docket No. 15-105 (filed June 11, 2015) (“Qualcomm Comments”) (“There have been, and will continue to be, extensive communications between 3GPP and IEEE 802.11 on LAA, and between LTE-U Forum members and the WFA and its members on LTE-U.”); Comments of T-Mobile USA, Inc. at 5, ET Docket No. 15-105 (filed June 11, 2015) (“3GPP, IEEE 802, and Wi-Fi Alliance – are collaboratively evaluating the co-existence of LTE-U and LAA with other technologies”).



We believe that LTE-U is likely to cause harmful interference to Wi-Fi operating in the same bands for a variety of reasons. Among other concerns, the LTE-U coexistence algorithms are proprietary, there appears to be significant differences in how manufacturers are implementing these proprietary coexistence mechanisms, and coexistence will be controlled—and possibly deactivated altogether—at time of operation by the operators.

LTE-U provides only high level guidance on how coexistence could be managed, and does not provide for precise instructions or requirements that dictate how this will be accomplished.⁴ Alcatel-Lucent, Ericsson, Qualcomm, and Verizon, who are all members of the LTE-U Forum, appear to disagree on whether LTE-U incorporates listen-before-talk in their comments. Alcatel-Lucent and Ericsson both say that coexistence will be managed through energy detection in Carrier-Sensing Adaptive Transmission (CSAT) in countries that do not have a regulatory requirement to implement listen-before-talk (LBT).⁵ Qualcomm and Verizon indicate that LTE-U has an LBT feature, but does not incorporate Dynamic Frequency Selection (DFS).⁶

In addition to differences in the definition of LBT, it appears that these LTE-U Forum members also contemplate different approaches to managing coexistence in other respects. As referenced in the Verizon and Qualcomm Comments, the LTE-U Forum hosted a meeting and provided simulations and test results on LTE-U coexistence with other unlicensed devices.⁷ During this meeting, it became apparent that some implementations of LTE-U will incorporate a Wi-Fi sniffer to better manage coexistence. If the LTE-U Forum is committed to fair coexistence with Wi-Fi and some LTE-U Forum members believe that a Wi-Fi sniffer is necessary to manage coexistence, then it is not clear why a Wi-Fi sniffer is not a requirement in the LTE-U Forum.

Communications engineers customarily design tests for the worst case scenario, but many of the tests submitted in this record instead appear to be designed to reach the most favorable conclusion regarding unlicensed LTE's coexistence with Wi-Fi. It is important that all of the parameters and assumptions are clearly defined so that all parties clearly understand the coexistence scenarios. At a bare minimum, the issues identified below must be better understood before any test or simulation sufficiently demonstrates that unlicensed LTE will fairly coexist with Wi-Fi.

- Qualcomm and Verizon indicated that the primary use case for unlicensed LTE was in dense deployments, and Broadcom agrees.⁸ If this is the primary use case, then coexistence scenarios depicted by any commenters in light or moderately dense deployments are irrelevant. What constitutes a dense deployment? Is it a single Access

⁴ See Qualcomm Comments at 5 (“The LTE-U Forum documentation does not set specific parameters for the techniques; rather, it provides a high-level description and leaves the implementation details to the equipment provider to allow for vendor differentiation.”).

⁵ Comments of Alcatel-Lucent at 4-5, ET Docket No. 15-105 (filed June 11, 2015); Comments of Ericsson at 10, ET Docket No. 15-105 (filed June 11, 2015) (“Ericsson Comments”).

⁶ See Qualcomm Comments at 5; see also Verizon Comments at 3. We note that when Qualcomm and Verizon refer to LTE-U containing LBT in their comments, it is not LBT as understood by IEEE and Wi-Fi Alliance, which requires the device to listen before sending each packet. In their description of LTE-U incorporating LBT, Qualcomm and Verizon appear to be referring to the functionality in LTE-U that checks the loading on the channel using CSAT before choosing which channel to occupy.

⁷ See Verizon Comments, Attachment Declaration of William H. Stone at 4-5; see Ericsson Comments at 12; see Qualcomm Comments at v.

⁸ See Qualcomm Comments at 3; see also Comments of Verizon, ET Docket No. 15-105 (filed June 11, 2015) (“Verizon Comments”) at 1.



Point (AP) or ten APs? How many client devices should be connected to each of the APs – 1, 10, or 200?⁹ Are coexistence tests truly representative of dense deployments?

- The most recent IEEE 802.11 standards incorporate Wi-Fi channels as wide as 80 or even 160 MHz, but coexistence tests offered by proponents of unlicensed LTE appear to contemplate far narrower Wi-Fi channels.¹⁰ What is the impact on an 80 or 160 MHz wide Wi-Fi signal? Similarly, what is the impact on Wi-Fi users if unlicensed LTE is aggregated and deployed in wider channels as is expected?¹¹ The current simulations do not cover either of these wider channel scenarios.
- Coexistence scenarios provided to the Commission appear to contemplate only one, or at most two, operator(s) using a small portion of the available unlicensed spectrum in a given geography.¹² What happens if there are multiple uncoordinated unlicensed LTE nodes operating in the same area, possibly using channels of 80 to 160 MHz each? In the US, there could easily be four unaffiliated operators in a given geographic region, especially in dense urban centers, at least some of which will likely choose to aggregate multiple 20 MHz channels for increased throughput.
- What happens when the propagation loss between an unlicensed LTE device and a co-channel Wi-Fi device is set such that the received signal levels are -75 dBm, for example? This is more than 10 dB below the thresholds proposed by the LTE-U Forum for coexistence protocols to detect Wi-Fi signals,¹³ and would normally support good Wi-Fi communications. Would such a scenario allow for functioning LTE? What would the impact be on surrounding Wi-Fi? Is this type of scenario likely in a dense deployment?

Unlicensed LTE is still in its infancy, and the impact on the unlicensed ecosystem, especially on Wi-Fi, which supports over 50% of all Internet traffic, is not well understood by the communications industry. It is not surprising to Broadcom that participation in this docket is primarily limited to only the few parties that have an interest in deploying unlicensed LTE technologies, those that are concerned about the potential disruption to the services they currently provide, and those with a deep technical expertise in the wireless ecosystem in general. However it is clear to us, that the most significant consequences would be felt by the hundreds of millions of end-users that have already purchased Wi-Fi devices, many of which rely on such devices as their only source for Internet connectivity. Such consumers are unlikely to realize why their connection to the Internet fails, or why their service has been severely disrupted.

⁹ Compare Qualcomm Comments at App. A, slides 22-23 (testing Wi-Fi networks with only one device per access point), with Broadcom Comments at 4 (simultaneously testing several Wi-Fi networks, each with 10 associated client devices), and Letter from Paul Nikolich, Chairman, IEEE 802 LAN/MAN Standards Committee, to Dino Flore, TSG RAN Chair, 3GPP, and Satoshi Nagata, RAN WG 1 Chairman, 3GPP, App. 2 at 5 (Mar. 13, 2015), available at http://www.ieee802.org/Communications/15_03/802-to-3GPP-liaison-cover-letter-w-appendices-18March-2015.pdf (for testing the effect of LTE-U on Wi-Fi, “50 to 200 devices per 802.11 AP radio is a reasonable starting point”).

¹⁰ See, e.g., Qualcomm Comments at App. B at 8.

¹¹ See Qualcomm Comments at 12 (“The anchor channel, which carries these primary operations, is aggregated with a set of secondary channels, each 20 MHz wide in the 5 GHz unlicensed band.”) (emphasis added).

¹² See, e.g., Qualcomm Comments at App. B at 8-17 (describing demonstrations involving a single Wi-Fi operator on a single 40 MHz channel, and, in 24 of 26 scenarios, no more than a single LTE-U operator. In the remaining two scenarios, only two LTE-U operators are considered).

¹³ See LTE-U Forum, *LTE-U SDL Coexistence Specifications V1.1*, at 7 (June 2015), available at http://www.lteforum.org/uploads/3/5/6/8/3568127/lte-u_forum_lte-u_sdl_coexistence_specifications_v1.1.pdf.



To ensure unlicensed LTE coexists well with unlicensed devices already broadly deployed in the US, Broadcom believes that the Commission must conduct robust oversight before LTE-U is deployed by convening roundtables and developing working groups comprised of LTE and Wi-Fi technical experts. Broadcom believes that the discussions would be most meaningful when entities that have both cellular and Wi-Fi interests bring their technical experts on both technologies to participate in the discussions. Broadcom would gladly support such an endeavor by offering its renowned Wi-Fi and LTE technical experts.

We look forward to reviewing other comments in relation to this docket and to working with the Commission should it have any questions with respect to this filing.

Sincerely,

/s/ Christopher Szymanski
Christopher Szymanski
Director, Global Regulatory Affairs
Broadcom Corporation