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

In the matter of

Office of Engineering and Technology	)	
and Wireless Telecommunications Bureau	)	
seek information on current trends in	)	ET Docket No. 15-105
LTE-U and LAA technology	)	

REPLY TO COMMENTS

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Summary

The FCC's Public Notice on unlicensed LTE has exposed many differences in opinion among the respondents. There is

1. no common view on whether or not unlicensed LTE is a standard,
2. disagreement on whether the various parties are collaborating, and
3. even less concurrence on the likely impact the technology will have on other users of the unlicensed bands, if deployed.

In addition, there are two basic suggestions about what the FCC should be doing.

- One view holds that the industry itself has the proper incentives to coordinate technologies, so the FCC should continue its "technology neutral" policy and "take no action".
- Others feel that the FCC either needs to act now to prohibit deployment of this technology, or at least it needs to keep that threat on the table to force industry players to work together.

As will be described in these Reply Comments, I continue to believe that *the FCC needs to move this conversation away from the specifics of unlicensed LTE, and towards the general concerns about the essential characteristics of the unlicensed spectrum bands, and how they should be managed to preserve those characteristics.* As I said in my Comments to this inquiry, I believe that ***the unlicensed bands are an example of a commons, and that the FCC has a major role to play in the management of that common resource***. Arguments that the FCC should do nothing are unconvincing, and certainly premature. Rather, what the FCC needs to do is to formally consider what the characteristics of the unlicensed bands are that it wishes to preserve, and then to discuss what needs to be done, if anything, to preserve them.

The FCC's inquiry has resulted in many contradictory responses

As is not much of a surprise, the FCC's inquiry into the status of the standardization and technical characteristics of unlicensed LTE has resulted in a number of conflicting messages. This is especially true around the question of standardization, and the question of whether or not unlicensed LTE can/will be a good neighbor to other users of the unlicensed spectrum bands.

1. Is unlicensed LTE, in any of its forms, a standard?

The responses show a broad diversity of opinions on this question. CTIA paints the picture of largely standardized solutions by saying that "[t]here are two versions of LTE-U under development. The initial version uses 3GPP Releases 10/11/12," and that "[a] second version of LTE-U, known as Licensed Assisted , Access (LAA), is being standardized in 3GPP in LTE Release 13."[1] This representation is put somewhat differently by entities such as the IEEE 802 LAN/MAN Standards Committee which says that "...LTE-U was not developed by a standards body. It is the understanding of IEEE 802 that LTE-U is a proprietary solution…",[2] or Broadcom which states that "Broadcom does not believe that LTE-U as envisioned by the LTE-U Forum meets the normal criteria of a standard."[3]

The general consensus, however, appears to be that the version of unlicensed LTE known as LTE-U is not a standardized technology; rather it is one developed by a closed group of participants, while the version known as LAA is, in fact, on the path to becoming a standard within the context of 3GPP, although this has yet to be finalized.

2. Are the various parties collaborating?

Even on the question of cooperation between industry groups in the definition of these proprietary or standardized solutions, there seems to be a wide diversity of responses. For example, according to Qualcomm "[t]here 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."[4] T-Mobile says "IEEE 802 and 3GPP in particular have collaborated on the coexistence of LAA and Wi-Fi."[5] These characterizations do not seem to align with the views of, for example, Broadcom, which says that "Broadcom is unaware of any formal collaboration or coordinating mechanism between IEEE 802.11 and

[1] Comments of CTIA, page 3.
[2] Comments of the IEEE 802 LAN/MAN Standards Committee, page 1.
[3] Comments of Broadcom, page 2.
[4] Comments of Qualcomm, page 15.
[5] Comments of T-Mobile, page 8.

the LTE-U Forum on LTE-U coexistence, with Wi-Fi,"[6] the Wi-Fi Alliance, which says "[t]here have only been limited and preliminary efforts to foster stakeholder agreement on appropriate spectrum sharing characteristics; further work and collaboration is necessary,"[7] and, most importantly, the IEEE 802 committee itself which states that "[t]here has been no coordination between IEEE 802 and any standards body associated with LTE-U" and that "[t]here has been no coordination between 3GPP and IEEE 802 on LAA."[8]

3. Will unlicensed LTE, in any of its forms, be able to successfully share the unlicensed spectrum with other technologies?

Again the information provided related to this question varies widely, from an unqualified "yes", to "maybe", to "no". CTIA, for example, says that "LTE-U Would Not Adversely Affect other Unlicensed Users."[9] Qualcomm presents a detailed document which explains their view that "LTE Unlicensed will fairly share unlicensed spectrum with Wi-Fi and other uses without any adverse impact."[10] And most of the proponents of the use of unlicensed LTE take this position.

On the other hand there are comments, like those from Broadcom, which state that "Broadcom believes that LAA can coexist with Wi-Fi given proper planning and the incorporation of robust coexistence mechanisms, but stakeholders must be incentivized to develop and implement those mechanisms", a comment which is tempered by their following statement that "Broadcom has considerable concerns about LTE-U's coexistence with Wi-Fi and believes that it is unlikely to be a good neighbor because the coexistence algorithms are proprietary, because of variations in equipment, and ultimately because coexistence is controlled at time of operation, among other reasons."[11] Nokia and Cisco, similarly, state

[6] Comments of Broadcom, page 2.
[7] Comments of the Wi-Fi Alliance, page ii.
[8] Comments of the IEEE 802 LAN/MAN Standards Committee, page 1.
[9] Comments of CTIA, page 5.
[10] Comments of Qualcomm, page i.
[11] Comments of Broadcom, page 1.

that a properly deployed network can happily co-exist, but point out (implicitly or explicitly) that it is also possible to imagine a poor implementation which will not.[12]

And finally there are dire comments like those from the Dynamic Spectrum Alliance, which believes that "[u]nlicensed technologies such as Wi-Fi will be at the mercy of LTE-U operators, whose incentive is to choose a duty cycle that maximizes LTE-U's time on air at the direct expense of Wi-Fi and other unlicensed technologies,"[13] Google, which submits a paper which "shows that in many circumstances, LTE-U coexists poorly with Wi-Fi in the 5 GHz band"[14], Cablevision, which believes that the use of unlicensed LTE "threatens to substantially diminish the quality and usability of unlicensed spectrum in America, eliminating a viable customer alternative to the licensed carriers for wireless broadband service,"[15] and Ruckus which says that "proprietary and pre-standard LTE-U implementations could have a potentially devastating effect on 802.11-based ("Wi-Fi") networks."[16]

The FCC is not equipped to, nor should it be the FCC's responsibility to, resolve these conflicting responses

How should the FCC respond to these differing opinions? For various reasons, I believe that the FCC only needs to recognize the diversity of opinions, and does not need to (probably cannot) come to a final answer to the questions.

1. Does it even matter if unlicensed LTE is standardized, or not?

Although it is interesting to see the diversity of opinion on the question of standardization and the state of collaboration between standards groups and other parties, in the end, this is not an issue with which

[12] Comments of Nokia, page 13: "The studies show that when an appropriate channel access scheme is used, it is feasible for LAA to achieve fair coexistence with Wi-Fi…", and Comments of Cisco, page 6: "If the coexistence issue is not carefully managed, there could be substantial consequences to Wi-Fi packets transmitted or received near LTE-U transmitters."
[13] Comments of the Dynamic Spectrum Alliance Limited, page 4.
[14] Comments of Google, page 1.
[15] Comments of Cablevision, page 1.
[16] Comments of Ruckus, page 1.

the FCC really needs to be involved. The reason is that one of the beautiful aspects of the unlicensed bands is that they provide all of us, the people of the United States, with access to spectrum in which to innovate with a very low barrier to entry. As was stated multiple times in comments to this proceeding by many different respondents, the only barrier is that the products meet the FCC's Part 15 requirements. We certainly would not want to go down a path in which participation in a standards organization became a prerequisite for the deployment of a technology in the unlicensed bands. Worse yet, we would not want it to be necessary for the product itself to conform to a standard that was ratified by one of these organizations. This would create a barrier to entry for these bands, limiting access to those with the time and resources to devote to the time consuming and expensive activity of participating in, and even driving, a standards-setting process.

2. Can the FCC determine if unlicensed LTE will be a good neighbor?

Although the FCC has strong engineering and testing resources, those resources are heavily loaded with other work, and they do not compare in scale to the resources that the LTE-U Forum participants[17], for example, could bring to bear. It seems an unrealistic goal for the FCC to expect to resolve this question. For example, while Qualcomm has presented detailed information on "Simulated LTE-U and Wi-Fi Outdoor Performance"[18] (among much other information), the National Cable and Telecommunications Association claims that the simulations and even testing which are being presented are fundamentally flawed.[19] This is an intractable problem on which the proponents and opponents will never agree, and simulation conditions and parameters can be discussed forever.

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[17] According to documents on their website, this group includes Alcatel-Lucent, Ericsson, LG Electronics, Qualcomm Technologies Inc., Samsung Electronics, and Verizon. http://www.lteuforum.org/, visited June 18th, 2015.

[18] Comments of Qualcomm, Presentation Slide 15.

[19] Comments of National Cable & Telecommunications Association, page 14. "LTE-U and LAA proponents claim that LAA and LTE-U will share spectrum effectively with Wi-Fi. But their assertions depend on badly flawed coexistence simulations. Most importantly, LTE-U proponents do not measure the probable impact of LAA and LTE-U on even moderately dense Wi-Fi deployments. The LTE-U demonstration staged by Qualcomm at the Consumer Electronics Show, for example, used a Wi-Fi network with only eight network nodes. This does not even offer an

This is why, in my Comments to this proceeding, I have suggested that ***the FCC should separate its inquiry from the specifics of any given technology***; instead, the FCC **should be asking what needs to be done (if anything) to protect the essential character of the unlicensed spectrum bands**.[20]

There are certain classes of response, however, that should be rejected by the FCC

There are a few general comments that surfaced in the responses to this inquiry that can, and should, be addressed before moving on to the more general question of the essential nature of the unlicensed spectrum bands. Specifically there are two comments that appear in multiple responses, which I characterize here as follows:

i. The "we have good intentions" argument says that because a company has interests in both Wi-Fi and LTE technology, they will, by definition, act in a way that will be in the best interests of the unlicensed spectrum users.

ii. The "FCC prefers technology-neutral rules" argument has been used by multiple respondents as a way of saying that the FCC should take no action.

Both of these arguments are invalid under any reasonable scrutiny, as I will discuss below.

i. The "we have good intentions" argument fails for multiple reasons

An argument which was presented by most, if not all, proponents of the use of unlicensed LTE, was that the respondent is also invested in Wi-Fi technology and, therefore, has every incentive to do only those

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adequate estimate of the impact on the average home Wi-Fi network, which supports an average of eleven devices, or a multiple dwelling unit with many dozens of devices, let alone a carrier-grade Wi-Fi network, or any other popular Wi-Fi hotspot."

[20] Comment of Leigh Chinitz, page 2. "The questions of importance are not those related to one specific technology or another. That is, if there were not a concern related to unlicensed LTE today, there would be a concern related to some other technology tomorrow (and there may well be.) And there will be new technologies after that. *The FCC does not, or should not, want to have a proceeding every time some new technology is developed for unlicensed spectrum use. Therefore, the questions which should have been raised are those related to the fundamental nature of unlicensed spectrum, and what steps need to be taken to protect it."*

things which would preserve the ability for Wi-Fi to operate in the unlicensed spectrum. Although the list of companies making this claim is too long to list all of them, they include

- Qualcomm ("Many of the companies developing LTE Unlicensed technology also develop and/or deploy Wi-Fi technology, so it is in everyone's interest that LTE Unlicensed successfully shares spectrum with Wi-Fi and all other unlicensed uses." [21], and "…carriers have a strong vested interest in ensuring that LTE Unlicensed shares spectrum equitably with Wi-Fi and that Wi-Fi does not suffer harmful interference."[22]),
- ATIS ("given the broad reliance on both licensed and unlicensed bands for mobile broadband and the ubiquity of smartphones that use both LTE and Wi-Fi, mobile operators and technology companies in the U.S. have a strong incentive to ensure that Wi-Fi device users do not suffer interference."[23],
- Verizon ("Verizon also has a particular interest in ensuring that new uses of unlicensed spectrum do not degrade existing unlicensed operations: Verizon has put Wi-Fi into hundreds of millions of its smartphones, tablets, mobile hotspots, and FiOS routers. It has a strong interest in ensuring that nothing compromises consumers' use of Wi-Fi."[24]),
- Cisco ("Our "build it all" perspective means that we want technologies to access spectrum fairly so that the unlicensed bands can continue to be a place where innovative technologies can operate."[25]), and
- T-Mobile ("T-Mobile has a particularly strong incentive – because of its leadership in integrating WiFi and licensed technologies – to ensure effective co-existence."[26])

The problem with ***this argument is that it fails for a number of reasons*** and, hence, should be rejected by the FCC as valid proof that the deployment of unlicensed LTE will be without harmful side effects to other users of the unlicensed bands.

The weighting of interests between Wi-Fi and licensed technologies is, in many cases, not balanced

When corporations claim that they have vested interests in one thing or another, it is worth looking into the size of those interests, especially when there is a comparison being made (in this case between Wi-Fi and licensed technologies.)

[21] Comments of Qualcomm, page 2.
[22] Comments of Qualcomm, page 4.
[23] Comments of ATIS, page 4.
[24] Comments of Verizon, page 2.
[25] Comments of Cisco, page 2.
[26] Comments of T-Mobile, page 4.

According to a recent analysis by the Boston Consulting Group[27], "[t]he mobile technologies industry generated revenues of almost $3.3 trillion worldwide in 2014." Although I know of no similar number which measures the value of Wi-Fi to these global mobile providers, it is likely to be much less than $3.3 trillion. This is one of the reasons that, in a recent opinion piece on this topic, author Claus Hetting writes *"[w]ith such a gigantic pile of money at stake, no wonder the powers that be shudder at the thought of Wi-Fi disruption."*[28] While many companies may have interests in both Wi-Fi and licensed technologies, the sizes of those interests are by no means the same.

Wording in the comments gives insight to the weighting of these vested interests

In many cases, the wording used in the Comments to this proceeding reveals the uneven balance of the interests of the parties. For example, Qualcomm makes the following statement: "As the FCC well knows, the wireless industry relies heavily upon both Wi-Fi in unlicensed bands and 3G and 4G in licensed bands."[29] This seems to imply that the "wireless industry" is made up only of players who rely on combinations of Wi-Fi, 3G, and 4G. This is, however, far from the case. There are numerous elements of the wireless industry that do not have any interest in any of these technologies, yet they are no less members of the "wireless industry" than the parties to which Qualcomm refers.

The Wireless Internet Service Providers Association, for example, points out the many different technologies that make use of the unlicensed spectrum: "In addition to fixed broadband service, other unlicensed spectrum uses include Wi-Fi access points (residential and commercial), Bluetooth devices, long-range point-to-point data links, utility company SCADA systems, cordless phones, baby monitors, video surveillance systems, personal medical alert alarms, inhome power management, RFID and

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[27] "Mobile Technologies Create Trillion-Dollar Impact and 11 Million Jobs", January 15, 2015, https://www.bcg.com/media/PressReleaseDetails.aspx?id=tcm:12-180517, visited June 20, 2015

[28] Analyst Angle: Wi-Fi convergence vs. Wi-Fi disruption, CLAUS HETTING IS CHAIRMAN AND CEO OF WI-FI NOW ON JUNE 10, 2015, http://www.rcrwireless.com/20150610/analyst-angle/analyst-angle-wi-fi-convergence-vs-wi-fi-disruption-tag9, visited June 20, 2015

[29] Comments of Qualcomm, page iv.

more."[30] As Cambium says, "…the Part 15 operating rules support not only low-power 802.11 Wi-Fi devices but also other vital services such as backhaul… The potential for coexistence between LTE-U/LAA and Wi-Fi services is only part of the issue."[31] Indeed, Qualcomm's definition of the wireless industry does not even seem to include parties who use *only* Wi-Fi, with no interest in 3G and 4G technologies. *The comment reveals a mobile-operator centric view of the "wireless industry", with little regard for others who have a stake in the unlicensed spectrum bands*.

T-Mobile, too, makes a very revealing statement in this regard. As they point out the benefits of innovation in the unlicensed bands, they point out that "[w]hat may be the dominant technology and use of unlicensed spectrum today may not be the same tomorrow."[32] While certainly true as a general statement, its use in this particular proceeding is particularly chilling. This opens for consideration the possibility that, for one reason or another, *unlicensed LTE may become the dominant technology and use of unlicensed spectrum. This thought alone should be enough to cause the Commission to consider whether this is a future that anyone (other than licensed mobile operators) would want to see*. Unlicensed LTE, in all of its forms being discussed in this proceeding, *requires* that the user have an anchor in licensed spectrum. As was detailed in the Comments from Cablevision, "[t]his limitation is not due to any technical impediment. Rather, it is a result of licensed carriers' intentional decision not to allow a "standalone" mode, in an effort to disadvantage unlicensed competitors."[33] A future in which the dominant use of the unlicensed bands is a form of unlicensed LTE like LTE-U or LAA is a future in which the unlicensed bands have been co-opted by the licensed mobile operators. ***This incredibly successful sandbox for innovation, accessible by anyone, without the barrier to entry posed by***

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[30] Comments of WISPA, page 2. Note that this comment seems to refer to all unlicensed bands, including the 2.4 GHz band, while the unlicensed LTE technology is aimed primarily at the 5 GHz band. The essential point, though, is still correct, that Wi-Fi is not the only technology operating in the unlicensed bands.
[31] Comments of Cambium Networks, Ltd., page 3.
[32] Comments of T-Mobile, page 3.
[33] Comments of Cablevision, page 18.

participation in an FCC spectrum auction process, will have been lost, in what can only be characterized as a spectrum grab by the licensed spectrum interests.

And actions speak even louder than words. While the CTIA claims, in this proceeding, that "CTIA and its members have tirelessly advocated for the allocation and utilization of both licensed and unlicensed spectrum for mobile services"[34], history does not seem to support this statement. In his article, Hetting writes that "Dr. Michael Marcus said at the WIS2015 in San Mateo: U.S. mobile carriers have resisted every allocation of more unlicensed bands since the birth of ISM. Going unlicensed is just not what they do." And recent history supports this view. In the FCC's recent 3.5 GHz Citizen's Band proceeding, the FCC proposed a three-tier structure, including a General Authorized Access (GAA) tier, which was the closest tier to an unlicensed tier – it was to be "licensed-by-rule to permit open, flexible access to the band to the widest possible group of potential users."[35] CTIA's comments in that proceeding stated that

> "[t]he optimal approach in the 3.5 GHz band is a two-tier spectrum access regime with incumbent operations and otherwise exclusive-use licenses… CTIA continues to believe, in the first instance, that the optimal approach in the 3.5 GHz band is a two-tier spectrum access regime with incumbent operations and otherwise exclusive-use licenses that will generate prompt investment and innovation in the band."[36]

There was no support for the GAA tier, and anything other than exclusive use licenses.

An argument which claims that manufacturers and operators will protect the unlicensed environment based on a mutual interest in both licensed and unlicensed operation **demands** that the weight of those mutual interests be considered. All available evidence should cause the FCC to view this rationale as a reason for the FCC to do nothing very skeptically.

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[34] Comments of CTIA, page 2.
[35] In the Matter of Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, GN Docket No. 12-354, FURTHER NOTICE OF PROPOSED RULEMAKING, at 6.
[36] CTIA REPLY COMMENTS TO 3.5 GHz PN, FCC 13–144, filed December 20, 2013, pages 1, 3.

The argument fails even if we believe that there are balanced interests, because the tragedy of the commons occurs even without ill-intent

In fact, even if we assume that the proponents of unlicensed LTE have exactly the same interest in unlicensed technologies such as Wi-Fi as they have in licensed technology, the argument still is not compelling. In fact, the argument is exactly what Hardin describes in his paper on the tragedy of the commons.[37] I made several references to this paper in my Comments to this proceeding, so I will not repeat them here. However, on this particular point I will emphasize again the lessons that Hardin draws from his case of the commons. There does not have to be any ill-intent in order to arrive at a tragedy of the commons situation. "Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. *Freedom in a commons brings ruin to all*."[38] The only conditions necessary are a common resource, freely accessible to all, and a completely hands-off management of that resource, allowing individual users to make whatever decision he determines to be in his own best interest. This is a well-known situation in game theory – ***just because individual users make decisions which are rational and in their own best self-interests, this does not necessarily lead to the optimal outcome for all users.***

And Hardin explicitly warns against the kind of logic being used by some in this proceeding, the logic which says that since users have the best interests of the unlicensed band at heart, they will act in such a way that the resource will be protected. Says Hardin, of this strategy:

> "The argument … applies equally well to any instance in which society ***appeals to an individual*** exploiting a commons ***to restrain himself*** for the general good – ***by means of his conscience***. To make such an appeal is to ***set up a selective system that works toward the elimination of conscience from the race***."[39]

That is, the only parties who will succumb to a "guilty conscience" argument will, eventually, be eliminated, either from the race (in Hardin's example), or at least, in the case of this proceeding, from

[37] Hardin, Garrett. "The Tragedy of the Commons", Science 13 December 1968: Vol. 162 no. 3859 pp. 1243-1248.
[38] Hardin, page 1244.
[39] Hardin, page 1246. Formatting has been added.

participation in the unlicensed spectrum band. Finally, he says, "[t]he long-term disadvantage of an appeal to conscience should be enough to condemn it; but it has serious short term disadvantages as well." I discuss this point in my Comments[40], and will not repeat the discussion here.

The situation in this case is worse than a traditional tragedy of the commons, since some of the participants have a way of escaping the commons, while others do not

If the previous two arguments were not enough to persuade the Commission to dismiss the "good intentions" argument, there is a final aspect that is particular troubling, which is that the proponents of the use of unlicensed LTE either are, or are speaking on behalf of, entities with licensed spectrum holdings to use as well. This requires us to seriously *consider the case of ill-intent* (which we specifically excluded in the previous section.) This concept was raised by numerous commenters in this proceeding. The Dynamic Spectrum Alliance says

> "if LTE-U and LAA take advantage of exclusive rights to licensed spectrum to operate a control channel and are deployed without appropriate co-existence mechanisms in unlicensed spectrum, then licensed carriers could exploit their unique ability to combine those two aspects to essentially drown out other users in the unlicensed bands."[41]

Aruba points out that

> "[t]here are no requirements, definitions, framework, tests, or standards in place to prevent unfriendly implementations of LTE-U from coming to market. And, there is performance to be gained by individual LTE-U device and operator implementations being less friendly to other users of the unlicensed bands."[42]

Google says that

> "LTE-U and LAA operators will have an exclusive, licensed spectrum option that allows them to minimize or entirely avoid the ill-effects of poor coexistence in the 5 GHz band, while other users of the same unlicensed band must rely on cooperative solutions."[43]

And Cablevision emphasizes that

> "…licensed carriers have an economic incentive to use LTE-U and LAA not only to advance their own service capability, but also to undermine new WiFi-powered competition."[44]

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[40] Comments of Leigh Chinitz, page 5.
[41] Comments of the Dynamic Spectrum Alliance, page 5.
[42] Comments of Aruba, page 3.
[43] Comments of Google, page 9.
[44] Comments of Cablevision, page 3.

To put this concern into the framework of the tragedy of the commons, there are two types of situations:

1. If *all users are using the same common area* (pasture land or unlicensed spectrum), then, at the very least, all of them have an incentive to maintain the health of that resource. Damaging the resource damages everyone equally. Even at that, as discussed by Hardin, the logic of human beings will lead to ruination of an unmanaged commons. However, mechanisms can be put into place to prevent the collapse. (Hardin's "Mutual coercion, mutually agreed upon.")
2. A more threatening situation exists when *some of the users do not depend entirely on the commons*, but have their own private resources as well. Imagine a shepherd that has both his own grazing land and access to the commons, competing in the market with shepherds who only have access to the commons. It is not hard to imagine that the first shepherd (although he has vested interests in both the common land and his own land) would recognize the utility of damaging the common land through overuse. He would still be able to maintain his flock using his own private land, while his competitors would be driven out of business through the loss of the commons. (If the commons eventually recovers, the only shepherd left to use it will be the one who had the private land as a fallback.)

The analogy to the unlicensed spectrum bands is not hard to see, and it was recognized by many of the commenters, as shown in the quotes from their comments, above. Unlicensed LTE users, with their fallback to the licensed bands, can certainly not be faulted for seeing the advantage to be had by causing intentional harm to the unlicensed bands, thereby reducing competition from companies that are providing competitive services using only those bands. The harm they would cause to themselves is much less than the harm they would cause to the competition. ***These Comments are not intended to ascribe this strategy to any of the participants in this proceeding, or any other entity in particular. The***

point is only that the incentive structure exists, and regardless of the technology under consideration, ***the Commission should act if it can identify incentive structures that would lead to undesirable outcomes.***

These are the types of scenarios with which the Commission should concern itself, and it should take as its mandate to ensure that its management of the unlicensed spectrum minimizes, to the extent possible, any incentive to overuse the unlicensed bands either through ill-intentions, or otherwise.

ii. The "technology-neutral is equivalent to doing nothing" argument is wrong both logically and historically

The majority of the comments in this proceeding lauded the FCC's statement that the "Commission has historically adopted rules that are technologically neutral and remains committed to this policy."[45] However, the implication by many of the proponents of unlicensed LTE is that this policy means that the FCC should do nothing in this case, as well as that the meaning of "technology neutral" is a set of rules governing mostly radio parameters. Qualcomm, for example, says that

> "[t]he FCC's light-touch, technology-neutral regulatory regime, which typically sets emission bandwidths, maximum transmit power levels, and out of band emissions limits, and allows any technology that complies with those requirements to be deployed, has worked well for countless spectrum bands … The FCC should continue this policy. There is no sound reason for the FCC to consider any regulatory change as a result of the development of LTE Unlicensed."[46]

CTIA offers that "[t]he Commission should maintain its policy of technology neutrality for unlicensed services and adopt only minimal technical requirements," and that it should maintain "its hands-off, technically neutral approach."[47] AT&T sounds a common theme, which is that it is

> "not the Commission's job to "pick winners or losers, or select the 'best' technology to meet consumer demand, but rather to ensure that the marketplace is conducive to investment, innovation, and meeting the needs of consumers,"[48]

[45] Public Notice, page 2.
[46] Comments of Qualcomm, page 3.
[47] Comments of CTIA, page 2.
[48] Comments of AT&T, page 6.

> and that, "there is no reason for the Commission to depart from its past precedent and mandate any form of technical standards that explicitly or implicitly prefer one technology over another."[49]

TIA's opinion of the FCC's technology neutrality is that technologies are permissible "…so long as they are in compliance with the agency's basic technical rules for power limits and associated properties,"[50] and Cisco sums up its view similarly, saying that "we support the Commission's view that limiting regulatory constraints on wireless technology to key radio emissions parameters, and stopping short of calling out a technology, is the best policy for innovation."[51]

All of ***these statements about the meaning of "technology neutrality", however, seem misinformed, at best, or misleading, at worst***. Setting technology-neutral policies means that policies are not instituted that will specifically advantage one *particular* technology over another, or that rules will not *explicitly* call out a certain technology. However, there is nothing that requires a technology-neutral policy to be consistent with "taking no action", nor is there any reason to equate "technology neutrality" with setting only a small set of radio emission specifications.

The history of the unlicensed bands do not even support such a view of the Commission's role. There are multiple examples of areas in which the Commission's role has been much broader than what is envisioned by these commenters.

(a) As mentioned in my Comments, an earlier version of 15.247(e) specified that any direct sequence system deployed in the bands should have a processing gain of 10 dB.[52]
(b) It was active FCC involvement that re-interpreted this rule to permit the deployment of a specific technology, the 11 Mbps IEEE 802.11b variant of Wi-Fi. Without the FCC's intervention on this point, the interpretation of the rules would have specifically prohibited that technology.
(c) Later action by the Commission removed this rule entirely, another case of active spectrum management.
(d) The frequency hopping rules still in place go far beyond simple power limits. Specific numbers of hopping channels are mandated ("Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies", "Frequency hopping systems in the 2400-

[49] Comments of AT&T, page 2.
[50] Comments of TIA, page 2.
[51] Comments of Cisco, page 3.
[52] Mike Marcus, http://www.marcus-spectrum.com/page4/SSHist.html

2483.5 MHz band shall use at least 15 channels"), dwell times are defined ("The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period"), and frequency hopping bandwidths are defined.

(e) In fact, the FCC was requested to modify its frequency hopping bandwidth rules in order to permit the entrance into the market of higher bandwidth frequency hopping devices, and those rules were eventually modified.

(f) Coordination among frequency hoppers is explicitly prohibited ("The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.")[53]

The point of these comments is to demonstrate **that the history of the Commission's management of the unlicensed bands does not support an interpretation that says that that the FCC has limited itself to only minimal RF emission standards, while letting any technology that meets those emission characteristics to occupy the band**. On the contrary, the Commission has considered what the specific characteristics of the band would have to be in order to make it a successful commons, and they have done their best (and have made changes over time) to put rules into place that would support those characteristics.

For example, we can ask ourselves why the Commission would have implemented any of the rules described above. The answer in most cases is the same – they wanted technologies deployed in the band to successfully co-exist with other technologies deployed in the band. This explains the initial requirement for 10 dB of processing gain. It also explains the ongoing requirement for frequency hopping systems to actually hop across different frequencies while not camping for too long on any specific channel.

The Commission has acted before to prevent technologies from "capturing" the bands

It is worthwhile spending a certain amount of time considering the current rule 15.247(h) which I quote here in its entirety:

> The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum

[53] §15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

> band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

Here we can see the FCC considering the behavior of systems within the band. A device which *individually and independently* makes decisions about its behavior in the band is permitted; coordination across multiple entities is not permitted. The reason for this is to limit the ability of a given system (of multiple frequency hopping devices in this case) to collaborate and occupy the entire spectrum, to the detriment of other users. This concern has echoes in the current proceeding. In their filing, CTIA describes the "CSAT" functionality of LTE-U as functionality which creates "a time cycle where a small cell transmits in a fraction of the cycle and "gates off" in the remainder of the cycle. This enables LTE-U operations to take turns with neighboring operations using Wi-Fi or another unlicensed technology."[54] The idea that the LTE-U technology would declare itself the spectrum manager of the unlicensed band sounds very similar to what the FCC is trying to prevent with its frequency hopping rules, and has certainly raised concerns among several respondents. The Dynamic Spectrum Alliance says that "[i]t is important that no technology in the unlicensed band has the power to regulate or control the amount of access for itself or other technologies."[55] Broadcom comments that

> "we understand that a common thread for LTE-U is that coexistence mechanisms appear to rely more on assessing the unlicensed spectrum, and forcing other technologies, such as Wi-Fi, to use their politeness protocols (e.g., listen-before-talk (LBT)) to transmit during LTE-U idle periods. In this way, LTE-U appears to control or manage the medium."[56]

Cablevision states that "LTE-U and LAA materials suggest that these technologies will avoid the problem of self-interference by relying on coordination between the operators themselves."[57] It would be very

[54] Comments of CTIA, page 10.
[55] Comments of DSA, page 4.
[56] Comments of Broadcom, page 3.
[57] Comments of Cablevision, page 11.

reasonable for the FCC to consider whether the behavior described here is appropriate to maintain the desirable qualities of the unlicensed bands and, if not, to take action to address the situation.

Many commenters who are proponents of the use of unlicensed LTE praise the FCC for their policy of technology neutrality, emphasizing the positive effects that policy has had on the development of new technologies in the unlicensed bands. Qualcomm, for example, says that "[t]he FCC's technology neutrality policy, which has worked exceedingly well for the nation, made these innovations possible. The FCC should continue this successful policy."[58] Nokia recommends that "the Commission should continue with its successful policy of defining only a minimum set of rules and technology neutrality."[59] CEA says that "there is no need for regulatory action at this time... the Commission "has historically adopted rules that are technologically neutral," and these policies have benefitted competition and innovation while ensuring that existing products and services can continue to grow."[60]

What all of these parties seem to fail to recognize is that the success of the unlicensed bands is not due to the FCC taking a hands-off management approach. *On the contrary*, it is due to the FCC taking a hands-on approach to managing the spectrum, and modifying that approach as events dictate.

Such a modification is what many of the respondents are suggesting may be required now. Not all of the respondents are advocating immediate changes, or even specific changes, but many of them believe that an evaluation of the situation ***demands that the FCC consider whether the characteristics that have made the unlicensed bands such a spectacular success are now under threat***. Among other comments there is the Dynamic Spectrum Alliance which says that

> "rules should be technologically neutral … however… there are common themes or principles that must be applied for operation in the unlicensed bands: in particular, these bands must be preserved as a platform for innovation and

[58] Comments of Qualcomm, page v.
[59] Comments of Nokia, page v.
[60] Comments of CEA, page 1.

> investment in emerging technologies, and *access to licensed spectrum should not become a de facto prerequisite for deploying unlicensed technologies*."[61]

Aruba goes further when it says that "[a]s a result of the conflict between potential benefit and risks, we believe that it is time for the technical requirements for coexistence to be defined and incorporated into the 47 CFR FCC Parts 2 and 15 device approval procedures."[62] The Wi-Fi Alliance takes a middle of the road approach when it states that "if … consensus cannot be reached, or if there is inadequate collaboration, the Commission must be prepared to act…" and "[i]n the event that … consensus cannot be reached, or if there is inadequate collaboration across industries, further FCC action must remain an option."[63] WISPA believes that "[t]he Commission must act now to ensure that LTE-U/LAA deployments cause no detrimental impact to current and future unlicensed spectrum users."[64] Microsoft states that "[i]f these efforts do not prove fruitful, we believe the Commission has a role to play as a convener, a facilitator, and a regulatory backstop."[65] And Cablevision believes that "[i]f oversight proves inadequate, the Commission must step in to ensure that carriers do not use their FCC licenses to unjustly and unreasonably disrupt consumer services and products and undermine competition."[66]

Again, not all of these commenters recommend immediate FCC action. However, all of them leave open the possibility of FCC action, and do not ascribe the success of the unlicensed band experiment to a laissez-faire FCC policy of limited, radio parameter related rule setting.

I find myself with a slightly different view from all of these commenters. On the one hand, I do not believe that the FCC should wait to act until it sees if industry consensus can be reached; I agree with those who say that the Commission should act now. On the other hand, I do not believe that that action should be to implement rules aimed specifically at unlicensed LTE. Rather, I believe, as previously

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[61] Comments of DSA, page 1. Emphasis added.
[62] Comments of Aruba, page 3.
[63] Comments of the Wi-Fi Alliance, page 2 and page 12.
[64] Comments of WISPA, page 6.
[65] Comments of Microsoft, page 2.
[66] Comments of Cablevision, page 4.

stated, that the FCC should not expect to be involved in every potential new technology that might be deployed into the unlicensed bands. The FCC should not intend to have to monitor every interaction between parties that want to use the unlicensed spectrum. That is the reason for ***having a framework for spectrum management that will protect the spectrum itself***, and I believe the FCC should ***immediately start an inquiry into what this framework should be.***

What are the characteristics of the unlicensed bands which have made them a success?

As I explained in my Comments, despite all of the information being discussed about unlicensed LTE in its various forms, I do not believe that those sets of technologies should really be the focus of the FCC's inquiry. Rather, the FCC should be concerning itself with the unlicensed spectrum bands in general, and the characteristics which have made them the hotbed of innovation that all appear to agree that they are. In my formulation they are an example of a commons, and to quote Hardin again, "Freedom in an unmanaged commons brings ruin to all."[67] They key here is "unmanaged". Since it is the FCC's role to manage this commons, the questions that need to be asked, and answered, are around the conditions that make the commons a success, and what rules need to be in place to maintain those conditions.

While I would support, and recommend, that the Commission conduct a formal proceeding to determine the successful characteristics, I propose a partial list of them here.

(a) The unlicensed spectrum bands are unlicensed, meaning that equipment can be deployed without obtaining site-specific permission. This provides easy access to all, even those without the ability to obtain an exclusive spectrum license.
(b) The rules for the unlicensed bands are technology neutral, which means that there are no specific technologies which must be used if the spectrum is to be accessed.
(c) The requirements for being able to operate a technology in the unlicensed bands are limited to the rules of those bands alone. There are no other requirements which act as a defacto barrier to entry to the commons.

[67] Hardin, Garrett. "An Ecolate View of the Human Predicament", 1985. http://www.garretthardinsociety.org/articles/art_ecolate_view_human_predicament.html

(d) The bands operate under an ethos of fair use, in which any given device will use only as much of the spectrum as it needs, and no more. In addition, even if the device could justify to itself the continuous use of the spectrum, it will give other users a fair opportunity to access the spectrum as well.

Are appropriate rules in place to preserve those characteristics?

The above list of characteristics is not complete, and I believe that it would be a worthwhile exercise for the FCC to engage the community in developing a more complete list of what essential characteristics need to be protected. As has been exposed by the comments in this proceeding, the main questions at issue are not whether or not certain technologies should be able to use unlicensed spectrum, or whether or not the regulations should be technology-neutral. Rather, the primary concern seems to be around the idea of fair access to the common resource. As I have described in these Reply Comments, there are two causes for concern, only one of which has to do specifically with unlicensed LTE. The first cause for concern is general, and is related to the basic structure of a commons, and its tendency towards the tragedy of overuse. It is worth considering, on its own merits, whether or not the current spectrum management regime for these bands is sufficient to protect against that event.

The second cause for concern, however, has been raised specifically by the unlicensed LTE discussions, and that concern actually has several components. Should technologies *other than* frequency hopping technologies be prohibited from coordination and declaring themselves to be de facto spectrum managers? Should technologies making use of the unlicensed spectrum be allowed to *require* concurrent access to licensed spectrum, and what kinds of incentives for behavior might that create?

These are valid questions, and would, I believe, benefit from being discussed in a separate FCC proceeding, focusing specifically on the protection of this natural resource.

These comments do not imply that licensed operators should be excluded from the unlicensed bands

As a pre-emptive response to potential misinterpretation of these comments, I would like to clarify a few items related to what users, and what technologies, should have access to the unlicensed spectrum bands.

Licensed operators should have access to unlicensed bands

Nothing in these comments should be interpreted as proposing to limit the access of licensed operators to the unlicensed bands. In fact, quite the opposite is already the case. Wi-Fi networks are already the workhorses of mobile operator networks. Without Wi-Fi, many mobile operators would likely be unable to provide the quality of service that their customers expect. "Juniper Research has released a report that indicates that Wi-Fi networks will carry almost 60% of smartphone and tablet data traffic by 2019 … Offload not only addresses the issue of patchy coverage, but also has the potential for the creation of new services, such as VoWi-Fi (Wi-Fi Calling), and would increase the usage of existing 3G/4G services."[68] Many reports confirm this result. Nothing being discussed in this proceeding, or in these Reply Comments, would propose to change this situation. Mobile operators are successfully making use of unlicensed spectrum today, with their widespread use of Wi-Fi. Mobile operator access to the unlicensed bands has been of great benefit, and should continue.

New technologies should be allowed to develop in the unlicensed bands

Just because Wi-Fi is the most common access mechanism for mobile operators using the unlicensed bands today, that doesn't mean that better technologies shouldn't be given the opportunity to be developed for use in those bands. As many have stated as part of this proceeding, the unlicensed bands are not "Wi-Fi bands." The difference in opinion that has surfaced in this proceeding is related to what

[68] Wi-Fi to carry up to 60% of mobile data traffic by 2019, 18 JUN 2015 12:35, HTTP://WWW.BIZCOMMUNITY.COM/ARTICLE/223/78/130044.HTML, VISITED JUNE 19, 2015

form these new technologies should take. The ethos of the unlicensed bands is that technology which is used there is available to all members of the community. People using the commons may vote for their preferred technology, but there is no barrier to anyone deploying the technology. The concern, often cited in this proceeding, is that unlicensed LTE has such a barrier, and it is a purposefully erected barrier at that. Users of the technology must have access to licensed spectrum.

Many commenters have discussed that, if the unlicensed LTE technology is "better" than current Wi-Fi, there are many ways in which it could be deployed in the unlicensed bands. Aruba says that

> "[i]n our view, LTE-U or similar technologies could eventually be just another implementation, or next generation, of IEEE 802.11 based Wi-Fi, and the advantages provided by proprietary LTE-U Forum standards could be realized in a future IEEE 802.11 open standard implementation."[69]

Ruckus calls out a different mechanism for mobile operators to make use of Wi-Fi, which is a variant of the unlicensed LTE concept, and which has not been as widely discussed in this proceeding as have LTE-U and LAA. The variant known as LTE Wi-Fi Aggregation (LWA)

> "would provide aggregation and tight integration at the radio level allowing for real time channel and load aware radio resource management across Wi-Fi and LTE. LWA will achieve the same goal as pre-standard LTE-U and LAA…"[70]

Qualcomm has also suggested a mechanism for deploying LTE technology into the unlicensed bands. "Qualcomm also is developing a standalone version of LTE Unlicensed, called MuLTEfire,™ that will not use a licensed anchor… The actual release of MuLTEfire equipment for deployment will of course depend on market demand and customer request."[71]

The advocates for the FCC taking no action use the "free market" as a rationale, saying that the market should be allowed to decide what technology is best. The concern of many commenters is that the current proposals for unlicensed LTE do not actually allow the free market to operate; rather, they limit

[69] Comments of Aruba, page 2.
[70] Comments of Ruckus, page 2.
[71] Comments of Qualcomm, page 19.

the market to holders of licensed spectrum, excluding other members of the unlicensed community, and setting the two communities against each other as seen in the comments to this proceeding. There are many other ways that unlicensed LTE, with its supposed benefits, could be deployed in the unlicensed bands; as an extension to existing standards, as a new standard, or simply as a new product with better characteristics that generates significant market demand. Some commenters have suggested that the FCC, in fact, play a role in this process: "ViaSat recommends that the Commission encourage the development of "LTE-U Standalone," a new and developing wireless technology that allows all wireless providers to utilize the efficiencies of LTE regardless whether they have an existing cellular, PCS or AWS network."[72]

In this case, I continue to prefer that the FCC remains technology-neutral and makes no comment on a specific technology like unlicensed LTE. However, I agree with the general sense of the comment and believe that it is appropriate for the FCC to ask questions about the requirement for a licensed-spectrum-anchor for a technology using the unlicensed bands. Does this requirement, or others which would be similar, help to preserve the characteristics of unlicensed spectrum that should be preserved, or could such requirements be detrimental to those characteristics?

An FCC proceeding to explore these questions would be appropriate and timely

The question of the deployment of unlicensed LTE has raised many interesting questions, but not necessarily about unlicensed LTE itself. Rather, the questions that are being raised are about the essential characteristics of the unlicensed bands, and what needs to be done to protect them. ***Although unlicensed LTE was only the instigator of these discussions, it would be appropriate and timely for the***

[72] Comments of ViaSat, page 1.

FCC to take the opportunity these conversations have afforded to open an inquiry into the general topic of how to appropriately manage the unlicensed spectrum bands.

Summary

The FCC's inquiry into questions related to unlicensed LTE has exposed a division between two groups of users of unlicensed spectrum. In one group are the proponents of unlicensed LTE, who have argued generally that they have the best interests of the unlicensed bands at heart, and that, therefore, there is no need for any FCC action. The other group is more concerned about the deployment of this technology, and either demands FCC action, or leaves open the possibility that FCC action might be necessary. I believe it is clear that the proponents of the unlicensed LTE technology have not made their case that "there is absolutely no basis for any new FCC regulation with respect to LTE-U and LAA."[73] Rather, the evidence is that there are valid concerns about the deployment of this technology, and that, furthermore, those concerns are not specific to unlicensed LTE itself. They raise fundamental questions about how this critical national, natural, resource should be managed, and it would be appropriate and advisable for the FCC to initiate a formal proceeding to consider what are the essential characteristics of the unlicensed bands, and what framework needs to be in place to protect those characteristics..

The unlicensed spectrum bands are special – they are bands for the people. There are millions of users of these bands without the knowledge of, or ability to participate in, FCC inquiries such as this one. The goals for the unlicensed bands are not simply about finding the highest and best use, or maximizing the spectral efficiency. A primary goal of the unlicensed bands is to provide access; hence, it is not appropriate to look at the rules the FCC uses in other bands and assume that those would be appropriate to the unlicensed bands. These bands ***are the bands for individuals, small businesses, homes, families, inventors, and entrepreneurs. It is that fundamental nature of the bands that the***

[73] Comments of Qualcomm, page i.

Commission must keep in mind when considering the comments that have been filed in this proceeding.

Respectfully submitted,

Leigh Chinitz
28 Bay View Road
Wellesley, MA 02482

June 22, 2015