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

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

SUPPLEMENTAL COMMENTS OF VERIZON AND VERIZON WIRELESS

Michael E. Glover
Of Counsel

John T. Scott, III
Christopher D. Oatway
1300 I Street, N.W.
Suite 400 West
Washington, DC 20005
(202) 515-2400

Attorneys for Verizon and Verizon Wireless

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INTRODUCTION AND SUMMARY

The Commission has correctly identified the 3.5 GHz band as holding substantial promise for small cell and other operations. Small cell technology holds real promise for providing wireless networks with additional capacity in the areas where capacity is most needed to serve customers' growing demand for broadband services. The Commission should thus move forward toward adopting rules in this proceeding and other proceedings[1] to facilitate small cell deployment. Given the infeasibility of clearing government operations from the 3.5 GHz band, it is an excellent candidate for experimenting with the regulatory, technological, and administrative innovations needed for future sharing arrangements.

The Commission should move forward promptly with its plan to explore a novel framework ("Multi-Tier Framework") under which three types of users – government incumbents (Tier 1), Priority Access Licensees (Tier 2), and General Authorized Access devices

[1] *See, e.g.*, *Acceleration of Broadband Deployment by Improving Wireless Facilities Siting Policies*, Notice of Proposed Rulemaking, WT Docket No. 13-238 (released Sept. 26, 2013).

(Tier 3) – will share spectrum under the management of a Spectrum Access System (SAS).[2] A successful sharing paradigm is most likely to emerge if the Commission pursues an incremental approach under which it dedicates part of the band to the ambitious Multi-Tier Framework, while also reserving some of the spectrum for a different regime (a "Transitional Framework") that supports shorter-term deployment of existing technologies. By establishing a Transitional Framework sub-band, the Commission can kick-start the investment in the infrastructure, device ecosystem, and SAS database management techniques needed for the ultimate success of the Multi-Tier Framework.

The Commission should dedicate a part of the spectrum between 3550-3700 GHz to the experimentation needed for the Multi-Tier Framework. In that spectrum, the Commission and various stakeholders can solve the novel regulatory and administrative challenges presented by that project, and can develop the technological and security innovations needed for it to succeed. In the short run, however, the Multi-Tier Framework will inevitably create substantial uncertainty. It contemplates a new licensing paradigm involving 74,000 very granular licensing areas with very short licensing terms – and that new regime would be administered by new SAS database administrators that would also manage the coexistence of multiple tiers of operators using the same spectrum. Also, for the Multi-Tier Framework to be viable, new control and security technologies will need to be developed to avoid rogue or unauthorized emissions by Tier 3 devices.

It is not reasonable to expect that all of the Multi-Tier Framework's interrelated challenges can be solved at once. The large number of regulatory and technical paradigms changing simultaneously under the Multi-Tier Framework will discourage substantial investment

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[2] *Commission Seeks Comment on Licensing Models and Technical Requirements in the 3550-3650 MHz Band*, GN Docket No. 12-354, Public Notice (issued Nov. 1, 2013) ("Public Notice").

in the short term. In turn, that lack of investment in 3.5 GHz technologies could stifle the development of the innovations needed for the Multi-Tier Framework to succeed. The Commission should therefore reserve a portion of the 3.5 GHz band for a transitional licensing framework that supports more rapid investment using existing technology. At least for an interim period, this sub-band should be free of Tier 3 operations and should be grounded in licensing paradigms proven to support investments: Tier 2 licenses should have secondary, exclusive-use rights (subject only to government incumbents' priority) in reasonably-sized geographic areas for relatively long terms. To ensure that Tier 3 operations do not frustrate Tier 2 users' quality of service requirements, the Commission should establish hardware-based limitations preventing Tier 3 devices from emitting in the frequencies reserved for Tier 2.

By establishing such a Transitional Framework in a portion of the 3.5 GHz band, the Commission can jump-start investment that may not take place if the Multi-Tier Framework is the only framework adopted. That hybrid approach would support shorter-term investment by Tier 2 licensees using existing LTE technology, which *already* has control and security features that can fully protect government incumbent operations from interference. That shorter-term investment would constitute an important step toward developing the device ecosystem, SAS management techniques, and other advances needed for the Multi-Tier Framework's success. Once the regulatory uncertainties and technical risks associated with the Multi-Tier Framework have been addressed, the Commission could sunset the Transitional Framework and create a unified licensing regime under the Multi-Tier Framework for the entire band.

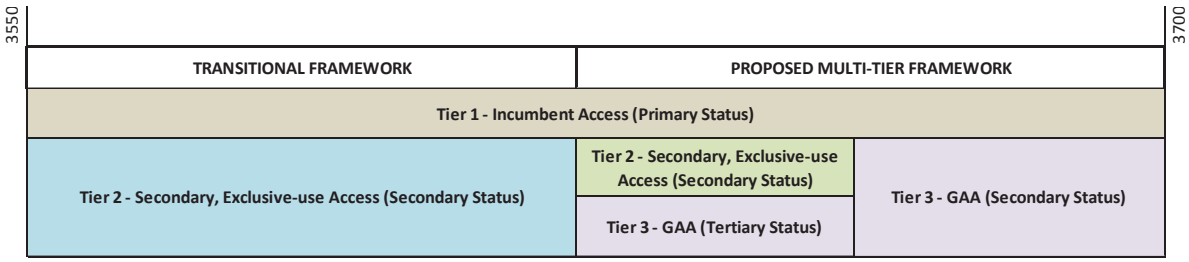
Of course, even under a hybrid licensing model that promotes shorter-term investment, the chances this experiment succeeds are low if 3.5 GHz spectrum cannot be efficiently deployed to serve a large majority of the U.S. population. Reducing the size of the zones where

government incumbent operations require interference protections – and developing techniques for providing such protections – is crucial. Importantly, the very large zones contemplated in the NPRM can likely be reduced substantially by focusing on protecting incumbent users from small cell operations, rather than by modeling macro cell power levels. By taking measures to reduce the size of those zones, exploring techniques for coordinating within them, and pursuing a hybrid band plan that promotes investment, the Commission can make this proceeding an important part of its overall commitment to encouraging and facilitating small cell deployment.

I. THE COMMISSION SHOULD PURSUE AN INCREMENTAL APPROACH TO DEVELOPING A SUCCESSFUL MULTI-TIER SHARING REGIME.

A. A Hybrid Band Plan Can Support Both the Proposed Multi-Tier Framework and a Transitional Framework Promoting Shorter-Term Investment.

The Commission should combine the 3.5 GHz band (3550-3650) with the 50 MHz of spectrum between 3650 and 3700 MHz, and thus make a total of 150 MHz of spectrum available for commercial use, subject to interference protections for incumbent government users. That will provide a sufficient amount of spectrum to create a hybrid band that supports both a Multi-Tier Framework where a robust ecosystem of Tier 3 devices can emerge, and a Transitional Framework. There are many potential configurations the Commission could establish for such a hybrid band plan. The figure below illustrates one potential configuration:



As discussed in detail below, shorter-term innovation and investment can take place in the Transitional Framework where only Tier 2 and Tier 1 operations exist. That innovation and

investment need not wait for the future innovations needed for the Multi-Tier Framework to be viable. At the same time, the more ambitious and complex sharing experimentation contemplated in the Multi-Tier Framework can take place in the portions of the band where Tier 3 operations are authorized.

B. The Technical, Security, Administrative, and Regulatory Challenges Presented by the Proposed Multi-Tier Framework Will Take Time to Solve.

1. Several Technical and Security Innovations Are Necessary for the Multi-Tier Framework to Support Substantial Investment.

Verizon looks forward to working with other industry stakeholders to develop the security and control features for Tier 3 devices needed under the Multi-Tier Framework. First, new control features will need to be developed because, unlike networked wireless air interface that have a control plane (e.g., LTE, which is commonly used by mobile network operators), many of the air interfaces that could be used in a multi-tier sharing paradigm (e.g., WiFi, point-to-point backhaul) do not have these centralized control features. For example, the use of the WiFi air interface in this band for GAA would require a mechanism, perhaps based upon Internet Protocol messaging, to control the WiFi-based GAA access points and their served GAA terminals. The standard WiFi air interface allows the access point to have local (or fixed) autonomous control of the channel use. There is no provision for unified centralized control as the WiFi access points in different deployments do not cooperate with one another (there is no handoff, no resource control, and no interference control or coordination) and hence there is no need for current WiFi to have any centralized "network" control features.[3] Thus, the use of such an air interface for Tier 3 GAA will require software and interfaces whereby the SAS manager can send control messages to the GAA access points and GAA terminals.

[3] WiFi's Lightweight Access Point Protocol (LWAPP) allows centralized secure control of one local deployment of access points.

Also, new security features are needed for the control system. The risk of rogue use of channels via hacking of the local microprocessor is well documented in other areas, including game consoles (to get access to locked games), cell phone cloning (to clone a subscriber identity for theft of service purposes), and cable set-top boxes (to gain access to restricted or subscription content). Strong security protections for a control system therefore need to be developed for the Multi-Tier Framework before it will ensure the interference protections needed to protect ongoing Tier 1 government users from possible rogue interference and support substantial investment by Tier 2 operators.

For GAA devices using non-networked air interfaces, at least three secure mechanisms are necessary. First, any GAA devices with hardware capable of emitting on channels where Priority Access Licenses (PALs) operate will need features to ensure they are not hacked in ways that would permit them to emit on those frequencies. The GAA access point and end user devices must be incapable of autonomously tuning their synthesizers using their own microprocessors' software or firmware control because such processes would be susceptible to hacking. Instead, their tuning must be controlled directly by the SAS via an encrypted technology.

Second, the identity of the GAA user making a request for spectrum allocation must be secure. Therefore, the user identification protocols must be encrypted so that the SAS cannot be spoofed by a Tier 3 device faking an incorrect identity.

Third, the GAA access point must report its valid location for interference purposes (for the SAS to determine the keep-out radius). That location report must be based on an internal GPS within the access point, in order to determine its own location accurately. That location report to the SAS must be secure, and therefore must be encrypted to avoid the possibility of

spoofing an incorrect location. And to the extent the GAA device is used indoors where there is no GPS signal, protocols will need to be developed so that accurate location information is provided to the SAS.

2. The Multi-Tier Framework also Requires Regulatory and Administrative Innovations.

The Public Notice contemplates a regime – one managed and largely administered by SAS database administrators – for keeping track of, auctioning, and controlling interference between 74,000 PALs. That regime will have little in common with anything the Commission has established in the past. Verizon looks forward to working with the Commission and with other stakeholders to help develop the regulatory and administrative innovations needed for the Multi-Tier Framework to work. While Verizon supports the Commission's commitment to exploring new regulatory and administrative paradigms, they will take time to develop, test, and implement.

The proposal to assign 74,000 PALs on a Census tract basis[4] would create substantial administration burdens, and it would be challenging for wireless operators and the SAS managers to address the various border interference issues that can be expected to emerge. One challenge will be the coordination of small cell site locations and managing border area interference between different licensed service providers. With smaller sized PALs, there will be more border areas between competing co-channel PAL license holders. Border coordination will need to take into account the fact that different operators are likely to use different air interfaces. Likewise, ascertaining cell site locations and ensuring that their coverage contours are within the authorized PAL is made more difficult if the PALs are smaller and there are more of them. New

[4] *Id*, ¶¶ 14-16.

techniques, along with an efficient dispute resolution mechanism, will need to be created to manage interference at the borders of highly granular licensing areas.

Similarly, the proposal for one-year non-renewable licenses that can be aggregated for multiple years[5] raises questions about how wireless operators could receive sufficient assurances to justify making investments that require numerous years to recover. It is unclear how the proposed predetermined cap on the total term length (the number of consecutive PAL terms that can be aggregated in time)[6] would work, and it is not clear what advantages such short license terms would have over longer-term ones.

C. A Transitional Framework (Limited to Tiers 1 and 2) in a Portion of the Band Can Support Shorter-Term Investment.

Until the emergence of the technical, regulatory, and other innovations discussed above, the business (e.g., time to market) and quality of service (e.g., rogue interference) risks to Tier 2 operators are too high to justify making substantial investments in the context of the Multi-Tier Framework. Accordingly, the Commission should dedicate a portion of the band to a Transitional Framework that facilitates the prompt deployment of service using existing technologies.

1. Tier 2 Licensees Can Fully Protect Government Incumbents Using Existing Technology.

One of the reasons a Transitional Framework sub-band without Tier 3 operations will support prompt investment is that Tier 2 licensees can use *existing* technology such as LTE that already has protocols to protect incumbent government operations. At least in urban areas, the most likely use case for Tier 2 operations will be for the small cell portions of heterogeneous LTE networks. Employing SAS control as an overlay on top of conventional LTE networks will

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[5] *Id.*, ¶ 13.

[6] *Id.* at 7 n.34; ¶ 24.

allow for fine control of frequency and usage on a per small cell base station, with no need for the development of new features or interfaces. By contrast, as discussed above, other technologies will need modifications in order to coexist with incumbent and other users.

By establishing a sub-band where the only private sector operators are Tier 2 licensees, there will be no need to hold up commercial use of the spectrum until such new Tier 3 features can be developed and proven. This may greatly aid the cost-effective development of subsequent Tier 3 devices, as the Tier 2 users will drive down the prices for key components in the 3.5 GHz band such as RF filters, power devices, synthesizers, and antennas.

2. To Provide Quality of Service Assurances to Tier 2 Licensees, the Commission Should Establish Hardware Limitations on GAA Devices.

To promote investment by Tier 2 users, the Commission should establish certification standards for GAA devices that preclude their hardware from having the capability of tuning to the frequencies reserved for Tier 1 and Tier 2 use. At least for an interim period, that is the best approach to creating the quality of service assurances needed to support substantial investment in the 3.5 GHz band.

Similar protections cannot be achieved by relying on software-based restrictions on the frequencies to which Tier 3 devices may tune because any such approach would be vulnerable to hacking. Over time, and especially to the extent substantial investments are made by Tier 2 PAL license holders in reliance on their spectrum licenses, the risks that such hacks would be developed (and then potentially widely distributed over the Internet) are substantial. The hardware-based limitations on GAA devices could be sunsetted once sufficient interfaces and security features emerge to ensure that GAA devices cannot autonomously tune their own synthesizers.

3. The Licensing Model for the Transitional Framework Should Initially Approximate Existing Exclusive-Use Models.

Unlike the Multi-Tier Framework portion of the band – where the Commission can and should experiment with ambitious new licensing paradigms – the Transitional Framework portion should embrace licensing models that will support shorter-term investment and innovation. For example, whatever the merits of extremely granular licenses for the Multi-Tier Framework, that proposal – along with the proposal that the licenses terms be only one year – should not be adopted for Tier 2 licensees operating in the Transitional Framework. Minute granularity (both geographic and temporal) does not afford the certainty needed for substantial investment.

Although the technical features of the 3.5 GHz spectrum (including greater capacity through denser frequency reuse; smaller cell sizes due to reduced propagation; reduced potential for long range interference due to lowered powers, low-gain antennas, low antenna heights or indoor antenna placements that guarantee the small cells are in the clutter; and the ability to operate in a higher co-channel interference environment) are consistent with small cell use, they should not necessarily dictate the license size. The principal value of mobile telephony has always been the provisioning of services over a wide area to allow mobility, and larger license sizes have been proven to support investment under that business paradigm. Similarly, while the Public Notice's proposal to establish one-year license terms can be explored in the context of the Multi-Tier Framework, it should not be imposed on the Transitional Framework because mobile network operators will need assurances that their investments can be amortized over a longer period of time.

Accordingly, in the Transitional Framework, the geographic areas, terms, and administration of licenses should approximate those used in the traditional exclusive use

licensing framework, which have been proven to support substantial investment by mobile network operators deploying LTE networks.

4. Any Experimentation with "Localized Critical Access" Operations Should Take Place Outside of the Transitional Framework.

While the Public Notice appropriately envisions open eligibility for PALs, it also seeks comment on whether to assign 3.5 GHz spectrum to "qualified critical access facilities" that could deploy that spectrum to operate "indoor small cell networks on a quality-assured basis."[7] To the extent the need for such operations is established, and appropriate interference management techniques can be developed for them, that experimentation should not take place in the context of the investment-focused Transitional Framework. The purpose of that portion of the hybrid band is to avoid authorizing operations that could undermine the quality of service guarantees needed to support substantial investment by Tier 2 operators, and uncertainty associated with authorizing "localized critical access" operations within that framework would substantially degrade those guarantees.

II. THE TECHNICAL SPECIFICATIONS FOR THE 3.5 GHz BAND SHOULD REFLECT LICENSEES' LIKELY USE CASES.

The Public Notice seeks comment on preliminary values for defining some of the technical parameters for the 3.5 GHz band.[8] The use case commensurate with the relatively low base station power limitations discussed in paragraph 45 of the Notice (24 dBm transmit power with antenna gain of 6 dBi) is indoor picocells, which can be used for relatively limited indoor coverage (e.g., homes, offices).[9] That power level is below the current Part 15 rules for ISM band use at 2.4 GHz and 5.8 GHz for WiFi. Such specifications may be appropriate for certain

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[7] *Id.*, ¶ 38.

[8] *Id.*, ¶¶ 45-47.

[9] For uses commensurate with engineered indoor picocells (e.g., stadiums, malls), a maximum power of +30 dBm with 6 dBi antenna gain (36 dBm EIRP) is appropriate.

Tier 3 operations, and/or for certain operations in or around zones where incumbent Tier 1 radar systems may operate, but they do not support additional important use cases for which 3.5 GHz spectrum is attractive.

The technical specifications for power limits should support substantially greater flexibility. First, for outdoor wide area coverage "base station" uses, commensurate with wide area sectorized small cell microcells, +30 dBm maximum transmit power with a maximum antenna gain of 17 dBi (EIRP of approximately 47 dBi) is appropriate. Second, for outdoor point-to-point narrow-beam use cases, commensurate with point-to-point backhaul uses, +30 dBm transmit power along with maximum antenna gain of 23dBi (consistent with EIRP of approximately 53 dBm) is appropriate.

With respect to the interference environment, different use cases similarly require different specifications. Some of the levels discussed in the Public Notice[10] may be too high for some of the contemplated use cases. In general, the IoT (the rise in Interference levels over the Thermal noise level) does correspond to the size of the cell. Very large rural cells are "coverage" limited (limited in ultimate range by receiver limitations in the presence of the thermal noise floor, i.e., noise-limited). Smaller urban cells are "capacity" limited (limited in ultimate performance or capacity by receiver limitations in the presence of the co-channel interference from nearby neighbor cells, i.e., interference-limited). The proposed rise in IoT (Interference over Thermal noise floor) of 20 dB does correspond to most urban interference limited scenarios. The proposed rise in IoT of 40 dB would correspond to very small picocell and femtocell use cases. At these high interference levels, the resultant range of the cells is very small in order to achieve adequate CIR (Carrier-to-Interference ratio) above the raised interference level, and would preclude other types of uses that have larger required propagation

[10] *Id.*, ¶ 47.

distances. Wide area outdoor coverage may not be economically feasible at such high raised IoT levels, because too many small cells would be required to cover a given area cost effectively. Different use cases (especially the high antenna gain, point-to-point case, if allowed as a permitted use) require careful analysis of antenna patterns and sidelobes to determine resulting interference scenarios.

III. ESTABLISHING STRONG PROTECTIONS FOR GOVERNMENT INCUMBENTS DOES NOT REQUIRE SACRIFICING THE ATTRACTIVENESS OF THE 3.5 GHz BAND TO WIRELESS OPERATORS.

Substantial investment in infrastructure and device development is only likely if the spectrum can be put to use promptly to serve a majority of Americans in major population centers. As Verizon and numerous other commenters have observed, the very large "exclusion zones" contemplated in the NPRM[11] would largely destroy the attractiveness of the 3.5 GHz band by excluding private operations for zones representing 60 percent of the U.S. population.[12] Therefore, minimizing the size of the zones where government incumbent operations require interference protections, and developing techniques for providing strong protections for government operations within the zones, is crucial for making the band attractive for small cell or other types of deployments.

The very large zones contemplated in the NPRM can likely be reduced substantially by focusing on protecting incumbent users from the small cell operations (not vice versa) and by modeling small cell rather than macro cell power levels. Also, within the zones, Tier 2 licensees can successfully coordinate with government incumbents using conventional LTE technology. As discussed above, in an LTE environment there will be no need to create any new air interface

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[11] *See Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, Notice of Proposed Rulemaking, 27 FCC Rcd 15594, ¶ 67 (2012) ("NPRM").

[12] *See* Verizon and Verizon Wireless Reply Comments, GN Docket No. 12-354, at 11-13(filed Apr. 5, 2013).

to allow an SAS overlay to have fine control of frequency and usage on a per small cell base station.

One potential technique that could facilitate successful sharing within the coordination zones would be the use of sub-block front end RF filtering to aid in band segmentation. By segmenting the channel set into a number of sub-blocks, high power incumbent users could be segregated from lower-power use cases, thus preventing front end overload and desensitization. In addition to facilitating Tier 2 operations within the former 'exclusion' zones, that technique could also be used to enforce the channelization of the hybrid band plan discussed above. This sub-block choice could also be managed by an SAS manager, thus allowing simultaneous use of channels within different sub-blocks but within the same geographic area. Of course, employing sub-block filters would increase device complexity and cost – considerations that should be weighed against their potential benefits with respect to enabling effective use of 3.5 GHz spectrum within the coordination zones.

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Respectfully submitted,

Of Counsel:
Michael E. Glover

John T. Scott, III
Christopher D. Oatway
1300 I Street N.W., Suite 400 West
Washington, D.C. 20005
(202) 515-2470

Attorneys for Verizon and Verizon Wireless

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