Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, DC 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
	)
	)

COMMENTS OF FEDERATED WIRELESS, Inc.
(Formerly known as Allied Communications, LLC)

Dr. T. Charles Clancy
Director of Strategy

Dr. Robert G. McGwier
Technical Director

John Serafini
General Manager

Federated Wireless, Inc.
(Formerly Allied Communications, LLC)
33 Arch Street, Suite 3201
Boston, Massachusetts, 02110
1-617-419-1833

Wilmer, Cutler, Pickering, Hale, and Dorr, LLP
60 State St
Boston, Massachusetts 02109
Attorney for Federated Wireless, Inc.

July 14, 2014

Executive Summary

Federated Wireless, Inc. (formerly Allied Communications, LLC), a subsidiary of Allied Minds Federal Innovations, is headquartered in Boston, Massachusetts with offices in Reston, Virginia. Federated Wireless was founded in 2012 by globally recognized wireless and radio communication leaders to enable and commercialize technologies to unlock the enormous potential of dynamically shared spectrum resources.

We applaud the Commission for generating the Further Notice Proposed of Rule Making, for the Citizens Broadband Radio Service (CBRS), which adopts many principles that are widely recognized as central to enabling effective and efficient spectrum sharing. Further, we strongly support the Commission's adoption of the Three-Tier model and making the Spectrum Access System (SAS) the central feature of an innovative dynamic spectrum management scheme.

However, it is the position of Federated Wireless that fixed geographic exclusion zones are unnecessary and counter-productive to the goals for this proceeding. We present findings for the Commission to consider in its reassessment of the incumbent Exclusion Zones. First, the characteristics of anticipated CBRS devices (CBSDs) differ significantly from the assumptions in the 2012 NTIA Fast Track Report, noticeably in terms of interference resilience and the proximity with which they can operate to an active radar system. We also report methods to protect such active radar systems from interference from CBSDs in a way that does not disclose the capabilities or limitations of those military systems beyond what already has been released by the US federal government into the public domain via Distribution Notice A, public release, distribution unlimited.

Second, in spectrum sharing scenarios, exclusion zones should not be designed to protect secondary devices from interference from primary devices (though primary devices should be

protected from secondary device interference). Instead exclusion zones, when used, should be designed to protect higher priority users from lower priority users.

Third, the characteristics of CBRS incumbents differ significantly from TV Band incumbents. Specifically, the mobility of the in-band incumbents (e.g., ship-borne radars) clearly establish that SAS should embody significantly more dynamic geospatial and temporal spectrum management.

We propose three approaches for dynamically protecting incumbents: a federal spectrum observatory (FSO) for dedicated sensing; the use of CBSDs in listening mode for distributed sensing; and collaboration with federal users. Approaches that combine sensing with SAS management will yield the most efficient and effective management of the spectrum. Therefore, CBSDs should not be preemptively precluded from operating anywhere in the US, including along the shore line.

When incumbent systems are active, the SAS manages CBSD operation to ensure that estimated and measured interference levels at the incumbent device locations do not exceed those power levels or other signal characteristics that would comprise harmful interference.

We disclose a patent-applied-for method for sensing the operation of incumbent systems that does not require signal classification. We argue that this should be used in conjunction with general obfuscation among regional SAS (RSAS) and secure communications between a commercially provided federal SAS (FSAS) and incumbent (federal and grandfathered commercial) users in order to protect those incumbents without undue revelation of federal incumbent RF systems capabilities or limitations.

This same method of dynamic SAS frequency management via estimated and measured interference and sensing to protect incumbent RF systems may be applied for the protection of

PAL devices from GAA interference to mitigate inefficiencies posed by auctioning PAL spectrum using fixed geographic regions, such as census tracts.

In a subsequent filing, we will provide data demonstrating the feasibility of our proposed approaches for protecting incumbent and PAL radio systems.

We further comment on proposed rules for SAS operation and approval of SAS operators. Specifically, we oppose any requirement for nationwide operation for SAS approval. Instead, we support permitting multiple regional SAS operators to reflect the differences in regional management characteristics of the band and the costs associated with developing the detailed propagation models and deploying dedicated sensors that enable more efficient spectrum management. We ask the Commission to revisit the information retention and security rules to ensure consistency of the final Rule and Order with industry best practices. We praise the Commission's proposed rules for registering and authorizing CBSDs, and request clarification on what steps are required of the SAS to confirm deactivation or reassignment of a CBSD found to causing harmful interference. We differ with the proposal that the Commission review SAS Fees and subsequently require changes; instead we propose that the Commission ensure competition and establish sunshine rules that minimize inadvertent pricing collusion among SAS operators.

We note that while the FNPRM lays out many desirable principles for spectrum sharing, many technical details are left unspecified; this is right and appropriate. Defining technical details is best handled via industry best practices and existing standards augmented by an FCC sanctioned not-for-profit multi-stakeholder group that facilitates technical consensus among federal users, service providers, network operators, CBSD suppliers, and SAS operators.

Finally, we note that the technical details of military radars published in the NTIA Fast Track report and the request for comments of this FNPRM regarding exclusion zones enables

double-blind measurements of signals radiated from military radar systems, e.g., using widely available academic tools like the GNU Radio. Therefore academic radios, including spectrum observatories, can observe the radars reported in the Fast Track Report and NTIA Report 14-499 or indirectly via academic radio equipment employed, e.g., for the many radio spectrum observatories currently reporting spectrum occupancy data on-line from multiple academic institutions (e.g., Illinois Institute of Technology) and any commercial entity interested in shared spectrum (e.g., Microsoft).

Comments

I. FIXED GEOGRAPHIC EXCLUSION ZONES FOR SHIP-BORNE RADAR SHOULD BE ELIMINATED

We concur strongly with the Commission's stated goal of helping to ensure the long-term viability of the 3.5 GHz Band[1] and believe that the FCC's reassessment of the NTIA Exclusions Zones is critical to the success of the Citizens Broadband Radio Service (CBRS). As widely recognized, the proposed NTIA exclusion zones will prevent 60% of the US population from accessing the 3550 MHz band of radio frequency (RF) spectrum. To aid in this reassessment, we suggest the reassessment consider the following principles.

1. The Robustness of Anticipated CBRS Devices (CBSDs) to Interference Differs Significantly from the Assumptions in the NTIA Fast Track Report

The NTIA Fast Track Report analysis uses WiMAX base stations attempting to achieve wide coverage areas as their model secondary service. In particular, the analysis assumes the base stations will have coverage radii up to 3.22 km (rural) or 0.64 km (urban) with base station separations ranging from 1.2 km (urban) to 6.1 km (rural).[2] The analysis then considers the potential interference levels that might be seen by these secondary systems from offshore radar systems spaced at 10 km intervals along the coastline and defines the Exclusion Zones as areas where interference from these hypothetical radar systems is such that the interference to noise (I/N) ratio exceeds -6 dB.

But the CBRS is primarily envisioned for use with anticipated small cells, e.g., CBSD's employing the commercial 3GPP Band 42 Long Term Evolution (LTE) standard in small cells or

[1] *See* Further Notice of Proposed Rule Making ¶ 74 (FNPRM)
[2] *See* Table 4-7 in NTIA, An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHz, 1755-1780 MHz, 3500-3650 MHz, and 4200-4220- MHz, 4380-4400 MHz Bands (rel. October 2010). (NTIA)

utilizing enhanced WiFi-like indoor and short range outdoor networks. Such usage establishes coverage radii on the order or 3 to 30 meters (up to 100 feet) for WiFi-like usage and 30 to 100 meters (up to 330 feet) for outdoor small cell usage, differing by an order of magnitude in path loss from the NTIA Fast Track Report's assumed range of up to 6.1 km. All of these differences impact the choice of appropriate thresholds at which a CBSD might not be able to operate.

Furthermore, the choice of -6 dB I/N for an interference threshold would be more appropriate to a continuous wave signal interfering with another continuous wave, un-encoded, non-interleaved signal. But the primary system radars have pulsed signals, and the envisioned secondary systems employ OFDM with relatively long interleaving periods and forward error correction (FEC). Thus, even strong interference from the radar systems' pulsed signals will induce only short bursts of errors, which CBSD protocols employing block interleaving and FEC schemes could easily correct. In fact, it should be expected that far higher levels of interference can be accepted than assumed in the NTIA analysis, as errors remain correctable as long as the interference is not strong enough to cause component failure in the RF front end or when RF front ends have sufficient memory / delay effects that the interference effects extends over a significant fraction of the frame.

To examine what threshold would be appropriate if CBSDs are protected from incumbent systems, we review experimental results of LTE performance in the presence of radar as published by the NTIA. Note that it is the position of Federated Wireless that CBSDs should not be protected from incumbent interference as we expand in subsequent sections.

In 2013, the NTIA published a report on the testing of the robustness of LTE base stations to 27 variations of generalized radar and noise interference.[3] To provide a controlled

[3] Sanders et al., *Effects of Radar Interference on LTE Base Station Receiver Performance*, (Washington, DC: US Department of Commerce) Dec 2013. (NTIA Report 14-499)

environment, the NTIA used cabled equipment with representative radar signals generated by an arbitrary waveform generator (to avoid security issues, actual waveforms were not used). The tested LTE equipment consistently provided greater than 10 Mbps of net data rate while undergoing a wide range of simulated radar interference having S/(I+N) levels of -10 to -18 dB, equivalently, jammer to signal (J/S) co-channel interference levels of +10 to +18 dB, comparable to what the NTIA fast track report terms interference to noise (I/N) ratio. The following figure extracted from that report is representative of the radar-LTE interference results.

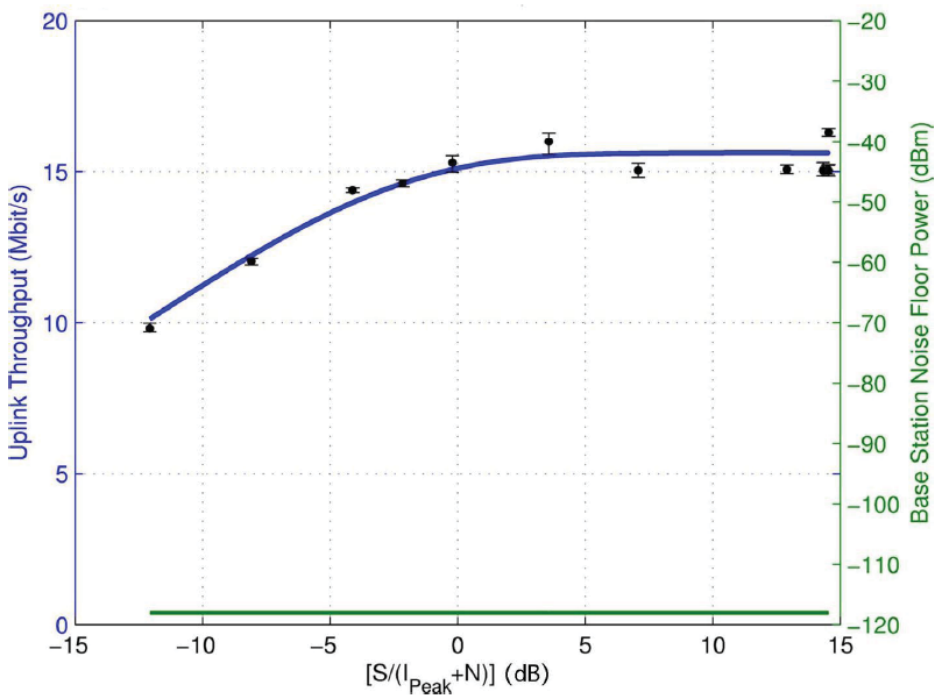

Figure 1: NTIA Experimental data throughput for LTE performance with varying interference power from radar waveform P0N-1 (PW = 1 μs, PRR = 1000/sec, DC = 0.1%).[4]

Thus, as NTIA Report 14-499 simulations demonstrate, even +10 dB interference from the radar systems' pulsed signals induces only short bursts of errors, which LTE's block interleaving and FEC schemes correct to < 10% block error rates while achieving > 10 Mbps net data rate. Thus, including NTIA analysis and simulations and on other IEEE literature regarding

[4]Figure 8 in NTIA Report 14-499.

WiMAX and radar, sound radio engineering principles would anticipate that CBSD base stations could accept interference powers 16 to 24 dB above the NTIA Fast Track interference to noise threshold of -6 dB I/N.

As noted above, the impact of interference depends on the quality of RF front ends. And it is expected that user equipment (UE) will employ lower cost and worse-performing front ends. However, as noted in NTIA Report 14-499 and in the technical literature, the low RF gains (typically 0 dB) of UE devices mitigate interference in a small cell and base stations will be sited in locations (e.g., on the top of buildings) that will experience much more interference than UE devices. In a subsequent filing, we will present data that considers the anticipated interference robustness in the field.

A related rationale for using Exclusion Zones to protect CBSDs is to protect the CBSD equipment itself from damage from the high-power signals emitted by the radar systems. In a subsequent filing, we will consider this issue. Additionally, it should be noted that some radars envisioned for the future are either X-band radar, or adaptations of a Lockheed Martin system to S-Band and used with an X-Band radar for pencil-beam search. Neither of these types of systems will be likely to induce harm to commercial devices as the X band radar will be largely filtered off by the front end systems.

From an examination of the measurements previously performed by the NTIA in 2013, it can be clearly seen that CBSDs can successfully operate in the presence of strong interference from radar transmissions, which would be consistent with close operation to radar installations. From this, the minimum separation distance from radar to CBSD is expected to be small enough that it should be expected that any protection scheme designed to protect incumbent systems from CBSD interference will be more than adequate to also protect CBSDs from interference from

incumbent systems. In a subsequent filing, Federated Wireless will report results examining the applicability of the NTIA measurements to CBSDs operating in the field.

2. Exclusion Zones Should Not Be Designed to Protect CBSD Devices from Interference from Incumbent Radio Systems

The Commission wisely proposed Rule 96.15, which requires that all CBSDs must accept harmful interference from authorized federal users. This spectrum sharing principle that lower tier devices should not expect protection from higher tier devices is reinforced in the descriptive text as the Further Notice of Proposed Rule Making (FNPRM) repeatedly states that it is the intention of the Commission that CBSDs must accept harmful interference from higher priority users.[5] In contrast, the NTIA Fast Track Report analysis proceeds from an assumption that CBSD base stations should be protected from high power U.S. Navy radar systems.[6]

The Commission's stated principle that CBSDs cannot expect protection from incumbent devices is correct and desirable since protecting CBSDs from interference from incumbent systems places an implicit burden on incumbent systems and deters future innovation in interference mitigation (e.g., via improved receiver design or enhanced spectrum management), suppressing paths to improved spectrum efficiency.

For instance, while the analysis in the NTIA Fast Track Report implicitly assumes interference between narrowband continuous wave systems, CBSDs with Orthogonal Frequency Division Multiplexing (OFDM), FEC, long frame lengths, and interleaving should be able accept much higher pulsed interferer powers. Similarly, the introduction of advanced interference-cancelling front ends, null-steering antennas, and dynamic SAS scheduling algorithms could

[5] *See*, e.g., FNPRM ¶ 87.
[6] *See* NTIA page 1-7.

allow secondary systems to operate with much worse nominal I/N ratios than considered by the NTIA in their 2013 report.

But with the rules of the FNPRM employing the NTIA Fast Track exclusion zones, providers of CBSD equipment would have little economic incentive to deploy highly interference tolerant CBSDs since regulatory constraints limit spatial access to spectrum in 60% of the US market. Similarly, the large protection margin employed in the Fast Track analysis stifles the technical incentives to innovate and deploy more interference tolerant devices.

To quantify the spectrum inefficiency posed by the Fast Track Exclusion Zones, consider that the NTIA Exclusion Zone analysis models an AN/SPN-43 radar along every 10 km of coastline[7] and the US has 19,924 km of coastline.[8] Thus the NTIA exclusion zones implicitly assume the fixed presence of nearly 2,000 AN/SPN-43 radars along the coast when two orders of magnitude fewer cited in the Fast Track Report. Further, a great many of these ship-borne radars will be deployed overseas at any point in time.

Instead, exclusion zones, when used, should be designed to protect primary systems from interference from secondary systems. In doing so, the FCC would promote technology innovation and gains in spectrum efficiency by equipment vendors and system managers. Such a principle was employed in the Television (TV) Bands where mechanisms were implemented to protect the reception of the TV broadcasts from interference from secondary transmissions, but secondary devices were given no assurances of protection from the TV broadcasts.

3. The Interference Generation Characteristics of the Incumbent Systems in the 3.5 GHz Band Differ Significantly from the Characteristics of the Incumbent Systems in the TV Bands Mandating Different Protection Mechanisms

[7] *See* NTIA Table D-1, Ship Distance Along the Coast
[8] *See* https://www.cia.gov/library/publications/the-world-factbook/fields/2060.html

In the preceding, we cited the TV Band exclusion zones as an example of exclusion zones designed to protect the incumbent systems' transmissions and not the secondary systems' transmission. However, the analysis used to define protection mechanisms for federal users in the CBRS band must consider the following significant differences between federal incumbent radar systems and TV broadcast sites.

a) In the TV bands, the broadcast antenna is separated from the receiver, but for radar systems, the receiver is co-sited with the transmitter. In the TV Bands, the receiver must be protected. Such receivers typically are hidden from RF sensing, having very low radiated signal strength by design. Thus it is impractical to detect a TV broadcast receiver by sensing. In contrast, the receiver for radar systems described in the NTIA Fast Track report are not hidden, but are collocated with Gigawatt strong signal transmitters. In practice, this means that sensing such incumbents is practical and as shown in Finding 1 can be accomplished without advice from the incumbent. Sensing of the radar transmission, therefore, is a viable mechanism for determining the presence of a protected receiver in the 3.5 GHz band, unlike in the TV Bands.

b) Ship-borne radar systems are mobile while TV broadcast sites are fixed. With fixed transmission sites, the use of fixed exclusion zones in geospatial zones of TV broadcast costs little in terms of spectrum efficiency compared to other methods. Ship-borne, airborne, and ground mobile radar systems are mobile or transportable, so designing exclusion zones based on all possible locations of such systems (as done in the NTIA Fast Track Report Analysis) is significantly less efficient use of spectrum than the dynamic methods available with contemporary technology.

The combined implication of both of these features is that fixed exclusion zones provide no significant contribution in the 3.5 GHz Band to protect incumbents compared to sensing with SAS enforcement of specified levels of RSS at mobile incumbent receivers.

4. Dynamic Methods Should be Employed to Protect Incumbent Users

We applaud the FCC's goal of employing a dynamic SAS to manage interference and to dynamically assign frequencies to Priority Access License (PAL) and General Authorized Access (GAA) devices.[9] Given the dynamic nature of these devices (e.g., mobile end users, varying spectrum use patterns), dynamic spectrum and interference management is required to achieve the intended levels of spectrum efficiency and spectrum utilization.

Further, we believe this principle should be extended to also allow dynamic SAS protection of ship-borne radars and other mobile radar systems. The extension of this principle is reasonable as, like the envisioned CBSDs, ship-borne radars are also mobile with highly varying spectrum usage patterns so that fixed geographic frequency assignments leads to significant spectrum and market inefficiencies. However, the application of this principle should be augmented with what Federated Wireless terms Informed Obfuscated Incumbent Protection, which will allow dynamic SAS protection without undue revelation of the capabilities or limitations of military systems

We propose the following mechanisms for consideration for secure, dynamic management of interference to ship-borne radar systems and other mobile incumbents.

a) <u>Dedicated sensing</u> – Aided by appropriately sited dedicated sensors arrayed in regional networks termed a Federal Spectrum Observatory(FSO), an appropriate SAS can rapidly detect that a radar system becomes active when moving into the area or turning on their radar. Once detected, the SAS would continue to enforce a dynamic, incumbent-specific exclusion zone that

[9] *See* FNPRM p 12 (paragraph 33)

moves with the incumbent, e.g., with the active radar in a geospatial area consistent with the interference tolerance capabilities of the specific incumbent. The Federal SAS and related CBSDs employ signal obfuscation described below to protect the knowledge regarding the specific interference tolerance of such an incumbent; the FSO and related CBSDs thus achieve the intent of the FNPRM with respect to interference protection without unauthorized exposure of the capabilities or limitations of related military systems to public knowledge.

b) CBSD sensing –Using spectrum sensing data from CBSDs reported to a regional SAS, the spectrum management system determines when a federal incumbent such as a ship-borne radar has moved into the area or has become active. Examples of appropriate spectrum sensing data includes channel state information (CSI) currently used in the operation of LTE networks. Once detected, the SAS computes a dynamic exclusion zone defined for each such federal incumbent (e.g., active radar) as it moves along the coast or for airborne systems overhead, commanding CBSDs to change frequency as needed by the specific incumbent, consistent with the incumbent protection provisions of the FNPRM. To ensure consistent operation, the regional SAS would reports CSI to a Federal SAS (FSAS) and coordinate the movement and implementation of dynamic Exclusion Zones with other regional SAS as appropriate.

c) Collaborative methods – Consistent with the methods envisioned for PAL / GAA interference management, operators of the ship-borne radars may inform the FSAS (Federal SAS) when they will be using the spectrum in a particular area. Then the FSAS would be sensitized to detect and enforce exclusion zones defined for specific mobile incumbents.

In all of these approaches, the use of an obfuscated and dynamic SAS to prevent interference to incumbent systems greatly improves spectrum efficiency and increases spectrum utilization by replacing fixed geographic exclusion zones with secure dynamic methods. We note

that the first three approaches place the least added management burden on federal incumbents. A general principle of spectrum sharing is that the burden for spectrum sharing should be minimized to incumbent systems, all else being equal.

5. Devices Having Appropriate Sensing Capabilities And Managed By An Appropriate SAS Should Be Allowed To Operate Anywhere

As discussed in the preceding, there are a variety of mechanisms by which a dynamic SAS can learn of the onset of in-band radar transmissions and evacuate CBSDs when a ship-borne radar becomes active within range of shore. Specifically, we assert that when any of three proposals in the preceding are implemented, CBSDs should be permitted to operate all the way to the coast whenever no radar or other incumbent system would be interfered with as enforced by the SAS.

In a subsequent filing, we will report data on the feasibility of this approach.

6. Rather Than Fixed Exclusion Zones, Per Incumbent I/N Values At Dynamic Locations Of Incumbent Antennas Should Be Used To Manage Interference To The Incumbent Systems

While we disagree with the specifics of the NTIA analysis, we endorse their approach for using maximum interference to noise (I/N) ratios as a basis for spectrum management. Extending the principle of dynamic SAS management to protect PAL devices from GAA interference, we further propose that a SAS be permitted to dynamically manage interference to incumbent users based on aggregate I/N at the incumbent receiver site. Repeatedly throughout the descriptive text and specifically in rule 96.15, the FNPRM notes that CBSDs must not cause harmful interference to federal incumbent users. We strongly endorse this position, but note that harmful interference is not defined in the proposed rules in a technical, implementable, sense.

One such implementable technical definition of harmful interference is provided in the NTIA Fast Track Report, which defines -6 dB I/N as the point at which radar operation would be noticeably degraded. A dynamic SAS could ensure that interference at a particular location does

not exceed this number or any other number that the Commission in conjunction with the NTIA might establish by judicious assignment of frequencies and power levels based on CBSD locations, propagation models, and sensing data. In this way, formal exclusion zones are not necessary and greater spectrum efficiencies can be gained through dynamic management. This elimination of formal exclusion zones is also consistent with the principles espoused throughout the FNPRM and the proposed rules to permit different interference levels to higher priority users as long as the levels are mutually agreed upon by the parties and are enforceable by the SAS. [10]

While this would most easily be accomplished by having the incumbent user report the interference levels to the SAS as we propose elsewhere in this Comment and as already required for CBSDs experiencing interference[11], the same result can be achieved via calibrated, high fidelity propagation models and knowledge of the locations and transmitter characteristics of the secondary devices so as to not impose a burden on the incumbent system. In contrast with the worst-case interference aggregation assumed for many analyses used for incumbent protection from Ultra-Wideband (UWB) devices[12], this would allow for lower density deployments of CBSDs to operate closer to incumbent receivers or higher density deployments to operate with less transmit power or on alternate channels.

Such an approach of considering the specific propagation conditions at specific locations would also provide greater protection to incumbent users than utilizing an exclusion zone defined by a fixed distance.

II. OBFUSCATED DETECTION OF INCUMBENT SIGNALS

---

[10] *See* FNPRM §96.17 (2) for mutual agreements between CBSD and FSS, §96.38 (c) for agreed alternate power levels at PAL boundaries, and §96.38 (e) (1) for agreed alternate power levels between PALs.
[11] *See* FNPRM §96.36 (d).
[12] *See* discussion in Section F: Cumulative Impact in Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, ET Docket 98-153, *First Report and Order*, (April 22, 2002).

In the preceding, we identified sensing-aided DSA as a critical method to protecting incumbent radio systems while making efficient use of the spectrum. However, classifying signals generally implies knowledge of those signals, which poses potential national security issues when attempting to sense the presence of those signals.

To preemptively address potential concerns that incumbents legitimately raise in response to our proposed use of sensing-aided DSA, we present herein an obfuscated means of detecting incumbents' signals (termed *informed obfuscation protection*). Federated Wireless has developed a patent-applied-for-technology for reliably detecting incumbent signals with high sensitivity while protecting the signal characteristics on which the detection and control algorithms are based. One realization of informed obfuscated protection is the creation of a Signal Categorization (SigCat) neural network (NN). A SigCat NN is trained to *categorize* detected signals into one of four classes: 1. Incumbent signal, 2. Managed signal, 3. Noise, and 4. Other. Because the incumbent signal class categorization mechanism used by the SigCat NN would be trained by a wide range of incumbent signals, such as those of NTIA Report 14-499, a SigCat NN would only be categorizing classes of signals and not classifying specific signals.

In light of our proposals in the preceding, informed obfuscation protection could be deployed as follows. An FSAS would have the national security information necessary to train a SigCat NN with samples of specific military radar modes as well as other incumbent signals. The FSAS could provide the resulting SigCat NN to CBSDs, regional SAS, and other FSOs. Because of the inherent infeasibility of reverse engineering a neural network's weights to determine the signals used to train it, it would be infeasible for a malicious agent obtaining a SigCat NN to infer unauthorized national security information. In addition the SigCat NN would be incapable of actually classifying signals into specific incumbent types such as SPN-43 or AN/SPY-1. Thus,

the SigCat NN successfully obfuscates federal signal usage while providing a highly reliable mechanism for alerting CBSDs and SASs to the presence of such an incumbent. We advise the FCC to adopt rules that require SAS operators to demonstrate SigCat NN or equivalent obfuscation and to further require CBSDs to test received signal epochs (such as needed for LTE CSI) at least once per second by a SigCat NN or equivalent.

III. PROBLEMS IN MANAGING GAA ACCESS TO PRIORITY ACCESS SPECTRUM

We praise the Commission for adopting many concepts that increase the flexibility of spectrum management and usage (e.g., license aggregation, allowing GAA use of PAL spectrum) as spectrum flexibility is the foundation to achieving spectrum efficiency in dynamic and varied systems. However, in this Section, we note a few difficulties that will arise from the proposed rules and comment specifically on how to measure PAL usage and permit GAA access to PAL spectrum.

1. Defining PAL boundaries by census blocks introduces efficiency problems for spectrum management

Proposed rule 96.23(c)(1) states that each PAL shall consist of a single census tract, as defined in the 2010 Census with subsequent rules noting that the SAS should attempt to ensure contiguity of area and channel assignment by licensee. While we recognize the expediency of well-defined fixed geographic areas for the auctioning process, the use of fixed, static census tract boundaries introduce problems for managing the spectrum usage of dynamic users.

First, Rule 96.38 (c) states CBSD transmissions shall be managed such that median signal strength shall not exceed -80 dBm on co-channel PAL boundaries. Without careful definition of

PAL frequency "use", this is in apparent tension with Rule 96.13(c) (GAA Access to unused PAL spectrum) and will more generally lead to inefficient spectrum usage when the unit for "usage" is the entire PAL and only a small fraction of that tract is intended for PAL operation. For instance, in rural areas census tracts can cover hundreds of square kilometers while the desired deployment area may only cover a few square kilometers (e.g., Nye County Nevada is a single census tract covering nearly 11,000 square km[13]).

However, with a definition of PAL usage based on protecting PAL devices instead of protecting PAL geography, these inefficiencies can be overcome. This approach would be analogous to and consistent with our proposal above to eliminate fixed Exclusion Zones for protecting incumbent users and instead relying on the SAS to manage interference levels to the devices of incumbent users. Further, Rule 96.36(d) (CBSD interference reporting) already provides the SAS with the information needed to effectively enforce protections to PAL devices, though a SAS further augmented with predictive channel modeling would be expected to provide better PAL interference protection and more efficient spectrum usage.

Accordingly, we request that the Commission modify Rule 96.38 (c) so that interference to PAL devices, rather than to PAL boundaries, be managed by the SAS. In a subsequent filing, we demonstrate the feasibility of this approach wherein we report the experimental success of reliably predicting received power levels of CBSDs to radar sites, which is analogous to predicting received power levels to PAL device locations.

2. **Measuring PAL Spectrum Usage**

Paragraph 37 of the FNPRM astutely notes that the efficient design of a mechanism for permitting GAA access to PAL spectrum depends on how "use" is defined. Clearly, that a PAL device has registered its location with the SAS does not imply that the PAL device is actively

[13] *See* http://en.wikipedia.org/wiki/Nye_County,_Nevada

transmitting or receiving. To differentiate between registration and usage, we previously proposed that PAL devices should pay a nominal usage fee for those periods that spectrum was actively needed by PAL devices while incentivizing PAL licensees to not reserve spectrum that they were not using.[14] If the SAS examination of this accounting stream were augmented with spectrum sensing data, such an approach would reliably protect PAL devices from GAA transmissions while maximizing spectrum efficiency. However, such a usage fee approach was not proposed in the current FNPRM. Accordingly, the following is what we believe to be a second-best approach, though consistent with the intent of the proposed rules.

Prior to initial operation and then as regularly directed by the SAS, a GAA device shall provide the SAS with spectrum sensing data. Based on recent measurements from multiple GAA devices, the GAA device locations, PAL device locations, and appropriate propagation models, the SAS will determine regions where no PAL device is actively using the spectrum. These PAL frequencies in these regions will then be made available for GAA use. Subsequently, if sensing data changes or if a PAL device reports interference exceeding some threshold (as defined by the Commission or agreed to among PAL and GAA parties), the SAS shall reassign the frequencies of relevant GAA devices. Similarly, if no PAL spectrum usage is detected for a sufficient period of time in a region previously considered to be in use by the PAL, the SAS shall treat the frequencies in the associated region as unused.

The details of this procedure, including the measurement procedure, reporting protocol, occupancy and evacuation times, should be finalized by an industry group and the Commission should certify compliance to this procedure to ensure consistent implementation. Note that the adoption of this procedure should not delay the issuing of a Report and Order, though

[14] *See* Comments of Federated Wireless Inc. in Response to Licensing PN in GN Docket No. 12-354 (filed December 5, 2013) (Federated Licensing PN Comments) at 17-25.

presumably SAS implementations that do not conform to this procedure, or do not have appropriate GAA sensing data, will be prevented from allowing GAA devices to operate in unused PAL spectrum.

3. Non-contiguous Census tracts exist

We take this opportunity to note that while census tracts are usually contiguous, non-contiguous census tracts exist,[15] generally due to irregular political boundaries. In such situations, it will be difficult for PAL licensees to cost-effectively deploy a network that completely covers a PAL census tract, particularly when adjacent PALs cannot be procured. The expected resulting spectrum underutilization is another incentive to allow GAA devices to unused PAL spectrum and to define PAL usage by device instead of by PAL geography.

IV. SPECIFIC COMMENTS ON THE REGULATION OF SPECTRUM ACCESS SYSTEMS

The following comments on specific aspects of the proposed rules and authorization of the SAS.

1. Spectrum Access System Purposes and Functionality (96.43)

Paragraph 97 of the FNPRM invites comments on the purposes and functionality of the SAS. As defined in the text of 96.43, we concur with the purposes and functionality of the SAS. We further note that 96.43 would also be consistent with allowing the SAS to automatically and dynamically determine appropriate Exclusion Zones, if the FCC chooses to delegate that authority. In the following are comments on descriptive text in the FNPRM related to 96.43.

a) Nationwide Service (paragraph 96)

Paragraph 96 of the FNPRM states that each SAS would provide nationwide service. While this requirement is not listed in the corresponding rule (96.43), we believe that it would be the intent

[15] *See* https://www.census.gov/geo/reference/gtc/gtc_ct.html

for the Commission to include this requirement as part of the SAS Administrator authorization process. We request clarification on if nationwide service is a requirement for SAS Administration and further suggest that permitting multiple regional SAS administrators will be better suited for fostering innovation and spectrum efficiency in the 3550 MHz Band.

Several proposals for SAS operation[16] have suggested the use of detailed propagation models, particularly in urban NLOS environments, to predict interference for enhanced dynamic interference management among GAA devices and between GAA devices and PAL devices. Scaling up these operations beyond regional networks to nationwide coverage will require a significant investment may be a significant barrier to entry for new spectrum sharing technologies.

Further, if automatic dynamic Exclusion Zone determination is permitted, the implementation complexity for SAS operation will vary greatly by region. For instance, a SAS covering Iowa could operate with effectively fixed Exclusion Zones and would be little different from a TVWS database outside of managing interference between PAL and GAAs. But a SAS serving Norfolk or San Diego would have to deploy sensing technologies or coordinate with dynamic Federal users, which are both significant undertakings.

Finally, the regional differences in the types of incumbent users present also imply that permitting a regional SAS deployment can shorten the time to market for those areas where testing and certification can be greatly simplified.

b) Rule Appropriateness (paragraph 97)

Paragraph 97 invites comment on the appropriateness of the rules for SAS operation and in particular asks if a compliant SAS can be built and operated using existing or "in development" technology. With exception only for those rules for which we seek clarification in

[16] *See*, e.g., the proposed methods herein and BLiNQ Comments (Dec. 5, 2013).

this Comment, Federated Wireless has demonstrated all of the components needed to implement a dynamic SAS as described in this filing.

c) Multiple SAS (paragraph 98)

Paragraph 98 of the FNPRM considers the possibility that multiple SAS Administrators could be authorized. We strongly concur with the proposal to permit multiple SAS Administrators as this will be critical to achieving market efficiencies and to encourage innovation in spectrum management. While most record keeping could be synchronized daily, as with TV White Space (TVWS) databases, achieving a reasonable response time to when a PAL device or incumbent Federal User reports interference implies asynchronous communications among overlapping SAS to address that specific event. A similar capability would be required with SAS-administered automatic dynamic Exclusion Zones. In both cases, the protocols required to implement this communication and coordination among SAS administrators should be standardized by industry and could be rapidly adopted by building from the Internet Engineering Task Force Protocol to Access White Space (IETF PAWS database) specification for TVWS database coordination[17] or ongoing applications of North Atlantic Treaty Organization (NATO) Standard Spectrum Resource Format (SSRF) standard for exchanging spectrum-related information.[18]

2. Information Gathering and Retention (96.44)

Paragraph 99 of the FNPRM requests comments on the Information Gathering and Retention requirements of the SAS (rule 96.44). We seek clarification on the retention period for which the SAS should maintain a record of CBSD information. Further, if automatic dynamic Exclusion Zones are adopted for ship-borne and other mobile radars, we propose that in a manner similar to

[17] *See* Draft PAWS Standards http://tools.ietf.org/wg/paws/draft-ietf-paws-protocol/
[18] *See* Open SSRF Reference Implementation, http://groups.winnforum.org/d/do/7435

the data retained for protected FSS systems and also for interference traceability, the SAS shall maintain a record of Exclusion Zones for a period of time to be defined by the Commission in conjunction with the NTIA.

Paragraph 100 of the FNPRM notes that if Exclusion Zones are altered, the SAS may need to gather and manage a significant amount of data on federal operations, which may be sensitive or classified. Paragraph 100 proceeds to request comment on if a separate database should be established, if a separate database is more efficient and secure than entrusting federal information to each registered SAS, the security measures that should be required and who should maintain such a database.

First, as we state in Section I.4, to protect dynamic incumbent users (e.g., ship-borne radar systems), the SAS should employ dynamic protection methods, which in turn implies Exclusion Zones that change frequently and automatically. We further proposed two different classes of methods for determining when dynamic incumbent users are present - coordination with Federal users and sensing.

If coordination with Federal users is required, the content of the communications (e.g., operational information) with the Federal users will be sensitive. In such a case, a separate database should be established for managing the interface to the Federal users and providing appropriately modified information to the SAS (e.g., a listing of census tracts or geographic regions and channels where transmission is prohibited or limited) for the following reasons. First, this will minimize the burden on the Federal users as they will have fewer interfaces to manage and secure. Second, this reduces the number of potential security vulnerabilities (no SAS would need access to sensitive information). Third, this would decrease the costs to the SAS

providers (thereby reducing the barrier to entry and increasing competition and innovation) as maintaining the appropriate facility and personnel clearances is a significant undertaking.

If a sensing approach is instead taken, then a suitable method for obfuscating the signal detection process, such as proposed in Section II, should be required. In this case, the SAS should be free to determine the presence of the Federal or other incumbent user, though the automatic adaptation of the Exclusion Zones should be coordinated among the various SASs if multiple SASs are permitted. The details of such coordination should be left to industry to finalize.

3. Registration and Authorization of CBSDs (96.45)

Paragraph 102 of the FNPRM invites comment on the proposed rules by which the SAS will register and authorize CBSDs. While we believe that the three step process of registration, application, and authorization we previously outlined will more effectively empower the SAS to manage the shared spectrum resource for the highest spectrum efficiency and market efficiency,[19] as specified in the text of 96.45, these processes are clear.

4. Frequency Assignment (96.46)

Paragraph 103 of the FNPRM invites comment on the proposed rules by which the SAS will dynamically assign frequencies (96.46). We applaud the FCC for identifying the importance of dynamic spectrum management for improving spectrum efficiency and broadly concur with rules as set forth.

However, we request clarification on what steps are required by the SAS to confirm that a CBSD causing harmful interference to an Incumbent User has been deactivated or reassigned upon request. It is a relatively simple task for the SAS to confirm that the SAS has dispatched a

[19] *See* Comments of Federated Wireless Inc. in Response to *Licensing PN* in GN Docket No. 12-354 (filed December 5, 2013) (Federated *Licensing PN* Comments) at 17-25.

message to a specific CBSD to change frequencies or cease operation and to confirm that the SAS has acknowledged receipt of that message (assuming appropriate protocol definition by industry). But confirming that a CBSD that may be malfunctioning has indeed ceased transmission requires capabilities not otherwise required (e.g., sensing and localization). With relatively dense CBSD deployments, this could be addressed by requiring the CBSDs to perform interference reporting (or more accurately, receive power reporting) on channels other than its operating or adjacent channels, from which it could be ascertained if all CBSDs had indeed evacuated the channel as requested. Alternately, reported observation of alarm signals transmitted by the CBSDs[20] would be another mechanism by which CBSD evacuation could be confirmed. The alarm signal method would have the related benefit of providing a mechanism to enforce channel evacuation when Internet connectivity is lost.

Note that "confirm" was also used in 96.45 for device registration, but 96.45 defined confirmation with a specific process to be implemented by the SAS (verify that the supplied FCC identifier is valid according to a specified list).

5. Security (96.47)

Paragraph 104 of the FNPRM invites comment on the proposed rules for securing the SAS and the communications and interactions between the SAS and CBSDs (96.47). We applaud the FCC for identifying the importance of this issue and for allowing the protocols to be defined by industry (subject to FCC approval). Signal type obfuscation should be required as an aspect of protecting national security information.

6. General SAS Requirements (96.48)

Paragraph 105 states that it is the intention of the Commission to follow an approval process similar to the one employed to approve TVWS Database Administrators while Paragraphs 107

[20] Comments of Federated Wireless at 33-36 (VI. Alarm Signals) (Dec 5, 2013)

and 108 invite comment on the qualifications for SAS Administrators. We believe that under the currently proposed rules with fixed Geographic Exclusion Zones, the TVWS procedures and approaches are mostly adequate and appropriate, with the exception that test procedures should be added to address the acceptance of interference reports and / or sensing data from CBSDs.

But if dynamic automatic Exclusion Zones for ship-borne radars and other mobile incumbents are adopted and if the Federal Users will be coordinating directly with SAS Administrators, then there should be additional requirements placed on the SAS Administrators to have appropriate facility and personnel clearances to handle sensitive Federal User information. Likewise, if SAS Administrators will be permitted to deploy sensing equipment for the purpose of implementing dynamic automatic Exclusion Zones, then this equipment should also be certified by the FCC following traditional equipment certification procedures to satisfy performance specifications to be coordinated with the incumbent Federal Users.

7. SAS Fees (96.49)

Paragraph 109 of the FNPRM requests comment on the proposed rule to allow SAS Administrators to collect fees from PAL and GAA users and requests (96.49) and for the Commission to review and require changes to fees, when excessive.

We believe that having a government agency set prices (implicit to 96.49b) is counter-productive to stimulating innovation and achieving market efficiencies and implies significant regime uncertainty for SAS administrators as plans could be changed post-deployment outside the constraints of the marketplace. Instead, we propose that the Commission work to maximize competition and innovation among the SAS Administrators by permitting multiple SASs, minimizing barriers to market entry for new SAS Administrators, and allowing differentiated and

regional operation. Additionally, the Commission should establish sunshine rules that minimize inadvertent pricing collusion among SAS Administrators.

V. COMMENTS ON INTERFERENCE REPORTING

The FNPRM proposed Rule 96.36 (d) requires CBSDs to report interference to an SAS if the CBSD experiences interference above a threshold and requests comment on the cost and implementation details of the requirement.[21] Given the variety of different wireless devices and applications envisioned for the 3550 MHz band, we believe that the details of this requirement (e.g., channels, bandwidth, measurement guidelines) should be left to industry to finalize and adopt. We note that IEEE standard 1900.6.1 has previously been defined for tasking sensing activities and communicating sensing results among devices with disparate capabilities. A subset of a standard like 1900.6.1 could be used as the starting point for rapid adoption of the technical details for interference reporting.

VI. INDUSTRY GROUPS SHOULD FINALIZE AND ADOPT THE TECHNICAL REQUIREMENTS AND PROCEDURES TO IMPLEMENT

Throughout the FNPRM, the Commission requests comments on specific implementation details of the methods and procedures used to manage the CBRS. While a political process best serves the objective of achieving a consensus among disparate stakeholders, once principles are agreed to, a technically-focused industry-led group is best suited to finalize implementation details.

VII. CONCLUSION

[21] *See* FNPRM ¶66.

For the foregoing reasons, Federated Wireless encourages the FCC to continue making progress towards promoting and enabling innovative spectrum access management in the 3.5 GHz band, providing an example for a new future paradigm. We encourage the Commission to quickly complete its reassessment of the Exclusion Zones, and to establish foundational rules for commercial use of the 3.5 GHz band, allowing early commercial access and the opportunity for experimentation to drive comprehensive solutions to challenges that arise.

Respectfully submitted,

John Serafini
General Manager
Federated Wireless, Inc.
33 Arch Street, Suite 3201
Boston, MA, 02110
617-505-6206
john.serafini@federatedwireless.com

July 14, 2014