

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, DC 20554**

In the matter of )  
 )  
Licensing Models and Technical Requirements ) GN Docket 12-354  
In the 3550-3650 MHz Band )  
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**COMMENTS OF FEDERATED WIRELESS, LLC  
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## Introduction and Executive Summary

Federated Wireless, LLC (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 Revised Framework, which makes significant steps in including the extensive comments from the wide range of stakeholders that have participated in the original comment solicitation and subsequent workshop. Furthermore, we strongly support the Commission's efforts in supplementing the record by soliciting further focused comments on licensing and authorization concepts discussed in the NPRM. Federated Wireless supports the core concepts of the proposed Revised Framework, as described in Section III.9<sup>1</sup>. However, we caution the Commission regarding the public interest. We believe that the public interest is best served by rules that support the sixth concept of the Revised Framework, which is enabling additional General Authorized Access (GAA) to unused Priority Access bandwidth, as identified and managed by a Spectrum Access System (SAS), to maximize dynamic use of the unutilized portion of the band and to ensure productive use of the spectrum.<sup>2</sup>

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<sup>1</sup> See Commission Seeks Comment on Licensing Models and Technical Requirements in the 3550-3650 MHz Band, GN Docket No. 12-354, *Public Notice*, FCC Rcd \_\_ (2013) (Revised Framework Public Notice), ¶ III.9

<sup>2</sup> *Ibid.*

We believe that it is necessary to align financial incentives with the core concepts of the Revised Framework. Adoption of a two-part tariff monetization scheme for utilization of shared spectrum encourages efficient use of spectrum and discourages warehousing and anticompetitive behavior, protecting the public interest. If the entirety of the payment for Priority Access is done on a yearly basis, then there is an incentive for the Priority Access Licensee to hoard the spectrum because they have paid for it for the entire period. However establishing a two-part tariff would mitigate hoarding. We propose a monetization scheme where the Priority Access Licensee annually pays a lump sum for the right to bid for Priority Access, and then pays for actual usage as needed. This will provide a financial incentive for Priority Access Licensees to request only the spectrum that they actually need at any given time, such as during peak hour. This can readily be accomplished by a three-step shared spectrum access process.

This process allows for dynamic real time SAS based management of the spectrum resource while minimizing the signaling information that is sent. Utilizing steps of *registration*, *priority application*, and *authorization*, the SAS is empowered to effectively manage the shared spectrum resource for the highest spectrum efficiency while ensuring that fluctuating market demand is reflected in the real time price of this scarce resource.

To support the highly dynamic nature of these supplemental spectrum resources, we propose that Entities use one or more Spectrum Access Control Systems to manage and control the use of shared spectrum resources by their network nodes, while enabling a flat system architecture that promotes the maximum efficiency and system flexibility. We introduce a digital token system called sCash which is used to manage the transaction and billing processes between Entities and the SAS in real time.

Spectrum sensing is an essential part of any dynamic shared spectrum system. We describe sensing requirements for user equipment and network nodes that must be part of the Commission's rules for any federal shared spectrum band. We describe how this sensing can be used to more effectively manage spectrum efficiency and to promote the use of increasingly innovative spectrum sharing technologies.

Incumbent tier systems require a unique level of operational agility that will always challenge any system that relies entirely on database technologies. We propose a SAS managed Alarm Signal which can be effectively used to clear specific spectrum resources efficiently and in an obfuscated manner, thereby ensuring that Incumbent systems do not suffer harm due to interference from Priority Access and GAA users.

We discuss in detail the ability for the SAS to identify and manage real time GAA Infrastructure Node and user equipment access to unused Priority Access bandwidth. Rules that support this ability are critical in order to maximize dynamic use of the unutilized and under-utilized portions of the band, and to ensure productive use of the spectrum while discouraging warehousing. We believe that this can be readily accomplished by direct PAL Infrastructure Node and GAA Infrastructure Node interaction with the SAS, utilizing spectrum sensing requirements combined with real time accounting streams from network infrastructure. With appropriate license rules and readily achievable device technical requirements as proposed in the following Comments, the SAS plays a significant role in efficient spectrum use enforcement, thereby serving the public interest.

Lastly, we discuss obfuscation and security requirements for the SAS, and ways in which the Comments herein serve to enhance the capabilities of the SAS with respect to protecting national security.

The second workshop planned for January 2014 to specifically address the technical aspects of the SAS will enable the Commission to leverage to the fullest extent possible the vast expertise and experience of the stakeholder community for spectrum resources. This collaborative and inclusive effort will ultimately ensure that the specific rules, when proposed, succeed in enabling highly efficient and diverse use of the 3.5 GHz band.

This Public Notice and Request for Comments and the planned Technical Workshop take an important step in making the 3.5 GHz Band concurrently available for federal, non-federal private, non-federal government, and broad commercial use. We believe this rule making process also paves the way for federal users to become secondary users in many other bands of spectrum that may be readily accessed by currently deployed federal devices but that are excluded by rule from use because of the historical role of spectrum clearing and legal guarantees of freedom from interference in those bands. Currently deployed technology such as TV whitespace and IEEE 802.11h radar avoidance demonstrates that unused radio spectrum may be employed by a secondary user without causing harmful interference to primary users. Thus the SAS with appropriate rules for PAL and GAA Infrastructure Nodes and user equipment will establish a next generation of spectrum sharing effectiveness. Building on this proceeding, in the future, in part mitigating negative aspects of spectrum sharing, federal users may obtain greater degrees of freedom in spectrum sharing with commercial incumbents than rules currently allow.

We therefore encourage the Commission to consider the Comments provided in this response as a contribution towards enabling a truly dynamic, efficient, and economically viable spectrum sharing ecosystem that promotes the public interest through leveraging technology with new legally binding expectations, that is to redress spectrum hoarding where it may have become particularly onerous to the public interest.

## Comments

### I. DEFINITION OF TERMS

This section of our response introduces new terms in order to clarify concepts of the FCC Request for Comments on Licensing Models and Technical Requirements in the 3550-3650 MHz band, GN Docket No. 12-354.

<b>Term</b>	<b>Meaning</b>
Entity	A legal entity that owns or directs one or more infrastructure nodes that form a wireless communication network is considered an Entity. Any wireless communication network that seeks access to the Priority Access tier must be represented by an Entity.
SAS	Spectrum Access System.
Registration	Any Entity or GAA Infrastructure Node that wants to access a shared spectrum resource must register with the Priority Access Database (PAD). All User Equipment (UE) must also register with the PAD. The registration includes all the information that is necessary to manage Priority or GA access to a particular shared spectrum resource.
PAD	The Priority Access Database is database in the SAS that contains a record for each Entity, Infrastructure Node, and UE that has completed the registration process.
PAL	Priority Access License, defined as a 10 MHz unpaired channel in the 3550-3650 MHz frequency band for one geographic census tract for the period of one year.
Priority Application	An Entity that is registered in the PAD may submit a Priority Application request to the SAS for a particular PAL. A Priority Application must be made and accepted by the SAS in order for any PAL Infrastructure Node

	of the Entity to make a Priority Access Authorization Request for a shared spectrum resource.
Priority Application Period	The Priority Application Period for a given PAL is the term for which a successful Priority Application is valid. During the Priority Application Period, a PAL Infrastructure Node of the Entity may bid to request Priority Access Authorization to a shared spectrum resource that is a subset of the PAL on a pay-per-use basis. The Priority Application Period is nominally one year as proposed in the Revised Framework.
Priority Application Fee	The Priority Application Fee is the fee that is charged to an Entity for a successful Priority Application for a single PAL for the Priority Application Period. The fee may vary depending on the class of the Entity as described in the registration record in the PAD, and on the specific PAL that it applies to. The Priority Application Fee is analogous to Upfront Payments in a traditional spectrum auction.
Access Authorization	Access Authorization is the process of granting temporary access rights to shared spectrum resources.
PAL Infrastructure Node	A PAL Infrastructure Node is a fixed node (such as a small cell), a transportable node (such as a cell on wheels), or a mobile node (such as a vehicle-based node) that has been registered in the PAD and associated with an Entity record as a base station, (e)NodeB, or other stand-alone radio access point (RAP). A PAL Infrastructure Node is entitled to request Access Authorization for shared spectrum resources directly from the SAS.
GAA Infrastructure Node	A GAA Infrastructure Node a fixed node (such as a small cell), a transportable node (such as a portable access point), or a mobile node (such as a vehicle-based node) that has type certification and has registered with the PAD. A GAA Infrastructure Node shall not emit RF energy without first obtaining authorization directly from the SAS.
Access Authorization Period	The Access Authorization Period is the period

	of time for which a Priority Infrastructure Node or a GAA Infrastructure Node is allowed to use a specific shared spectrum resource. Such a period may be extendable through a continuation process or through regular interaction with the SAS.
Access Authorization Bid	When a PAL Infrastructure Node requests Priority Access Authorization from the SAS with respect to a specific shared spectrum resource, the SAS manages mutually exclusive applications through auction mechanisms, in which the monetary value that the PAL Infrastructure Node is willing to pay for Priority Access Authorization to use the specific shared spectrum resource for the Access Authorization Period is the Access Authorization Bid.
Spectrum Cash (sCash)	A digital token representing monetary value ultimately collectable by the SAS from a registered Entity that has a successful Priority Application associated with a PAL.
PAL User Equipment (PAL-UE)	User equipment (UE) such as a smart phone capable of, and authorized to, interact with one or more PAL Infrastructure Nodes. Information about all PAL-UE shall be contained in the PAD, however they obtain access grants from their associated PAL Infrastructure Node, and do not interact directly with SAS.
GAA User Equipment (GAA-UE)	A GAA User Equipment such as a smart phone capable of, and authorized to, interact with one or more GAA Infrastructure Nodes. Information about all GAA-UE shall be contained in the PAD, however they obtain access grants from an associated GAA Infrastructure Node, and do not interact directly with SAS.
GAA Spectrum Pool	This is the minimum “floor” of GAA spectrum availability as defined in the Revised Framework.
Allocation Transaction Price	The Allocation Transaction Price is the fee-for-use paid by the Priority Access Authorization bidder that is successful in securing the priority rights to use a spectrum resource for the Access Authorization Period.
Equipment Level Measurements (ELM)	Spectrum measurements made by all

	equipment that is enabled to use a federal shared spectrum frequency band.
Spectrum Access Control System (SACS)	The SACS is an Entity function to help Entities manage their shared spectrum inventory and to structure bids in dynamic auctions. The SACS determines the amount of money that the Entity wishes to spend on Priority Access shared spectrum resources, and interacts with and manages the Entity PAL Infrastructure Node capacity requests through the distribution of sCash.

## II. INCENTIVIZING EFFICIENT SPECTRUM USE THROUGH TWO-PART TARIFF PAL MONETIZATION

Federal spectrum resources are monetized by payment for Priority Access to the 3.5 GHz band. It is important that the monetization scheme provides strong incentives for productive and efficient spectrum use. One of the Revised Framework core concepts is granular but administratively-streamlined licensing of the Priority Access tier.<sup>3</sup> We request that the Commission consider Priority Access payment based on a two-part tariff scheme.

A two-part tariff is an appropriate pricing system in competitive markets when consumers are uncertain about their ultimate demand. The Priority Application Fee forms the lump sum payment of the two-part tariff, and is analogous to the Upfront Payment typically required in the FCC Auction processes with the submission of FCC Form 175.<sup>4</sup> The Priority Application Fee

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<sup>3</sup> See Revised Framework Public Notice, ¶ III.09.

<sup>4</sup> <https://auctionfiling.fcc.gov/form175/submit175/home.htm>

may vary from PAL to PAL, and also may vary depending on the class of the Entity that is requesting priority for the PAL. For example, the Priority Application Fee for a given PAL required for an Entity that operates a point to point directional system may be different from the Priority Application Fee required for a Small Cell Network to request priority for the same PAL. The Priority Application Fee is a flat fee charged on a yearly basis (once per Priority Application Period). The payment of this fee does not grant the Entity usage rights for the PAL; it gives the Entity the right to request Priority Access Authorization for subsets of the PAL for a given Access Authorization Period. As discussed in the Public Notice, we agree that micro-targeted licensing and annual pre-payment requirements for Priority Access use of shared federal spectrum would sufficiently incentivize construction of network facilities. However we feel that annual payments alone would not incentivize intensive spectrum use for a diverse range of uses in the public interest while discouraging warehousing.<sup>5</sup> It is critical that the PAL concept provides strong incentives for licensees to productively use their priority rights.<sup>6</sup>

The second part of the two-part tariff is the Allocation Transaction Price which is part of the Priority Access Authorization process. This establishes a “pay-per-use” model, enabled by a dynamic auction process which reflects the competitive market for the scarce spectrum resource at any given point of time. The granularity of the pay-per-use period (the Access Authorization

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<sup>5</sup> See Revised Framework Public Notice, ¶ III.A.3.24.

<sup>6</sup> See Revised Framework Public Notice, ¶ III.C.35.

Period) is significantly shorter than the Priority Application Period, therefore the Allocation Transaction Price is able to correctly reflect changes and fluctuations in market demand.

We believe that establishing a two-part tariff monetization system will provide a strong incentive against spectrum warehousing and anticompetitive behaviors while simultaneously encouraging intensive spectrum use.

### **III. THREE-STEP ACCESS APPROACH FOR FEDERAL SHARED SPECTRUM**

The Revised Framework defines a set of Priority Access Licenses (PALs) by which to manage and control spectrum use in the Priority Access tier. One of the core concepts of the Revised Framework is mutually exclusive spectrum rights for Priority Access, subject to licensing by auction.<sup>7</sup> The Commission is seeking comment on the Priority Access tier, including Open Eligibility for PALs, the specific construct of PALs, and the assignment, authorization and administrability of PALs.<sup>8</sup> Additionally, the Revised Framework seeks to balance the benefits of exclusive licensing and open eligibility with the need to preserve GAA spectrum access and promote productive small cell use of the band.<sup>9</sup> We believe that a three-step access approach

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<sup>7</sup> See Commission Seeks Comment on Licensing Models and Technical Requirements in the 3550-3650 MHz Band, GN Docket No. 12-354, *Public Notice*, FCC Rcd \_\_ (2013) (Revised Framework Public Notice), ¶ III.9.

<sup>8</sup> See Revised Framework Public Notice, ¶¶ III.A.1.11, III.A.2.12-13.

<sup>9</sup> See Revised Framework Public Notice, ¶ III.A.10.

managed by the SAS enables the widest variety of market-derived licensing models with the least onerous technical requirements, while simultaneously guaranteeing the best protection of federal spectrum use capabilities and operations. The proposed three-step access approach, consisting of *registration*, *priority application*, and *authorization* steps, offers an innovative and effective way to maximize efficient spectrum usage and to concurrently protect the public interest, thereby realizing the full potential of government-held spectrum to spur economic growth.<sup>10</sup> It additionally serves as a model for future coexistence scenarios in other encumbered spectrum bands.

Splitting up the access process into three steps serves to ensure that the frequency that information is sent from networks to the SAS is directly correlated to the frequency at which this information is likely to change. Minimizing message sizes decreases the signaling load, and serves to reduce the latency of the access process, increasing the efficiency of the overall system.

### **1. Step 1 – Registration and the NTIA Priority Access Database (PAD)**

The protection of federal spectrum use capabilities and operations is best served by rules in which a secure Priority Access Database (PAD) contains registration records that can be used to align licenses to Entities. The PAD also contains information about all equipment that will

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<sup>10</sup> See PCAST, Report to the President: Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth (rel. July 20, 2012) (PCAST Report), available at: [http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast\\_spectrum\\_report\\_final\\_july\\_20\\_2012.pdf](http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf)

operate in a federal spectrum band. The PAD interacts with the SAS, which is responsible for managing access to federal shared spectrum through all three steps of the access process.

The Commission sought comment on the amount and type of information that would need to be collected from potential Priority Access licensees.<sup>11</sup> The Communications Act establishes certain categories of eligibility for license applications, while giving the Commission broad discretion to determine specific eligibility criteria.<sup>12</sup>

An Entity that wishes to obtain Priority Access through priority application and authorization must first register with the Priority Access Database (PAD). The PAD registration contains all the information that would be necessary for the FCC to ensure that the Entity meets the legal constraints necessary for authorization to use federal shared spectrum at a Priority Access level. In the auctions context, the Commission typically requires applicants for spectrum licenses to submit short and long form applications detailing their qualifications and any supplemental information the Commission deems necessary. The Communications Act also limits foreign ownership of FCC licenses and comprehensive ownership information is required for all license

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<sup>11</sup> See Revised Framework Public Notice, ¶ III.A.2.20.

<sup>12</sup> See 47 U.S.C. §308 (b) (“All applications for station licenses, or modifications or renewals thereof, shall set forth such facts as the Commission by regulation may prescribe as to the citizenship, character, and financial, technical, and other qualifications of the applicant to operate the station; the ownership and location of the proposed station and of the stations, if any, with which it is proposed to communicate; the frequencies and the power desired to be used; the hours of the day or other periods of time during which it is proposed to operate the station; the purposes for which the station is to be used; and such other information as it may require.”)

applications, whether or not they are subject to competitive bidding. Certain additional qualifications are prescribed by statute.<sup>13</sup>

At the time of registration, an Entity record is created in the PAD and a unique ID is assigned to the Entity. In order to permit the SAS to make real time dynamic authorizations of spectrum within PALs, it is necessary that the record in the PAD for each Entity contains, for example, all the information that is currently found in FCC Forms 160, 175, 601, and 602.<sup>14</sup> A single network operator may have multiple Entity records each with unique IDs for different operations within their business. Without an Entity record in the PAD, the Entity is not able to request priority use of any federal shared spectrum.

For the GAA tier, a license-by-rule approach was proposed in the NPRM, whereby GAA users would be licensed under Part 95.<sup>15</sup> Separate licenses would not be required for individual GAA Infrastructure nodes. However in order to protect national security, the PAD still needs information about the GAA Infrastructure Nodes that intend to use federal shared spectrum, as set forth in the Revised Framework.<sup>16</sup> Therefore a GAA Infrastructure Node record will be created in the PAD for each GAA Infrastructure Node which intends to utilize federal shared

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<sup>13</sup> See Revised Framework Public Notice, ¶ III.A.2.20.

<sup>14</sup> <http://transition.fcc.gov/Forms/Form160/160.pdf> , <https://auctionfiling.fcc.gov/form175/submit175/home.htm> , <http://transition.fcc.gov/Forms/Form601/601.pdf> , <http://transition.fcc.gov/Forms/Form602/602.pdf>

<sup>15</sup> See Amendment of the Commissions' Rules with Regard to Commercial Operations in the 3550-3650 MHz Band, GN Docket No. 12-354, *Notice of Proposed Rulemaking*, 27 FCC Rcd 15594 (2012) (3.5GHz NPRM)

<sup>16</sup> See Revised Framework Public Notice, ¶ III.A.3.23.

spectrum. This record will be referenced by the SAS in subsequent authorization requests from the GAA Infrastructure Node.

## **2. Step 2 – Priority Application**

The Commission sought comment on approaches to spectrum assignment and auction that could be used to productively manage use of the Priority Access tier, while allowing SAS authorized opportunistic use of the GAA tier as described in the NPRM.<sup>17,18</sup> Priority Application is the process by which an Entity which has registered with the PAD makes an application to the SAS in order to obtain priority rights for a specific PAL. A PAL Infrastructure Node cannot make Priority Access Authorization requests to the SAS for spectrum resources associated with that PAL unless the SAS has approved priority rights to the PAL Infrastructure Node Entity for that PAL via the Priority Application process.

Each Entity determines which PALs in which geographic areas it is interested in having priority use of for the upcoming Application Period. For example, an Entity may not be interested in a PAL in a census tract in Nebraska, but that Entity does want the option to use 30 MHz of spectrum in adjacent census tract areas that cover all of Boston, and therefore will make a Priority Application for those specific PALs to the SAS. A Priority Application to the SAS must be accompanied by the Priority Application Fee, which will be held in trust by the SAS during

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<sup>17</sup> See 3.5GHz NPRM, 27 FCC Rcd at 15620, ¶ 75.

<sup>18</sup> See Revised Framework Public Notice, ¶ III.A.3.22.

the Application Review process. When the SAS receives a Priority Application request from a specific Entity, the SAS will check the Entity record in the PAD, which contains all of the necessary information about the type of system that the Entity has including, but not limited to, RF properties like TX Power, RSSI measurement capability, ACPR, antenna heights, frequency reuse pattern, and so on. If no Entity record exists in the PAD, the Priority Application will be rejected by the SAS.

Under the Revised Framework, the time frame for Priority Access Licenses is proposed to be one year, and the geographic granularity is proposed to be at the census tract level. We believe that this represents significant progress from the current spectrum lease formats and durations, and support the Commission in the proposal of this granularity. Therefore we suggest that the Priority Application Period is nominally set to one year to align with the Revised Framework.<sup>19</sup>

The information sent with the Priority Application request is designed to supplement information that is already in the PAD record for the Entity to include, but not limited to, information about the type of operations of the Entity. This choice of information sent at the Priority Application step is predicated on the assumption that the type of operations associated with the Entity are likely to be stable through the one year Priority Application Period. As this information will be stored by the SAS, it would not need to be sent with each individual Priority Access Authorization Bid, which serves to significantly reduce the size of those messages.

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<sup>19</sup> See Revised Framework Public Notice, ¶ III.A.13

Priority Applications are made by Entities prior to the start of the next Priority Application Period, during an Application Window. At the close of the Application Window, the SAS considers all of the received Priority Applications and determines which Priority Applications to approve for the next Priority Application Period. When a Priority Application is approved, the Priority Application Fee held in trust is transferred to the SAS. The approved Priority Application is valid for the upcoming Priority Application Period. Note that an approved Priority Application does not grant the Entity permission to use the PAL; however, it does grant the Entity the priority to bid to use spectrum resources within that PAL on a pay-per-use basis, provided that the SAS indicates that the spectrum is available for use at that specific time.

The SAS may approve a Priority Application for more than one Entity for a given PAL, even if the Entities are of the same entity class. Mutual exclusivity is resolved during the Priority Access Authorization process via competitive bidding to be enabled by dynamic and flexible auction mechanisms. We encourage the Commission to consider antitrust rules to prevent collaboration between Entities with the intention of preventing fair competitive bidding.

The SAS may allow Entities to make a Priority Application for multiple consecutive Priority Application Periods for a given PAL, in order to secure multiyear rights to request Priority Access Authorizations for that PAL while retaining flexibility through the short term Priority Access Authorization process.<sup>20</sup> We support the Commission's recommendation that payment for each consecutive year's Priority Application Fee for a given PAL could be due annually

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<sup>20</sup> See Revised Framework Public Notice, ¶¶ III.A.2.13, III.A.3.24.

during the application window prior to the start of the next Priority Application Period.<sup>21</sup> If an Entity fails to make a consecutive year payment for a multiyear PAL Priority Application, then the Entity would lose their multiyear priority rights, and would be required to make a new Priority Application request during the application window preceding the next Priority Application Period that they were interested in this PAL for.

### **3. Step 3 – Access Authorization**

There are two different types of Access Authorization. Priority Access Authorization is for Entities that have approved Priority Applications and that seek to utilize the Priority Access tier. General Access Authorization (or simply Access Authorization) is for Infrastructure Nodes that seek to utilize spectrum as part of the GAA tier.

The Public Notice<sup>22</sup> sought comments on ensuring productive spectrum use. Specifically, the Commission requested comment on whether the PAL-based allocation model outlined in the Revised Framework could, by assigning priority spectrum rights in a targeted and dynamic fashion, help to ensure that Priority Access rights are allocated to the parties that would make the most productive use of quality-assured spectrum within a given geographic area.<sup>23</sup> We believe that Priority Access Authorization for shared spectrum use needs to be considered at a much

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<sup>21</sup> See Revised Framework Public Notice, ¶ III.A.3.24.

<sup>22</sup> See Revised Framework Public Notice.

<sup>23</sup> See Revised Framework Public Notice, ¶ C.33

finer granularity than PAL units in order to enable the most productive and intense use of the 3.5 GHz Band.

As put forth in the Revised Framework and as described in these Comments, the granularity of the spectrum that an Entity is approved to make a Priority Application request for is in PAL units, defined as 10 MHz spectrum blocks for a geographic census tract for the period of one year (aligned with the Priority Application Period).<sup>24</sup> A first consideration is to make the Access Authorization Period in the order of six minutes, rather than aligning this period with the Priority Application Period. Timers in six minute increments are common in GSM networks, used for example for periodic network selection attempts.<sup>25</sup> Combining this shortened authorization period with a pay-per-use model will provide a significant incentive to minimize spectrum warehousing and prevent anticompetitive behavior. The Access Authorization Period may vary depending on the class of the Entity as listed in the registration record in the PAD.

Further, we suggest the Commission consider that there are potentially negative efficiency consequences that arise from making the bandwidth granularity utilized for Access Authorizations equal to the PAL granularity as defined in the Revised Framework. An Infrastructure Node will not necessarily want or need 10 MHz of bandwidth. Similarly, an Infrastructure Node would not likely need the spectrum for the entire census tract. Consider for example a small cell in a personal residence. This small cell may need additional spectrum

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<sup>24</sup> See Revised Framework Public Notice, ¶¶ III.A.16-17.

<sup>25</sup> See 3GPP TS 22.011, available at: <http://www.3gpp.org/DynaReport/22011.htm>, §3.2.2.5.

within the confines of the residence at that address, which is considerably smaller than a census tract. It may need only the smallest usable LTE bandwidth of 1.4 MHz, not 10 MHz, and it may only need this bandwidth for the duration of a large gathering to be held on the premises, which is planned for a period of several hours over the course of an evening.

Infrastructure Nodes have the best knowledge at any given time as to what additional capacity they require in order to serve the UEs that are attached to them. If the Access Authorization granularity is fixed at the Priority Application granularity (which we recommend to coincide with the PAL as defined in the Revised Framework), then there is a potential for significantly less efficient spectrum use than is possible.

For optimal spectrum efficiency, the SAS should be able to allocate a subset of a PAL (in bandwidth, geography, and time) to PAL Infrastructure Nodes or GAA Infrastructure Nodes for the Access Authorization Period. The SAS knows many things about the Infrastructure Node based on the information that is stored in the PAD record for this node. It has knowledge of the location of the Infrastructure Node (when fixed, or it may track the location of the Infrastructure Node if it is mobile). The SAS has knowledge of the radio frequency characteristics and transmission parameters and therefore understands the coverage footprint for this node. The Infrastructure Node knows what additional capacity it needs to serve its UEs, and embodies this information in the Access Authorization request. Combining this knowledge with the knowledge of the other Access Authorization requests for subsets of the same PAL, the SAS is able to manage Access Authorizations to maximize frequency reuse, resulting in the greatest possible spectrum efficiency. The entire 10 MHz PAL should not need to be completely idle for any portion of it to be made available to another user.

One option for addressing the PAL granularity issue is having the Entity itself request PAL Access Authorization, and then the Entity is subsequently responsible for allocating subsets of the PAL to its PAL Infrastructure Nodes. The Entity pays for the entire PAL for the Access Authorization Period, and it should only request the PAL(s) it needs for all of its PAL Infrastructure Nodes. However this is still prone to waste. Say for instance the Entity really only needs 5MHz of additional spectrum for its network during the day, and only needs 1.4MHz of additional spectrum for its network overnight. There is no way for the Entity to request and pay for Priority Access Authorization for part of a PAL, so the Entity needs to request an entire PAL because of the authorization granularity limit in frequency. The Entity pays for the entire PAL, but only truly needs a fraction of it. The Entity is therefore not incented to use the spectrum resource efficiently, which therefore does not achieve productive use of the spectrum, which is one of the core concepts of the Revised Framework.<sup>26</sup> Additionally, it is not easily possible to make a portion of the PAL available to the GAA tier. Because the entity paid for the entire PAL, there is no reason to be spectrally efficient in its use, and therefore gaps that might be usable by another node are unlikely to exist. We advise the Commission to seek a different option to address the PAL granularity issue.

Another possible outcome is that the Entity that has “purchased” the entire 10 MHz PAL for the Access Authorization Period could “sell” smaller portions of it on a secondary market. The problem with this approach is that this spectrum may move between Priority Access users but it

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<sup>26</sup> See Revised Framework Public Notice, ¶ III.9

won't end up going to the GAA tier, because GAA users are not going to pay the Entity for it. Since the Entity has already paid for it, if they can't sell it on the secondary market then they might as well keep it and use it inefficiently rather than have it used by the GAA tier. As in the previously presented option, this arguably does not serve the public interest.

It is relatively straightforward to implement a smaller granularity of Access Authorization in time and geography. The SAS is able to manage this finer granularity. A significantly finer frequency granularity (in particular for Infrastructure Nodes using LTE) may take longer to achieve commercially, however there are bandwidth options smaller than the 10 MHz PAL bandwidth, which should be readily supportable in the first version of the system.

LTE Release-8 supports six different bandwidth options: 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, and 20 MHz.<sup>27</sup> An LTE UE reads the complete system information from the Physical Broadcast Channel (PBCH), which contains information about the bandwidth of the LTE signal. The PBCH contiguously occupies the 1.08 MHz wide central portion of the transmission bandwidth. The occupied bandwidths for each of the aforementioned bandwidth options are therefore 1.08 MHz, 2.7 MHz, 4.5 MHz, 9 MHz, 13.5 MHz, and 18 MHz. Many standardized LTE bands only allow a subset of these six possible bandwidth options with the most common being 5 MHz and 10 MHz and the least common being 1.4 MHz and 3 MHz. The 3.5 GHz band is covered by LTE TDD Bands 42 and 43.<sup>28</sup> Only 5 MHz and 10 MHz (also 15 MHz and 20

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<sup>27</sup> See 3GPP TS 36.101, available at: <http://www.3gpp.org/DynaReport/36101.htm>

<sup>28</sup> Ibid. Table 5.5-1.

MHz, but these are bigger than the proposed PAL bandwidth size) channel bandwidth is currently supported for these bands in the specifications.<sup>29</sup> However TDD Band 35 (1850-1910 MHz) and TDD Band 36 (1930-1990 MHz) support the 1.4 MHz and 3.0 MHz bandwidth options, so it should not be too onerous to support these smaller bandwidth granularities in the 3.5 GHz band.

The LTE Release-8 physical layer specification actually supports 105 different bandwidth options (180 kHz granularity between 1.08MHz and 19.8MHz occupied bandwidth). However Release-8 performance requirements were only defined for the six bandwidth options previously described<sup>30</sup> and today only those six cases are commercially viable. It would require significant minimum performance specification expansion effort to add new LTE channel bandwidth options, and additionally, device implementation impact has not yet been fully evaluated. Because of this, in the near term, all Infrastructure Node Access Authorization requests should use one of the currently standardized LTE bandwidth options.

We propose that the finest possible granularity in bandwidth, geography, and time should be the ultimate goal of the Commission's rulemaking. It may take time for existing systems to evolve to be able to support 180 kHz granularity for LTE radio access systems, but it is essential that the SAS architecture, the license model and technical requirements and the Commission's related

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<sup>29</sup> Ibid. Table 5.6.1-1.

<sup>30</sup> See 3GPP TS 36.101, available at: <http://www.3gpp.org/DynaReport/36101.htm>, Table 5.6-1.

rulemaking for the 3.5 GHz band, do not preclude evolving to finer bandwidth granularity and therefore greater spectrum efficiency.

**a. Priority Access Authorization**

Priority Access Authorization is the process by which a PAL Infrastructure Node requests, bids for, and may be given permission by the SAS to use some portion of spectrum from a Priority Approved PAL for the current Access Authorization Period.

The architectural assumption is that, in the first version of SAS managed shared spectrum, individual UEs in a given Entity network are not allowed to communicate directly with the SAS. Instead, their requests are managed by PAL Infrastructure Nodes. Furthermore, the PAL-UE usage requirements are aggregated by the PAL Infrastructure Nodes in order to determine the supplemental bandwidth requirement to request Priority Access Authorization for at any given time. Entities have to pay for priority access to shared spectrum. They in turn bill individual users of their network based on various service level agreements and user plans. If an individual PAL-UE is allowed to request PAL spectrum directly from the SAS, then the current billing and customer management systems will not readily scale to support this.

#### IV. ENTITY MANAGEMENT SYSTEMS - SACS

As discussed the Public Notice<sup>31</sup>, given the large number of license areas and relatively short license terms envisioned in the Revised Framework, combined with the increasingly finer granularity proposed for Access Authorization in these comments, we agree with the Commission that there is an opportunity for third-parties to add value to the auction process by developing tools to help bidders manage their shared spectrum inventory and to structure bids in dynamic auctions. Entities have multiple choices for where to utilize Authorized Priority Access shared spectrum in their networks. We proposed that each entity has a Spectrum Access Control System (SACS). The SACS determines the amount of money that the Entity wishes to spend on Priority Access shared spectrum resources. The SAS interacts directly with PAL Infrastructure Nodes in the Priority Access Authorization process; however the SAS bills the Entity for the spectrum use of its PAL Infrastructure Nodes. We propose that the Entity SACS utilize a digital token system called sCash to manage shared spectrum resources in their networks.

sCash is a digital token that represents an actual amount of legal currency. The PAL Infrastructure Nodes bid for Priority Access shared spectrum resources using sCash, and the SAS, via sCash digital token accumulation, provides a complete audit trail of Priority Access shared spectrum costs for the Entity. The SACS thereby effectively controls and manages the Entity PAL Infrastructure Node capacity requests through the distribution of sCash. This leverages the existing network operator billing management systems.

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<sup>31</sup> See Revised Framework Public Notice, ¶ III.A.3.25.

The Entity SACS would determine, for example, how much additional spectrum it wishes to make available to its PAL Infrastructure Nodes, and will use this information to determine which PALs to submit a Priority Application for. The SACS will then determine how much sCash to provide to each PAL Infrastructure Node per month, integrating, for example, the knowledge of which PAL Infrastructure Nodes could bid for Priority Access Authorization for spectrum belonging to the same PAL resource because they can use the same resource simultaneously without interfering with each other due to spatial or temporal separation. The SACS also utilizes business logic which takes into account, for example, different customer service level agreements and other factors in determining how to distribute sCash to its PAL Infrastructure Nodes. The aggregate needs of all of the PAL Infrastructure Nodes (and therefore of the PAL-UEs themselves) may be parsed by the Entity SACS. This allows the Entity to determine the boundary on the total spend with the FCC. Additionally, the SACS can use accumulated learning from past Priority Access Authorization requests from its PAL Infrastructure Nodes in analyzing and prioritizing these requests in order to make better future decisions about how to distribute its sCash through its network.

The sCash distribution from the SACS serves to empower the PAL Infrastructure Nodes to make Priority Access Authorization requests directly to the SAS according to their sCash balance, their UE population needs, and other rules that may be defined by the Entity SACS. The monetary liability of the Entity to the SAS for shared spectrum resources is controlled by how much sCash the SACS distributes to its network nodes.

If a network operator is an integrated carrier with multiple operations of different classes (for example a carrier with a mobile network, as well as a wireless backhaul network), they may have

more than one Entity record in the PAD, and they may choose to operate one SACS per Entity (i.e. one for the mobile network and one for the backhaul operations) in order to manage separate business divisions more effectively.

The PAL Infrastructure Node makes a Priority Access Authorization request to the SAS and includes specified parameters, for example frequency range, minimum necessary bandwidth, radio access technology, maximum output power, EIRP with RBW, antenna radiation pattern, spectrum mask with lowest and highest possible frequencies, etc. In the Priority Access Authorization request, the PAL Infrastructure Node does not include information that is already known by the SAS, such as information that is part of the PAD record for the Entity or for the PAL Infrastructure Node itself, or information that was sent as part of the Priority Application process by the Entity for the PAL that includes the spectrum resource that the PAL Infrastructure Node is requesting Priority Access Authorization for. In addition, the PAL Infrastructure Node makes an initial sCash bid for the requested bandwidth. This process empowers individual PAL Infrastructure Nodes to request additional spectrum when and they need it, but within boundaries that the Entity SACS can control based on the PAL Infrastructure Node sCash balance.

When the SAS receives a Priority Access Authorization request from a PAL Infrastructure Node (authorized by a network operator through the distribution of sCash), the SAS has all the information necessary to decide whether or not to grant that request given the needs of federal spectrum usage. The SAS may decline the Priority Access Authorization for a given portion of a PAL in order to obfuscate sensitive federal operations, for example.

There are two different approaches for Priority Access Authorizations. One approach allows continuations and one approach only allows authorization for a single Access Authorization Period.

*i. Single Priority Access Authorizations*

If only Single Priority Access Authorizations are permitted, then the PAL Infrastructure Nodes must request Priority Access Authorization in each Access Authorization Period, regardless of whether or not the PAL Infrastructure Node had successfully bid for Priority Access Authorization in the previous Access Authorization Period.

In each Access Authorization Period, the SAS considers all Priority Access Authorization Requests that it has received for the particular spectrum resource, and where necessary, conducts a dynamic auction where PAL Infrastructure Nodes can increase their sCash bid by the minimum bid increment in order to successfully win the right to use the spectrum resource.

Various kinds of traditional or innovative methodologies can be used to manage the dynamic auction process. The SAS will indicate the parameters of the Priority Access Authorization to the successful PAL Infrastructure Node for Access Authorization Period N.

*ii. Continuations of Priority Access Authorizations*

If Continuations of Priority Access Authorizations are allowed, then a PAL Infrastructure Node that was granted Priority Access to a spectrum resource in Authorization Period N (at the Allocation Transaction Price, measured in sCash) may request a Continuation of Authorization for Access Authorization Period N+1 at the start of the next Access Authorization Period.

If the spectrum resource is still available for Priority Access during Access Authorization Period N+1, then the SAS may grant the PAL Infrastructure Node permission to continue using the same spectrum resource for Access Authorization Period N+1 for the previous Allocation Transaction Price. If continuations are permitted, a PAL Infrastructure Node may have increased certainty of being able to have use of a specific spectrum resource for a longer period of time at a known price, provided that the resource continues to be available for Priority Access use as previously described. For example, the SAS may grant the PAL Infrastructure Node permission to continue using the same spectrum resource for multiple future Access Authorization Periods, based on a duration request from the PAL Infrastructure Node.

***iii. Reserve Priority Access Authorization Bid***

The SAS may establish a minimum reserve bid value for a given time, geography, and frequency granularity for each PAL. The minimum reserve bid may vary depending on several different factors, for example the time of day, the day of the week, specific Calendar days (e.g. Thanksgiving, Veterans Day), the month or the year, specific geography, spectrum resource geographic footprint size, bandwidth, etc.

If during the Priority Access Authorization process, no PAL Infrastructure Node submits a bid for a shared spectrum resource that is above the SAS reserve bid value for that specific spectrum resource, then the SAS will authorize the use of that specific spectrum resource to the GAA tier for the duration of the current Access Authorization Period.

## **b. GAA Access Authorization**

The Revised Framework proposed a defined “floor” of GAA spectrum availability, to ensure that GAA access is available nationwide subject to Incumbent Access tier use.<sup>32</sup> We identify this spectrum as the GAA Spectrum Pool.

For the spectrum within the GAA Spectrum Pool, GAA Infrastructure Nodes make Access Allocation requests directly to the SAS for a spectrum resource for the next Access Authorization Period. The SAS will make a determination of whether or not to grant the GAA Infrastructure Node permission to access the requested spectrum resource. This determination may be based on Incumbent Access tier use, obfuscation and security needs, and other GAA Infrastructure Node requests. The GAA Infrastructure Node may need to make a new request for the SAS for each subsequent Access Authorization Period, or alternatively the GAA Infrastructure Node may have permission to keep using the previously granted spectrum resource until the SAS indicates that the GAA Infrastructure Node needs to vacate the band and silence its transmitter and its GAA-UEs. A GAA-UE may not emit RF energy without first receiving permission from a GAA Infrastructure Node.

Additional GAA access to unused Priority Access bandwidth, as identified and managed by the SAS, is also one of the core concepts of the Revised Framework, and will serve to maximize dynamic use of the unutilized portion of the band, thereby ensuring productive use of the

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<sup>32</sup> See Revised Framework Public Notice, ¶ III.9

spectrum.<sup>33</sup> If the SAS identifies to the GAA tier that there is unused Priority Access bandwidth, the GAA Infrastructure Node may request permission to use this spectrum resource using the same GAA Access Authorization process.

## V. SPECTRUM SENSING REQUIREMENTS

All PAL Infrastructure Nodes, GAA Infrastructure Nodes, PAL-UEs, and GAA-UEs will be capable of sensing power in the federal shared spectrum band. The rules for the 3.5 GHz Band to be established by the Commission need to make such Equipment Level Measurements (ELM) a requirement for every UE or Node that intends to operate using shared federal spectrum. PAL-UEs and GAA-UEs can measure Channel State Information (CSI) utilizing well established techniques for CSI measurements that are already available in LTE and WiFi products.

The PAL-UEs and the GAA-UEs report these measurements back to the Infrastructure Nodes to which they are attached. The Infrastructure Nodes will aggregate the UE measurements with their own spectrum sensing measurements and report this back to the SAS at regular intervals, as well as when requested by the SAS to do so, or combined with any other message or request that is sent to the SAS.

The ELM requirement for all Nodes and UEs should be no more than required for the equipment to operate efficiently in its own channel with respect to its own spectrum usage, assuring

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<sup>33</sup> See Revised Framework Public Notice, ¶ III.9

affordable introduction and rapid market uptake. Even such minimalistic spectrum measurement enables the collection of significant information on actual channel occupancy that allows the SAS to compute valuable analytics. The aggregate information could be combined with accounting information and used, for example, for tuning the Access Authorization Period durations, for determining the appropriate reserve bid amount, and for monitoring for anticompetitive behavior that is detrimental to the public interest.

Aggregated statistics of spectrum utilization are essential to determining the success of the Revised Framework, and to measuring improvements as enhanced technology features of the SAS are adopted. It is important for the SAS to be able to calculate and report aggregated spectrum efficiency (perhaps on a PAL by PAL basis, or for some other granularity) for the purpose of understanding how this federal resource is being used, and such that the SAS may attribute the efficiency of PAL spectrum use to the licensee, for FCC, NTIA, and Public Scrutiny.

## **VI. ALARM SIGNALS**

The Priority Application and Access Authorization processes previously described should encourage optimally efficient spectral use during normal planned functioning, bounded by the implemented system granularities.

There will be times, however, when the SAS is not aware of the planned usage by Incumbent tier systems. This can be due to basic needs for operational agility for federal systems, but also it will likely take time for the federal spectrum databases (e.g. GEMISIS) to have the temporal

capabilities and real time flexibility needed to keep the SAS fully updated of all planned Incumbent tier spectrum use. In the fullness of time, a majority of federal use of the band may be accurately and dynamically reflected in the GEMISIS database; however in the short run, based on a need for operational agility of federal systems, there is a high probability of unplanned Incumbent tier use of the band. The SAS therefore needs a way of clearing spectrum resources near instantaneously when an Incumbent tier system is detected. Spectrum clearing via Alarm Signal generation also supports the operational obfuscation of federal usage of the band.

Equipment Level Measurements (ELM), made by all equipment using the federal shared spectrum, are sent to the SAS by all Infrastructure Nodes. The SAS may process the received ELM in order to determine if there is an unplanned Incumbent tier system operating in one or more frequency channels in specific locations at a specific time. The SAS determines through aggregation and analysis of the ELM which portions of which PALs have the potential of negatively impacting the Incumbent tier system, and therefore the SAS can identify which Infrastructure Nodes (both PAL and GAA), along with their respective UEs, that it needs to silence in order to prevent interference to the Incumbent tier system.

We proposed that this SAS controlled targeted band clearing will be accomplished by way of a standardized Alarm Signal. All equipment (both Infrastructure Nodes and UEs) that operates in federal shared spectrum need to be capable of recognizing this Alarm Signal and must be programmed to disable all transmissions in signaled channels upon detection of the Alarm Signal. All equipment that operates in federal shared spectrum needs to be capable of transmitting the Alarm Signal upon request of the SAS (if the equipment is an Infrastructure Node) or upon the request of their associated Infrastructure Node (if the equipment is a UE).

The SAS gives the Alarm Signal proxy to communication equipment, requiring it to transmit the Alarm Signal, thereby allowing the SAS to be able to rapidly disable all transmissions in signaled channels in very specific geographic areas.

The transmission of the Alarm Signal must not cause interference with the Incumbent tier system. To prevent such interference, the Alarm Signal may be transmitted over resources that are not part of the shared federal spectrum. The SAS may send the Alarm Signal to the Infrastructure Nodes via a secure IP connection. Once defined, Infrastructure Nodes may retain a reference model of the Alarm signal in space, termed the waveform so that thereafter the SAS may indicate ‘Alarm’ in a message without transfer of the Alarm Signal per se. In general, however, the Alarm Signal may be transmitted in existing supported licensed bands (with respect to PAL Infrastructure Nodes and PAL-UEs) or in existing unlicensed supported bands (with respect to GAA Infrastructure Nodes or GAA-UEs). The Alarm Signal could contain specific location information (e.g. GPS coordinates) in which operating equipment must be quiet. Alternatively, the specific geographic region in which the federal spectrum must be cleared of transmissions may be implicitly described by the equipment that is instructed by the SAS to proxy the Alarm Signal, combined with the power at which they are instructed to transmit it. In other words, if the equipment can hear the Alarm Signal, then it must silence its transmitter in the signaled channel(s). If it cannot hear the Alarm Signal, then it does not have to change its operation.

The duration of the suspension of transmissions may be controlled in a number of ways. The Nodes and UE that detect an Alarm Signal can be required to remain silent in the signaled channels as long as the Alarm Signal is still being transmitted. Once the Alarm Signal has

stopped, Infrastructure Nodes may need to wait until they have alerted SAS that they have responded to an Alarm Signal, have requested permission to restart, and have received instruction from the SAS that they have permission to restart using the Alarm Signaled channel that they previously had Authorized Access for. Alternatively, the Infrastructure Nodes may need to wait at least until the start of the first Access Authorization period after the Alarm Signal stops, at which time they may request Access Authorization for the signaled channel for the next authorization period. The Infrastructure Nodes may request Access Authorization for a different channel which is not being advertised in the Alarm Signal, even while the Alarm Signal itself or the alarm condition induced by such a signal persists.

PAL-UE and GAA-UE will follow the existing paradigms, which is that they must listen before transmitting (according to the radio access standard that they are utilizing).

## **VII. GAA ACCESS TO UNUSED PRIORITY ACCESS BANDWIDTH**

Under the Revised Framework, when Priority Access rights have not been issued (e.g. due to lack of demand) or the spectrum is not actually in use by a Priority Access licensee, the SAS would automatically make that spectrum available for GAA use locally. This approach would ensure that the greatest possible portion of the 3.5 GHz Band would be intensively used.<sup>34</sup> The Commission seeks comment on implementation details, including, for example, how the “use-it-or-share-it” concept described above could be implemented. We support the Commission in

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<sup>34</sup> See Revised Framework Public Notice, ¶ III.B.28

seeking rules to protect the public interests of balancing GAA and Priority Access use in the 3.5 GHz Band through ensuring that spectrum is intensively used when and where there is demand.

Successful Priority Access Authorization for a spectrum resource within a Priority PAL gives the successful PAL Infrastructure Node the right to use the spectrum resource with priority over any other user. There is a risk that an Entity with significant market power may bid for, pay for, and be granted Priority Access rights for significant tracts of Priority Access License units in order to prevent other Entities from having access to them. To mitigate this risk, a PAL Infrastructure Node that has obtained Priority Access rights to use a given spectrum resource has an obligation to actually use this spectrum resource; if the bandwidth is unused then this spectrum resource should be provided to the GAA tier, as described in the Revised Framework core concepts.<sup>35</sup> This requirement serves the public interest by preventing Entities who have significant market power from excluding other smaller Entities, which would compromise the principle of Open Eligibility for Priority Access tier use.<sup>36</sup>

If the PAL Infrastructure Node that has been granted Priority Access to a spectrum resource does not occupy the spectrum resource within a reasonable amount of time after the start of the Access Authorization Period, then the SAS may make this spectrum resource available to another user. This other user could be part of a different Priority Access Entity (perhaps another PAL

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<sup>35</sup> See Revised Framework Public Notice, ¶ III.9

<sup>36</sup> Ibid.

Infrastructure Node that bid for the spectrum resource but was not successful) or it could be a GAA Infrastructure Node.

The likelihood that the 3.5 GHz band will include significant small cell deployment makes the task of verification of usage of PAL infrastructure devices configured as small cells potentially onerous, particularly if the SAS must interact via incumbent Operations and Support Systems (OSS) with the associated panoply of legal constraints regarding, among other things, requirements for permission from end spectrum users to disclose their physical location. A universal spectrum sensing requirement for all Infrastructure Nodes and UE that plan to operate in federal shared spectrum can be utilized in order to determine whether a Priority Access spectrum resource is actually being used by the PAL Infrastructure Node that achieved Priority Access Authorization. If, for example, after one minute into the Access Authorization Period, the SAS determines through aggregated ELM information that Priority Access spectrum resources are not being used and verifies this information through real time accounting streaming data, the SAS may announce this spectrum to other Infrastructure Nodes on a GAA basis (whether it is a PAL Infrastructure Node or a GAA Infrastructure Node), thereby providing Authorization Access to that Infrastructure Node when the spectrum is not being used by the Priority Access Authorized node.

Physical tap measurements and aggregation on individual Infrastructure Nodes to measure spectrum utilization will not likely scale up to the anticipated quantities and densities of PAL Infrastructure Nodes due to the expectation of significant small cells use in the 3.5 GHz band, and this therefore becomes impractical in the envisioned ecosystem. However, the Commission can make rules that require PAL Infrastructure Nodes and GAA Infrastructure Nodes to have

Application Programming Interfaces (APIs) on each small cell or access point that can be provided to the SAS in order to determine in real time what bandwidth in what specific location might be available for use by the GAA tier.

Precise real time accounting streaming data can be required from Infrastructure Nodes, and can be collected and aggregated by the SAS. Based on this information, the SAS could determine what licensed Priority Access spectrum is not being currently used, and could announce this available spectrum resource to the GAA tier such that GAA Infrastructure Nodes could make an Access Authorization request to use it. A hybrid approach which combines spectrum sensing with real time accounting streaming data is also possible.

## **VIII. SECURITY: OBFUSCATION, ANONYMIZATION, AND THE SECURE SAS**

The Commission must take steps to ensure that Incumbent tier user information is protected through obfuscation and anonymizing techniques. Additionally, the Rules proposed by the Commission must ensure that any spectrum sensing or accounting information is sufficiently aggregated and anonymized such that it cannot be used to identify Incumbent tier users, compromising federal operations or National Security. There is a concern about the SAS susceptibility to probing attacks. In our comments, we propose that the registration record of each Entity, Infrastructure Node and User Equipment in the PAD provides the SAS a direct way to check that the credentials of a PAL Infrastructure Node making a Priority Access Authorization request matches the corresponding credentials in the PAD. In addition, as detailed in our Comments, our recommendation is that the FCC requires requests for spectrum usage of a

portion of a given PAL to be provided directly to the SAS from the PAL or GAA Infrastructure Node seeking that usage. In alternative license models not having the technical requirement that PAL and GAA Infrastructure Nodes use sCash to request spectrum directly from the SAS, an Entity known to the SAS may probe the SAS for the availability of spectrum, resulting in operationally unacceptable aggregation of information. In the access method proposed in these Comments, in order for a malicious agent to effectively mount a probing attack against a specific federal user, the entity would have to acquire PAL or GAA Infrastructure Nodes, register them with the PAD, and cause them to interact directly with the SAS with monetary consequences. Although false information might be provided via a less secure PAD, we envision a high level of due diligence regarding PAD credentialing for Entities, and PAL and GAA Infrastructure Nodes.

Specifically, industry best practice would include the use of public key infrastructure (PKI) for the registration of such Entities and Infrastructure Nodes with PKI requirements phasing in, over time, with sCash, according to the balancing of divergent needs of commercial and federal aspects of shared spectrum.

Rules that require a direct interface between PAL Infrastructure Nodes and GAA Infrastructure Nodes and the SAS enable a wide range of measures for operational obfuscation of federal use of shared spectrum. These methods include a level of randomized denial of spectrum access requested by PAL or GAA Infrastructure Nodes. In addition, the definition of an Alarm Signal from the SAS itself limits the exposure of technical features of federal signals (e.g. there need be no “federal signal detector” in any 3550 MHz capable device), and the initiation of the Alarm Signal from the SAS can be a tool used in operational obfuscation. Generation of the Alarm Signal by federal devices also may provide further operational obfuscation initiated by a

particular federal entity without recourse to the SAS per se, allowing a distributed operation that is scalable and that allows independency of action of each of the federal agencies. Such obfuscation is necessary to protect the operations of federal users while denying malicious agents knowledge of the capabilities and limitations of such federal radio devices, networks, and related capabilities, which is essential to public safety and National Defense. We encourage the Commission to create a Secure SAS core, employing well known Defense in Depth techniques as described in NIST standards. The outer layer of the SAS would interact with devices based on data that is in the outer layer. This data may have been manipulated by inner layers of the SAS in order to protect confidential information. The middle layer controls the database that the outer layer of the SAS is using (the PAD). The inner core communicates with the middle and outer layer via Secure IP, for example using VPN or IPsec or PKI.

The core is the Secure SAS. This is the part of the SAS that interacts with the federal agencies and the Federal Spectrum Management System. The Secure SAS should be implemented so as to be fully trusted with respect to federal users. People who interact with and operate the Secure SAS would need security clearance.

Simple obfuscations, anonymization, and other known techniques which are in the public domain may be relevant but are not sufficient, and having a Secure Core in the SAS will be necessary to protect the public interest. Therefore, the FCC should adopt a license model that anticipates a SAS Secure Core, with technical requirements that recognize federal standards and practices. Specifically, the National Security Agency (NSA) is responsible for securing DoD information

systems. The NSA web site for Information Assurance (IA) includes an exemplary reference.<sup>37</sup> The National Institutes of Standards and Technology (NIST) publish standards that realize defense in depth (such as for cryptographic modules which are used, for example, in banking and other critical information systems) and including the NIST Federal Information Processing Standard (FIPS) 140-2. In addition, the NIST 800 series specifies best commercial practice for information assurance which is applicable to the SAS, particularly to the degree that it will of necessity interact with federal information systems. Requirements and models for federal spectrum sharing should include a SAS secure core that follows best commercial practice as outlined in the NIST 800 series, and that conforms to the degree practicable to federal needs for operational security, specifically for defense in depth, e.g. as articulated by NSA's report "Defense in Depth." We encourage the Commission to require that the NTIA and its affiliate federal agencies support spectrum sharing by evaluating the effectiveness of any proposed SAS architecture with respect to including defense in depth, as well as understanding of, commitment to, and implementation of NIST 800 best practices.

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<sup>37</sup> "Defense in Depth" found at: [http://www.nsa.gov/ia\\_files/support/defenseinddepth.pdf](http://www.nsa.gov/ia_files/support/defenseinddepth.pdf)