

**Before the  
Federal Communications Commission  
Washington, D.C. 20554**

In the Matter of

Amendment of the Commission's	)	
Rules with Regard to	)	GN Docket No. 12-354
Commercial Operations in the	)	
3550- 3650 MHz Band	)	

**Comments of iPosi, Inc.**

July 15, 2015

Richard Lee  
Ira Barron

**iPosi, Inc.**  
1127 Auraria Parkway  
Suite 604  
Denver, CO 80204  
[www.iposi.com](http://www.iposi.com)

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## Introduction and Summary

iPosi congratulates the Commission on adopting new sharing rules for the 3.5 GHz Band, making initially 150 MHz of new spectrum partly available on a shared basis to many US citizens. As the Commission has previously noted, American business and US consumers faced a 300 MHz spectrum deficit as of year-end 2014<sup>1</sup> and this demand for mobile spectrum continues to grow. As spectrum is a finite resource, meeting our increasing demand requires making new bands available as this Order does, and in using these bands efficiently. These Comments address primarily, the goal of efficient spectrum use.

In the *Second Further Notice of Proposed Rulemaking* section of this release, the Commission asks for Comments, some of which are directed toward using the 3.5 GHz band more efficiently. In its rules still to be defined, specifically relating to Section A, “Defining ‘Use’ of PAL Frequencies”, and Section C, “Optimizing Protections for FSS,” the FCC has an opportunity to adopt an approach that greatly increases spectrum efficiency and have the Commission, to quote Chairman Wheeler, make “fundamental advances in how it manages spectrum”<sup>2</sup>.

Key to this, the Commission should define the interference protection afforded FSS in terms of an aggregate interference level (Harm Threshold) from all 3.5 GHz users at the FSS antenna “account[ing] for the measurement of receiver performance degradation when presented with both interfering signals and wanted desired signals (C / (I+N)).”<sup>3</sup> To protect incumbent users, the Commission should adopt harm thresholds that maximize new use without harming practical operations by the incumbent. As the incumbents in this Band (FSS and the US Navy maritime radar) are power limited, the Commission should base these rules on limiting potential degradation from incoming shared users to maintain incumbent quality of service. We agree with keeping the rule one that states interference relative to the channel noise.

The Commission should also apply this Harm Threshold approach to improve spectrum use with PAL to PAL sharing at the census tract border and to improve spectrum use between GAA CBSDs and PAL operations. It can do so in how it defines “Use” of PAL Frequencies” on which the Commission has asked for comments. In contrast with primarily protecting incumbents (as is the case with FSS and Navy radar), the Commission should strive here for aggregate spectrum efficiency. The Commission’s goal for setting harm thresholds among common-type users should be to maximize the data throughput to users in a given area using a given amount of

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<sup>1</sup> Report to the President; Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth, July, 2012, p. 4, quoting an FCC Staff Technical Paper, 2010, pp. 2-5.

<sup>2</sup> Report and Order and Second Further Notice of Proposed Rulemaking (“**R&O/2FNPRM**”), GN Docket No. 12-354, April 17, 2015, Statement of Tom Wheeler, p. 178.

<sup>3</sup> *Id.*, at p. 130.

spectrum – “bits/Hz/km<sup>2</sup>”.<sup>4</sup> Maximizing throughput epitomizes efficient spectrum use and recognizes the economic trade-offs between building wireless networks for capacity and building for coverage. Additionally, the anticipated mobile radio standards for CBSDs are designed to be interference limited, not noise limited; the harm thresholds for PAL to PAL and GAA to PAL should thus be defined in terms of C/I.

In adopting deterministic harm thresholds, certainty should be favored over one dependent on path loss model probabilities. Where signal strength and propagation contours can be based on real world sensing and measurements, tolerances can be set that assure compatibility between legacy and incoming services with greater assurance than those based exclusively on models and stochastic methods. But even certainty must be balanced with the Commission’s objectives as stated above; harm thresholds should ensure “practical” operations by the incumbent; the Commission should not for example write rules to protect lack of filtering or poor receiver design<sup>5</sup>.

## About iPosi

iPosi combines its technology, embedded in small cells, with its cloud-based processing to provide automatic small cell location and time synchronization. Among other functions, the iPosi platform:

- Automatically locates (and automatically relocates if they are moved) iPosi-enabled small cells, meeting the 3.5 GHz location requirements in 47 C.F.R. §96.39.
- Provides E911 location indoors for all current (LTE-4G) and future handsets communicating over iPosi-enabled small cells, meeting the indoor E911 location requirements in 47 C.F.R. §20.18.
- Provides GPS-level time synchronization to iPosi-enabled indoor small cells without the need for externally mounted antennas connected to the small cells.
- Operates as an Environmental Sensing Capability (ESC), facilitating the “...coexistence of Citizen Broadband Radio Service users with federal Incumbent Users through signal sensing<sup>6</sup>” pursuant to 47 C.F.R. §96.67. It is important to note here that iPosi’s sensing differs from and is complementary to other proposed ESCs.<sup>7</sup>

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<sup>4</sup> See, iPosi FNPRM Comments, pp. 4-5.

<sup>5</sup> iPosi commends the responsibility shown by stakeholders in this proceeding to not base rules on anomalous propagation conditions such as rare and transitory forms of ducting.

<sup>6</sup> **R&O/2FNPRM**, p. 163.

<sup>7</sup> For example, an ESC designed to sense Navy radar signals would be complementary to iPosi as iPosi would identify which CBSD signals could operate without interfering with the Navy radar while the radar-sensing ESC would allow all CBSDs to use the Navy radar signals when the Navy radars aren’t present.

- Through its ESC operations, iPosi can also significantly improve spectrum efficiency between PAL operations along census tract borders and between GAA and PAL users.

iPosi intends to provide its automatic location and interior containment sensing capabilities to all SASs<sup>8</sup>.

### **How iPosi works**

iPosi provides GNSS (GPS) derived location and time synchronization to indoor small cells without the need for an external GNSS antenna. iPosi-enabled CBSDs detect very faint (-175dBm) GNSS signals deep indoors. The CBSD sends these signals to iPosi servers for processing. iPosi analyzes them, deciphering and separating them from noise. By comparing these signals with the GNSS signals from iPosi reference receivers and from other iPosi-enabled small cells, iPosi determines a particular CBSD's precise location and provides that CBSD with GNSS-derived time synchronization. Small cells remain fixed for hours to years. iPosi continuously updates these measurements at regular intervals, refining the accuracy of the location and detecting if a small cell has been moved or its propagation environment has changed.

This process of collecting and analyzing thousands of data points from GNSS signals, over time, measured at the small cell, allows iPosi to measure the small cell's actual loss and thus calculate each small cell's propagation in a hemispherical map.

The loss (adjusted for the difference in building material absorption of 3.5 GHz signal versus the material absorption of the 1.6 GHz GNSS signals<sup>9</sup>) results in that small cell's propagation map. Aided by the measurements of other nearby iPosi-enabled small cells (e.g. on the lower floors of an office building), iPosi measures and determines the 3D propagation map and signal strengths of each cell in directions relevant to the incumbent (or another CBSD). This measured loss, plus free space loss, allows an iPosi-informed SAS to determine whether a particular iPosi-enabled CBSD would add interference to for example to an FSS earth station, or to a PAL CBSD in an adjacent census tract, or to a PAL small cell within its licensed census tract.

iPosi's tomographic mapping of a CBSD's propagation is similar to the creation of a contour map or conducting a TSB-88 study of field strength with one key difference: The iPosi-derived "contour" results from **actual sensing** and measuring of the CBSD's environment and is not based on assumptions and statistical models. Actual

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<sup>8</sup> iPosi is capable of providing very detailed information to SASs capable of using it. For example, iPosi can provide time synchronization information to ensure less aggregate interference from multiple cells.

<sup>9</sup> See *generally*, National Institute of Standards and Technology, Electromagnetic Signal Attenuation in Construction Materials, TIR 6055, 1997 [hereinafter, **NIST**]. iPosi has summarized some of the NIST report into a table and has included it as an Appendix to these comments.

measurements are critically important here given that Category A CBSDs are indoors and are far more heavily affected by their immediate environment and the materials that make up the building.

For example, a CBSD located in the parking garage of a Manhattan sky-scraper would likely have no effect on Navy radar operations while a CBSD the fourth floor of a New Brunswick NJ office building might. Actual sensing and measuring the containment loss of each individual environment enables the iPosi-informed SAS to assign many more channels with much less chance of interference.

### **Wireless's new architecture**

Historically, cell sites located outdoors (on towers, on the sides of buildings, etc.) serve most indoor customers as well as those outdoors. To the degree these cells have a clear view of the sky, they rely on GPS for time synchronization required by LTE. GPS (along with professional installers) determine the cell site's location. To locate E911 callers, the phone connected to the outdoor cell site interacts with a reference receiver that helps deduce the caller's location. The exploding demand for mobile broadband access challenges the viability of the traditional architecture. 80% of wireless traffic is indoors<sup>10</sup>. This may be even higher depending on how one characterizes Wi-Fi access from desktop devices.

This new architecture calls for low-cost, time-synchronized, location-aware, user-installable small cells that tie into the fiber and metro Ethernets populating the wiring closets of office buildings across the country and the DSL/cable modem connected homes and apartments that surround them. This R&O recognizes this migration to indoor small cells; Category A CBSD will be well suited to help meet the exploding demand for indoor broadband capacity.

Indoor cells present new challenges. Shrinking the cell size by a factor of ten can raise spectral efficiency up to 100 times, but indoor cell success will require small cell unit costs including installation in the hundreds of dollars, not tens of thousands.

### **What's unique about Category A CBSDs**

Indoor small cells present technical challenges as well, indoor cells – specifically because they are indoors – propagate differently than outdoor cells. Most of the path loss incurred by an indoor cell signal is from the outer (sometimes referred to as the “first”) wall. This is important to understand. There could be millions of Category A CBSD deployed along the coast with no deleterious effect on US Navy Radar, while another dozen on upper floors of a residential or office building in Houston, pointed toward the Gulf, may deleteriously harm radar on a ship. Similarly, there may be a co-channel Category A CBSD operating in the first floor of an FSS earth station and

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<sup>10</sup> See e.g. research conducted by ABI Research and Cisco.

have no impact on the satellite on the roof, while another, 10 kilometers away but in line-of-sight with the dish, could be another harmful interference case.

Not only is the indoor to outdoor path loss a critical factor, this through building path loss is especially variable. In developing its technology, iPosi has tested in many different building environments. We have seen, depending on the building material used, the elevation of the measurement point, and the azimuth of the signal, building material loss can vary by 50 dB<sup>11</sup>. With a 50 dB containment loss surrounding each indoor cell, CBSDs could share a channel while only being 10 meters apart. It is quite different if cells incur less building containment loss. Even measuring signal strength through “standard” commercial office window glass, we have observed a 20 dB variation.<sup>12</sup> .

Typical modeling methods (Longley Rice for terrain – Urban Hata for building clutter) cannot account for and thus don’t model these environmental variations accurately. While preferable to an exclusion zone (in that modeling is more accurate and less over-exclusive than a geographic boundary), neither is a particularly appropriate method for optimizing an indoor CBSD’s use while protecting other CBSDs and more importantly protecting critical incumbent users. Knowledge (of measured loss) is power; knowing and applying the actual propagation (derived through measurement and free space path loss calculation) of a CBSD ensures both the most efficient spectrum use and appropriate incumbent protection.

### **Defining “Use” of PAL Frequencies, ¶¶s 419-430**

In ¶418 the Commission highlighted the solid foundation it has created for industry stakeholders to develop standards and operating parameters necessary to launch service in the 3.5 GHz Band. The Commission has determined that allowing opportunistic access to unused Priority Access channels would serve the public interest<sup>13</sup> but has expressed concerns about ensuring this efficient spectrum use.

Here it’s important to distinguish and address each of the components that comprise “use” in this context: Geography, Frequency, and Time. Geography refers to the area being “used” and thus requiring protection and the area being “used” by the potential interferer. Frequency refers both to the 10 MHz channel licensed to the PAL, but more granularly to the sub-channels used by a CBSD<sup>14</sup>. The same holds

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<sup>11</sup> Propagation through building materials alone may vary by 30dB at 3.5 GHz. *See generally*, NIST. *See also*, Appendix A.

<sup>12</sup> For example, some coated glass used for LEEDS compliance has much greater loss compared conventional tinted architectural glass.

<sup>13</sup> **R&O/2FNPRM**, p. 123

<sup>14</sup> While a wide-band radio technology might take up an entire 10 MHz bands, more likely operators will deploy technologies that break up the 10 MHz into channels and blocks of channels. With for example, LTE, 15 kHz channels are aggregated into blocks (say 180 kHz) that are then further

true for “time.” Time can range from when “is the CBSD powered up” to the time slots of each sub-channel. While no one expects a SAS to operate with the speed and granularity of say an LTE scheduler, the Commission should address all three of these factors in defining “use” here.

iPosi offers a solution to measure and map the propagation of each iPosi-enabled CBSD and provide an SAS with information necessary to determine that CBSD’s signal level at a for example a census tract border or with respect to another’s iPosi-enabled CBSD’s coverage area. Consequently, iPosi’s comments on the Commission’s requested definition of “use” will focus on the geographic component of that definition.

### **Geography**

This concern about geography and “Use” is heightened because of the way the Commission regulates co-channel operations at census tract borders. 47 C.F.R. §96.41(d) requires that all CBSD transmissions must not exceed -80dBm at a census tract border “unless the affected PAL licensees agree to an alternative limit...”<sup>15</sup>. Where each operator must be -80dBm at the border, absent cooperation, users at the borders will likely not have service<sup>16</sup>. For traditional CMRS operations, the market sizes tend to be much larger<sup>17</sup> and their borders usually correlate with low population densities. In contrast, where census tracts are smallest and suffer most from border issues, they are generally populated most densely. In its Comments, Google described areas where census tract borders bisect buildings or where 5 census tracts meet at virtually a point in the middle of a city (7<sup>th</sup> and K street NW in Washington, D.C.)<sup>18</sup>.

For PAL-to-PAL sharing, cooperation is more likely as each side benefits from raising signal levels at the border<sup>19</sup>, but for GAA operations there are no mutual benefits. In its comments, Google argues that the Commission should define “unused” spectrum available for GAA use as any geographic area where the GAA device “would not exceed the interference protection afforded to nearby PAL

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aggregated into bands (e.g. ranging from 1.4 to 20 MHz for LTE). A PAL licensed in adjacent census tracts would likely divide up these blocks among adjacent CBSDs.

<sup>15</sup> **R&O/2FNPRM**, p. 157

<sup>16</sup> This is dependent on the radio technology being used. Wideband CDMA can operate where the dB delta between interferer and interfered is 0 (albeit with degraded capacity), but most systems (e.g. LTE) are interference limited. Thus, at the census tract border, the channel would not be usable if there is a CBSD in each census tract trying to use the channel; with an interference-limited system, one side must have a “hotter” signal to work.

<sup>17</sup> For example there are approximately 300 urban CMAs for cellular and 50 MTAs or 500 BTAs for PCS (depending on the spectrum block).

<sup>18</sup> See Google comments, pp. 10-17.

<sup>19</sup> While cooperatively raising the -80dBm limit would be beneficial, PAL-to-PAL co-channel sharing would operate most efficiently if the SAS coordinated the use of that channel knowing the propagation pattern of each affected CBSD.

deployments.”<sup>20</sup> iPosi agrees. With respect to GAA use of PAL channels (and also with respect to census tract border management among PAL users), the Commission should embrace additional approaches focused on the effect of one CBSD on another, not just on a static geographic boundary.

Another Commenter, Pierre de Vries, describes approach this as an “interference limits policy.”<sup>21</sup> He argues for setting a maximum signal level (emitted by the non-protected CBSD) at the protected receiver. iPosi also supports this approach. It’s important to understand that since “protected receivers” are likely mobile, the Commission should protect PAL CBSDs operating inside their census tracts based on the CBSD’s actual coverage.

Using measured building loss,<sup>22</sup> coupled with a free space path loss calculation, is the most accurate way to determine the optimal C/I and at what signal strength the C/I should be measured from. Free space path loss is preferable to clutter models like Hata because the latter are statistical and require a leap of faith as to their accuracy for the specific scenario, whereas the free-space calculation does not. Further, as previously discussed, iPosi knows of no stochastic model that accurately captures the biggest component of Category A CBSD path loss – highly variable building attenuation as the CBSD signal goes from indoors to outdoors. Measured loss reduces most of the statistical variation as well provides a conservative deterministic approach to the protection of other devices.

### **Proposed Rules for “Use or Share”**

Using the goal of maximizing throughput to users in a given area, the Commission should establish a harm threshold or “reception limit”<sup>23</sup> This C/I harm threshold approach should be applied to facilitate PAL protection from GAA users and to set PAL to PAL sharing along census tract borders. With over 74,000 Census Tracts its critical that border-to-border sharing be as spectrally efficient as possible.

- Geographically, this harm threshold measured at the border of the coverage area for the CBSD deserving protection. It should be based as much as practically possible on a carrier to interference bases (C/I) set to maximize utilization of the channels.
- The Commission should define a PAL’s CBSD’s “use” geography as its -97 dBm contour using 3GPP 36.101 Band X as representative of the likely sensitivity of an LTE radio at 3.5 GHz. At that boundary and anywhere within that “contour,” a potentially infringing signal with inferior rights (e.g. a PAL

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<sup>20</sup> Google FNPRM Comments, p.18. *See also*, FNPRM Comments of the White Space Alliance, p.2

<sup>21</sup> **R&O/2FNPRM**, pp. 124, quoting de Vries Comments, p. 22

<sup>22</sup> Adjusted to reflect the CBSD’s operating frequency Band. *See* NIST.

<sup>23</sup> *See* FNPRM Comments of Pierre de Vries.

signal outside its census tract or a GAA signal) must limit its signal within the PAL's contour by an additional factor to minimize the impact to the inherent system C/I. If the interfering signal is 6dB below the inherent noise floor, this will cause a measurable 1dB rise in the protected signal's noise floor. If the interference is calculated using a stochastic propagation model, then an additional 10dB margin<sup>24</sup> should be added commensurate with errors of the propagation model.

- As the Commission's goal here should be to maximize throughput to users, models such as Longley-Rice should also be used to facilitate PAL-to-PAL and GAA-to-PAL sharing, but would need to operate under more conservative parameters due to their imprecision compared with measurements. C/I deltas that are derived through actual sensing and measurements should be less restrictive than those based on statistics, estimates, and probabilities.
- In an environment where some CBSDs are "modeled" while others are "measured," the Commission should encourage PAL and GAA devices to be as accurate as feasible. Above all, this modeled-versus-measured discrepancy should not serve as a way for CBSD operators to "game" the difference between the two methodologies.
- Where a "measured" CBSD shares with a channel with a "modeled" CBSD, the "measured" CBSD should operate under the "measured" C/I ratio, while the "modeled" CBSD should operate under the "modeled" C/I ratio. To elaborate:
  - A "measured" protected CBSD should get -6dB of C/I protection against a "measured" potentially interfering<sup>25</sup> CBSD.
  - A "measured" protected CBSD should get -16dB against a "modeled" potentially interfering CBSD.
  - A "modeled" protected CBSD should get -6dB of protection against a potentially interfering "measured" CBSD.
  - A "modeled" protected CBSD should get -16dB against a potentially interfering "modeled" CBSD.
- All PAL operators should share spectrum with GAA operators on the same terms and conditions that they share with other PAL operators.

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<sup>24</sup> iPosi proposes this 10DB delta as an average number. Some propagation models might be more accurate than others; iPosi estimates modeling needs to be between 6dB and 16dB more conservative than the protection based on measured propagation as proposed by iPosi.

<sup>25</sup> A potentially interfering CBSD here might be a PAL CBSD in an adjacent census tract or a GAA CBSD.

- In the frequency domain, the definition of “use” should be granular and mimic how carriers would likely deploy frequency ranges internally among their CBSDs.
- In the time domain, “use” should be measured when the CBSD is using the frequencies in question. Again, basing a sharing protocol on how carriers operate internally is a good starting point. With time, as opposed to frequency, this may be more of a challenge, as the SAS is not contemplated to manage time synchronization as an LTE scheduler might.

What actual interference parameters the Commission adopts is likely less important than for the Commission to adopt a harm threshold approach that which recognizes the accuracy of measurements over modeling. While iPosi recommends a -97dBm signal level for protection, this may be viewed as a starting point for further analysis leading to optimal resolution. The industry will adapt to whatever rules exist but it is important to have rules (e.g. these harm thresholds) exist for the industry to adapt to them.

#### **PALs unduly “triggering SAS protections”**

In ¶423, the Commission speculated about PAL licensees deploying “low-cost CBSDs whose main purpose is to trigger SAS protections”<sup>26</sup> and has asked for comments regarding this. iPosi anticipates both 3.5 GHz capabilities being added to most all pico and femto cells also bearing licensed CMRS traffic as well as 3.5 GHz capabilities being added to most enterprise-grade and many consumer-grade access points. This demand will lead to scale economies that will further lower small cell prices, creating a virtuous circle to the benefit of the consumer. As the costs of small cells plummet, it may be economically advantageous for a PAL operator to deploy small cells to foreclose proximate GAA operators, depending of course how the rules are written.

- Consistent with the goal of maximizing throughput to users, the Commission should first require all CBSDs registered by a SAS to be fully operational, i.e. connected to a network and providing service to end users. This is already implicit in the FCC’s rules, but making it more explicit will help with the Commission’s SAS protection concerns.
- With the goal of maximizing throughput to users, it should not matter to the Commission whether a PAL or GAA operator provides the service. With a well-executed harm claim threshold, the deployed PAL CBSD’s protection is coterminous with its coverage area, not with the census tract. This helps the Commission ensure that the spectrum is used to its maximum efficiency. As

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<sup>26</sup> R&O/2FNPRM, p. 124

each CBSD's coverage area can be known with precision,<sup>27</sup> GAA users can adjust their channel selection and output power to interwork efficiently with PAL operations.

### **Optimizing Protections for FSS earth Stations, ¶¶s436-442**

Most importantly, the Commission should also use an aggregate interference or harm threshold approach when devising a rule to protect incumbents. To protect incumbent users, the Commission should adopt harm thresholds that maximizes new use without harming practical operations by the incumbent. The Commission should base these rules on limiting the degradation of the incumbent transmission relative to the noise floor. The incumbents in this Band (FSS and US Navy radar) are power limited with relatively low link margins. Thus, a conservative and reliable method to determine the interference present at an FSS is needed. The need to protect incumbent users and the relatively small link budgets in which they operate argue for a more conservative "relative to the noise floor" approach. It is better suited for FSS (and Navy radar) protection than the C/I approach iPosi advocates for intra-CBSD sharing.

### **Determining the proper Harm Threshold to protect incumbents**

The Commission should define the interference protection afforded FSS<sup>28</sup> in terms of an aggregate interference level (Harm Threshold) from all 3.5 GHz users at the FSS antenna "account[ing] for the measurement of receiver performance degradation when presented with both interfering signals and wanted desired signals (C / (I+N))."<sup>29</sup>

The aggregate interference allowable at an FSS terminal must be small due to the fore mentioned limited link margins. However the loss must be measurable. A total increase in noise of 1 dB provides a minimum sensitivity loss is a reliably measurable value of noise rise and iPosi urges its adoption. To ensure legacy protection through and beyond transition to shared operations, this should be set forth as an aggregate source I/N of -6 dB. The interference allowed for an individual CBSD should be much lower than the aggregate interference harm level. It could follow the SIA recommendation of I/N of -13dB. Given the great variability of potential CBSD interference (depending on where inside and in what type of

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<sup>27</sup> The level of precision is directly proportional to the degree the coverage area is based on sensing and measurements as opposed to modeling, especially with indoor cells.

<sup>28</sup> This approach may also be applied to Navy radar. However, as ships move, the aggregate interference limit -- I/N of -6dB -- should apply to anywhere a ship with Navy radar might operate. In conversations at ISART, 2105, Frank Sanders told iPosi personnel that an aggregate I/N of -6dB would be an appropriate harm threshold protection level for Navy radar.

<sup>29</sup> **R&O/2FNPRM**, p. 130.

building), iPosi favors aggregate limits over individual limits on CBSDs to be a general solution for a range of legacy services which offer future shared potential.

Both the individual and the aggregate measurements should be based on a straight line to incumbent FSS antennas, taking into account key propagation parameters such as:

- 1) Antenna gain in the direction (azimuth) of the small cell including the elevation angle,
- 2) The noise figure of the FSS receiver.

Using these FSS parameters, building containment loss of the CBSD, free space path loss and the interfering transmitted EIRP the interference power incident at the victim receiver can be calculated and the FSS (or Navy radar) protected. With respect to protecting FSS in-band and C-Band satellites from out-of-band CBSDs, it's critical to know how the dish is pointed. Satellite transmissions are highly directional. This combined with the low-power and indoor location of CBSD Category A base stations means that only a few Category A CBSD's would cause interference to an FSS location. Further, the Commission should not regulate to protect poor receiver design. Harm Thresholds should be set to ensure "practical operations" by the satellite incumbents. Incumbents with high noise receivers or insufficiently discriminating filters should update their equipment to receive protection.

### **Optimizing out of band Protection for FSS earth Stations, ¶¶s436-442**

The out of band into the FSS band emission levels are currently at -13dBm/MHz. This has been acceptable because there is a 50 MHz guard band between the FSS and high -power military radars as discussed in ¶293. This provides for a natural roll off of out of band emissions from radar and is likely responsible for the acceptable high regulatory limit.

The aggregate protection afforded FSS from co-channel operations should be equivalent to the protection from out of band emissions (OOBE). Therefore the aggregate OOBE into the FSS should also be 6dB below the FSS noise floor, as measured at the FSS station. This is calculated in the same way as the co-channel I/N and can provide a calculated allowable interference limit for regulatory purposes. The value should be set according to the out of band signal rejection afforded by the FSS stations to calculate the maximum out of band signal allowed. Then the OOBE limit should be set to allow for a minimum impact to the FSS due to the OOBE impairment, -6db (if measured) lower than the inherent noise floor at the FSS.

## **The role of propagation modeling to protect incumbents**

In ¶438, the Commission asks for comments on Propagation Modeling and path loss calculations. Propagation models are usually used to predict desired signal power available at some point to achieve quantified performance for reliable communication. They can also be used for interference calculations allowing for a given probability of exceeding a power level as opposed to calculating the probability of being below some power levels for minimum communication. This allows for some error in interference level prediction, as it is statistical.

Models for determining maximum interference levels, such as are needed for FSS and US Navy radar protection, are better-suited using deterministic methods as we must know how high the interference is rather than how often some level is exceeded. The most practical and most certain model for interference prediction employs free space path loss. There is little argument with the accuracy and conservative nature of its calculation. All other methods are prone to be optimistic in prediction of maximum interference levels.

Measured building loss coupled with free space path loss calculations is the best way to protect critical incumbents. Clutter models are statistical and require a leap of faith as to their accuracy for the specific scenario; in contrast free space path loss calculations do not. The measured loss also reduces much of the statistical variation as well as provides a conservative deterministic approach to the protection of FSS.

### **Summary**

These Proposed Harm Threshold Rules proposed here are important, not only for the first 150 MHz proposed for sharing and its ability to help meet the demand for more licensed and unlicensed spectrum for wireless broadband, but for the 450 MHz to 850 MHz of shared spectrum to follow.

A harm threshold, based on the actual propagation patterns of both the incoming operations protecting and the protected legacy operations results in the most efficient spectrum use, which should be the Commission's primary policy objective. iPosi encourages the Commission, paraphrasing Chairman Wheeler, to make one more of its "fundamental advances" in how it manages spectrum, by adopting harm-threshold based rules for defining PAL "use" with respect to PAL/GAA spectrum sharing, and more importantly for determining how Citizens Broadband Service can share with and protect FSS and other satellite users.

## Appendix A

