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

In the Matter of

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

Response of iPosi, Inc. to Petitions for Reconsideration and to Oppositions Thereof

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iPosi, Inc.
5555 Central Avenue
Suite 100
Boulder CO 80301

1127 Auraria Parkway
Suite 604
Denver, CO 80204

www.iposi.com

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Summary

iPosi, Inc.[1] files this Response in light of the Commission's call for replies to parties' seeking reconsideration of a limited aspect of the Commission's Order in the above proceeding, GN Docket 12-354.

In their Petitions for Reconsideration, WInnForum, Nokia, and Motorola proposed eliminating or reducing reliance on automated location measurements, specifically the ± 3 meter vertical accuracy requirement. Google and Federated Wireless also promote a general lessening of network cell automated and self-surveyed geo-location[2]. These parties argue that standards-free self-reporting is sufficient to protect incumbents and facilitate sharing.

In contrast, the National Association of Broadcasters (NAB) argues oppositely and petitions the Commission to not allow manual-entry "by so-called professional installers".[3] NAB's concern is with assured, trusted and accurate geographic location of in-building CBSDs. NAB argues backed by substantial error rates in TV White Space databases that used manually-entered geodetic data entries[4] that individual and certainly collective inaccuracies will arise and lead to interference problems that are preventable by automated geo-location methods. iPosi concurs.

iPosi asks the Commission maintain its recently adopted Geo-location and Reporting Capability requirement set forth in §96.36 (a) (1).

Further, iPosi agrees that the NAB has raised fair concerns for a promising shared spectrum future. Adequate incumbent protection argues against self-reported locations and reliance on manually entered CBSD site location data. Inaccuracies in user-entered location necessitate real-time verification of these entries by objective, automated, and active means (e.g. GPS).

Those advocating eliminating or lessening location accuracy requirements:

1. Ignore other Commission objectives or mandates – specifically the requirement for determining and delivering accurate 3D indoor location to First Responders from indoor mobile E911 callers;

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[1] iPosi, Inc. is a private technology development company located in Denver and Boulder, Colorado. The company develops next generation, indoor-grade assisted GPS and GNSS embedded technology in the form of digital signal processing and software for various network applications including wireless small cell and access point devices, and enables indoor mobile and IoT location.
[2] *See* Google Response pp 10-15; Federated Response pp 5-11.
[3] NAB Petition for Reconsideration, pp. 5-7.
[4] Reply to Oppositions to Petition for Reconsideration of the National Association of Broadcasters, submitted October 29, 2015, GN Docket Number 12-354.

2. Ignore solutions to use automated methods to ensure accurate, verifiable network CBSD site locations to reasonably protect legacy services from single point and aggregate interference effects.

3. Ignore the fact that as a practical matter, users will frequently move (and add additional) indoor CBSD sites in enterprise built-out spaces. Absent self-reporting by the CBSD, this may create inadequate protection to incumbents.. Ensuring the integrity of site location databases through diligent, automated updating is important to maintain interference-free operation, future scalability, and PAL license values.

Rules that the Commission has adopted in this proceeding will likely be in effect for decades, applying not only to this 150MHz but also to future shared spectrum services. It would disserve the public to promulgate rules based on either expedience or the limits of yesterday's technology.

The Commission's tie between location requirements for 3.5 GHz Shared Spectrum and Indoor E911 is well conceived.

Irrespective of what spectrum band someone uses one should be able to make an E911 call and have their location delivered to public safety Dispatchers and First Responders. Locating the CBSD directly assists determining the caller's mobile location[5].

Locating a fixed CBSD indoors offers much higher yield than locating an indoor mobile user. Wireless carriers are diligently pursuing developments to meet their location mandate for public safety; the Commission has rightly aligned 3.5 GHz to this requirement. Indeed, many CBSD sites will be multi-band, offering Cellular, Wi-Fi and other future bands. These multi-band capable indoor cells will likely have embedded technology to deliver E911 indoor location.

Common requirements spur technical innovation and development

The Commission's indoor E911 proceeding has led to a tremendous amount of technical development in indoor location. Three different technologies were tested in the CSRIC test-bed locations for indoor E911 location, with further trials set for 2016.

Maintaining similar location requirements for both E911 and Shared Spectrum services has benefits beyond public safety. In adopting a common location

[5] iPosi also delivers GNSS-derived location and time synchronization to iPosi-enabled indoor cells. Precise time synchronization enables accurate relative location via OTDOA, which is part of LTE and 5G. The iPosi GNSS-derived location accurately locates the indoor small cell or CBSD on the earth. In the case of E911, iPosi combines the two for delivery to the PSAP. For 3.5 GHz location, iPosi delivers the accurate CBSD 3D location to the SAS.

requirement for both 3.5 GHz and Indoor E911, the Commission recognizes the role indoor small cells positively play in servicing a variety of indoor location demands.

Today, America communicates mostly over two topologically different networks: a largely uncoordinated network of Wi-Fi Access Points with hotspot oriented coverage operating in unlicensed 2.4 and 5.6 GHz bands, and coordinated outdoor microcells operated by carriers in the licensed service bands. 75% of data traffic served by this latter network occurs indoors; similarly, most Wi-Fi traffic is indoors. Shared Spectrum will not replace Wi-Fi or Licensed LTE services – it's a powerful complement. Indoor cells will aggregate a variety of bands; making indoor location requirements consistent will benefit band aggregation.

From the manufacturers' perspective, common radio band and location requirements facilitate scale and platform economies which in turn promotes wide adoption and usage, both keys to commercial success.

Further, wireless communications standards deployed in the 3.5 GHz Band will likely be synchronized following radio access technology trends. Local synchronization has many benefits including significantly lower cost, enhanced spectrum efficiency, improved handover quality, and less aggregate cell interference. LTE, LTE-U, LAA, 5G already require GPS/GNSS-grade synchronization; future 802.11 standards are considering adding inter-cell synchronization. If the CBSD obtains synchronization through GPS means, why should it not also derive location from the same technology?

Trusted, accurate CBSD and related mobile location are both delivered through automated self-surveying technologies

Using just a subset of its technology, iPosi has demonstrated 3D indoor location capability enabling compliance with FCC requirements in a variety of indoor locations, including CSRIC in-building test sites. iPosi embedded technology uses multi-band L1 and L5 GNSS signals and through digital signal processing obtains fix for each indoor cell's precise location. iPosi captures and uses GNSS signals attenuated to as low as -175dB, or 500-1000 times less signal power than detected by the most sensitive GPS receivers.

Using just a single iPosi-enabled cell and using just the L1 signal, iPosi meets the requirements at issue here for most CBSD indoor site locations. Adding the new L5 signal improves accuracy by 2-3 times. Additional capabilities such as iPosi's Cooperative Receiver technology[6] reduce error and improve accuracy a further 2-3

[6] Cooperative receiver solutions enhance accuracy by sharing satellite observable measurements from separately placed cells, for instance over a office building floor plate, or several floor plates.

times[7]. As previously discussed, iPosi is not the only entity creating technologies which aim to fulfill this mandate. Carriers and end-customers expect to have multiple location options from which to choose.

Trusted site location is key. The history of E911 has worked to reduce error and increase speed of response for two decades. For E911, iPosi proposes cells use indoor-capable assisted GNSS to not only locate cells (which in turn locates indoor mobiles), but also use the information to verify manually entered Dispatchable Locations.[8]

There is ample opportunity for error even with good faith manual surveying inside buildings. It is difficult to obtain reliable land survey references and accurate "shoots" of horizontal and vertical measurements to the CBSD site inside. The process takes specialized and skilled technical professionals. The NAB's concern increases in validity commensurate with the success of CBRS. In the long run, accurate, verified, automated, and remotely-retrievable location is key to successful sharing.

We want to be clear. Accurate manual survey techniques will still be needed for cases where automated measurement methods are beyond their capability or performance margin and thus are infeasible for this purpose. Those sites will likely be the most radio-occluded and thus pose inherently the least risk to legacy operations. This manual method is best reserved for those relatively few sites. In these cases, professional installers may survey and register a CBSD site using traditional land surveyor means including use of GPS receivers. It's important to understand that contrary to Google's assertion[9] about accuracy of geo-location registration through accreditation of installers, assuring accurate survey is non-trivial and would require at installation a mix of skills such as a land surveyor, who has professional tools and practices currently not common in the wireless industry. Even this must be used carefully since practical problems can arise where the survey and true site location cannot be reconciled or verified except to physically visit the sites, which raises deployment or maintenance costs.

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[7] iPosi uses this technique to provide GPS-level time synchronization as well as location. Thus, technologies like OTDOA, currently implemented in LTE networks and mobile devices, provide high accuracy position and by precise inter-cell synchronization assure high quality mobile hand-offs.

[8] These two independent data are then correlated through automated GIS databases for ready retrieval from a public safety E911 NEAD database for First Responder purposes. The civil address data once correlated, thus verified can also serve interference prevention and mitigation purposes at 3.5 GHz.

[9] Google Response p. 10.

Accurate and automated location of CBSDs offers the best incumbent protection and assures highest spectrum re-use as shared operations grow

The 3.5 GHz Band is shared on many levels: Incumbent with Citizen Broadband, PAL to PAL, GAA to PAL, GAA to GAA, etc. Knowing with accuracy where the CBSDs are located is critical for the SAS to ensure spectrum-efficient sharing. iPosi asserts that accurate location and mapping a CBSD's propagation are the best and most reliable ways to facilitate sharing. Without these, the Commission will either leave the Band grossly underutilized or subject incumbents (including 3.5 GHz PALs) to adverse, service-affecting interference.

In its response, Google reported non-interfering WISP deployments within 10 kilometers of an FSS station[10]. WISP and CBSD radio propagation are highly variable depending on among other factors such as station heights, antenna gain patterns, earth station antenna look-angle in relation to the directions of surrounding small cell transmissions, not to mention a myriad of radio visibility, reflection and atmospheric propagation factors.

We agree in general with Google that indoor devices "pose a comparatively lower risk of interference to protected operations"[11] but the variability in RF containment loss precludes any regulation by inference. Indoor transmissions present highly variable propagation losses. The indoor loss factor with respect to an outdoor legacy receiver can be as little as 2dB or as much as 60dB over a range of RF signal containments or building materials attenuation factors[12]. That range of loss attenuation is significant to managing coordination, expected path loss, and thus prospect of interference as sharing grows across the dense urban landscape.

For example, a CBSD by a non-tinted upper-floor window may experience low loss whereas a CBSD at a lower floor interior office with a conventional concrete-window shell building may attenuate signals 50 or 60dB. At the latter limits, the CBSD is very radio-occluded and would be able to share spectrum without interference.

Indeed a CBSD on the South side of the 10th floor of an office building may present no interference to naval or maritime radar or to a FSS, but an identical CBSD sited and operating on the opposite side even lower elevation might. While accurate 3D location is critical, iPosi also offers an additional feature to increase spectrum

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[10] Google Response p. 4

[11] Google Response, p.13

[12] For further reference see "NIST Construction Automation Program Report No. 3 Electromagnetic Signal Attenuation in Construction Materials", Report # NISTIR 6055, 1997, US National Institute of Standards and Technology, retrieved at http://fire.nist.gov/bfrlpubs/build97/PDF/b97123.pdf

sharing. The iPosi self-surveying solution also has the ability to determine the propagation pattern and range of individual indoor CBSD cell transmissions in situ.

An iPosi-enabled cell captures GNSS signals from dozens of satellites as they traverse the sky, measuring building penetration loss contours by comparing known outside with recovered indoor signal levels as RF passes through the building to the indoor CBSD cell. Signals propagation are essentially straight-line and ingress-egress symmetries are close enough to estimate CBSD radio containment. That is done by applying loss factors in the inverse direction[13] of this collection constitutes the propagation map of that small cell.[14] This data, about 800-2400 bytes per cell, can be transferred to the SAS to condition radio operating parameters. It can be continuously updated to ensure that environmental changes are managed to prevent interference with incumbents or other CBRS operations.

Conclusion

The Commission is right to require automated as well as accurate 3D location such as GPS for CBSDs. The Commission is right to make that accuracy requirement similar to prevailing indoor location requirements for indoor E911. Too much variability exists to hope that indoor to outdoor propagation will categorically eliminate legacy service interference concerns. In fact, indoor CBSD points situated at mid to and high floors can impact legacy operations due to unobstructed radiated paths. Too many opportunities exist for survey and registration errors. Further, the lack of ready remote verification of correct CBSD site position exist with manual self-reporting schemes. As reviewed here, GPS/GNSS offers a ready, remotely access method to verify CBSD site position to ensure high compatibility operations with respect to FSS and radar services.

Respectfully submitted,

Richard Lee
Ira Barron

[13] Along with other factors such as the CBSD antenna gain pattern
[14] After adjusting for propagation differences between 1.6 GHz and 3.5 GHz.