Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Review of the Commission's Rules Governing the 896-901/935-940 MHz Band	)	WT Docket No. 17-200
	)	
Realignment of the 896-901/935-940 MHz Band to Create a Private Enterprise Broadband Allocation	)	RM-11738 (Terminated)
	)	
Amendment of the Commission's Rules to Allow for Specialized Mobile Radio Services Over 900 MHz Business/Industrial Land Transportation Frequencies	)	RM-11755 (Terminated)

COMMENTS OF SENSUS USA INC.

Sensus USA Inc. ("Sensus") respectfully submits these comments in response to the Commission's Notice of Inquiry ("*NOI*") in the above-referenced proceeding.[1]

I. INTRODUCTION.

Sensus designs, manufactures, and sells solutions that help critical infrastructure companies, particularly electric, gas and water distribution utilities, better and more safely monitor, manage, and control their infrastructure. As discussed in Section II below, Sensus's systems operate in the licensed narrowband PCS ("NPCS") spectrum at 901-902/940-941 MHz, which is adjacent to the 896-901/935-940 MHz ("900 MHz") band. In a separate but related proceeding, Sensus has submitted extensive comments and other filings opposing the proposal of the Enterprise Wireless Alliance and pdvWireless, Inc. (the "PDV Proposal") to create a private enterprise broadband allocation in the 900 MHz band, due to the interference any such

[1] *Review of the Commission's Rules Governing the 896-901/935-940 MHz Band*, Notice of Inquiry, 32 FCC Rcd 6421 (2017).

broadband allocation would cause to adjacent band and in-band operations.[2] All of those submissions are incorporated herein by reference.[3]

The Commission should not move forward, or should at least proceed cautiously, on any proposals in the instant proceeding to permit broadband operations in the 900 MHz band. Such operations would pose a risk of harmful interference to critical infrastructure industry ("CII") operations in the adjacent NPCS spectrum, as well as in the 900 MHz band. Proponents of broadband operations at 900 MHz bear the burden of showing that such interference can and will be prevented. To date, they have not done so.

The Commission must also carefully weigh the costs of destabilizing CII operations against the benefit of creating a relatively small amount of broadband spectrum at 900 MHz. The near-unanimous opposition to the PDV Proposal confirms that the benefits of any such proposal are overwhelmingly outweighed by its costs. Moreover, a significant number of NPCS users are utilities that distribute electric power, natural gas and/or water to residences and businesses – quintessential CII services. The licensed NPCS spectrum provides connectivity for these utilities, particularly in rural areas where fiber is not a cost-effective option. Conversely,

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[2] *See* Petition for Rulemaking of the Enterprise Wireless Alliance and Pacific DataVision, Inc., RM-11738 (filed Dec. 8, 2014). In the *NOI*, the Commission once again seeks comment on the PDV Proposal. *NOI*, 32 FCC Rcd at 6425-27 ¶¶ 12-14, 6428 ¶ 18.

[3] *See* Letter from Julian P. Gehman, Counsel for Sensus USA Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, RM-11738 (filed Aug. 10, 2015); Letter from Julian P. Gehman, Counsel for Sensus USA Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, RM-11738 (filed July 28, 2015); Reply Comments of Sensus USA Inc. in Response to Public Notice Dated May 13, 2015, RM-11738 (filed July 14, 2015); Comments of Sensus USA Inc. in Response to Public Notice Dated May 13, 2015, RM-11738 (filed June 29, 2015) ("Sensus Comments"); Letter from Julian P. Gehman, Counsel for Sensus USA Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, RM-11738 (Mar. 10, 2015); Reply Comments of Sensus USA Inc., RM-11738 (filed Jan. 27, 2015); Comments of Sensus USA Inc., RM-11738 (filed Jan. 12, 2015).

the benefit of facilitating broadband capability in the 900 MHz band is mitigated by significant financial, logistical and interference concerns.

Should the Commission nevertheless decide to make changes to the 900 MHz band framework, it must fully protect adjacent band users from harmful interference. Any such changes must be based on realistic technical assumptions drawn from empirical evidence, not speculation, and must recognize the unique needs and associated interference vulnerabilities of CII providers in adjacent spectrum. As Sensus has previously demonstrated on the record, earlier proposals for such rules are inadequate and would result in significant and costly interference to neighboring spectrum holders.

II. BACKGROUND.

Sensus uses an innovative and distinctive network communications technology called FlexNet that operates in adjacent NPCS spectrum to provide utility customers with secure and reliable connectivity solutions that support multiple applications, including advanced metering infrastructure, distribution automation and monitoring, demand response, and equipment monitoring and control, among others. The Sensus FlexNet radio system allows users to: read end user meters and report on usage or trouble at the end point residence or business; send alerts of outages, surges, imbalances, or other emergencies occurring in a utility's network, including detection of leaks for water utilities; and enable end users to manage electrical, natural gas, or water usage. Many of these applications, such as, for example, outage reporting, demand response, and service disconnection and reconnection, rely on near real time communications that would be directly impacted by interference.

Sensus's subsidiary Sensus Spectrum, LLC holds a number of (effectively) nationwide NPCS licenses, from which it leases spectrum to customers for operation of FlexNet radio

systems in their respective service areas.[4] Sensus presently has approximately 1200 customers that operate FlexNet systems in the NPCS spectrum, most of which are electric, natural gas and water utilities. There are more than 15 million FlexNet endpoints operating on NPCS channels throughout the continental United States.[5] Accordingly, Sensus and its FlexNet customers would be directly affected by broadband operations in the 900 MHz band. Sensus and others have already shown that such broadband operations would cause unacceptable adjacent channel interference in the context of the PDV Proposal.[6] The same interference risks must be considered under all of the approaches proposed in the *NOI* for permitting broadband operations in the 900 MHz band.

III. BROADBAND OPERATIONS IN THE 900 MHZ BAND WOULD CAUSE HARMFUL INTERFERENCE TO USERS IN ADJACENT SPECTRUM.

A. The Record Already Demonstrates That the PDV Proposal is Not Feasible.

Sensus has previously and conclusively demonstrated that the PDV Proposal is deeply flawed and incomplete, and does not merit further consideration by the Commission. PDV requested that the Commission realign the 900 MHz band into a 3 x 3 megahertz broadband segment for Private Enterprise Broadband or "PEBB" licensees at 898-901/937-940 MHz, and a 2 x 2 megahertz narrowband segment for B/ILT and SMR operations 896-898/935-937 MHz. [7]

[4] Sensus and Sensus Spectrum LLC are wholly-owned subsidiaries of Xylem Inc., a leading global water technology company.

[5] Sensus Spectrum also holds approximately 600 Multiple Address System ("MAS") licenses in the 928/959 and 932/941 MHz bands. Approximately 1200 Sensus customers operate FlexNet systems in the MAS spectrum.

[6] *NOI*, 32 FCC Rcd at 6425-27 ¶¶ 12-14, 6428 ¶ 18.

[7] *Id.* at 6425-26 ¶ 12.

Under PDV's proposal, the broadband segment of the 900 MHz band would be immediately adjacent to the narrowband PCS allocation at 901-902/940-941 MHz.

In its comments opposing the PDV Proposal (the "Sensus Comments"),[8] supplemented by an extensive technical study by its consultant, Real Wireless Ltd. (the "Real Wireless Study"),[9] Sensus demonstrated that the PDV Proposal would cause harmful interference to adjacent channel NPCS operations.[10] In short, the Real Wireless Study found that many of the assumptions underlying the PDV Proposal were either unrealistic or unsupportable, and that the proposal presented an overly optimistic interference case that has a low probability of occurring in a purely mobile deployment and a nearly zero probability of occurring with substantial machine-to-machine traffic.[11] In addition, the Real Wireless Study found that, among other things, the PDV Proposal significantly understated out of band emissions ("OOBE"), misstated the noise floor at which FlexNet systems operate, and in many cases used inappropriate calculation parameters that produced inaccurate results.[12] PDV's response failed to demonstrate that Sensus's concerns were not technically correct or well founded.[13]

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[8] *See* Sensus Comments.

[9] *Id.* at Exhibit 1.

[10] To ensure inclusion of those submissions in the record for the *NOI*, the Sensus Comments (including the Real Wireless Study and all other supporting exhibit material) are attached to these comments as Attachment 1.

[11] Sensus Comments at 9, 11-12.

[12] *Id.* at 12-14; *see also* Real Wireless Study at 3.

[13] *See* Reply Comments of the Enterprise Wireless Alliance and Pacific Datavision, Inc., RM-11738 (filed July 14, 2015).

Ultimately, regardless of whether the Commission proposes to permit 900 MHz broadband operations via a 3 x 3 megahertz broadband segment,[14] a 5 x 5 megahertz broadband channel,[15] or greater operational flexibility under the existing 900 MHz licensing framework,[16] the underlying technical issue remains the same: broadband operations at 900 MHz will cause harmful interference to adjacent NPCS operations unless the Commission's technical rules protect NPCS users. To date, no such rules have been presented to the Commission.

B. The Commission Must Recognize the Near-Unanimous Opposition to the PDV Proposal.

Nearly every party who filed comments on the PDV Proposal opposed it, and many opposed the proposal due to concerns over the interference broadband users will cause to incumbent systems.[17] For example, Southern Company, a major FlexNet user, stated that "[t]he Petitioners have failed to demonstrate how broadband PEBB systems could operate in the Part 90 land mobile allocation without causing harmful interference to Southern's AMI system in the

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[14] *NOI*, 32 FCC Rcd at 6430 ¶ 27.

[15] *Id.* at 6430 ¶ 28.

[16] *Id.* at 6428-30 ¶¶ 19-25.

[17] *See, e.g.*, Comments of American Association of Railroads, RM-11738, at 2 (filed June 29, 2015) ("AAR Comments"); Comments of American Petroleum Institute, RM-11738, at 9 (filed June 29, 2015) ("API Comments"); Comments of the Ad Hoc Refiners Group, RM-11738, at 4 (filed June 29, 2015); Comments of The Salt River Agricultural Improvement and Power District, RM-11738 (filed Jan.12, 2015); Comments of Duke Energy Corporation, RM-11738, at 6 (filed June 29, 2015); Comments of Lower Colorado River Authority, RM-11738, at 4-6 (filed June 29, 2015). *See also* Reply Comments of Southern Company Services, Inc. on Supplement to Petition for Rulemaking, RM-11738, at 1-2 (filed July 14, 2015) ("With one notable exception, all of the commenting parties – representing the licensees and users of hundreds of radio systems serving millions of end point devices in the affected frequency bands – were in agreement with Southern that the Petitioners have not demonstrated how a "Private Enterprise Broadband" ("PEBB") system could be operated without significant potential for harmful interference to licensees in adjacent frequency bands. Aside from PDV's technology partner, Motorola, none of the commenting parties sees any need to open a rulemaking on this proposal.") ("Southern Reply Comments").

adjacent NPCS band."[18] PECO Energy Company, another significant FlexNet user, opposed the proposal because "Petitioners may have underestimated the amount of interference they may cause to [adjacent-channel] operations of PECO."[19] Similarly, the Sensus Partners and Advisors Network ("SPAN"), a membership user group comprised of utilities using FlexNet, opposed the proposal over fears of OOBE.[20]

Moreover, concerns about OOBE and interference protection levels were not just limited to licensees outside the 900 MHz band – other parties with interests within the 900 MHz band expressed the same concerns. The American Petroleum Institute, for instance, observed that "[w]ithout real world engineering it is impossible to determine whether Petitioners' proposals adequately protect narrowband systems. A proof of concept or pilot program demonstrating the interference potential of Petitioners' proposed deployment would be useful to collect data to develop proposed rules."[21] Likewise, the American Association of Railroads stated that "it is not inclined to support the proposal because of its continued concerns regarding the potential interference from the proposed PEBB service to adjacent-band operations . . . ."[22] Similarly,

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[18] Comments of Southern Company, RM-11738, at 8 (filed June 29, 2015); *see also id.* (citing petitioners' "cavalier" attitude towards interference).

[19] Comments of PECO Energy Company, RM-11738, at 4 (filed June 29, 2015) ("PECO Comments").

[20] Comments of Sensus Partners and Advisors Network, RM-11738, at 3 (filed June 29, 2015) ("SPAN Comments") ("SPAN understands that the LTE system proposed by Petitioners would throw off a significant amount of out of band emissions (OOBE) . . . SPAN further understands that this much noise power would seriously degrade affected FlexNet systems, resulting in a loss of more than 70 per cent of the message traffic. Loss of traffic of this magnitude would effectively render the FlexNet system unusable for the duration of the interference.").

[21] API Comments at 8.

[22] AAR Comments at 1.

Harris Corporation noted that the proposal "significantly puts into jeopardy expansion of existing operational 900 MHz systems."[23]

These near-unanimous opposing comments confirm that introduction of broadband service will cause unacceptable adjacent channel interference. The substantial evidence and argument on record regarding this interference has not been rebutted by any proponent of the 900 MHz rebanding. This is true with respect to both the PDV Proposal and other proposals in the *NOI* that are based on similar technical concepts.

C. Adjacent Channel Interference to NPCS Users from 900 MHz Broadband Operations Would Impose Substantial Costs but Yield Virtually No Public Interest Benefits.

Harmful adjacent channel interference to users of the NPCS spectrum will impose high costs on CII providers.[24] In some cases the effects could be calamitous. As described by SPAN:

> From a public safety perspective, loss of distribution management and outage alarm functions would be particularly troubling. FlexNet helps to warn of overloads or imbalances in the distribution network, thereby facilitating corrective action by the utility before an imbalance becomes something more serious. Similarly, prompt alarm notification of an electric outage, or gas or water leak . . . helps to protect the public. Reliance on the old fashioned way of outage notification (phone call from a customer, or the police or fire department) could have potentially disastrous consequences.[25]

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[23] Comments of Harris Corporation, RM-11738, at 5 (filed June 29, 2015). *See also* Comments of NextEra Energy, RM-11738, at 3-4 (filed June 29, 2015); Comments of Eversource Energy, RM-11738, at 3 (filed June 29, 2015).

[24] *See, e.g.*, PECO Comments at 4 ("As a CII entity, PECO requires the highest level of protection from harmful interference for reliable communication based monitoring and control for its distribution grid. If PECO's radio system experiences harmful interference, this could reduce the safety and security of its operations and may require PECO to add additional infrastructure, at a substantial cost, in order to maintain the same level of service.").

[25] SPAN Comments at 4. *See also* Sensus Comments at 18 ("[U]tilities have turned to FlexNet systems for critical utility functions, including outage and dangerous condition alarms, and network management and distribution automation functions. Utilities, customers and regulators rely on FlexNet to continue providing these functions.").

At the same time, the benefits of accommodating broadband operations at 900 MHz are speculative at best. Under the PDV Proposal, for example, broadband users would be limited to a 3 x 3 megahertz swath of spectrum, and even that amount would be held by one party, pdvWireless. The remaining 2 x 2 megahertz narrowband segment would not be fully available, as a guard band between the broadband and narrowband segments will be necessary to avoid harmful interference.

Moreover, to the extent pdvWireless intends to provide service to CII providers, any corresponding benefit is diminished by the fact that many other broadband solutions are or will soon be available to CII providers, including FirstNet and other commercial offerings.[26] And, in response to the PDV Proposal's requirement that the broadband licensee offer "build to suit" broadband solutions to any requesting B/ILT entity,[27] nearly every party that commented on the PDV Proposal expressed no interest in pdvWireless's proposed broadband service at 900 MHz.[28] Upending the 900 MHz band to accommodate broadband thus appears to be a solution in search of a problem, particularly as 900 MHz incumbents are willing to make significant investments to upgrade and enhance their facilities under the *existing* 900 MHz rules.[29]

Finally, it is impossible for the Commission to conduct a meaningful cost-benefit analysis unless and until *all* the costs of repurposing the 900 MHz band are fully known. The Critical Infrastructure Coalition has already warned the Commission that the PDV Proposal understates

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[26] *See* Letter from Bryan N. Tramont, Counsel to NextEra Energy, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, RM-11738, Attachment 1 at 4 (filed Apr. 29, 2016) ("NextEra Letter").

[27] *NOI*, 32 FCC Rcd at 6427 ¶ 13.

[28] *See* Southern Reply Comments at 2.

[29] *See* NextEra Letter, Attachment 1 at 3.

relocation costs significantly: "PDV's proposed technical rules would effectively prevent incumbent users from restoring the current functionality of their systems. The true cost of PDV's proposal therefore far exceeds estimated relocation and increased operational costs."[30] Accordingly, even if the benefits of repurposing the 900 MHz band for broadband were more substantial, it is dubious whether they could justify the enormous costs of relocating 900 MHz incumbents to comparable facilities, if such facilities exist.

IV. CONCLUSION.

For the foregoing reasons, Sensus respectfully urges the Commission not to move forward, or to at least proceed cautiously, with any proposals to permit broadband operations in the 900 MHz band. Should the Commission move forward, it must ensure that any changes to the 900 MHz framework fully protect adjacent channel operations from harmful interference.

Respectfully submitted,

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/s/ David Alban

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October 2, 2017

[30] Letter from Bryan N. Tramont, Counsel to NextEra Energy, to Marlene H. Dortch, Secretary, Federal Communications Commission, RM-11738, Attachment B at 6 (filed June 22, 2016).

ATTACHMENT 1

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Petition for Rulemaking of	)	RM-11738
The Enterprise Wireless Alliance	)	
And Pacific DataVision, Inc.	)	
	)	
Realignment of the	)	
896-901/935-940 MHz Band	)	
to Create a Private Enterprise	)	
Broadband Allocation	)	

To: Chief, Wireless Telecommunications Bureau

COMMENTS OF SENSUS USA INC.
IN RESPONSE TO PUBLIC NOTICE DATED MAY 13, 2015

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TABLE OF CONTENTS

SUMMARY

Sensus' FlexNet™ systems operate over narrowband PCS (NPCS) frequencies at 901/940 MHz, immediately adjacent to the broadband allocation suggested by Petitioners. More than 800 electric, natural gas and water utilities operate FlexNet™ systems over NPCS frequencies. These utilities use FlexNet™ for advanced metering infrastructure and smart grid applications, including: automatic metering, alarms and outage management, demand response, SCADA and distribution automation, voltage regulation, and street lighting control.

Many of the above operations require real time data with no interruption. Public safety could be endangered if harmful interference were to delay a FlexNet™ outage or overload alarm. Utilities rely on FlexNet™ to manage their distribution networks in real time; loss of real-time network management function would harm service to the public.

More than 15 million FlexNet™ endpoints are operating on NPCS channels throughout the continental United States. That number will rise substantially, as Sensus has a large order book (one customer alone is deploying two million additional endpoints), and Sensus continues to add new FlexNet™ customers every month.

Petitioners' Suggested Rules would allow widespread harmful interference to FlexNet™ systems, thereby endangering these critical infrastructure industry (CII) operations. FlexNet™ systems have experienced isolated instances of harmful interference from substantially less noise than what would be permitted under the Suggested Rules. Two incidents cited in these comments (including one where the Enforcement Bureau intervened), demonstrate that FlexNet™ systems suffered harmful

interference from OOBE of approximately ***one one hundredth*** (1/100) the noise power that Petitioners' Suggested Rules would allow.

Petitioners presented to the Commission their own LTE-to-FlexNet™ coexistence model, on which Petitioners based their conclusions that their proposed OOBE limits would protect FlexNet™ users. However, Sensus' technical experts, Real Wireless, Ltd, found that Petitioners used ten questionable or unsupportable assumptions. For example, Petitioners assumed that only one handheld LTE device would be operating at a time when, more realistically, three or four could be operating simultaneously. Real Wireless used more realistic assumptions and found that Petitioners significantly understated OOBE. For the uplink scenario (LTE user equipment interferes with FlexNet™ base station), Petitioners understated OOBE by at least 27 dB under a moderate interference case and 54 dB under a challenging interference case. Petitioners similarly understated interference for the downlink scenario. Further, Petitioners' model assumes that its LTE system would be used exclusively for mobile service (where units move around and briefly interfere) and ignores machine-to-machine traffic causing non-stop interference.

FlexNet™ users have a reliance interest in the continued use of their licensed frequencies, originally purchased at auction, operating with the noise floor the same as it has been for the last ten years. In reliance on their exclusive use licenses and low OOBE from the narrowband channel, FlexNet™ users have invested over one billion dollars in FlexNet™ systems on which they depend for critical utility functions. Sprint Nextel's iDEN systems (with 23 million subscribers) operated on the adjacent narrowband channels up until a year or two ago. With millions of subscribers packed onto a relatively small number of narrowband land mobile channels, iDEN phones had to be designed with

tight protection for OOBE to prevent intra-system interference. While using the 900 MHz Part 90 spectrum for its allocated purpose – narrowband land mobile – Sprint Nextel successfully co-existed with adjacent band licensees, including FlexNet™ users, in the NPCS band.

Now, Petitioners propose a dramatic change in the OOBE profile for the Part 90 narrowband land mobile spectrum. The actual change in OOBE is much larger than would be suggested by simply comparing the Petitioner's suggested emission mask to the Part 90 emission mask: the economics of commercial narrowband land mobile service required Sprint Nextel to use equipment with tighter emissions than required by Part 90 rules.

Before reallocating spectrum for flexible use, the Commission must find that it will not result in harmful interference. However, the Commission cannot make this finding here. Petitioners have the burden to adequately demonstrate that their broadband service – both mobile and fixed – can be provided on this narrowband Part 90 land mobile spectrum without harmful interference to adjacent band users. Unless and until Petitioners meet this burden, which they have not done, the Commission should decline to revisit existing rules or initiate a rulemaking proceeding.

The Suggested Rules would confiscate Auctioned SMR licenses in six MTAs, with no compensation for the value of these licenses, and no opportunity for the licensees to object or negotiate. This gives the appearance of a spectrum grab.

When it sought wideband authorization, Sprint Nextel proposed realistic measures that far exceeded Part 90 rules and that addressed adjacent narrowband channel concerns. Petitioners could help their case in this proceeding by following that precedent. Here,

such measures would include emission limitations at the band edge that fully protect against interference to FlexNet™ systems, as well as more effective and timely harmful interference mitigation procedures.

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In the Matter of	)	
	)	
Petition for Rulemaking of The Enterprise Wireless Alliance And Pacific DataVision, Inc.	)))	RM-11738
	)	
Realignment of the 896-901/935-940 MHz Band to Create a Private Enterprise Broadband Allocation	))))	

To: Chief, Wireless Telecommunications Bureau

COMMENTS OF SENSUS USA INC.
IN RESPONSE TO PUBLIC NOTICE DATED MAY 13, 2015

Sensus USA Inc., through counsel, hereby responds to the Public Notice of the Wireless Telecommunications Bureau.[1] The Public Notice solicits comments on the submission of suggested rules, dated May 3, 2015, by The Enterprise Wireless Alliance and Pacific DataVision, Inc. ("PDV") (together, the "Petitioners") in the captioned proceeding.

I. INTRODUCTION

On November 14, 2014, Petitioners submitted a Petition for Rule Making (the "Petition") urging realignment and reallocation to broadband of the 896-901/935-940 MHz Band, including a so-called Private Enterprise Broadband (PEBB) license in each

[1] Wireless Telecommunications Bureau Seeks Comment on Supplement to Enterprise Wireless Alliance and Pacific DataVision, Inc. Petition for Rulemaking Regarding Realignment of 900 MHZ Spectrum, *Public Notice*, RM-11738, 29 FCC Rcd 14424, DA 15-157 (May 13, 2015).

market.[2] The Petitioners' most recent submission, dated May 3, 2015, transmitted their suggested rules for the requested spectrum reallocation (the "Suggested Rules").[3]

Sensus opposes Petitioners' Suggested Rules because Petitioners have failed to demonstrate that the rules would prevent PEBB systems from causing significant harmful interference to adjacent-channel operations of critical infrastructure industries (CII). In fact, evidence discussed below establishes that significant harmful interference **will** result if the Suggested Rules are adopted.

A. Interest of Sensus

As described in its initial Comments in this proceeding, Sensus designs, manufactures, installs, operates and services its FlexNet™ system for advanced metering infrastructure (AMI) and smart grid applications.[4] Sensus and other FlexNet™ users hold Narrowband PCS (NPCS) licenses at 901/940 MHz, immediately adjacent to the Petitioners' proposed PEBB allocation. FlexNet™ users are utilities that distribute electric power, natural gas and/or water to residences and businesses. These are quintessential CII services. One of the advantages of FlexNet™ is that it facilitates development and use of smart grid functionality by utilities, large or small, including those operating in rural areas.

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[2] Petition for Rulemaking of the Enterprise Wireless Alliance and Pacific DataVision, Inc., filed Nov. 17, 2014.

[3] Realignment of the 896-901/935-940 MHz Band to Create a Private Enterprise Broadband Allocation, Petition for Rulemaking of the Enterprise Wireless Alliance and Pacific DataVision, Inc., RM-11738, Proposed Rules, filed May 3, 2015.

[4] Comments of Sensus USA Inc. 3, filed January 12, 2015.

More than 800 electric, natural gas and water utilities operate FlexNet™ systems over NPCS frequencies. These utilities use FlexNet™ for advanced metering infrastructure and smart grid applications, including: automatic metering, alarms and outage management, demand response, SCADA and distribution automation, voltage regulation, and street lighting control.

Although FlexNet™ sends repeat messages for meter reading, many of the above operations require real time data with no interruption. For example, public safety could be endangered if harmful interference were to delay a FlexNet™ outage notification or overload alarm. Similarly, utilities rely on FlexNet™ to manage their distribution networks in real time. Repeat messaging cannot be relied on for alarm or network management functions.

More than 15 million FlexNet™ endpoints are operating on NPCS channels throughout the continental United States. That number will rise substantially, as Sensus has a large order book (one customer alone is deploying two million endpoints), and Sensus continues to add new FlexNet™ customers every month.

FlexNet™ is a unique, innovative fixed communications network that is not designed or operated like a narrowband land mobile radio system. A FlexNet™ system is a critical machine-to-machine network. It requires highly reliable fixed communications links to (often difficult to reach) static locations. The design of a FlexNet system cannot be based on the statistics of mobility to overcome coverage deficiencies.

FlexNet™ endpoints transmit at up to 1.4 watts ERP. FlexNet™ systems transmit at relatively low power in exclusively-licensed spectrum that is generally interference-free, thereby conserving spectrum and allowing utilities to deliver services to large and/or

remote service territories with less infrastructure. Utilizing lower power conserves spectrum by permitting more FlexNet™ systems to operate within a given geographic area over the same frequencies. This is consistent with the mandate of the Communications Act of 1934, as amended, that radio stations "shall use the minimum amount of power necessary to carry out the communication desired."[5]

In the United States, FlexNet™ operates at 900 MHz over 50 kHz X 50 kHz channels. FlexNet™ subdivides this spectrum and internally assigns channel widths of between 1.6 kHz and 25 kHz, depending on the specific functions needed by the utility. FlexNet™ receivers automatically adjust to the bandwidth of the desired signal and do not "look into" the adjacent channel. In other words, this is different from the GPS/LightSquared situation, where GPS receivers looked into the licensed spectrum of LightSquared: FlexNet™ successfully coexisted with millions of iDEN subscribers in the immediately adjacent channels. FlexNet™ delivers smart grid applications to CII entities[6] over a fraction of the spectrum that the proposed PEBB band would occupy. For these reasons, FlexNet™ is very different from the broadband, higher power LTE system that Petitioners now propose to operate in the adjacent band.

B. The Suggested Rules Are Not Ripe For An NPRM

The Commission has authority to allocate spectrum for "flexibility of use" where it finds, after notice and opportunity to comment, that the proposed allocation "would not

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[5] 47 U.S.C. § 324 (2015).

[6] These are the same entities that PDV intends to target and deploy local LTE systems upon request by the CII customer.

result in harmful interference among users."[7] The Commission's rules define "harmful interference" as "[i]nterference that . . . seriously degrades, obstructs or repeatedly interrupts a radio communications service."[8] Consistent with the language of this rule, in making a harmful interference determination, the Commission has focused on whether the interference complained of is perceptible to, or noticed by, the users.[9]

Operation of an LTE system under the Suggested Rules has the potential to seriously obstruct FlexNet™ operations, resulting in harmful interference to FlexNet™ users. As described in greater detail below, in the field, FlexNet™ systems have experienced harmful interference from receiving less than ***one one hundredth*** (1/100) the noise that the Suggested Rules would allow. In one case where the harmful interference

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[7] 47 U.S.C. § 303(y) (2015). Petitioners' Suggested Rule Section 90.1415 describes a flexible use arrangement, triggering the requirements of Section 303(y) of the Communications Act of 1934, as amended. Neither Congress nor the Commission appears to have defined the term "flexibility of use." In its 1999 Spectrum Policy Statement, the Commission gave examples of flexibility with respect to spectrum allocation: "Flexibility can be permitted through the use of relaxed service rules, which would allow licensees greater freedom in determining the specific services to be offered. Another way is to allow flexibility in use of spectrum is to allow licensees to negotiate among themselves arrangements for avoiding interference . . .." *In the Matter of Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millenium*, Policy Statement, 14 FCC Rcd 19868, 19870 (Nov 22, 1999). Petitioners' proposed rule 90.1415 would establish the PEBB Licensee as a sort of band manager. The PEBB Licensee would negotiate with CII entities and others to do "build to suit" systems of as yet indeterminate type or use, with flexible ownership, operating and licensing arrangements, to be negotiated by the parties (proposed rule 90.1415(a)(3)), and a sliding scale of priority of access to spectrum among potential users (proposed rule 90.1415(b)). Under this arrangement, the Commission would not "[p]rescribe the nature of service to be rendered by each class of licensed stations and each station within any class." *See* 47 U.S.C. § 303(b) (2015). Thus, the Commission's authority to make the proposed spectrum allocation would derive from Section 303(y) and its attendant requirement of making certain findings, and not from the more general authority of Section 303(b). Nevertheless, even if proceeding under Section 303(b), the Commission would need to make the same finding of no harmful interference, in fulfillment of the agency's general mission of regulating to prevent harmful interference.

[8] 47 C.F.R. § 1.907 (2015).

[9] *See, e.g., Northpoint Tech., Ltd. v. FCC,* 414 F.3d 61, 68-69 (D.C. Cir. 2005) (affirming FCC standard for harmful interference: whether DBS subscribers would notice the interference).

disrupted ongoing FlexNet™ operations, it resulted in loss of 70% of message traffic at affected FlexNet™ base stations.[10] Clearly, this is interference that is perceptible to and noticed by FlexNet™ users.

Given that Petitioners' proposal could result in the loss of 70% or more of message traffic on FlexNet systems as a result of disruptions caused by out of band emissions (OOBE), it is clear that operation of PEBB systems would create harmful interference, and therefore the Commission would lack authority to promulgate the Suggested Rules.

II. THE SUGGESTED RULES WOULD ALLOW HARMFUL INTERFERENCE

Operation of an LTE system under the Suggested Rules has a significant potential to cause harmful interference because: (1) the Suggested Rules would allow significant adjacent-channel interference to FlexNet™ systems, and (2) this interference would seriously degrade and interrupt FlexNet™ radio communications thereby constituting harmful interference. Each of these points is reviewed in turn below.

A. The Suggested Rules Would Allow Significant Adjacent-Channel Interference

Depending on the assumptions used, operation of an LTE system under the Suggested Rules are predicted to put significant amounts of power into FlexNet™ receivers. As described in the next section, even at the low end of the projected OOBE range, this amount of noise is proven to cause harmful interference.

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[10] Given that FlexNet™ SLAs require a 98.5% to 99.9% message delivery rate (*infra*, n23), within the stated time period, loss of most of the traffic at a single base station would cause the entire FlexNet™ system for a utility to breach the SLA.

1. Method of calculating noise

Petitioners have presented no evidence of laboratory or field testing of how their intended operations would impact FlexNet™ receivers in the adjacent NPCS bands. Therefore, the methodology and assumptions used to project the amount of noise becomes critical. Generally, there are three parts to these calculations:

1. The emission mask and other technical specifications intended to limit noise entering the licensed spectrum of FlexNet™ users from the proposed PEBB. Petitioners suggested an emission mask consisting of attenuation of 55+10log(P) dB relative to the in-band transmit power in a 30 kHz band segment. This translates into -70 dBm/Hz ERP of power emitted into the frequencies used by FlexNet™.[11]

2. The coexistence model used to project the strength and type of LTE signals reaching FlexNet™ receivers. In other words, starting with the -70 dBm/Hz ERP entering the FlexNet™ frequencies, how much power is left over to hit the FlexNet™ receivers once the signal dissipates through free space loss and other factors? Sensus and Petitioners agree on the overall structure of the model but do not agree on key assumptions. On the uplink (LTE UE to FlexNet™ base station), Petitioners told the FCC that no more than -168 dBm/Hz would hit FlexNet™ receivers, while Real Wireless more realistically projects -139 dBm/Hz under a moderate interference case, and -

[11] Suggested Rule § 90.1419 does not specify whether the limit would apply on an ERP or EIRP basis. The analysis presented herein assumes ERP. If in fact the limit were intended on an EIRP basis, it would increase interference by approximately 2 dBm/Hz.

114 dBm/Hz under a challenging interference case.[12] On the downlink (LTE base station to FlexNet™ UE), Real Wireless projects -147 dBm/Hz for the moderate interference case and -138 dBm/Hz for the challenging case.[13]

3. The <u>protection level</u> to which noise from the LTE system should be attenuated in the NPCS band so that FlexNet™ systems can continue to perform their mission without interruption or degradation. Citing ambiguous studies, Petitioners claim that FlexNet™ systems should be protected only to -160.5 dBm/Hz. By contrast, FlexNet™ users' ten years of experience with actual noise floors indicates the protection level should be -168 dBm/Hz for a moderate interference case and -170 dBm/Hz for a challenging interference case.

The coexistence model and protection level are discussed below.

2. Coexistence model and assumptions

Petitioners developed a spreadsheet-based, LTE-to-FlexNet™ coexistence model and presented the high level conclusion of that model to the Commission in claiming to protect FlexNet™ users.[14] As noted, based on their model, Petitioners told the Commission that no more than -168 dBm/Hz would hit the FlexNet™ receivers. But is

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[12] Real Wireless' moderate and challenging interference cases are explained *infra*, at 9-10.

[13] Petitioners' calculations, leading to their *ex parte* presentation of March 23, 2015, apparently added the gain of their base station antenna systems to the proposed emission limits. The analysis herein corrects for Petitioners' apparent mistake and interprets the proposed limits as ERP.

[14] Letter from Elizabeth R. Sachs to Marlene H. Dortch, Secretary, Federal Communications Commission, transmitting *ex parte* presentation of Enterprise Wireless Alliance and Pacific DataVision Inc., slide 10 (Mar 25, 2015).

that model reliable?[15] Sensus' consultants, Real Wireless Ltd., found that many of the Petitioners' assumptions were unrealistic or, in one case, unsupportable.[16] Real Wireless' assessment is that Petitioners presented a very optimistic case to the FCC that has a low probability of actually occurring in a purely mobile deployment (and a nearly zero probability with substantial machine-to-machine traffic).

In response, Real Wireless prepared two projections – a "challenging" interference case, and a "moderate" interference case. Both cases use Petitioners' model but with differing assumptions. The challenging case was intended as a counter-weight to Petitioners' overly optimistic case. Like Petitioners' case, the challenging case has a lower probability of occurring; and the challenging case demonstrates what happens when more conservative assumptions are used. The Commission should consider Real Wireless' challenging case because the Suggested Rules are premised on Petitioners' low probability case. Fairness dictates that the Commission should consider Real Wireless' conservative, lower-probability analysis along with Petitioners' optimistic, lower-probability analysis.

Real Wireless prepared its "moderate" case to represent what a higher probability case would look like. Real Wireless developed its moderate case in consultation with Southern Company, a major FlexNet™ user, and SouthernLINC Wireless, which is deploying an LTE system. The moderate case is based on those companies' operational experiences as to an interference case with a higher probability of occurring.

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[15] Petitioners' inability to define the equipment to be used in PEBB systems precludes laboratory or field-testing at this time. This absence of real-world testing forces reliance on models and calculations. Since LTE interference modeling is relatively new with little real-world experience against which to compare the model, the Commission should err on the side of caution when assessing whether certain assumptions, used as LTE model inputs, are "realistic."

[16] Real Wireless' analysis is set out at Exhibit 1, hereto.

Sensus believes that any emission masks for PEBB systems must fully protect - at the edge of the 900 MHz Band - against the likely potential for interference as depicted by Real Wireless' moderate case. In any event, rules for PEBB would need clear and effective procedures to mitigate actual interference, including: (i) mobile interference depicted by Real Wireless' challenging case, and (ii) machine-to-machine interference.

Petitioners' proposed service offering includes a significant machine-to-machine component. Petitioners' suggested rule section 90.1415 describes a build-to-suit arrangement with priority given to CII entities. CII entities rely heavily on machine-to-machine traffic. If they are indeed serious about serving CII entities, Petitioners likely would be building substantial machine-to-machine systems. Similarly, Petitioners' Suggested Rule § 90.635 specifies power limits for fixed stations; and Suggested Rule § 90.149 specifies an emission mask for fixed stations. However, Petitioners' model assumes strictly mobile user equipment (UE), where a UE might interfere for a short period of time, but then the person carrying the handheld, or vehicle with a mobile unit, moves to another location and the interference lessens or ceases. By contrast, with machine-to-machine traffic, the endpoints typically are fixed and can operate non-stop, 24 hours per day, seven days a week. For example, Sensus utilizes machine-to-machine cellular modems to provide backhaul from FlexNet systems, and these modems run mostly 24 X 7. This feature eliminates the location and call duration probability calculations inherent in a mobility model.

Consistent with the old computer saying "garbage in, garbage out", the amount of noise a model projects depends on the assumptions used. Summarized below is Real Wireless' analysis of questionable assumptions in Petitioners' model.

#	**PETITIONERS' OVERSTATED ASSUMPTIONS** ***Petitioners' Assumed Parameter* and Real Wireless Comment**	**Unit**	**Petitioners' Parameters**	**RW Challenging Case Parameter**	**RW Moderate Case Parameter**
1	***UE antenna gain and body loss* -** Body shielding prompts greater transmit power by UE, negating effect of shielding.	dBi	-10.0	0	-3.0
2	***UE power back off*** – Petitioners rely on wide area statistics not relevant to analysis of individual UE interference.	dB	9.0	0	3.0
3	***Effect of UE power control on OOBE* -** OOBE doesn't always scale w/ fundamental power.	dB per dB	1.0	0	1.0
4	***LTE eNodeB cable loss* -** Phantom parameter to artificially lower interference calculation; UE feeder loss is properly included in separate UE antenna gain category.		4.0	0	0.0
5	***Number of simultaneous UE* -** Only 1 UE transmitting at a time out of 15 resource blocks? Not a high-probability scenario.	# UEs	1.0	15	3.0
6	***Protection level* -** Petitioners extrapolated noise floor from generalized studies while FlexNet users have 10 years of actual data.	dBm/Hz	-160.0	-170	-168.0
7a	***FlexNet base station antenna boresight gain* -** Petitioners quote non-existent antenna pattern.	dBi	12.2	12.2	12.2
7b	***FlexNet base station antenna pattern*** - same: Petitioners quote non-existent antenna pattern.		Unknown pattern per Petitioners' model	Amphenol, BCD-871010-6-25 (6 elec. downtilt)	Amphenol, BCD-871010-3 with 3 degree elec. Downtilt

8	***FlexNet base station antenna height*** - Petitioners chose a non-typical antenna height that coincidentally would reduce projected interference.	feet	147.6'	60'	110'
9	***Propagation model*** **-** Inappropriate for short distances.		W-I LOS	Free Space	Free Space
10	***Maximum antenna attenuation*** **-** Real world operation fills in null spaces.	dB	Unlimited	20	Unlimited

Petitioners assumed that just a single UE device would be operating in a given area at any one time. However, in an actual deployment, seldom -- if ever -- would just one handheld be operating at a time, and some models assume full loading of mobiles in contrast to Petitioners' assumption of just a single operating unit.[17] Similarly, Petitioners assumed the use of an antenna that is not suitable for an LTE system but, conveniently, allowed Petitioners to calculate a lower amount of noise. Petitioners also assumed antenna heights that do not match FlexNet deployments, but which facilitated Petitioners' calculation of reduced OOBE. Petitioners further made overly optimistic assumptions on power back-off (which might not materially impact OOBE) and body shielding (which in any event would not be applicable to machine-to-machine communications).

As these and other parameters illustrate, one can get a wide variation of possible OOBE projections depending on the assumptions used. In the absence of real world equipment, performance histories and test data, the Commission should be skeptical of

[17] *See, e.g.,* Commerce Spectrum Management Advisory Committee, Final Report, Working Group 1 – 1695-1710 MHz Meteorological Satellites, Jan 22, 2013, Appendix 3-2 (simplifying assumptions, used in modeling LTE uplink characteristics, include 100% loading and use of propagation curves that may result in higher calculated power).

Petitioners' modeling claims. The Commission should weigh carefully Real Wireless' challenging case, as well as the moderate case.

Real Wireless re-stated Petitioners' inputs using more realistic assumptions. For the uplink scenario (LTE UE transmits to FlexNet base station, degrading receiver performance and impacting performance of all FlexNet endpoints), Real Wireless finds that Petitioners understated OOBE by at least 29 dB in the moderate interference case and 56 dB in the challenging interference case.[18] For the downlink scenario (LTE base station transmits to nearby FlexNet endpoints), Petitioners understated OOBE by 22 dB in the moderate interference case and 32 dB in the challenging interference case.[19] Even at the lower ends of these ranges, 22 dB and 29 dB of additional interference will cause harmful interference to FlexNet systems.

3. Protection level and noise floor

An essential element in determining the appropriate protection levels for adjacent band operations is the establishment of a realistic noise floor. Petitioners, however, do not present any evidence of the actual noise floor for the spectrum in question. Rather, Petitioners claim a noise floor of -160.5 dBm/Hz, citing only to "environmental noise values analyzed [and] normalized from government sponsored studies in the U.S.,

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[18] As indicated at n9, *supra*, Suggested Rule § 90.1419 does not specify emission limits in terms of ERP or EIRP, and the analysis presented herein assumes ERP. If the limit were in terms of EIRP, the understatement is 2dB lower in each case.

[19] This is when the proposed emission limits are expressed as ERP and the aggressor base station antenna gain is not added to the limit. *See* n11, *supra*. Adopting Petitioners' method of calculation and interpreting as EIRP adds a further 10 dB to the level of understatement of interference in both cases.

England and the EU."[20] Petitioners further concede that studies that might support their assumed noise floor "were difficult to find," that the studies they did find delivered only "mean or median values from a limited amount of samples," and that "some cases had to be extrapolated for [Petitioners'] analysis to develop a *generalized* threshold for the use in modeling and determining a baseline ceiling reference" value.[21]

At Exhibit 2 hereto, Sensus presents empirical evidence that the actual noise floor in which the FlexNet systems operate equals or is lower than -168.5 dBm/Hz at the overwhelming majority of FlexNet™ base stations in the United States. Each FlexNet™ system is designed for the noise floor that it encounters in any given location. Nationwide, the proper protection level for FlexNet™ operations is -168 dBm/Hz for a moderate interference case and -170 dBm/Hz for a challenging interference case, as identified by Sensus' technical consultants, Real Wireless.[22] This is more realistic than the -160 dBm/Hz, which may have been purposefully selected by Petitioners in order to minimize their filtering requirements. The Commission should consider the actual noise floor in the spectrum it regulates, rather than Petitioners' citation to studies that Petitioners admit are of limited utility.

B. The Interference Would Be Harmful Interference

Noise coming from Petitioners' systems would degrade and disrupt radio communications of FlexNet™ systems. This would be harmful interference under 47

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[20] Letter from Elizabeth R. Sachs to Marlene H. Dortch, Secretary, Federal Communications Commission, transmitting *ex parte* presentation of Enterprise Wireless Alliance and Pacific DataVision Inc., Slide 4 (Mar 25, 2015).

[21] *Id*. at Slide 14 ("Bibliography") (emphasis added).

[22] Exhibit 1 hereto, Slides 28, 29, 30, 37.

C.F.R. § 1.907. FlexNet™ systems are designed to meet and operate under ongoing service level agreements (SLA), or a performance standard that was satisfied upon placement into operation.[23] The failure of a FlexNet™ system to satisfy an SLA (where the system had been satisfying the SLA prior to Petitioners' OOBE) constitutes an objective measure that the interference is harmful under FCC rules.

FlexNet™ systems experience occasional instances of harmful interference (from wireless internet service providers, wireless baby monitors and from other devices and systems) sufficient to degrade performance and to require field investigations. Two examples illustrate the levels of OOBE that cause harmful interference to FlexNet™ systems. In both illustrations, FlexNet™ base stations received (on the uplink) power spectral density of approximately -162 dBm/Hz. This harmful interference resulted in loss of 70% of message traffic at affected FlexNet™ base stations in one instance, and prevented the placement in service of a FlexNet™ system in another instance.[24]

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[23] FlexNet™ systems are designed to meet specific performance requirements or SLAs. The specific design (i.e., the number and location of base stations) depends on the area to be covered, endpoint density, terrain and the granularity and resolution of the data (e.g., one utility might require electric meter data measured each hour at a resolution of 1 kw hour, while another utility might need electric meter data measured each 15 minutes at a resolution of 1 watt-hour.) Typical SLAs require the delivery of data from a percentage of endpoints (generally between 98.5% and 99.9%) within a defined time window. The size of the time window depends on granularity and resolution of the data and can range from 15 minutes to 3-4 days. FlexNet™ systems use the Aloha method and have a fixed channel bandwidth assigned to each function. Interference reduces the number of messages that can be received at a base station, particularly from more distant endpoints. In one example, later resolved by addition of filters, 12 dB of interference from adjacent channel Sprint/Nextel base stations reduced messages received by 70%.

[24] To Sensus' knowledge, the FlexNet™ systems have not experienced harmful interference coming from the immediately adjacent 900 MHz Band channels. As described below, millions of iDEN subscribers successfully coexisted with FlexNet™ on the adjacent channel. The instances of harmful interference that are described herein were to a FlexNet™ system operating over multiple address system channels (Portland, Oregon), or the interference came from the Part 15 unlicensed band (Purcell, Oklahoma). These instances are instructive for the amount of OOBE noise hitting FlexNet™ receivers that caused the harmful interference.

In the first instance, in Portland, Oregon, Sprint Nextel transmitters caused harmful interference to the uplink side of the FlexNet™ system that was operating on licensed multiple address system (MAS) channels. Sensus investigated and contacted Sprint Nextel, which agreed to a brief shut-down test to determine whether its transmitter was the source of the interference. The result of this shut-down test, attached hereto as Exhibit 3, shows a threefold increase in throughput (from a very low level) during the period that the Sprint Nextel transmitter was turned off. This story had a happy ending, as Sprint Nextel agreed to install a filter and the problem was resolved. The amount of OOBE, as documented in the shut-down test, was about -162 dBm/Hz.

In another instance, in early 2014, a Wireless Internet Service Provider (WISP), located in Purcell, Oklahoma, prevented the local FlexNet™ system from being placed into operation, by putting approximately the same amount of OOBE into the FlexNet™ receivers. The FCC's Dallas Field Office investigated and determined that the WISP was operating an illegally programmed transmitter. After the WISP transmitter was re-programmed, the noise floor returned to normal. Attached hereto as Exhibit 4 is a spectrum analyzer screen shot of the OOBE in Purcell, Oklahoma.

From the experience in Portland, Oregon, Sensus knows that OOBE of approximately -162 dBm/Hz likely would result in loss of about 70% of message traffic at affected FlexNet™ base stations. However, the -162 dBm/Hz OOBE that caused extensive harmful interference is **far less** than what Petitioners propose to do. As noted above, under Petitioners' Suggested Rules, in the uplink, OOBE would be permitted in the amounts of -141 dBm/Hz under a moderate interference case, and -116 dBm/Hz under a challenging interference case. These amounts of noise are far greater than what

caused a loss of 70% of message traffic in Portland, Oregon. On the downlink, OOBE would be permitted under Petitioners' Suggested Rules in the amounts of -147 dBm/Hz for the moderate interference case and -138 dBm/Hz for the challenging interference case. In summary, Petitioners' Suggested Rules would allow extensive harmful interference to FlexNet™ operations.

III. FLEXNET™ USERS HAVE A RELIANCE INTEREST

A. Expectation of Continued Use of Frequencies

FlexNet™ users have a reasonable expectation of continued use of licensed, exclusive-use frequencies at the noise floor they were designed for, and have enjoyed, for the past ten years. The Commission should therefore give "adequate consideration" to the reliance interests of incumbent FlexNet™ licensees.[25]

Attached hereto as Exhibit 2 are current noise floor readings from FlexNet™ systems operating on NPCS frequencies. Exhibit 2 shows noise floors at or below -168.5 dBm/Hz to be typical for the overwhelming majority of FlexNet™ systems. Many of the FlexNet™ systems depicted on Exhibit 2 have noise floors below -170 dBm/Hz.

FlexNet™ users manage their noise floors. Each FlexNet™ system monitors the noise floor it operates in and sends an alarm when the noise floor rises to a pre-determined level. Sensus investigates the cause of interference upon receipt of a noise floor alarm. Sensus field engineers currently investigate 15 to 20 instances of harmful interference per year. Sensus identifies the source and seeks to resolve any instances of harmful interference. Usually, the incidents are resolved amicably, with the interferer re-

[25] *See, e.g., Mobile Commc'ns Corp. v. FCC*, 77 F.3d 1399, 1407 (D.C. Cir. 1996).

programming or installing a filter. On a few occasions, Sensus had to call on the Commission's Enforcement Bureau to resolve harmful interference.

The noise floor for the NPCS frequencies (channel blocks N1 – N5), that were acquired by Sensus and other FlexNet™ users, was -168.5 dBm/Hz to below -170 dBm/Hz at the time of acquisition of the respective FCC licenses. Except for isolated incidents, which were resolved relatively promptly, the noise floor for FlexNet™ systems has remained more or less constant in the ten years that FlexNet™ systems have been operating over NPCS channels.

In reliance on exclusive-use licenses for NPCS channel blocks N1 – N5, which were auctioned frequencies, and on Commission enforcement against harmful interference, FlexNet™ users have invested over one billion dollars in FlexNet™ infrastructure, premised on existing noise floors. In further reliance, utilities have turned to FlexNet™ systems for critical utility functions, including outage and dangerous condition alarms, and network management and distribution automation functions. Utilities, customers and regulators rely on FlexNet™ to continue providing these functions. To date, these systems have operated largely as designed with, as noted, just a few instances of harmful interference that were resolved. The utilities that use FlexNet™ systems, as well as the residential and business customers of these utilities, expect that the systems will continue to operate as designed and to continue to provide valuable public service. FlexNet users thus have a reliance interest in their systems continuing to operate as designed.

Although licensees do not "own" the spectrum, and the FCC has authority under Section 316[26] to modify licenses through rulemaking, the FCC should not authorize new allocations or services that will jeopardize licensees in adjacent bands. In this case, not only would such an action jeopardize critical communications networks used by CII entities, it would also have a chilling effect on applicants wanting to secure exclusive-use spectrum at auction if they are aware the FCC could jeopardize their investment in spectrum and network technology by authorizing conflicting uses in adjacent bands without adequate interference protections.

B. FlexNet™ Users' Reliance Interest is Reasonable

Whether FlexNet™ users' decade-long reliance interest, in enjoying little or no adjacent-channel noise, was reasonable depends on what actually occurred in the adjacent channels and what reasonably might have occurred.

As Petitioners correctly noted, most of the 896-901/935-940 MHz band "was heavily used for many years in Sprint's iDEN network, [and] is not available for narrowband licensing by other entities."[27] Nextel had a subscriber base of approximately 23 million customers in the United States when it merged with Sprint in 2005 at a stand-alone value of $36 billion.[28] These customers operated over licensed spectrum at 800 MHz and 900 MHz. Thus, the 896-901/935-940 MHz band, indeed, was heavily used by the iDEN network. Further, over time Nextel acquired many licenses and came to

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[26] 47 U.S.C. § 316 (2015).

[27] *Supra*, n3, Reply Comments of the Enterprise Wireless Alliance and Pacific DataVision, Inc., iv, filed Jan 27, 2015.

[28] Pacific Datavision, Inc., Registration Statement (Form S-1) 5 (Apr. 27, 2015), http://www.sec.gov/Archives/edgar/data/1304492/000119312515149880/d911831ds1.htm visited May 13, 2015.

dominate the band. This dominance was continued by Nextel's successor, Sprint. Therefore, the band, indeed, has been largely unavailable for narrowband licensing by other entities. In other words, the spectrum that Petitioners propose to be allocated to PEBB was dominated by Sprint/Nextel for many years; and Sprint/Nextel operated a commercially successful iDEN service and largely precluded other types of narrowband systems from taking hold.

iDEN handheld units had (and still have) very low out of band emissions (OOBE). Sensus is not aware of a single instance of iDEN handheld devices causing harmful interference to a FlexNet™ operation over NPCS spectrum. There may have been some instances of interference that were too fleeting to register as a problem. The reason that there was no or negligible harmful interference from iDEN devices at 901 MHz (and that the noise floor did not increase due to adjacent channel interference) is that the OOBE characteristics of narrowband iDEN devices are quite benign. Some of the iDEN devices generate OOBE of -45 dBm/30 kHz to -41 dBm/30 kHz,[29] while other iDEN and other narrowband devices intended for use under Part 90 generate OOBE of -40 dBm/30 kHz to -33 dBm/30 kHz.[30] By contrast, Petitioners' Suggested Rules would allow a much noisier -25 dBm/30 kHz.

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[29] iDEN i475 and iDEN r750 with OOBE of -45 dBm/30 kHz; and Motorola i325 with OOB emission of -41 dBm/30 kHz.

[30] *See* Exhibit 5 hereto; *See also* iDEN devices with OOBE of: i680 Brute -40.15 dBm/30 kHz; i290 -40.13 dBm/30 kHz; i576 and i776 -39.45 dBm/30 kHz; i465 Clutch -39.15 dBm/30 kHz; i9 -38.43 dBm/30 kHz; i335 -38.13 dBm/30 kHz; i580 -37.46 dBm/30 kHz; i880 -37.45 dBm/30 kHz; i410 -37.15 dBm/30 kHz; i296 and iDEN800 -37.15 dBm/30 kHz; i856w Debut -37.15 dBm/30 kHz; i890 -37.15 dBm/30 kHz; i930 -36.44 dBm/30 kHz; i605 -35.64 dBm/30 kHz; BlackBerry 835i Curve -35.49 dBm/30 kHz; i365 and i365IS -35.15 dBm/30 kHz.

Theoretically, other types of systems could have been operated in the adjacent channels, under Part 90 rules, that would generate much more adjacent channel noise. However, as a practical matter, that was not going to happen. The Part 90 spectrum is allocated for narrowband land mobile operations, which virtually compels the licensee to take extra measures to limit OOBE in order to minimize intra-system interference and optimize commercial use of this limited spectrum.

In summary, FlexNet™ users' reliance interest was reasonable because: (i) iDEN dominated the neighboring band thereby largely precluding other types of systems from coming into operation, (ii) iDEN was a good neighbor and generated almost no OOBE, (iii) iDEN was commercially successful and reasonably appeared set to continue to dominate the band, and (iv) even if iDEN had not been there, Part 90 narrowband spectrum allocation compels the licensee to minimize intra-system interference.

IV. PETITIONERS PROPOSE A RADICAL CHANGE

A. The Change is More Radical Than That Suggested By Emission Masks

Exhibit 6 hereto shows the relative levels of OOBE permitted or generated by: the iPhone 5, an LTE standard, the Emission Mask J under Part 90 of the Commission's rules, Petitioners' Suggested Rules, and finally, by certain iDEN devices.

Typical vendor behavior, illustrated by the iPhone 5, is to design the device to the outer edge of the applicable rule or standard.[31] No profit seeking carrier or service provider wants to pay extra for unnecessary engineering and manufacturing. However, as

[31] Apple iPhone 5 has OOBE of -18.2 dBm/30 kHz, while the LTE standard specifies OOBE of -18 dBm/30 kHz.

illustrated by Exhibit 6, something else is going on with iDEN because these devices far and away exceed the OOBE limitations imposed by FCC emission masks.[32]

The economics of commercial narrowband systems are straightforward: one must load a large number of subscribers on a small amount of spectrum. The iDEN devices are super-protective of adjacent channel users because the adjacent channel users they are protecting are other subscribers of the same iDEN system. iDEN took relatively modest amounts of spectrum, broke it down into discreet channels, and assigned subscribers to individual channels when making calls. In order to do this with millions of subscribers, the iDEN devices needed to far exceed FCC-mandated emission masks. This way, the iDEN devices would not interfere with other, internally-assigned, adjacent-channel iDEN users.

Thus, unlike in most radio services, the FCC-mandated emission mask was NOT the limiting factor for iDEN handheld OOBE. Rather, the economics of a large, commercial narrowband system was the limiting factor. The device manufacturer would need to far exceed the Emission Mask J, in order to satisfy commercial requirements and good spectrum management.

As illustrated by Exhibit 6, Petitioners are proposing a radical change to the OOBE profile of the 896-901/935-940 MHz Band. Petitioners propose to move from -37 dBm/30 kHz (where the band is now) to -25 dBm/30 kHz (Petitioners' proposed emission mask). The big change would occur, not because of a change in the FCC-permitted emission mask (which is superfluous here), but because Petitioners would scrap the economics of narrowband systems in favor of broadband systems.

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[32] *See, e.g.*, iDEN i475 and iDEN r750, each having OOBE of -45 dBm/30 kHz, while Part 90 Emission Mask J requires only -20 dBm/30 kHz.

The Commission's narrowband spectrum allocation and licensing policies kept this band quiet, even while heavily used by iDEN. If the spectrum were reallocated to broadband, it would change not only the technical characteristics of the Part 90 band, but also the economics of the band, thereby greatly increasing the OOBE emission from this band. Thus, it is irrelevant whether or how the Petitioners' suggested emission mask for broadband compares with Emission Mask J for the Part 90 band. The FCC should consider the actual impact on the band of Petitioners' proposal, not the theoretical impact implied by comparison of emission masks.

B. Petitioners Should Follow the Precedent of Sprint Nextel in the *800 MHz ESMR Proceeding*

Ironically, while citing to the *800 MHz ESMR* proceeding,[33] Petitioners fail to follow the precedent established therein. Sensus is concerned about a different interference scenario than that presented in the Commission's previous broadband/narrowband proceedings; that is, the Nextel base stations caused the interference at 800 MHz, where, here, Sensus is most concerned about LTE UE causing interference to FlexNet™. Nevertheless, there are important similarities: a wireless carrier is proposing a reallocation to broadband and is proposing new standards and rules.

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[33] Petitioners' Reply Comments in this proceeding opined that:

> The Commission recently determined that deployment of broadband technology on 800 MHz ESMR spectrum should be permitted, and interference to adjacent 800 MHz narrowband systems was not expected, provided that ESMR systems satisfy the existing OOBE and co-channel separation rules. While EWA and PDV agree entirely that the continued interference-free operation of narrowband 900 MHz systems is essential, they are confident that the FCC will reach the same conclusion regarding the compatibility of broadband and narrowband operations at 900 MHz, even if compliance with the OOBE standard requires the broadband operator to add filters to its infrastructure and subscriber equipment.

Supra, n3, Reply Comments of The Enterprise Wireless Alliance and Pacific DataVision, Inc. iii, filed Jan 27, 2015. However, as described herein, Petitioners failed to follow this precedent.

In the *800 MHz ESMR* proceeding cited by Petitioners, Sprint Nextel made a genuine effort to alleviate concerns about OOBE. Sprint Nextel committed to a base station emission mask of -69 dBm/30 kHz that provides significantly greater protection (44 dB greater) to adjacent band operations than the emissions mask for base stations proposed by Petitioners in this proceeding.[34] This went above and beyond the requirements of FCC rules. Sprint Nextel also submitted test results demonstrating that its proposed new technology was better for adjacent channel licensees and committed to a notification/coordination procedure with adjacent channel licensees.[35] With its commitments, Sprint Nextel looked beyond the then existing Part 90 rules and truly attempted to address the concerns of adjacent channel licensees.

In marked contrast to Sprint Nextel in the *800 MHz ESMR* proceeding, Petitioners offered up a scheme that is guaranteed to cause harmful interference and makes a mockery of adjacent channel concerns. The near certainty that the Suggested Rules would permit massive harmful interference to CII operations is reviewed above in these Comments.

In addition, Petitioners seem intent on preventing FlexNet™ users from ever being able to file a claim of harmful interference. Suggested Rule § 90.1421 is drafted to *insulate* the PEBB licensee instead of providing a mechanism to address harmful interference. Petitioners cherry picked from 47 C.F.R. §§ 90.672 *et seq.*, utilizing land mobile standards for the adjacent channels occupied by FlexNet™ users. However, the

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[34] Reply Comments of Sprint Nextel Corporation, *Petition for Declaratory Ruling From Sprint Nextel to Allow Wideband Operations in the 800 MHz Enhanced Specialized Mobile Radio Service Bands*, WT Dkt. No 11-110, 8-10 and Exhibit A, filed Aug 16, 2011.

[35] *Id.*

land mobile standards bear no relation to the fixed, CII FlexNet™ systems operating under Part 24 of the Commission's rules.

For example, even though Petitioners acknowledged that FlexNet™ should be protected to the level of -160 dBm/Hz,[36] Suggested Rule § 90.1421 would not protect to that level. A harmful interference claim lodged to protect to that level would be deemed to not qualify for relief. This Suggested Rule is designed to fail at its stated purpose. Petitioners have not followed the precedent of Sprint Nextel in *800 MHz ESMR* in truly addressing the adjacent-channel situation as it actually exists.

Petitioners should follow the Sprint Nextel precedent, namely, that when a spectrum reallocation is proposed the new rules need to actually address the co-channel and adjacent channel situation. New standards apply in a spectrum reallocation.

C. Suggested Rules Mandate a Spectrum Grab

The Suggested Rules would enable Pacific DataVision, Inc., one of the Petitioners, to confiscate valuable Auctioned SMR licenses in six MTAs. The holders of these licenses would have no recourse to object or to hold out for compensation. This gives the appearance of a spectrum grab by Petitioners.

Under Suggested Rule 90.1405(b)(2)(i), for MTAs in which a single entity is the licensee for fifteen (15) or more geographic licenses in such MTA, that entity would be awarded the PEBB license in the MTA, while for MTAs in which no single entity is the licensee for fifteen (15) or more geographic licenses, the licensees could negotiate. This Suggested Rule is referring to Auctioned SMR licenses, which were auctioned in Auction

[36] As described above, FlexNet™ needs protection to -168 dBm/Hz for the moderate interference case and -170 dBm/Hz for the challenging interference case. This example at -160 dBm/Hz is provided to demonstrate that the Proposed Rules do not even satisfy what Petitioners have acknowledged is a necessary protection level.

7. The Commission issued 20 of these licenses per MTA, Channel Blocks A through T. Most of the originally issued Auctioned SMR licenses are still outstanding. Pacific DataVision holds the overwhelming majority of these licenses and is the only licensee to hold 15 or more of these licenses in any MTA.

A review of the FCC database indicates that there are six MTAs (see chart below) where licensees other than Pacific DataVision hold five or fewer Auctioned SMR licenses.[37] Presumably, under the Suggested Rules, the FCC would award Pacific DataVision the PEBB license in these markets. By this action, the Auctioned SMR licenses held by the licensees listed in the chart below would be extinguished, and Pacific DataVision effectively would have confiscated these licenses. The Suggested Rules do not give these licensees the right to negotiate in, object to, or hold out from, the confiscation of their licenses. As the PEBB licensee and pursuant to Suggested Rule § 90.1405(b), Pacific DataVision would have certain obligations with respect to these MTA licensees. However, those obligations relate entirely to the retuning of the licensees' radio systems and the provision of "comparable [radio system] facilities." There is no obligation to reimburse the MTA licensees for the valuable spectrum rights that would have been forcibly taken from them. Suggested Rule § 90.1413(c)(ii) provides that "the geographic coverage of [replacement frequency] channels shall be at least coextensive with that of the original system," NOT coextensive with the geographic boundaries of the original license. Petitioners are proposing to convert these valuable MTA licenses into site-based licenses. This would result in economic loss to the MTA licensees and could

[37] Five or more licensees other than Pacific DataVision hold Auctioned SMR licenses in nine other MTAs (MTA 002, 008, 015, 027, 032, 036, 039, 040, 045). Presumably, these MTAs would be subject to negotiation under Suggested Rule 90.1405(b)(2)(i)(B), and these MTA licensees presumably could avoid the plight described herein by refusing to go along with the PEBB license concept and retaining their MTA licenses.

limit the future growth of their systems to the extent they do not currently cover the entire MTA.

CALL SIGN	MTA LICENSES SUBJECT TO CONFISCATION LICENSEE	FRN	MTA
WPOL827	INDUSTRIAL WIRELESS TECHNOLOGIES INC	4036042	001
KNNY201	INDUSTRIAL WIRELESS TECHNOLOGIES INC	4036042	022
KNNY202	INDUSTRIAL WIRELESS TECHNOLOGIES INC	4036042	022
KNNY214	North Sight Communications, Inc.	1729565	025
KNNY215	North Sight Communications, Inc.	1729565	025
KNNY255	P R Communications	8246399	025
KNNY269	RADIO DISPATCH NETWORK LLC	3011012	026
KNNY299	RADIO DISPATCH NETWORK LLC	3011012	026
WPST324	Radio Dispatch Network LLC	3011012	026
KNNY256	Houston 936 SMR Inc.	6352611	033
KNNY224	SAIA COMMUNICATIONS INC	5007141	035
KNNY225	SAIA COMMUNICATIONS INC	5007141	035

Conclusion

The Commission should be concerned with the *actual* noise floor, *actual* interference levels, and *actual* narrowband economics and practices, instead of what might be theoretically possible. A harmful interference determination is an exercise in identifying the *actual* effect on users.

What the Petitioners propose is radically different from, and out of character with, current and past practice in this band. In and of itself, there is nothing wrong with proposing something new. However, in making a new spectrum allocation, the Commission should protect adjacent channel licensees by requiring the new service to maintain out of band emissions that are at least equivalent to, if not better than, the *status*

quo ante. The Suggested Rules do not meet this standard. Consequently, Sensus urges that the Commission decline to take further action on the Petition unless and until the Petitioners can adequately demonstrate that broadband service can be provided on this narrowband Part 90 land mobile spectrum without causing harmful interference to adjacent band users.

Please direct any questions or follow up to the undersigned.

Respectfully submitted,

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Counsel to Sensus

DATED: June 29, 2015

realwireless
independent wireless experts

for SENSUS

Coexistence between proposed Pacific DataVision LTE systems and existing Sensus FlexNet systems in the 900MHz band

Review and analysis by Real Wireless

Version History

Version	Date	Comment	Who
5.0	26/06/2015	Issued to Sensus	RW

Summary of findings

1. Real Wireless has reviewed coexistence calculations and emission specifications proposed by pdvWireless (PDV) to protect adjacent FlexNet systems on behalf of Sensus
2. We have reproduced PDV's calculations using an independent model, **and agree broadly with PDV's calculation methodology**
3. We found that **the interference threshold proposed by PDV is inappropriate**, since it is based on inappropriate noise environment assumptions. Our review of field measurements conducted by Sensus suggests a threshold around **-170dBm/Hz** rather than the -160 dBm/Hz proposed by PDV
4. We have conducted a detailed review of the calculation parameters proposed by PDV and found that in many cases **the parameters are inappropriate**, resulting in a far greater level of interference than PDV has suggested
5. The table below summarises our findings regarding the extra attenuation needed for each: interference mode (uplink, downlink) case (challenging, moderate) and the interpretation of the proposed limits (A or B): Even in moderate cases **tens of dB extra attenuation is needed**
6. Additionally the **test conditions for specifying emission limits need to be properly specified** to account for the measured characteristics of real LTE devices: this could create a 7dB increase in emissions compared with the test conditions specified by PDV

Interference mode				Challenging Case		Moderate Case	
		Rule proposal	Interpretation	A	B	A	B
PDV UE aggressor to Sensus TGB victim (PU2FT)	UL	03-May	PSD dBm/Hz	-116	-114	-141	-139
			Extra attenuation needed (dB)	54	56	27	29
PDV eNodeB aggressor to Sensus endpoint victim (PB2FE)	DL	25-Mar	PSD dBm/Hz	-146		-155	
			Extra attenuation needed (dB)	24		14	
		03-May	PSD dBm/Hz	-128	-138	-138	-147
			Extra attenuation needed (dB)	42	32	31	22

Note: blank cells were not calculated

Contents

1. Introduction and scope

- pdvWireless (formerly Pacific DataVision, PDV) has made a proposal to FCC to realign the bandplan in the 900MHz spectrum adjacent to Sensus's FlexNet systems, introducing nationwide LTE systems into the band
- This proposal changes the basis for adjacent channel coexistence and raises the risk of additional harmful interference
- Sensus has commissioned Real Wireless to undertake a critical review and independent analysis of the PDV's proposals based on:
  - Documentation and technical model supplied by PDV
  - Information on FlexNet technology and deployments supplied by Sensus
- This slidepack represents the report from the Real Wireless analysis
- It is based on our best endeavours and assumes the accuracy and currency of the information supplied to us

2. About realwireless

- Leading independent wireless advisory firm, bridging the gap between the wireless industry and wireless users
- Team of over 35 experts with deep technology, business, market and economics experience
- Experience:
  - Technical and policy advice on 4G spectrum auction to Ofcom
  - Manage wireless at Wembley Stadium and other major venues
  - Founded and chaired Small Cell (Femto) Forum
  - Founded the UK Spectrum Policy Forum

Bridging the gap

independent wireless experts

Some Clients

Ofcom Office of Communications; Department of Enterprise, Trade and Investment; BAA; Wembley connected by EE; European Commission; Cisco; ECB

Our services

Technology
- Performance analysis
- Coexistence
- Spectrum
- Network architecture

Deployment & Management
- Venue wireless advisors
- Network deployment and costing advice
- Event management

Economics & Business
- Business case analysis
- Social and economic impact
- Regulatory support & advocacy

Markets
- Market evaluation
- Product roadmap definition
- Competitive analysis

3. About FlexNet systems

Overview of FlexNet

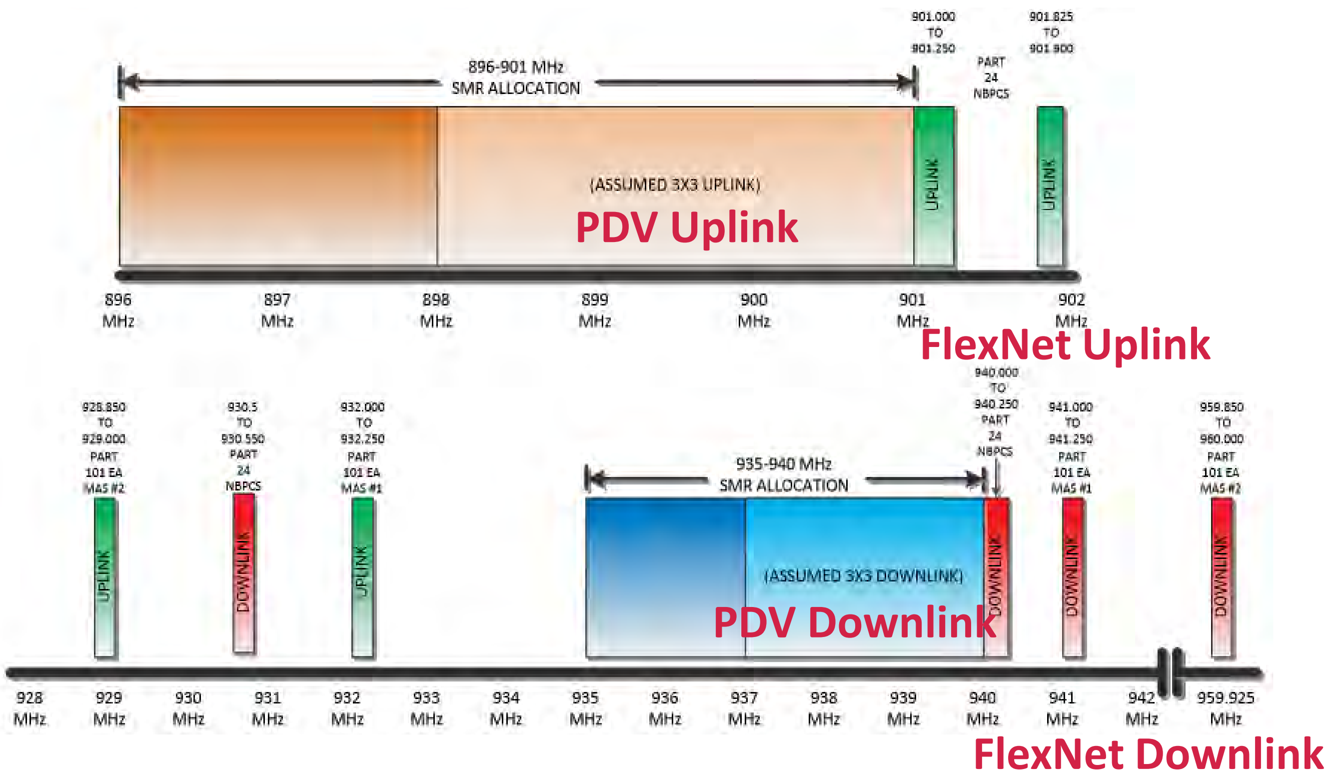
- The Sensus FlexNet system is a long-range radio network that serves as a dedicated and secure two-way communications highway for utilities.
- The network is designed to be highly reliable and resilient to suit the critical infrastructure needs of FlexNet customers
- FlexNet base stations, known as TGB, serve endpoints which are predominantly static (other modes of operation are also supported)
- In order to achieve high reliability, the FlexNet system operates in narrow channels from 1.6 kHz-30 kHz bandwidth width and 0.805-37.5 kbps adaptive modulation and coding schemes according to the endpoint needs and channel conditions
- Unlike mobile systems, FlexNet, as a critical machine-to-machine network requires highly reliable individual links to static locations and cannot rely on the statistics of mobility to overcome coverage deficiencies
- This is achieved via adaptive modulation and coding, automatic repeat requests and very sensitive base station receivers operating in low interference environments

Scale of FlexNet deployments

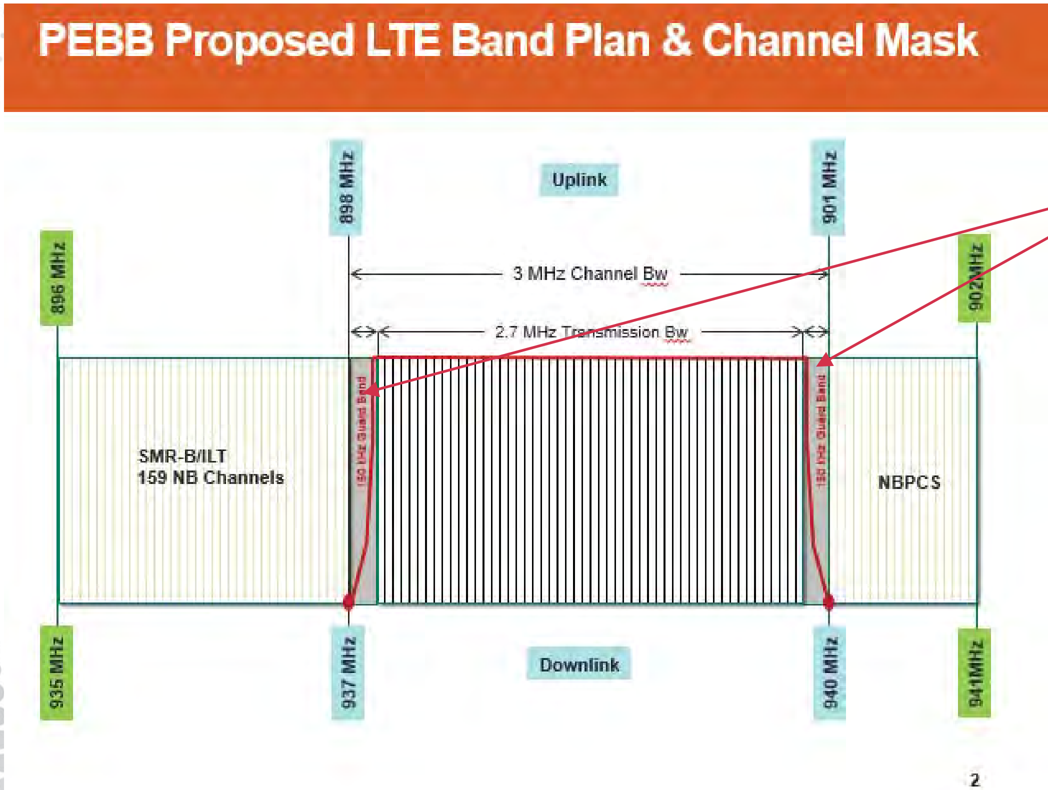
- According to Sensus data, the scale of current US NBPCS FlexNet deployments is as follows:
  - 15.6 million endpoints
  - 692 customers
- New customers are added every month
- Several million additional endpoints to be deployed by existing customers (one customer alone has 2M to deploy)
- So while our analysis will focus on the impact of interference on individual base stations or endpoints, it should be recalled that any impacts could affect millions of customers and devices

4. Overview of Pacific DataVision (PDV) proposals

900 MHz spectrum realignment proposed by PDV



PDV's proposed channel usage



The 2x150kHz guard band is an inherent feature of LTE, not a coexistence measure suggested by PEBB

- PDV proposes to allow UEs to transmit at up to 3W ERP

PDV’s proposed network deployment and usage

- Little information has been supplied by PDV relating to their planned network deployment and usage
- From their website [1]:

pdvWireless is building and supporting a state of the art, private push-to-talk network in major U.S. markets dedicated solely to dispatch centric businesses. This network will provide business customers with a true push-to-talk (PTT) user experience that has been missing in the marketplace for several years. This PTT network will minimize call set-up time, eliminate telephone tag and voicemail backlog. Utilization of this network will allow businesses to achieve operational efficiencies while reducing their costs of telecommunications.

pdvWireless-DispatchPlus

DispatchPlus will be supporting a next generation PTT solution utilizing state of the art digital two-way radio technology integrated with proprietary cloud-based mobile resource management solutions. This DispatchPlus offering will combine the efficiencies of a digital network with the value of a cloud based work order management solution. This solution, including intelligent call prioritization, worker tracking, status mapping and other workforce management capabilities will provide business customers substantial benefits and cost savings including improved workforce productivity and increased operational efficiencies.

Businesses in the markets where pdvWireless will be providing service will be able to reduce their telecommunications expenditures while providing superior customer service to their clientele. In the long term, pdvWireless will provide added value to the small business marketplace by providing solutions focused on meeting all their wireless telecommunications needs in the most cost effective manner possible.

pdvWireless-pdvConnect

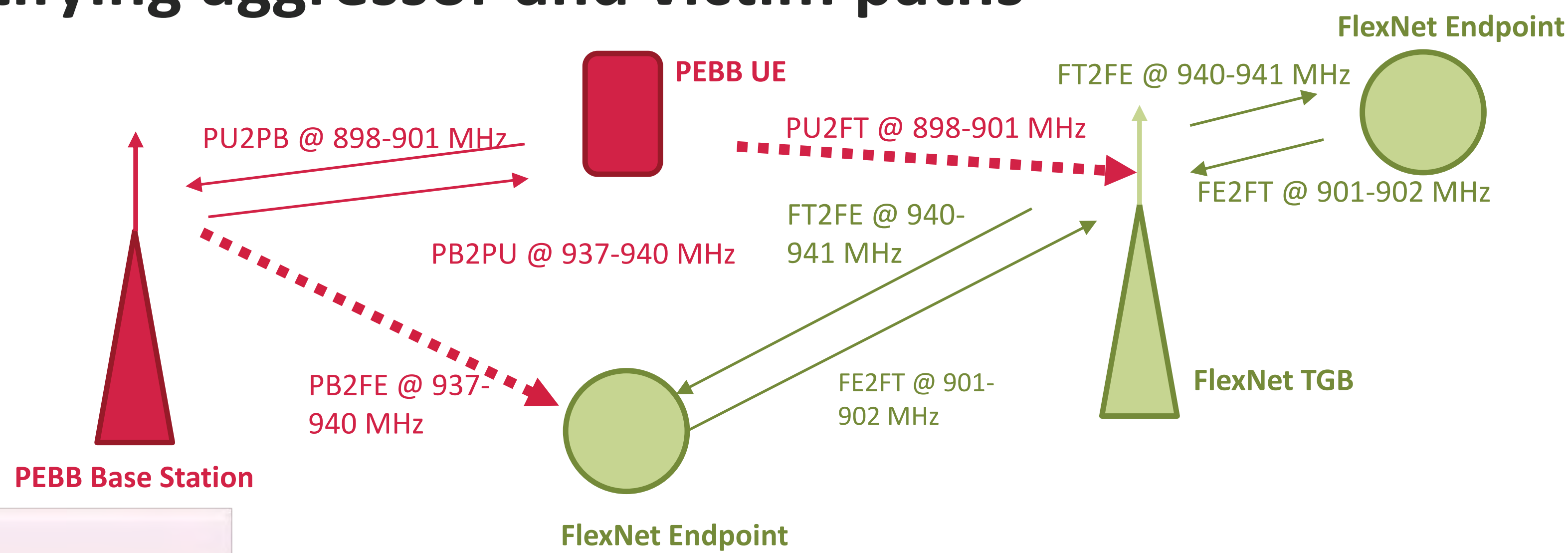
pdvWireless is a recognized innovator in developing mobile workforce communications and management solutions. The company will continue to provide advanced voice & photo documentation along with GPS tracking and cloud-based management tools that increase profitability and workforce efficiency under the pdvConnect product offering. pdvConnect technology is utilized at a wide variety of enterprises in the United States and Mexico, ranging from national deployments at Fortune 500 companies to local deployments by other businesses and governmental agencies.

- Based on this and the other information supplied, we understand that PDV’s network will be:
  - Nationwide
  - Based on LTE technology
  - Supporting a range of mobile and potentially static devices
  - Operating entirely in the proposed realigned 900 MHz spectrum block of 2 x 3MHz

[1] http://www.pdvwireless.com/

5. Identifying interference modes

Identifying aggressor and victim paths



Key
PB: PEBB Base Station
PU: PEBB UE
FT: FlexNet TGB
FE: FlexNet Endpoint
PDV wanted path
Aggressor path from PDV
FlexNet wanted path

- Wanted and interfering paths are shown above as a basis for identifying the key interference modes

Key interference modes

- Two key interference modes have been identified and are analysed in this slidepack:

Link direction	Aggressor path	Victim path	Description	Remarks
Uplink (UL)	**PU2FT**	**FE2FT**	PDV UE Tx to FlexNet TGB Base Rx	Degrades performance of all Endpoint uplinks using that FlexNet TGB
Downlink (DL)	**PB2FE**	**FT2FE (or FB2FE)**	PDV Base Tx to FlexNet endpoint Rx	Impacts any endpoint in the neighbourhood of the PDV base

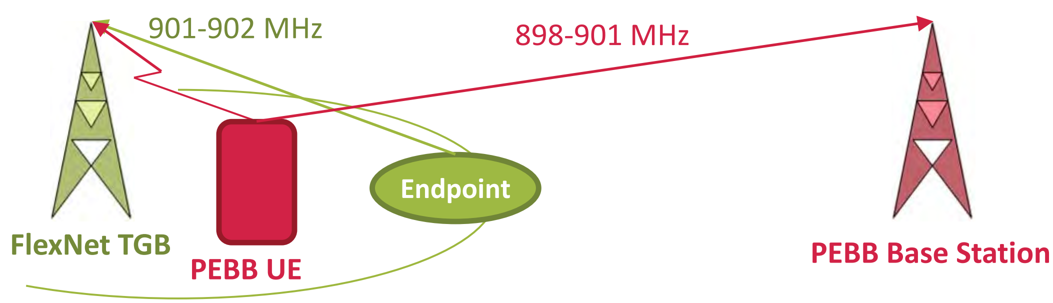
- In each mode interference may arise from out-of-band emissions (ACLR impact) and/or receiver blocking (ACS impact)
- While one of these effects will usually dominate, the overall impact will be additive
- This slidepack only assesses the impact of out-of-band emissions

Interpretations of PDV's proposed emission limits

- We have found PDV's proposed emission limits to be ambiguous and potentially incorrectly calculated by PDV
- Given this ambiguity, we have analysed the interference levels according to two distinct interpretations of the OOBE limits:
  - **Interpretation A:** Assume the proposed limit refers to attenuation relative to the in-band EIRP and adopt PDV's method of calculation, which adds the aggressor antenna system gain to the proposed limit.
  - **Interpretation B:** Assume the proposed limit refers to attenuation relative to the in-band ERP and that the limit refers to the emitted power, so the aggressor antenna system gain is irrelevant.
- The sections which follow analyse the outcome according to both interpretations

6. Interference mode PU2FT (Uplink PDV mobile to FlexNet base station) - Interpretation A

Scenario PU2FT

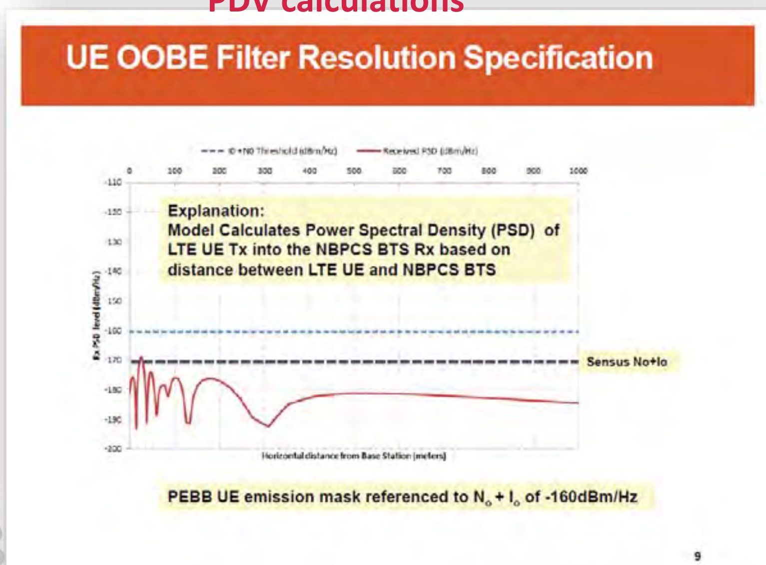


- An endpoint is at the cell edge of a FlexNet TGB (Tower Gateway Basestation)
- One (or multiple) PEBB UE is (are) nearby FlexNet TGB, and at the edge of the PEBB Base station's coverage area, thus transmitting at full power
- Degrades performance of all Endpoint uplinks using that FlexNet TGB

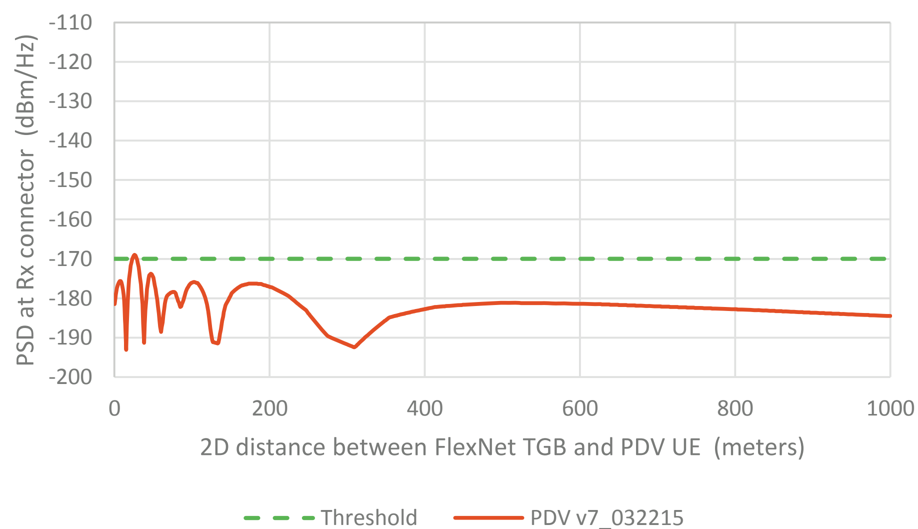
PDV analysis of interference mode PU2FT

- PDV have analysed this mode and have provided a spreadsheet-based model to represent their calculations [1]
- The result of their analysis for the PSD of the LTE UE as received at the FlexNet TGB receiver is shown below [2]
- Also shown is a Real Wireless calculation based on our own model using the same parameters. This result matches closely to the PDV calculations
- PDV have compared with a -160dBm/Hz threshold. Sensus have proposed a -170dBm/Hz threshold, which would be breached by a UE at a distance of around 29m according to PDV's own calculations

PDV calculations



Real Wireless calculations based on PDV parameters



[1] Sensus_Coexistence Analysis_v7_032215

[2] PDV ex parte notice RM-11738 03-25-2015

Real Wireless agrees with the calculation methodology proposed by PDV

PDV's proposals based on their modelling

- Based on their calculations, PDV have proposed that UL emissions for each UE would be attenuated by at least $55 + 10\log(P)$ in a 30 kHz segment and have referenced the FCC rule section 90.691 [1] for this
- We understand P in this expression to represent the total in-band emission power of the UE, P where P is in watts
- It is not clear from PDV's proposals whether this is intended to relate to an EIRP limit or an ERP limit: in the proposed rules [3] neither is specified. In PDV's calculations they have assumed EIRP.
- We have therefore analysed the impact based on two potential interpretations:
  - **Interpretation A: The proposed emission limit is specified as EIRP**
    In this case the proposed emissions are -25 dBm/30 kHz EIRP
  - **Interpretation B: The proposed emission limit is specified as ERP**
    In this case the proposed emissions are -25 dBm/30 kHz ERP
- The proposed emission limit for any given value of P can be compared with the 3GPP out of band emission specification [2] which is -13 dBm/30kHz. In 3GPP this is input power to the antenna, so the actual emissions would depend on the UE antenna gain/feeder loss.

Comments:

- Sensus systems operate in channel bandwidths as narrow as 1.6 kHz, so measuring in a 30kHz segment may not protect the base station receiver if the emissions vary significantly within the 30kHz range
- PDV have not provided any suggestion as to the measurement conditions under which these limits are to be reached. We have reviewed FCC test results for several popular LTE phones (see Annex) and have determined that **it is essential that tests be made with both full bandwidth operation and with a single resource block active**: the latter case usually produces around 7 dB higher out of band emissions

Proposed Technical Specifications - Emissions

UPLINK – Portables, Fixed Endpoints, Mobiles

- On any frequency outside 898-901MHz (UL) emissions shall be attenuated below the transmitting power (P) by a factor of at least 55+10log(P) dB in a 30kHz segment

§ 90.1419 Emission limitations.

For operations in the 898-901/937-940 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, in accordance with the following:

...

(b) On all frequencies between 898-901 MHz, by a factor not less than 55 + 10 log (P) dB in a 30 kHz band segment, for mobile stations and portable stations.

Real Wireless has reservations as to:
- the intended emission specification (EIRP or ERP)
- the level to be protected,
- the bandwidth in which the emission level is specified,
- the lack of clarity regarding the relevant measurement conditions

[1] FCC 47 CFR 90.691
[2] 3GPP TS 36.101
[3] PDV proposed 900 MHz PEBB Allocation rules - 3 May 2015

Real Wireless determination of coexistence parameters

- We have reviewed each of the parameters which PDV has used in their calculations
- Where we believe the parameters are incorrect or inappropriate we have applied more appropriate values according to two cases:
  - 1) A ***challenging*** case, based on realistic but challenging parameters
  - 2) A ***moderate*** case, based on parameters with a higher likelihood of occurrence

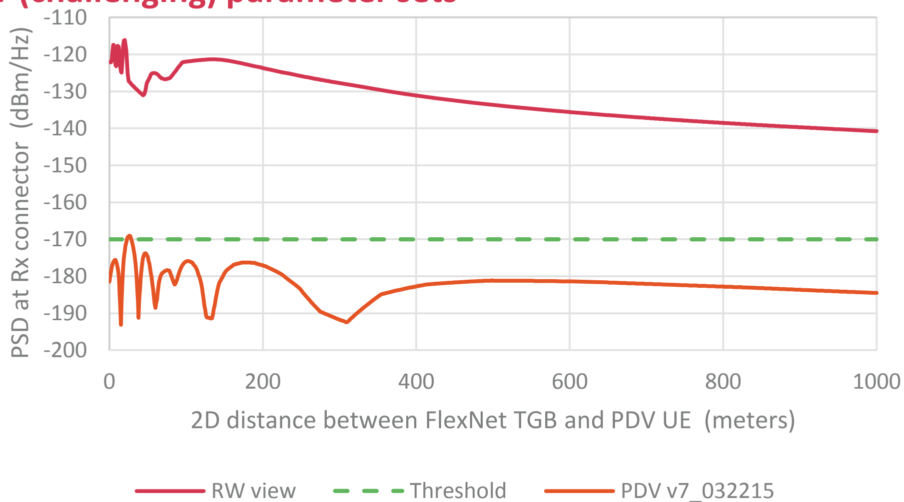
Challenging case - UL

Interpretation A

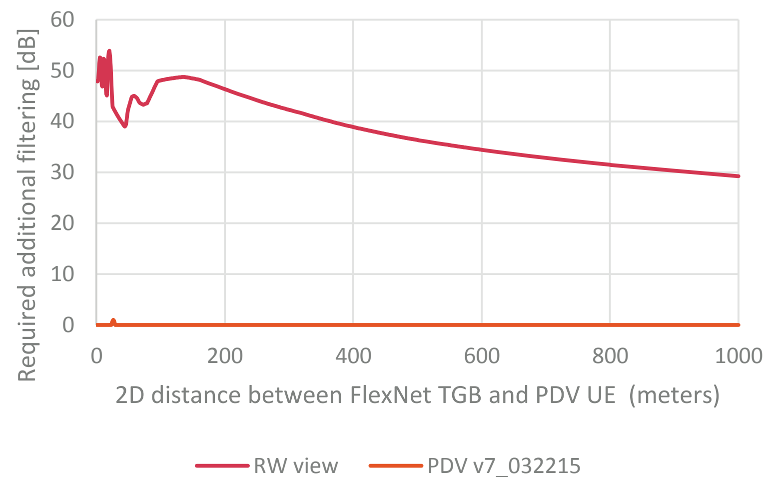
Challenging case outcomes

- The comparison below is based on the PDV proposed emission mask and a protection threshold at -170 dBm/Hz
- The parameters used are compared on the following slide and individually discussed in the remainder of this section

Comparison of interference levels based on PDV and RW (challenging) parameter sets



Required attenuation (additional to PDV proposal) to protect -170dBm/Hz threshold



Our view of parameters indicates that at 54dB of additional attenuation could be required to adequately protect FlexNet base stations in this challenging case

PDV and RW challenging case parameters compared

Challenging case - UL

Interpretation A

- The calculations on the previous slide are based on the following parameters
- In the subsequent slides we examine each of the 10 issues flagged here

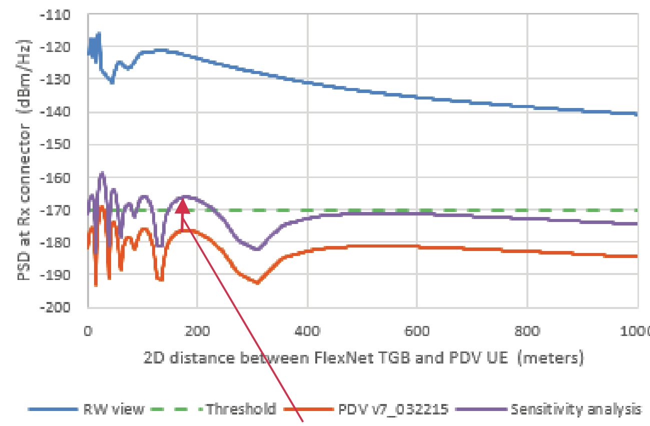
Section	Issue	Parameter	Symbol	Unit	RW view		PDV v7 032215	
UE transmit system		PDV Tx center frequency	f	MHz	833.5	The correct center frequency	833.0	Incorrectly stated
		LTE channel bandwidth including guard band	BW	MHz	3		3	
		Number of available RB	NoRB		15	3GPP TS 36.101	15	3GPP TS 36.101
		PDV terminal OOB PSD immediately adjacent to channel		dBm/30kHz	-25.2	PDV's proposal	-25.2	Equivalent of -20dBm/100kHz from FCC 47 CFR 90.691CMRS BC 26
		as above in dBm/Hz	P_t	dBm/Hz	-70.0		-70.0	
	1	PDV UE antenna gain	G_A	dBi	0.0		0.0	PDV quote 10dB for combined (head body loss-antenna gain) quoting FCC 12-151 Para. 142
	1	PDV UE body loss	G_B	dB	0.0	Assumption, Interference assessment when there is no human in close proximity to the UE	10.0	
	2	LTE UE Power back off	PC	dB	0.0	Assumption, Interference assessment when the UE transmits at maximum licence	9.0	95% point of CSMAC WG-1 CDF curve for Suburban
	3	Effect of UE power control on OOB PSD	a		0.0	Assumption, the 3GPP OOB emissions do not scale with the in-band power	1.0	OOBE reduction dB for dB with fundamental power
	4	UE cable loss	G_C	dB	0.0	Part of definition of UE antenna gain	4.0	Called "NB-BTS Cable Loss" by PDV
	5	No. of simultaneously transmitting PDV UE	NoUE		15.0	Max no of UEs simultaneous Tx at one time	1.0	
		OOB EIRP density		dBm/Hz	-58.2		-93.0	
TBG receive system		Thermal noise PSD		dBm/Hz	-174		-174	
		FlexNet TBG noise figure		dB	4	Input from Sensus	4	
		Thermal noise PSD at Rx input		dBm/Hz	-170		-170	
	6	Environmental noise margin		dB	2	Based on Sensus measurements [TBD]	9.5	TIA-TSB-88.2-D
		Thermal noise PSD at Rx input, incl env. noise		dBm/Hz	-168		-161	
	7	FlexNet TBG antenna gain		dBi	12.15	Amphenol, BCD-87010-EDIN-6-25	12	Amphenol, BCD-87010-EDIN-6
	7	FlexNet TBG antenna pattern			BCD-87010-EDIN-6-25		BCD-87010-EDIN-6	
Other parameters	8	FlexNet TBG height		feet	60	Input from Sensus, 80% of the heights > 60ft	147.6	
			h_b	m	18.29		45.00	No source given
		FlexNet Endpoint height	h_m	m	1.5		1.5	
	9	Median propagation model			Free space		W-I LOS (slant distance)	
		FlexNet TBG mechanical downtilt		deg	0	Input from Sensus	0	No downtilt used
	10	Max attenuation due to V antenna pattern	SLA_v	dB	20	3GPP TR 36.814: multipath fills nulls	999	No consideration of multipath

Challenging case - UL

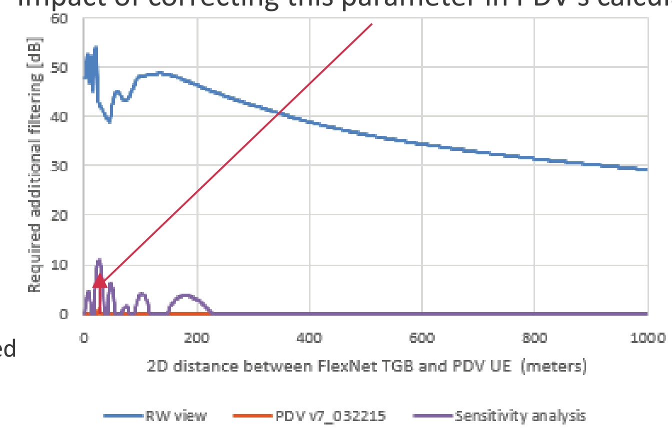
Interpretation A (1)

UE antenna gain and body loss

- PDV have assumed that the combination of the UE antenna gain and the head/body loss produce a composite gain of **-10dBi** citing FCC 12-151 Para. 142
- For standard UEs in the form of phones it is usual to assume an antenna gain of around 0dBi (see for example ITU-R and 3GPP system simulation assumptions [1][2][3])
- Body loss is entirely dependent on the way in which the UE is held, and on the orientation of the user with respect to the Flexnet system. Also if the UE is not already at its maximum transmit power, the body loss will cause the transmit power to increase, negating the impact of the loss. It cannot be relied upon to provide protection against interference.
- Hence our view is that a more appropriate value for the composite loss is **0dBi**
- We note however that UEs may not be smartphones, but could be for example consumer CPE intended for rural broadband applications. This can have an antenna gain as high as +10dBi, zero body loss and a high elevation, so our view by no means represents a worst case



Impact of correcting this parameter in PDV's calculations



[1] ITU-R Rep. M.2135-1 "Guidelines for evaluation of radio interface technologies for IMT-Advanced
[2] 3GPP TR 25.816, "UMTS 900 MHz Work Item Technical Report"
[3] 3GPP TR 36.942, "Radio Frequency (RF) system scenarios"

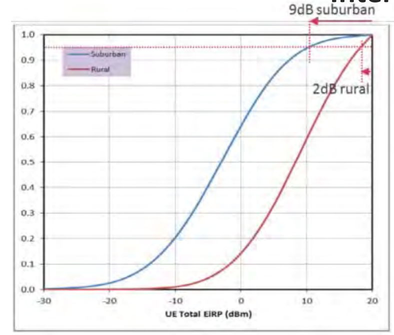
Body loss has been overestimated: Impact of correcting this: +10dB worse interference

LTE UE power backoff

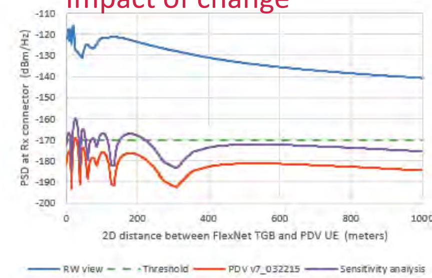
- PDV have assumed that the transmit power of the UE is reduced by **9dB**, citing “95% point of CSMAC WG-1 CDF curve for Suburban ”
- It appears that the reference is intended to be to [1]
- This report relates to sharing studies between terrestrial LTE UEs and meteorological satellites, whose receiver sees cumulative interference from UEs distributed over a wide area. We have several concerns with this approach:
  - The calculations relating to the statistics of UEs distributed over a wide coverage area and many cells, not to the power which may be encountered by an individual UE at a particular specific location. Such statistics are irrelevant to the analysis of an individual path between a specific aggressor UE and its victim
  - PDV have chosen the suburban curve. Many FlexNet systems operate in rural areas. The rural backoff value is closer to 2dB
  - PDV have chosen the 95% probability level. In order to protect FlexNet base stations we need to consider that a PDV UE may not be mobile, but could be permanently located close to a FlexNet TGB, so we are concerned with UEs at or near their maximum transmit power
  - Hence we believe it is appropriate to evaluate interference based on **0dB backoff**

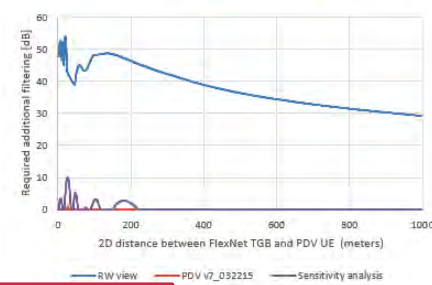
From Appendix A in [1]

Interpretation A (2)



Impact of change





[1] NTIA CSMAC WG-1 Final Report link

Impact of correcting this: +9dB worse interference

Challenging case - UL

Interpretation A

3

Effect of UE power control on OOBE

- PDV have assumed that UE out of band emissions reduce by **1dB** for every dB of reduction in fundamental power as a result of power control
- No reference is cited for this behaviour
- 3GPP (and FCC) specifications for OOBE relate to an absolute power level, and do not specify a reduction with fundamental power
- It is possible that some OOBE sources in some UEs might reduce with power control: however OOBE can also be caused by sources such as spurious emissions from local oscillator leakage and wideband noise from linearised PAs, neither of which is likely to scale with the fundamental power
- So we believe it is inappropriate to assume that OOBE emissions reduce with power control, and this parameter should be set conservatively to **0dB**
- This parameter works together with the previous parameter (power backoff assumption ②). So even if our view on power backoff is not accepted, the impact of the power backoff on OOBE would be negated and the same 9dB increase in interference would be experienced.

Impact of correcting this: +9dB worse interference (taken together with issue ②)

Challenging case - UL (4)
Interpretation A

"NB-BTS cable loss"

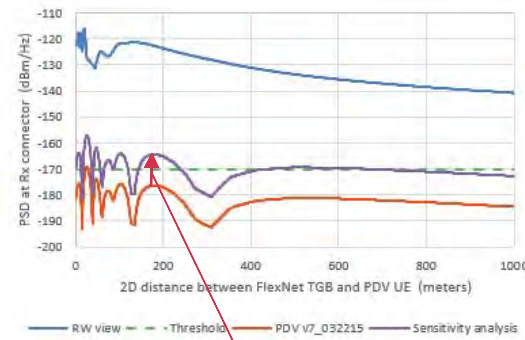
- PDV's calculation includes a parameter called "NB-BTS Cable Loss", set to a value of **4.0 dB**. No reference source for this parameter is provided
- In PDV's model, this parameter directly reduces the level of the UE OOB emissions, so it appears in fact to be applied as a UE feeder loss
- The UE feeder loss would in practice be treated as part of the definition of the UE antenna gain, with no separate parameter necessary
- It appears therefore that PDV have mistakenly included this parameter and it should be removed or set to **0 dB** to correctly determine the UE OOBE level

PDV have mistakenly included a parameter which is not relevant.
Impact of correcting this: +4 dB worse interference

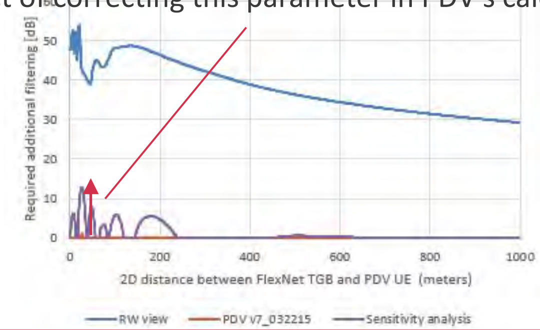
No of simultaneously transmitting PDV devices

Interpretation A 5

- PDV have assumed that only a single UE is transmitting in the channel, although they have included a parameter to set the numbers of UEs in their model
- In a 3 MHz LTE channel there are 15 individually addressable resource blocks, in each of which the base station (eNB) can schedule a single UE. In this situation each UE can simultaneously transmit at full power, creating a cumulative interference level 15x (12dB) greater than analysed



Impact of correcting this parameter in PDV's calculations



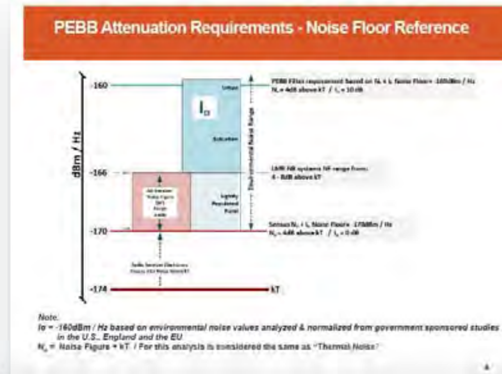
PDV have not included the effect of multiple UEs.
Impact of correcting this: +12 dB worse interference

Environmental noise margin (1)

Challenging case - UL

Interpretation A 6

- The basic noise floor seen at a Sensus base station is at thermal noise PSD (kT = -174dBm/Hz) plus the base station system noise figure (4dB based on Sensus data) –
  i.e. **-170 dBm/Hz**
- The noise floor *may* be raised at individual sites by environmental noise
- PDV has included a noise margin of 10dB, resulting in a 9.5 dB noise rise to **-160.5 dBm/Hz** This is based on their reading of a collection of studies which made in various environments, but they note that: "studies…were difficult to find…deliver values from a limited amount of samples…had to be extrapolated" suggesting a low confidence in their chosen value.
- We note that environmental noise arises in practice from specific sources which vary substantially with location, time and frequency. At any given base station the environmental noise may be much lower than these values.
- In contrast to the generalised data which PDV have used, Sensus have made explicit measurements at a several base stations over several years



-160dBm Reference Noise Floor – $N_o + I_o$

1. IEEE 473 1985 -
   IEEE Recommended Practice for an Electromagnetic Site Survey (10 kHz to 10 GHz)
2. World Metrological Organization
   COMMISSION FOR BASIC SYSTEMS STEERING GROUP ON RADIO FREQUENCY COORDINATION
   Results of Ambient RF Environment and Noise Floor Measurements Taken in the U.S. in 2004 and 2005
3. Man Made Noise in Our Living Environment
   International Union of Radio Science
   No. 334, September 2010
4. CEPT REPORT 19 - Revision 10/30/08
   Report from CEPT to the European Commission
   in response to the mandate to develop least restrictive technical conditions for frequency bands addressed in the context of WAPECS

Note: In their model PDV also cite TIA-TSB-88.2-D

Note:
Studies to determine the -160dBm reference noise floor were difficult to find. Publically available studies deliver mean or median values from a limited amount of samples and some cases had to be extrapolated for this analysis to develop a generalized threshold for use in modeling and determining a baseline ceiling reference $N_o + I_o$ value.

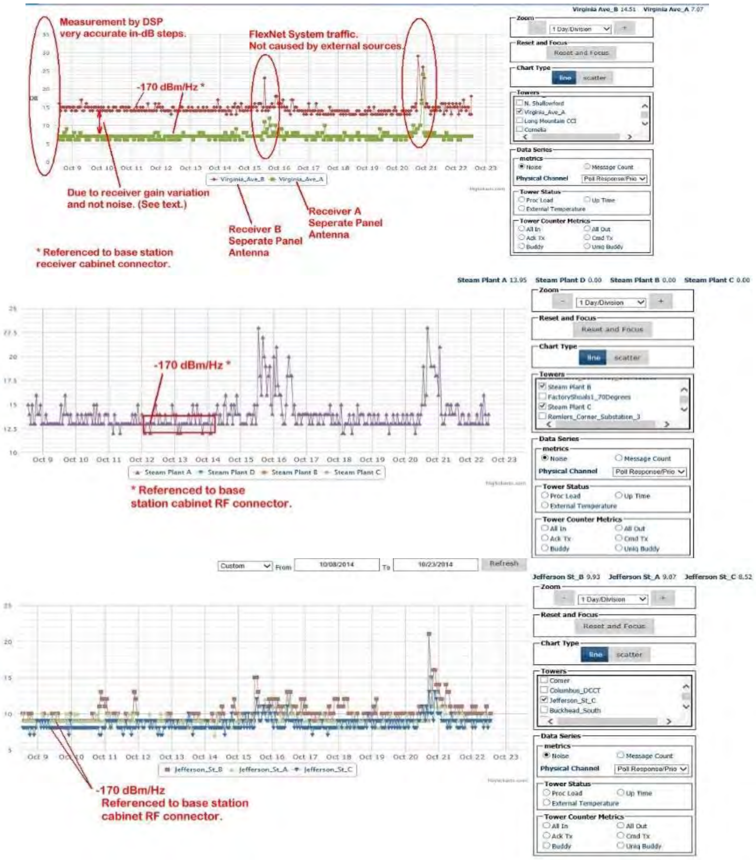
Environmental noise margin (2)

Challenging case - UL

Interpretation A 6

- Shown opposite are measurements by Sensus at FlexNet base station receivers at three sites in downtown Atlanta
- These show minor (**1-3 dB**) excursions from a -170dBm/Hz noise floors (the larger peaks are due to active traffic, not noise), despite the urban environment – rural environments would be expected to exhibit less noise
- Sensus report that they also have data from paging companies' base stations from '03, '04 and '05. They have seen no significant change in the noise floor environment over the last 10-13 years

Environmental noise measurements in Downtown Atlanta



Environmental noise margin (3)

Challenging case - UL

Interpretation A 6

- Hence we consider that PDV have applied an excessive allowance for environmental noise, based on unsuitable data, and suburban/urban environments rather than rural cases
- Even where environmental noise does occur, interference from PDV UEs will be additive, degrading the overall system reliability and capacity
- Hence we believe it is appropriate to protect FlexNet base stations at their noise floor of **-168 dBm/Hz**, not the PDV suggestion of **-160.5** dBm/Hz

- PDV's suggestion is based on inadequate data and inappropriate environments and is out of line with the real-world environment encountered by FlexNet
- Impact of correcting this: 7.5 dB worse interference impact (through lowered protection threshold)

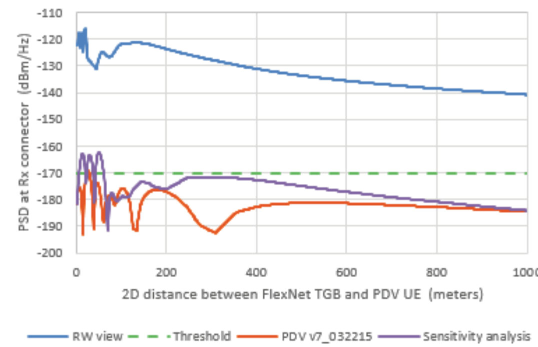
Challenging case - UL

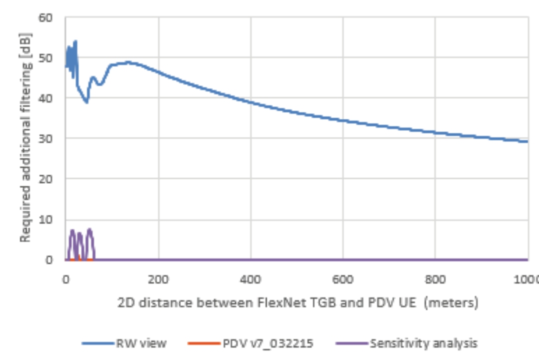
Base station antenna radiation pattern and gain

Interpretation A

7

- In the first version of their model [1] PDV quoted antenna pattern BCD-87010-EDIN-6: we have checked the manufacturer's website for this and compared: the pattern is entirely different from that used by PDV – this appears to be a mistake
- In the newer version of the model [2] PDV quote antenna type BCD-87010-EDIN-1-25, but the pattern data used is identical to the previous version: we cannot find this on the manufacturer's website
- The most commonly used patterns in the FlexNet network are the BCD-87010-25 series model: we propose to use the BCD-87010-6-25 which has 6 degrees of electrical downtilt
- While the antenna gain is unchanged, the increased downtilt results in peaks of interference around 7dB higher and extended over a greater ranges of distances





PDV appear to have used the wrong antenna radiation pattern: a realistic pattern increases short-range interference by around 7 dB

[1] P-S_Coexistence Analysis_021815.xlsx
[2] Sensus_Coexistence Analysis_v7_032215

Challenging case - UL

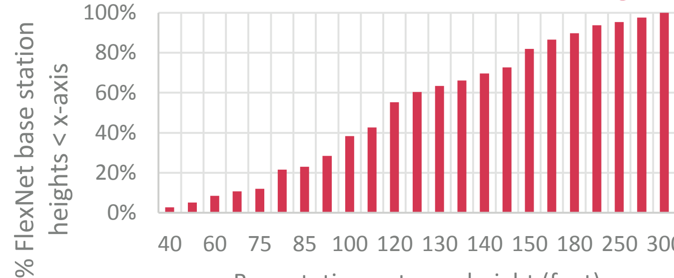
8

Base station antenna height

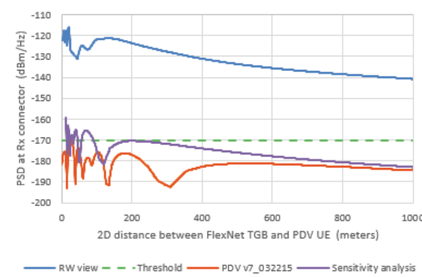
- PDV have assumed a base station antenna height of **148'** (45m)
- Analysis of the actual antenna heights of FlexNet base stations shows that:
  - The median (50%) antenna height is between 110'-120'
  - Around 20% antennas are below 80'
  - Around 10% of antennas are below 60'
- PDV have chosen a non-typical height
- Lower antenna heights reduce the path loss to the UE, increasing the maximum interference level
- In order to protect most base stations , we select the 10% value of **60'**
- The impact of this change is shown opposite

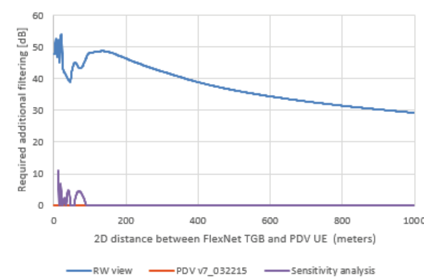
Interpretation A

Distribution of FlexNet antenna heights



Impact of changing height from 148' to 60'





PDV have overestimated the height for the FlexNet antenna
Correcting this increases the interference level by up to 10 dB

realwireless

Propagation model (1)

Challenging case - UL

Interpretation A

9

- PDV have used the **Walfisch-Ikegami LoS model** in their calculations. They have made provision for calculations using the free space loss, but have not applied this and the model does not appear to function correctly for this case (it reverts to the “WI-LOS” model even when “Free Space Model” is selected)
- The Walfisch-Ikegami model is a theoretically-based model with empirical extensions, published by a European research project COST-231 [1]. The full text of the model description shown opposite.
- When a line-of-sight path is present and the distance is greater than 20m, the model reverts to an empirical adjustment intended to represent the presence of scattering within an urban canyon environment
- It has several key limitations in this applications:
  - It is not defined for use below 20m (it matches free space loss at that range, but is not intended to be used below that range)
  - It is not applicable in locations represented by anything other than a street canyon, which is an environment rich in multipath and urban furniture features.
  - It is only intended for base station heights below 50m
- For short distances, propagation models converge to free space loss formulation and parameters. The free space loss model is commonly used in co-existence studies to model short and line-of-sight interference paths
- We therefore recommend the use of the **free space loss model** at all ranges where there is potential for a line-of-sight
- We note that indeed at short ranges <20m PDV have adopted the free space model (which is not specified by the Walfisch-Ikegami model)

The Walfisch-Ikegami LoS model

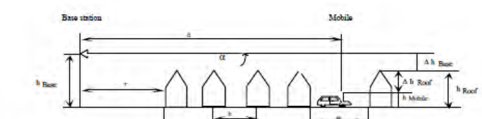


Fig 4.4.1 Typical propagation situation in urban areas and definition of the parameters used in the COST-WI model and other Walfisch-type models [24], [45], [52].

The model distinguishes between line-of-sight (LOS) and non-line-of-sight (NLOS) situations. In the LOS case -between base and mobile antennas within a street canyon - a simple propagation loss formula different from free space loss is applied. The loss is based on measurements performed in the city of Stockholm:

$$L_b(\mathrm{dB}) = 42.6 + 26\log(d/\mathrm{km}) + 20\log(f/\mathrm{MHz}) \quad \text{for } d \geq 20\ \mathrm{m} \qquad (4.4.5)$$

where the first constant is determined in such a way that L_b is equal to free-space loss for $d = 20$ m. In the NLOS-case the basic transmission loss is

Applicability of Walfisch-Ikegami LoS model

The COST-WI model is restricted to:

f :	800 ... 2000 MHz
h_{Base} :	4 ... 50 m
h_{Mobile} :	1 ... 3 m
d :	0.02 ... 5 km

[1] “Digital mobile radio towards future generations”, COST action 231, 1999

Propagation model (2)

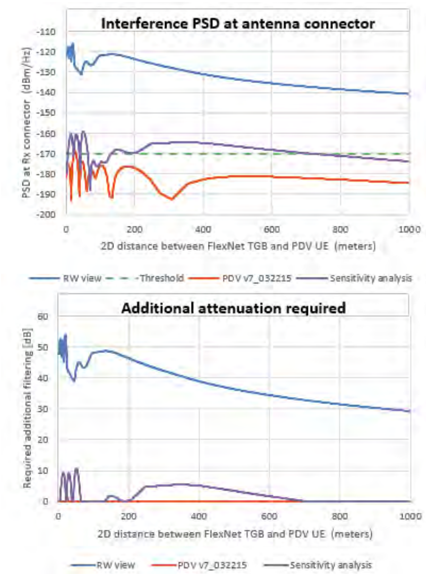
Challenging case - UL 9

- Since Walfisch-Ikegami exceeds the free space loss model at all ranges > 20m, it risks understating the extent of interference
- It has a small (1.4 dB) impact on interference at a range of around 30 m taken on its own
- However when taken together with the change to the antenna pattern the impact is compounded and results in a 3.5 dB increase in interference (on top of the 7 dB due to the antenna change)

Interpretation A

Comparing the Walfisch-Ikegami LoS and free space models

Combined impact of propagation model and antenna pattern



Challenging case - UL

Interpretation A

10

Maximum attenuation due to antenna pattern

- Antenna patterns are measured in anechoic chambers, which exhibit no multipath propagation
- In practical environments even small amounts of multipath can substantially reduce the depth of antenna pattern nulls (see example from [1]) , so these should not be relied on to provide interference protection in particular directions
- PDV has **not considered** this effect
- In order to deal with this it is typical to cap the attenuation from the antenna at some level, typically around 20 dB (see [2, 3])
- The impact is to significantly increase the level of interference at the shortest ranges, resulting in an extra 2.5 dB attenuation

Theoretical pattern

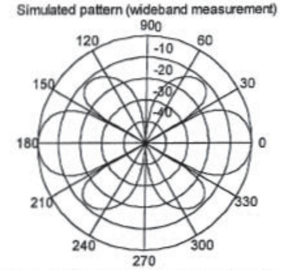


Figure 10. This simulated pattern represents the use of a wideband profile to plot the true antenna pattern by using only the LOS component. (dB vs. θ°)

Real world

Practical pattern [1]

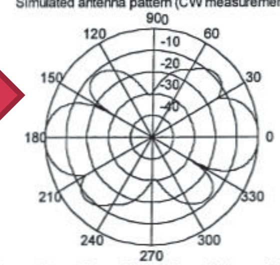
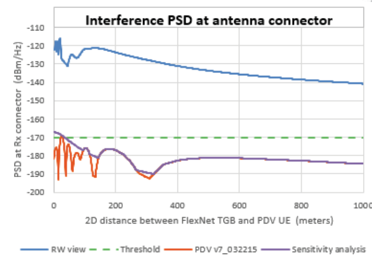
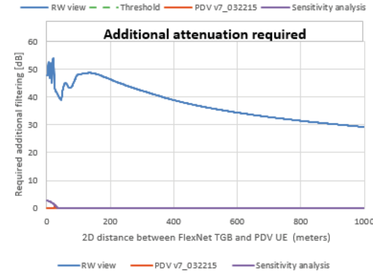


Figure 11. The effect of a single multipath component is seen by the distortion of lobes and filling of nulls compared to the true pattern illustrated in Figure 10. (dB vs. θ°)





[1] "Antenna pattern measurement technique using wideband channel profiles to Resolve Multipath Signal Components", Newhall & Rappaport, AMTA 19th symp. Boston, Nov. 1997

[2] 3GPP TR 36.942

[3] 3GPP TR 36.814

Challenging case - UL

Interpretation A

Summary of differences – challenging case

- We believe PDV has understated the impact of interference due to the following inappropriate parameter choices:

#	Parameter	Comment on PDV assumptions	Impact of each correction on interference (relative to RW challenging case):
①	UE antenna gain and body loss	Body loss does not always protect from interference	+10dB
②	UE power back off	PDV assumed a statistical backoff based on UE mobility	+9dB
③	Effect of UE power control on OOBE	PDV assumed power control impacts on OOBE by 1dB per dB	
④	"UE cable loss"	Appears to be mistakenly included	+4dB
⑤	Number of simultaneous UE	Assumed only 1 UE active	+12dB
⑥	Environmental noise margin	Assumed 9.5 dB noise rise from reference sources, no measurements	+7.5 dB
⑦	Flexnet TGB antenna gain & pattern	Used an unrealistic antenna pattern	+7 dB
⑧	Flexnet TGB antenna height	Overestimated antenna height	+10 dB
⑨	Propagation model	Propagation model used is for different environment	+3.5 dB
⑩	Maximum antenna attenuation	No consideration of impact of real environment on nulls	+2.5dB
	Overall	**Effects are not simply additive**	**~50-55dB**

Moderate Case - UL

Interpretation A

Moderate case parameters

#	Parameter	Unit	PDV Parameters	RW Challenging case parameters	RW moderate case parameters
1	UE antenna gain and body loss	dBi	-10.0	0	-3.0
2	UE power back off	dB	9.0	0	3.0
3	Effect of UE power control on OOBE	dB per dB	1.0	0	1.0
4	PDV eNodeB cable loss		4.0	0	0.0
5	Number of simultaneous UE	# UEs	1.0	15	3.0
6	Protection level	dBm/Hz	-160.0	-170	-168.0
7a	Flexnet TGB antenna boresight gain	dBi	12.2	12.2	12.2
7b	Flexnet TGB antenna pattern		Unknown pattern per PDV model	Amphenol, BCD-87010-6-25 (6 elec. downtilt)	Amphenol BCD-87010-3 with 3 degree electrical downtilt
8	Flexnet TGB antenna height	feet	147.6'	60’	110’
9	Propagation model		W-I LOS	Free space	Free space
10	Maximum antenna attenuation	dB	Unlimited	20	Unlimited

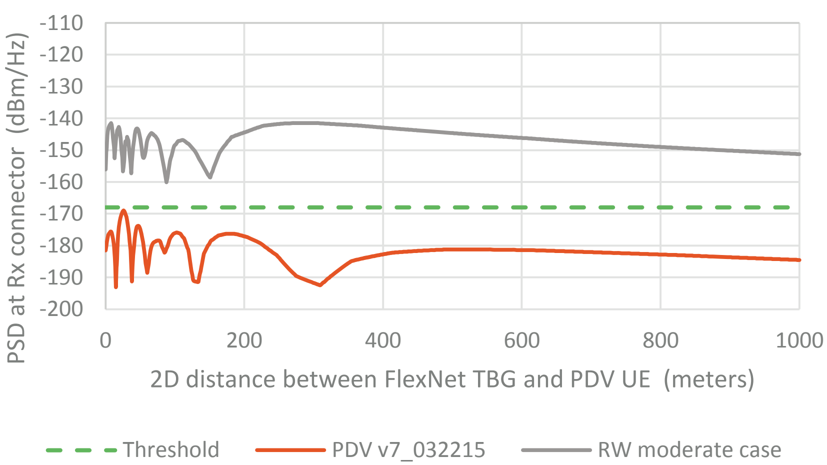
Moderate Case - UL

Interpretation A

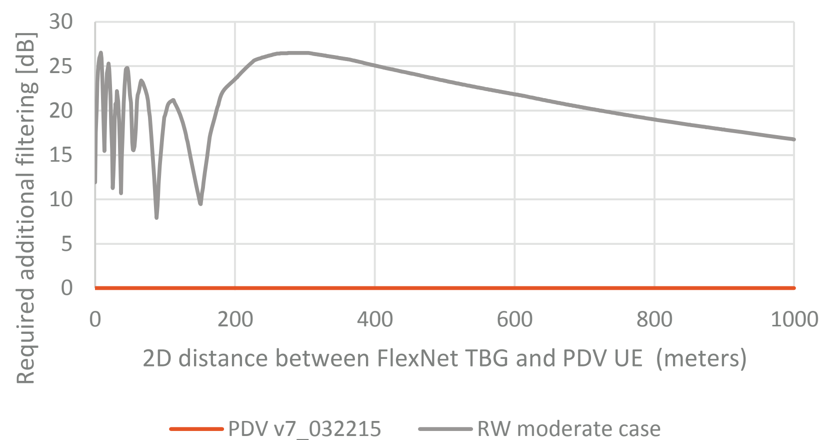
RW moderate case: coexistence parameters

- We have conducted the RW moderate case analysis. The PDV case results are also shown below.

Comparison of interference levels between PDV and proposed moderate case



Required attenuation (additional to the threshold) to protect -168dBm/Hz threshold



Our view of parameters indicates that some 27 dB of additional attenuation could be required to adequately protect FlexNet base stations in this moderate case

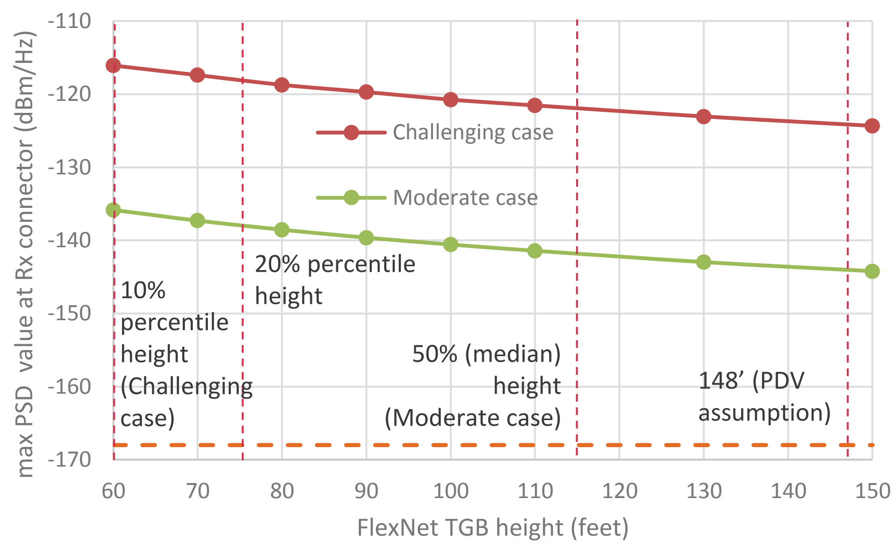
Moderate Case - UL

Challenging case - UL

Interpretation A

Effect of TGB antenna height

- We have varied the height of the Sensus TGB base station to determine the sensitivity to this parameter
- The graph shows the value of the highest PSD encountered at any distance for a given TGB antenna height
- There is around 10 dB of variation between the PDV assumption and our challenging case (which represents protection of ten percent of all Sensus TGBs)
- There is around 5dB of variation between our moderate and challenging cases
- This points to the potential for a site-specific protection level
- However in all cases the PSD remains above the required protection level



7. Interference mode PU2FT UL (PDV mobile to FlexNet base station) - Interpretation B

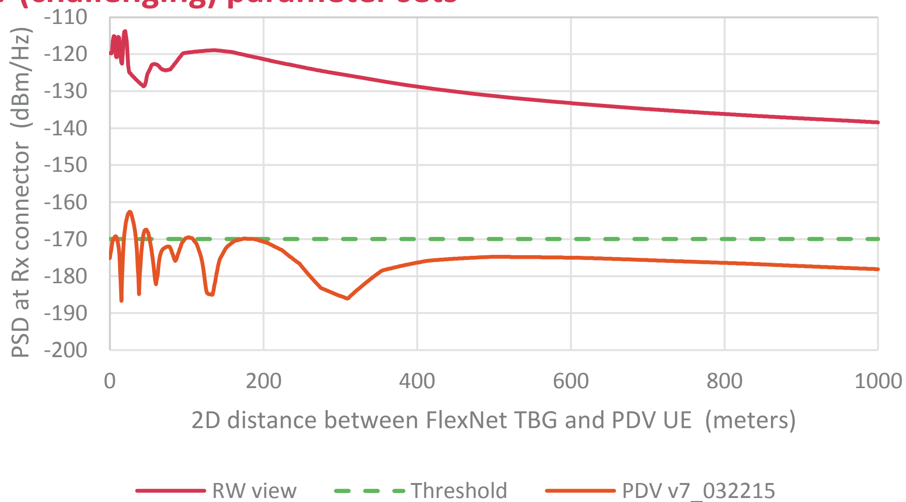
Challenging case - UL

Interpretation B

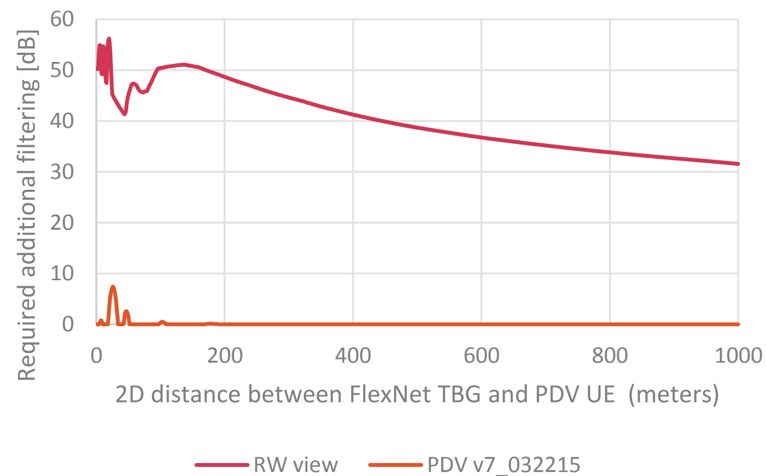
Challenging case outcomes

- The comparison below is based on the PDV proposed emission mask and a protection threshold at -170 dBm/Hz
- The parameters used are compared on the following slide and individually discussed in the remainder of this section

Comparison of interference levels based on PDV and RW (challenging) parameter sets



Required attenuation (additional to the -170 dBm/Hz threshold)



Our view of parameters indicates that 56dB of additional attenuation could be required to adequately protect FlexNet base stations in this challenging case

Interpretation B

Challenging case and Moderate case parameters

#	Parameter	Unit	PDV Parameters	RW Challenging case parameters	RW moderate case parameters
1	UE antenna gain and body loss	dBi	-10.0	0	-3.0
2	UE power back off	dB	9.0	0	3.0
3	Effect of UE power control on OOBE	dB per dB	1.0	0	1.0
4	PDV eNodeB cable loss		4.0	0	0.0
5	Number of simultaneous UE	# UEs	1.0	15	3.0
6	Protection level	dBm/Hz	-160.0	-170	-168.0
7a	Flexnet TGB antenna boresight gain	dBi	12.2	12.2	12.2
7b	Flexnet TGB antenna pattern		Unknown pattern per PDV model	Amphenol, BCD-87010-6-25 (6 elec. downtilt)	Amphenol BCD-87010-3 with 3 degree electrical downtilt
8	Flexnet TGB antenna height	feet	147.6'	60’	110’
9	Propagation model		W-I LOS	Free space	Free space
10	Maximum antenna attenuation	dB	Unlimited	20	Unlimited

Challenging case - UL

PDV and RW challenging case parameters compared

- The calculations on the previous slide are based on the following parameters
- In the subsequent slides we examine each of the 10 issues flagged here

Interpretation B

Issue	Group	Parameter	Symbol	Unit	Value RW view	RW comment	Value PDV v7_032215	PDV comment
	UE transmit system	PDV Tx center frequency	f	MHz	899.5	The correct center frequency	899.0	Incorrectly stated
		OOB attenuation factor		dB	55	+10log(P)	55	+10log(P)
		PDV terminal OOB PSD immediately adjacent to channel		dBW/30kHz ERP	-55.0		-55.0	
				dBm/30kHz ERP	-25.0		-25.0	Equivalent of -20dBm/100kHz from FCC 47 CFR 90.691/CMRS BC 26
				dBm/100kHz ERP	-19.8	PDV's proposal	-19.8	
				dBm/100kHz EIRP	-17.6		-17.6	
				dBm/Hz ERP	-69.8		-69.8	
				dBm/Hz EIRP	-67.6		-67.6	
1		PDV UE antenna gain		dBi	0.0		0.0	PDV quote 10dB for combined (head body loss-antenna gain) quoting FCC 12-151 Para. 142
1		PDV UE body loss	G_B	dB	0.0	No body shielding of UE	10.0	
2		LTE UE Power back off	PC	dB	0.0	Assumption: interference assessment when the UE transmits at maximum licence	9.0	95% point of CSMAC WG-1 CDF curve for Suburban
3		Effect of UE power control on OOB PSD	a		1.0	Assumption: the 3GPP OOB emissions do not scale with the in-band power	1.0	OOBE reduction dB for dB with fundamental power
4		UE cable loss		dB	0.0	Part of definition of UE antenna gai	4.0	Called "NB-BTS Cable Loss" by PDV
5		No. of simultaneously transmitting PDV UE	NoUE		15.0	Max. no of UEs simultaneous Tx at one time	1.0	PDV assume best case of a single UE
		OOB EIRP density		dBm/Hz	-55.9		-86.6	
	TGB receive system	Thermal noise PSD		dBm/Hz	-174		-174	
		FlexNet TGB noise figure		dB	4	Input from Sensus	4	
		Thermal noise PSD at Rx input		dBm/Hz	-170		-170	
6		Environmental noise margin		dB	2	Based on Sensus measurements	9.5	TIA-TSB-88.2-D
		Thermal noise PSD at Rx input, incl env. noise		dBm/Hz	-168		-161	
		FlexNet TGB antenna gain		dBi	12.15	Amphenol, BCD-87010-6-25	12	Amphenol, "BCD-87010-EDIN-6"
7		FlexNet TGB antenna pattern			6-25 Amphenol		1-25 PDV	
8	Other parameters	FlexNet TGB height		feet	60	Input from Sensus, 10% of the heights <60ft	147.6	
			h_b	m	18.29		45.00	No source given
		PDV UE height	h_m	m	1.5		1.5	
9		Median propagation model			Free space		W-ILOS (slant distance	
		FlexNet TGB mechanical downtilt		deg	0	Input from Sensus	0	
10		Max attenuation due to V antenna pattern	SLA_v	dB	20	3GPP TR 36.814: multipath fills nulls	999	No consideration of multipath

Challenging case - UL

Interpretation B

Issues with 10 parameters

- Details of our views on the following issues are available in the previous section: the same issues apply equally to this interpretation:
  - UE antenna gain and body loss
  - LTE UE power backoff
  - Effect of UE power control on OOBE
  - "NB-BTS cable loss"
  - No of simultaneously transmitting PDV devices
  - Environmental noise margin
  - Base station antenna radiation pattern and gain
  - Base station antenna height
  - Propagation model
  - Maximum attenuation due to antenna pattern

Challenging case - UL

Interpretation B

Summary of differences – challenging case

- We believe PDV has understated the impact of interference due to the following inappropriate parameter choices:

#	Parameter	Comment on PDV assumptions	Impact of each correction on interference (relative to RW challenging case):
①	UE antenna gain and body loss	Body loss does not always protect from interference	+10dB
②	UE power back off	PDV assumed a statistical backoff based on UE mobility	+9dB
③	Effect of UE power control on OOBE	PDV assumed power control impacts on OOBE by 1dB per dB	
④	"UE cable loss"	Appears to be mistakenly included	+4dB
⑤	Number of simultaneous UE	Assumed only 1 UE active	+12dB
⑥	Environmental noise margin	Assumed 9.5 dB noise rise from reference sources, no measurements	+7.5 dB
⑦	Flexnet TGB antenna gain & pattern	Used an unrealistic antenna pattern	+7 dB
⑧	Flexnet TGB antenna height	Overestimated antenna height	+10 dB
⑨	Propagation model	Propagation model used is for different environment	+3.5 dB
⑩	Maximum antenna attenuation	No consideration of impact of real environment on nulls	+2.5dB
	Overall	**Effects are not simply additive**	**~50-55dB**

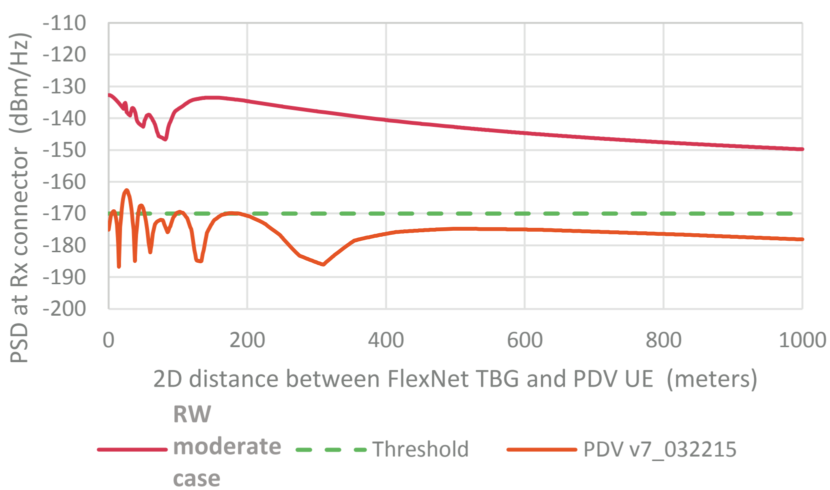
Moderate Case - UL

Interpretation B

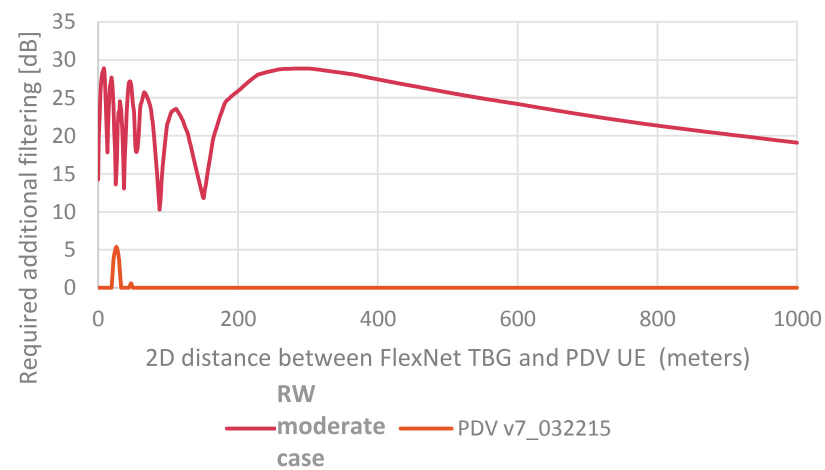
RW moderate case: coexistence parameters

- We have conducted the RW moderate case analysis. The PDV case results are also shown below.

Comparison of interference levels between PDV and proposed moderate case



Required attenuation (additional to the -168 dBm/Hz threshold)



Our view of parameters indicates that some 29 dB of additional attenuation could be required to adequately protect FlexNet base stations in this moderate case

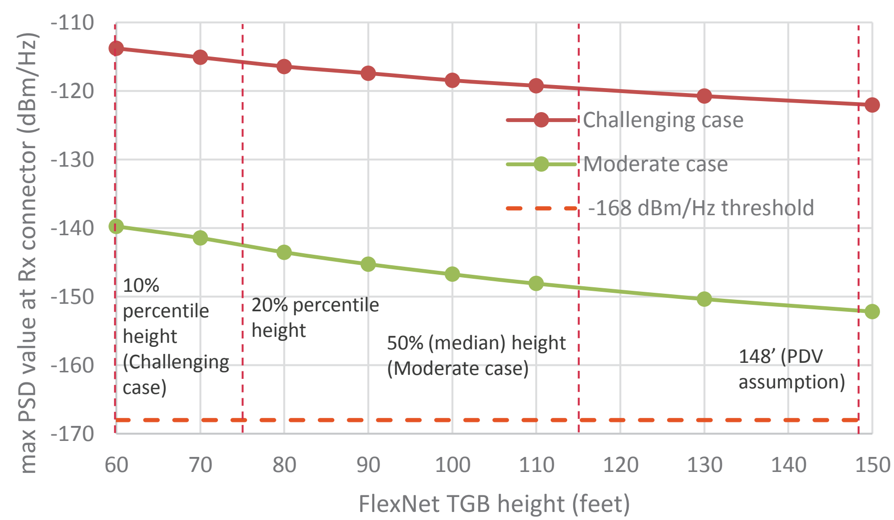
Effect of TGB antenna height

Moderate Case –UL

Challenging case - UL

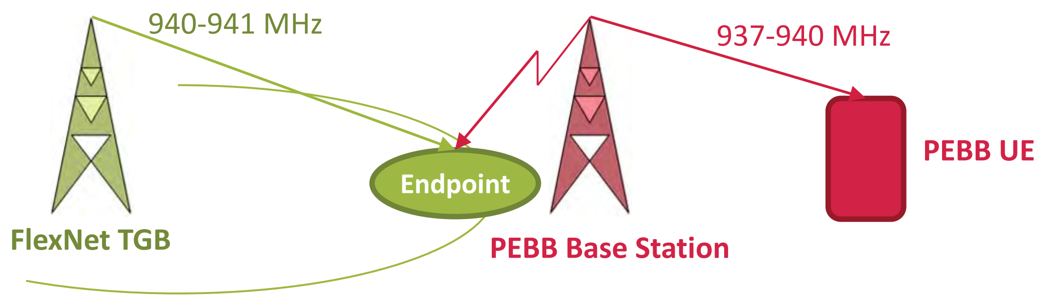
Interpretation B

- We have varied the height of the Sensus TGB base station to determine the sensitivity to this parameter
- The graph shows the value of the highest PSD encountered at any distance for a given TGB antenna height
- There is around 10 dB of variation between the PDV assumption and our challenging case (which represents protection of ten percent of all Sensus TGBs)
- There is around 5dB of variation between our moderate and challenging cases
- This points to the potential for a site-specific protection level
- However in all cases the PSD remains above the required protection level



8. Interference mode PB2FE DL (PDV base station to FlexNet endpoint) – Interpretation A

Scenario PB2FE

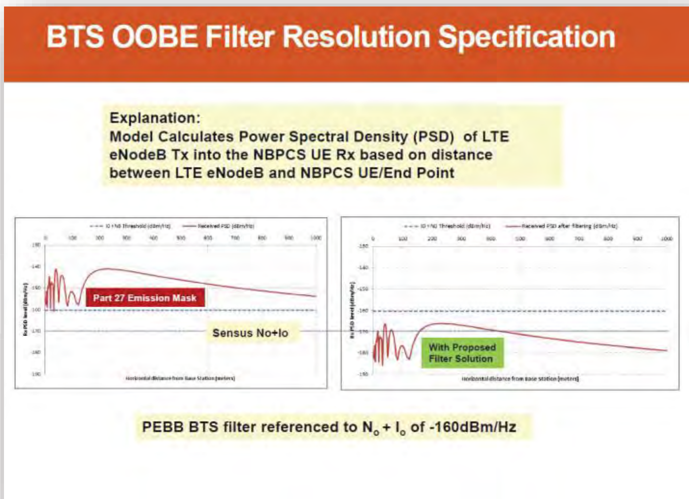


- An endpoint is at the edge of a FlexNet
- A PEBB Base Station is nearby and causes excessive interference to an endpoint Rx

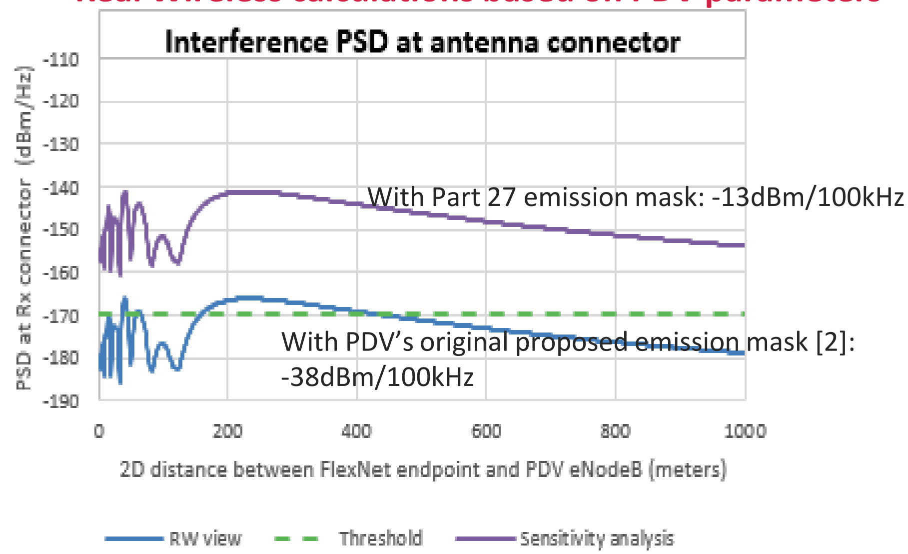
PDV analysis of interference mode PB2FE

- PDV have analysed this mode and have provided a spreadsheet-based model to represent their calculations [1]
- The result of their analysis for the PSD of the LTE eNB as received at the FlexNet endpoint receiver is shown below [2].
- Also shown is a Real Wireless calculation based on our own model using the same parameters. This result matches closely to the PDV calculations

PDV calculations



Real Wireless calculations based on PDV parameters



[1] Sensus_Coexistence Analysis_v7_032215

[2] PDV ex parte notice RM-11738 03-25-2015

Real Wireless agrees with the calculation methodology proposed by PDV

PDV's proposals based on their modelling

- Based on their calculations, PDV proposed in their initial ex parte filing [1] that DL emissions for each eNodeB would be attenuated by at least:

  73 + 10log(P) in a 30 kHz segment (March 25 proposal)

  which they say is 25dB lower than the FCC Part 27 specifications
- Subsequently PDV revised their proposals in [2] to an attenuation of

  55 + 10 log (P) in a 30 kHz segment (May 3 proposal)
- W understand that P is in watts and represents the total in-band emissions of the eNodeB
- It is not clear from PDV's proposals whether this P is intended to relate to an EIRP limit or an ERP limit: in the proposed rules [2] neither is specified. In PDV's calculations they have assumed EIRP. In PDV's calculations they have also assumed that the antenna gain-feeder loss of their eNB is added to the proposed emission limit, thereby increasing the actual emissions beyond the proposed limit
- We have therefore analysed the impact based on two potential interpretations:
  - **Interpretation A (as per PDV's calculations) : The proposed emission limit is specified as EIRP and the eNB antenna gain-feeder loss is added to this**

  In this case the proposed emissions are -43 dBm/30 kHz EIRP PLUS antenna gain of 16 dBi MINUS feeder loss of 4dB i.e. effectively
  - **Interpretation B: The proposed emission limit is specified as ERP and the emission limit relates to the actual emissions, not the antenna input**

  In this case the proposed emissions are -25 dBm/30 kHz ERP INDEPENDENT of the eNB antenna gain/feeder loss
- We note the following:
  - This is referenced to a -160.5 dBm/Hz threshold. Sensus have proposed a -170 dBm/Hz threshold. The threshold would be breached by an eNodeB at any distance, in the case of the FCC Part 27 specification, and at a distance of around 16m and 150-400m according to PDV's calculations
  - Sensus systems operate in channel bandwidths as narrow as 1.6 kHz, so measuring in a 30kHz segment may not protect the Endpoint receiver if the emissions vary significantly within the 30kHz range
  - Need to properly specify the eNB traffic and other measurement conditions in which this applies

PDV initial proposal (in ex parte filing[1]):

Proposed Technical Specifications - Emissions

DOWNLINK – Base Station and Fixed

- On any frequency outside 937-940MHz (DL) emissions shall be attenuated below the transmitting power (P) by a factor of at least 73+10log(P) dB in a 30kHz segment

PDV proposal (in ex parte filing [2]):

(a) On all frequencies between 937-940 MHz, by a factor not less than 55 + 10 log (P) dB in a 30 kHz band segment, for base and fixed stations.

[1] PDV ex parte notice RM-11738 - 25 March 2015
[2] PDV proposed 900 MHz PEBB Allocation rules - 3 May 2015

Real Wireless has reservations as to the intended emission specification (EIRP or ERP) , the level to be protected and the bandwidth in which the emission level is specified

Real Wireless determination of coexistence parameters

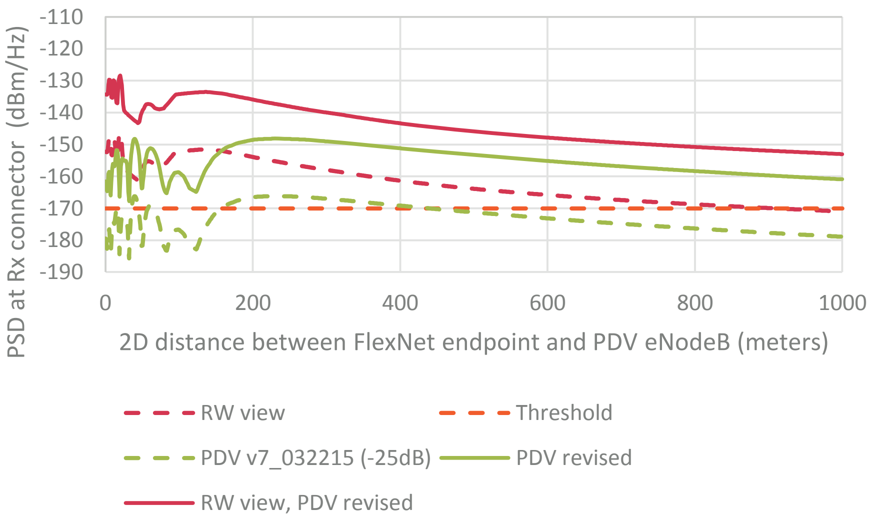
- We have reviewed each of the parameters which PDV has used in their calculations
- Where we believe the parameters are incorrect or inappropriate we have applied more appropriate values according to two cases:
  - 1) A ***challenging*** case, based on realistic but challenging parameters
  - 2) A ***moderate* case**, based on parameters with a higher likelihood of occurrence

Real Wireless challenging case outcomes

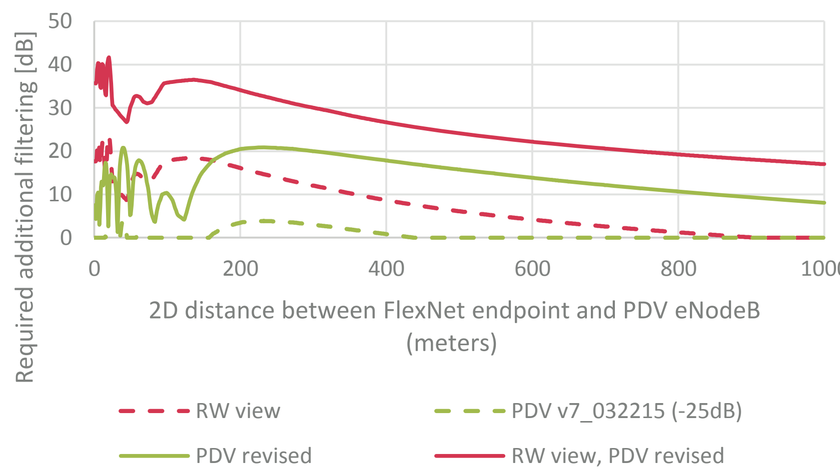
Interpretation A

- The comparison below is based on the PDV proposed emission mask and a protection threshold at -170 dBm/Hz
- The parameters used are compared on the following slide and individually discussed in the remainder of this section

Comparison of interference levels based on PDV and RW challenging parameter sets



Required attenuation (additional to PDV proposal) to protect -170dBm/Hz threshold



Our view of parameters indicates that 24 dB of additional attenuation could be required to adequately protect FlexNet Endpoints given the original PDV proposal and **42 dB extra attenuation for the revised PDV proposal**

PDV and RW challenging case parameters compared

Challenging case - DL

Interpretation A

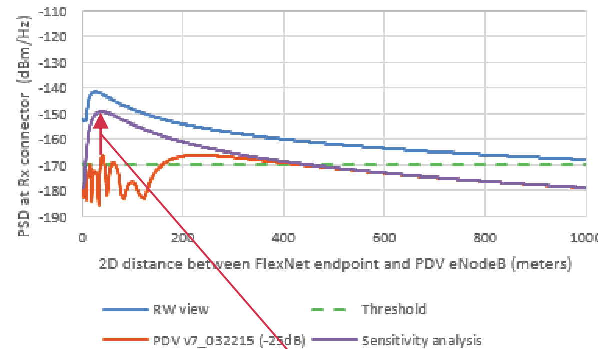
- The calculations on the previous slide are based on the following parameters
- In the subsequent slides we examine each of the 6 issues flagged here

Group	Issue	Parameter	Symbol	Unit	Value RW view	RW note	Value PDV v7_032215 (-25dB)	PDV note	Comment
Base station (eNB) transmit system		PDV Tx center frequency	f	MHz	938.5	The correct center frequency	938.0	Incorrectly stated	
		LTE channel bandwidth including guard band	BW	MHz	3		3		
		Number of available RB	NoRB		15	3GPP TS 36.101	15	3GPP TS 36.101	
		PDV eNodeB OOB PSD immediately adjacent to channel		dBm/100kH	-38.0	PDV's proposal	-38.0	FCC CFR 22.917 - 25dB	
		as above in dBm/Hz	P_1	dBm/Hz	-88.0		-88.0		
	1	PDV eNodeB antenna gain	G_A	dBi	16.0	Irrelevant because licence restriction is in EIRP	16.0	PDV assumes ARGUS HPX308R (2deg), which operates 1525–1710MHz	
	1	PDV eNodeB cable loss	G_C	dB	4.0	Irrelevant because licence restriction is in EIRP	4.0	PDV's assumption	
	1	PDV eNodeB antenna pattern			BCD-7001-EDIN-X	Single Band, Omni, V-Pol, 696-960 MHz, 360°, 1.1 dBd, 3.2 dBi, 0°T, Vertical beamwidth 70 deg	ARGUS HPX308R (2deg)	PDV assumes ARGUS HPX308R (2deg), which operates 1525–1710MHz	
		OOB EIRP density		dBm/Hz	-76.0		-76.0		=P_1+G_A-G_C
FlexNet endpoint receive system		Thermal noise PSD		dBm/Hz	-174		-174		Constant, 10*LOG10(kT)+30
		FlexNet Endpoint noise figure		dB	4	Input from Sensus: Bob_Notes_For_RW	4	No source given	
		Thermal noise PSD at Rx input		dBm/Hz	-170		-170		
	2	Environmental noise margin		dB	2	Based on Sensus measurements	9.5	TIA-TSB-88.2-D	
		Thermal noise PSD at Rx input, incl env. noise		dBm/Hz	-168		-160.5		
	3	FlexNet Endpoint antenna gain		dBi	0	Input from Sensus, email from Bob.Da	1.15	Equivalent to -1dBd no source given	
	3	FlexNet Endpoint cable loss		dB	0		1.9	No source given	
Other parameters	4	PDV eNodeB height		feet	60		98.4		
	4		h_b	m	18.29		30.00	No source given	
		FlexNet Endpoint height	h_m	m	1.5		1.5		
	5	Median propagation model			Free space		W-I LOS (slant distance		
		PDV eNodeB mechanical downtilt		deg	0		0	PDV's assumption	
	6	Max attenuation due to V antenna pattern	SLA_v	dB	20	3GPP TR 36.814: multipath fills nulls	999	No consideration of multipath	

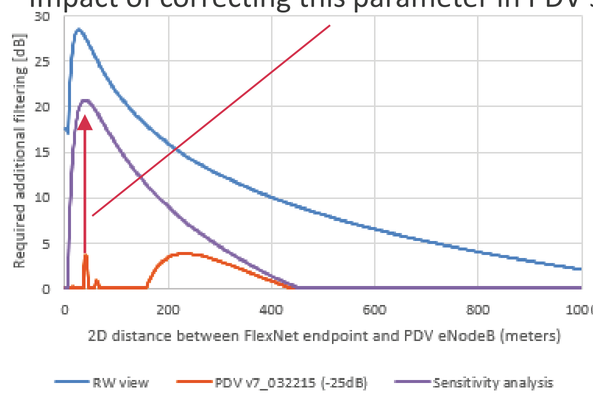
eNodeB antenna pattern, boresight gain, cable and connector losses

- PDV have assumed that the eNodeB antenna gain is 16dBi, citing ARGUS HPX308R (2deg)
- PDV have assumed that the eNodeB antenna cable and connector losses are 4dB
- The OOB density is expressed in EIRP, hence our view is that the values of antenna gain and cable losses are not relevant

- PDV have assumed that the eNodeB antenna is ARGUS HPX308R (2deg)
- ARGUS HPX308R (2deg) operates in 1525–1710MHz, thus its pattern is not applicable to the desired frequency 938.5MHz
- ARGUS HPX308R (2deg) has a relatively narrow vertical beamwidth. An antenna with a wider vertical beamwidth would exacerbate interference reception close to eNodeB. Amphenol BCD-7001-EDIN-X (Single Band, Omni, V-Pol, 696-960 MHz, 360°, 1.1 dBd, 3.2 dBi, 0°T) has 70 deg vertical beamwidth.
- We note that Amphenol BCD-7001-EDIN-X comes with electrical downtilt options, and that with increasing electrical downtilt, the received interference increases close to eNodeB.
- Our view is that a more appropriate antenna pattern is one that has wide vertical beamwidth such as **70deg and 0 electrical downtilt**
- The impact of varying mechanical/electrical downtilt also has to be taken into account



Impact of correcting this parameter in PDV's calculations



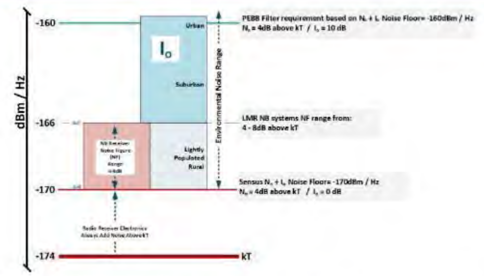
Vertical beamwidth has been underestimated: Impact of correcting this: +18dB worse interference

Environmental noise margin

- The basic noise floor seen at a Sensus Endpoint is at thermal noise PSD (kT = -174dBm/Hz) plus the Endpoint's noise figure (4dB based on Sensus data) – i.e. **-170 dBm/Hz**
- The noise floor *may* be raised at individual Endpoints by environmental noise
- PDV has included a noise margin of 10dB, resulting in a 9.5 dB noise rise to **-160.5 dBm/Hz** This is based on their reading of a collection of studies which made in various environments, but they note that: "studies…were difficult to find…deliver values from a limited amount of samples…had to be extrapolated" suggesting a low confidence in their chosen value.
- As discussed earlier, Sensus have made explicit measurements resulting in an environmental noise margin of **2dB** and individual endpoints may experience less than this

- PDV's suggestion is based on incomplete data and inappropriate environments and is out of line with the real-world environment encountered by FlexNet
- Impact of correcting this: 7.5 dB worse interference impact (through lowered protection threshold)

PEBB Attenuation Requirements - Noise Floor Reference



Note:
Io = -160dBm / Hz based on environmental noise values analyzed & normalized from government sponsored studies in the U.S., England and the EU
N_o = Noise Figure + kT / For this analysis is considered the same as "Thermal Noise"

4

-160dBm Reference Noise Floor – N_o + I_o

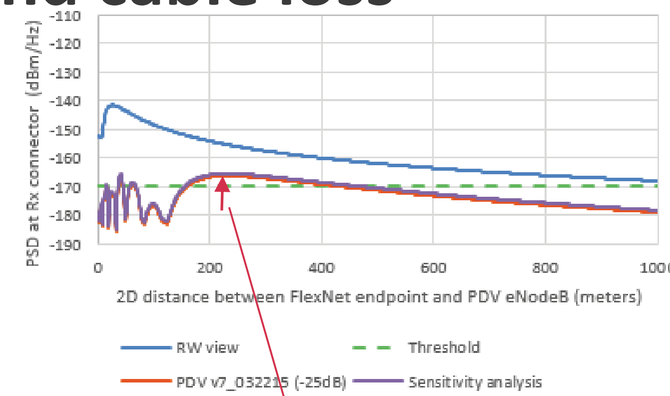
1. IEEE 473 1985 -
   IEEE Recommended Practice for an Electromagnetic Site Survey (10 kHz to 10 GHz)
2. World Metrological Organization
   COMMISSION FOR BASIC SYSTEMS STEERING GROUP ON RADIO FREQUENCY COORDINATION
   Results of Ambient RF Environment and Noise Floor Measurements Taken in the U.S. in 2004 and 2005
3. Man Made Noise in Our Living Environment
   International Union of Radio Science
   No. 334, September 2010
4. CEPT REPORT 19 - Revision 10/30/08
   Report from CEPT to the European Commission
   in response to the mandate to develop least restrictive technical conditions for frequency bands addressed in the context of WAPECS

Note: In their model PDV also cite TIA-TSB-88.2-D

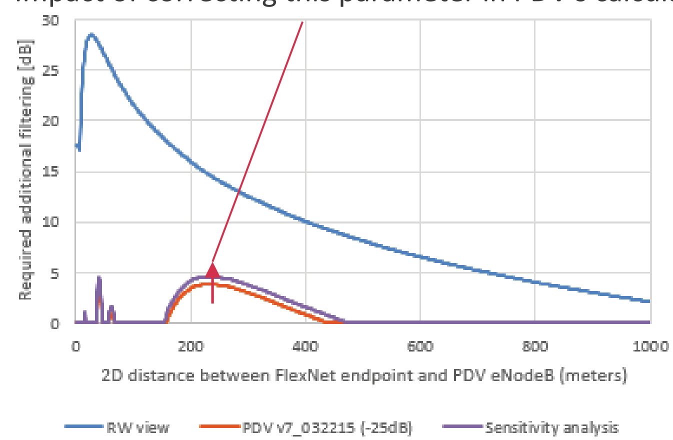
Note:
Studies to determine the -160dBm reference noise floor were difficult to find. Publically available studies deliver mean or median values from a limited amount of samples and some cases had to be extrapolated for this analysis to develop a generalized threshold for use in modeling and determining a baseline ceiling reference N_o + I_o value.

FlexNet Endpoint antenna gain and cable loss

- PDV have assumed that the FlexNet Endpoint antenna gain is -1dBd, i.e. **1.15dBi**, without providing any source for this input
- Sensus' data support that the FlexNet Endpoint antenna gain may be at least **0dBi** (or even higher in some cases)
- PDV have assumed that the FlexNet Endpoint antenna cable losses are **1.9dB**, without providing any source for this input
- Sensus' data support that the FlexNet Endpoint antenna cable losses are **0dB**



Impact of correcting this parameter in PDV's calculations



FlexNet Endpoint antenna gain has been underestimated and cable losses have been overestimated: Impact of correcting this: +0.75dB worse interference

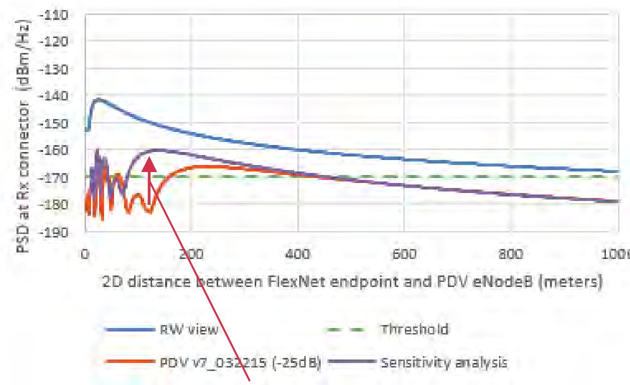
Challenging case - DL

Interpretation A

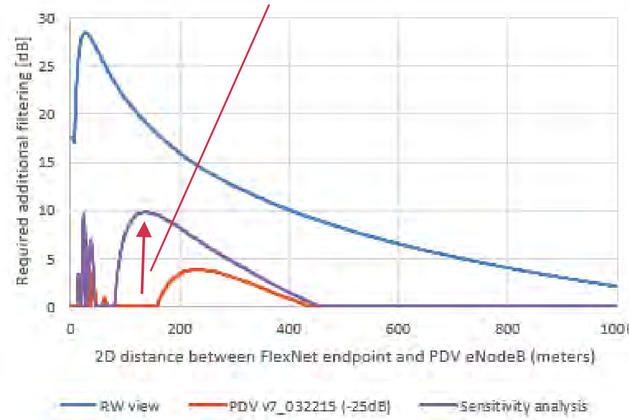
Base station antenna height

- PDV have assumed a base station antenna height of **98.4'** (30m)
- This is relatively high and LTE eNBs are often operated at lower heights
- In order to protect the Endpoints, a lower antenna height should be considered. Our view is that the height of **60'**, as in the PU2FT calculation (PDV UE to FlexNet base station), should be considered
- The impact of this change is shown opposite

4



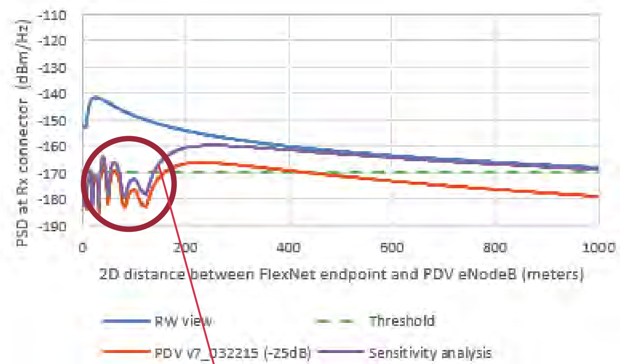
Impact of changing height from 98.4' to 60'



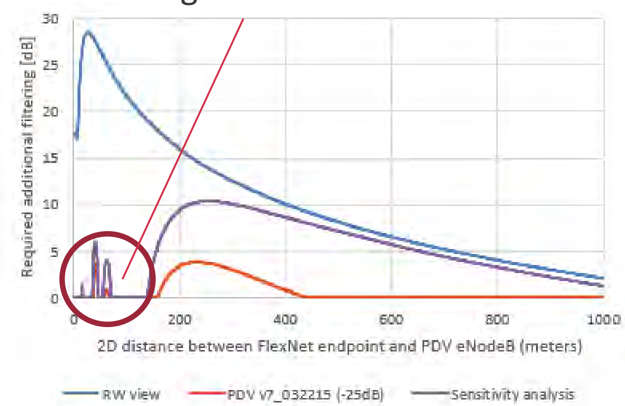
PDV eNB antenna heights may lower than the 98.4' modelled
Changing the height from 98.4' to 60' increases interference level by about 6 dB

Propagation model

- As explained earlier we believe that the free space loss model (not W-I LoS) should be used for short range interference calculation
- It has a small (1.4 dB) impact on interference at a range of around 30 m taken on its own
- At longer ranges other propagation models may need to be considered



Region of interest



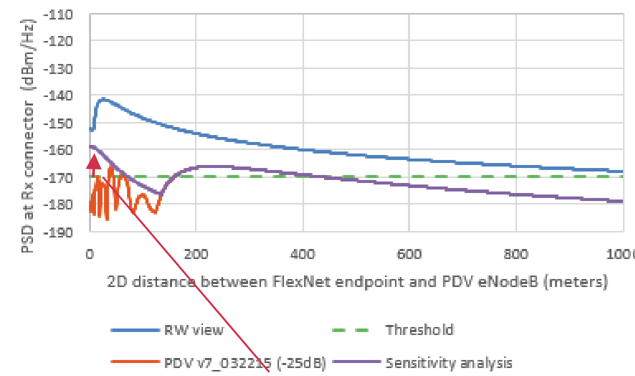
Challenging case - DL

Maximum attenuation due to antenna pattern

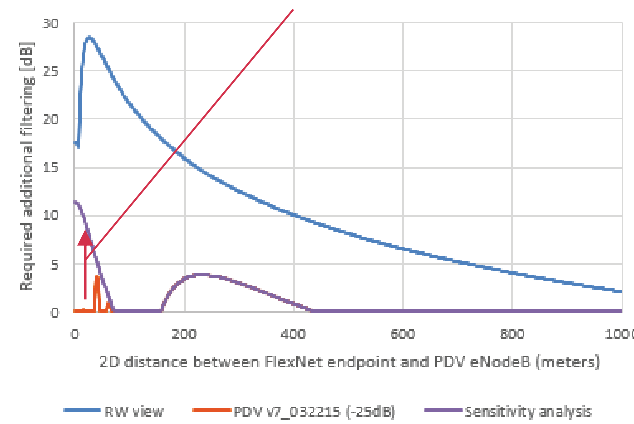
Interpretation A

6

- As discussed earlier, multipath tends to fill base station antenna nulls so these should not be relied on to provide interference protection in particular directions
- PDV has **not considered** this effect
- Capping the attenuation from the antenna at some level, typically around 20 dB (see [2, 3])
- The impact is to significantly increase the level of interference at the shortest ranges, resulting in an extra 8 dB required attenuation



Impact of accounting for null filling



[1] "Antenna pattern measurement technique using wideband channel profiles", Newhall & Rappaport, AMTA 19th symp. Boston, Nov. 1997

[2] 3GPP TR 36.942

[3] 3GPP TR 36.814

Challenging case - DL

Interpretation A

Summary of differences (challenging case)

- We believe PDV has understated the impact of interference due to the following inappropriate parameter choices:

#	Parameter	Comment on PDV assumptions	Impact of each correction on interference:
①	eNodeB antenna pattern, boresight gain, cable and connector losses	Vertical beamwidth has been underestimated	+18dB
②	Environmental noise margin	Assumed 9.5 dB noise rise from reference sources, no measurements	+7.5dB
③	FlexNet Endpoint antenna gain and cable loss	FlexNet Endpoint antenna gain has been underestimated and cable losses have been overestimated	+0.75dB
④	Base station antenna height	PDV cause excessive interference when their antennas are at heights lower than 98.4'	+6dB
⑤	Propagation model	Propagation model for a different environment	+1.4dB
⑥	Maximum attenuation due to antenna pattern	No consideration of impact of real environment on nulls	+8dB
	Overall	**Effects are not simply additive**	**~25 dB**

Moderate Case - DL

Interpretation A

Moderate case parameters

- The following parameters represent a higher likelihood moderate case

#	Parameter		PDV Parameters	RW Challenging case parameters	RW moderate case parameters
1a	eNodeB boresight gain	dBi	16.0	16	16.0
1b	eNodeB antenna pattern		ARGUS HPX308R (2deg)	Amphenol, BCD-87010-6-25 (6 elec. downtilt)	Kathrein 80010736V01 – (realistic LTE eNB antenna for these frequencies)
1c	eNodeB cable and connector losses		4.0	4	4.0
2	Protection level	dBm/Hz	-160.0	-170	-169.0
3	FlexNet endpoint antenna gain & cable loss	dBi	1.15	0	0.0
4	eNodeB antenna height	feet	98.4'	60’	98.4'
5	Propagation model		W-I LOS	Free space	Free Space
6	Maximum antenna attenuation	dB	Unlimited	20	20.0

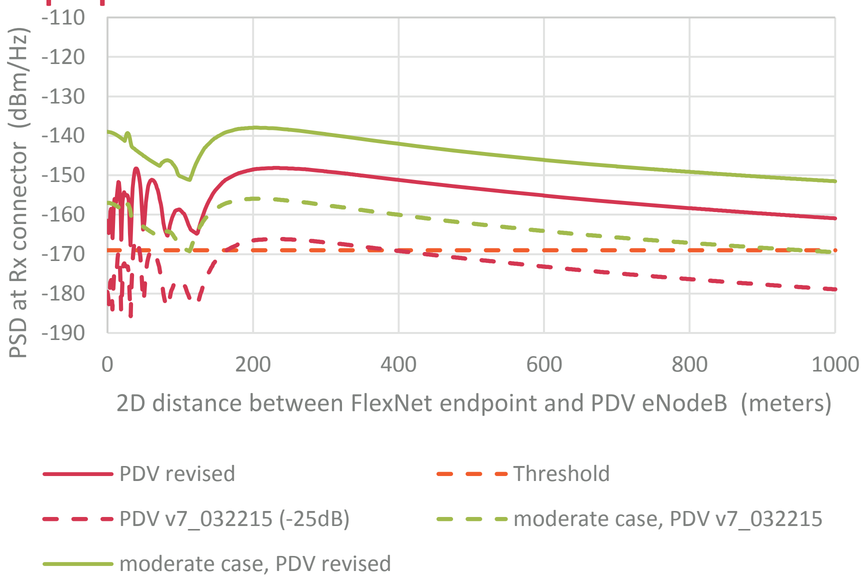
Moderate Case - DL

Interpretation A

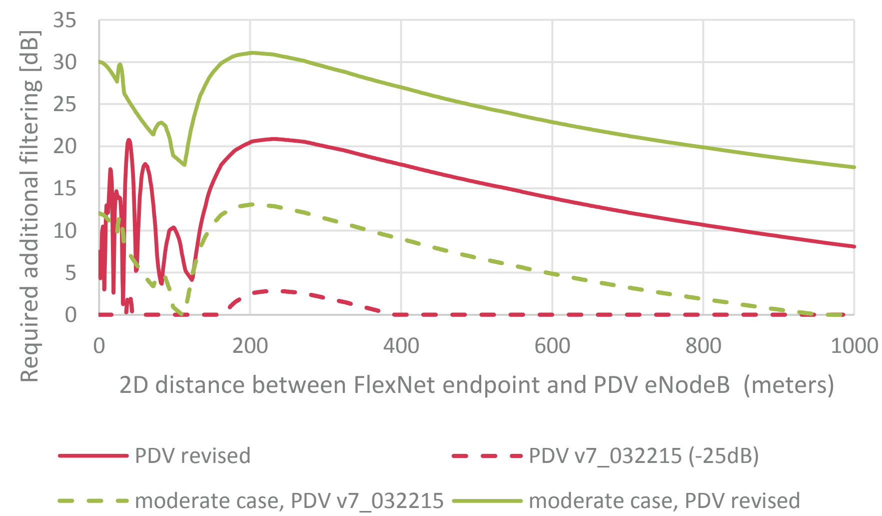
RW moderate cases

- We have considered the proposed moderate case for the interference calculation.
- The parameters used are shown on the previous slide.

Comparison of interference levels between PDV proposals for the moderate case



Required attenuation (additional to threshold) to protect -169dBm/Hz threshold



Our view of parameters indicates that 14 dB of additional attenuation could be required to adequately protect FlexNet Endpoints given the original PDV proposal and **31 dB extra attenuation for the revised PDV proposal**

realwireless

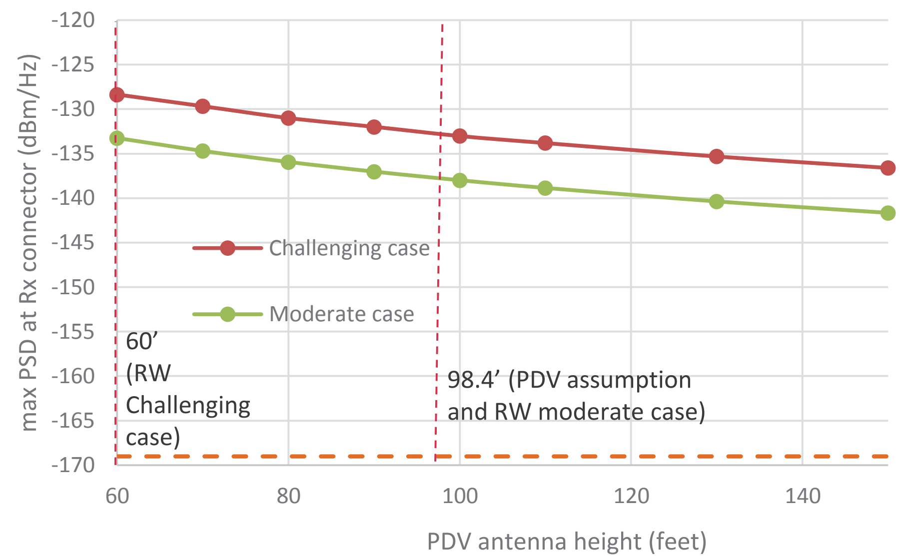
Moderate Case - DL

Challenging case –DL

Effect of PDV eNodeB antenna height

Interpretation A

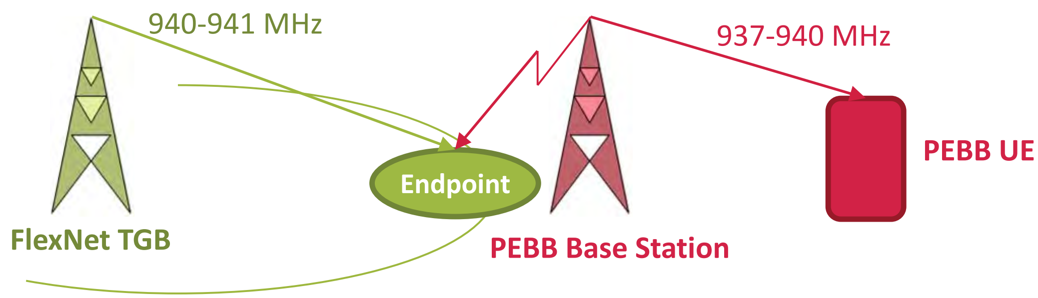
- Since we do not know the height at which PDV will deploy its eNodeB base stations, we have varied the eNB height to determine the sensitivity to this parameter
- The graph shows the value of the highest PSD encountered at any distance for a given eNB height
- There is around 5 dB of variation between the PDV assumption and our challenging case
- In all cases the PSD remains above the required protection level



9. Interference mode PB2FE (PDV base station to FlexNet endpoint) - Interpretation B

Scenario PB2FE

Interpretation B



- An endpoint is at the edge of a FlexNet
- A PEBB Base Station is nearby and causes excessive interference to an endpoint Rx

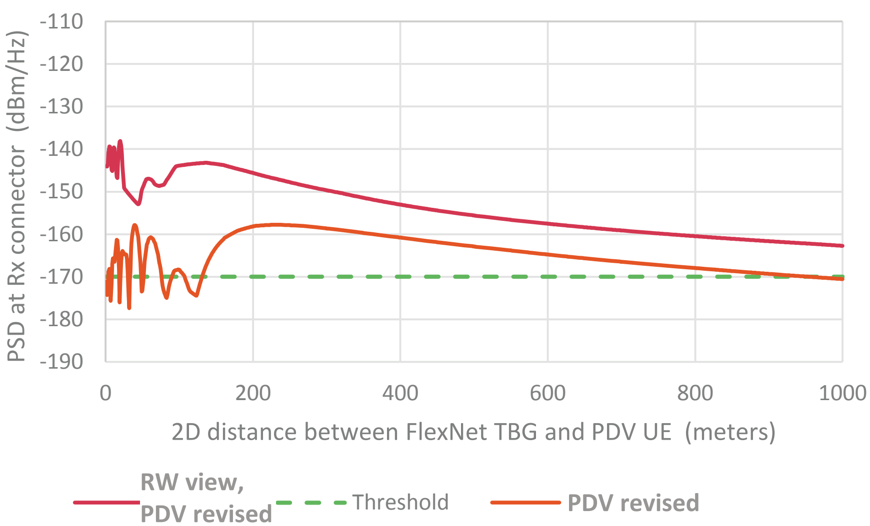
Real Wireless challenging case outcomes

Challenging case - DL

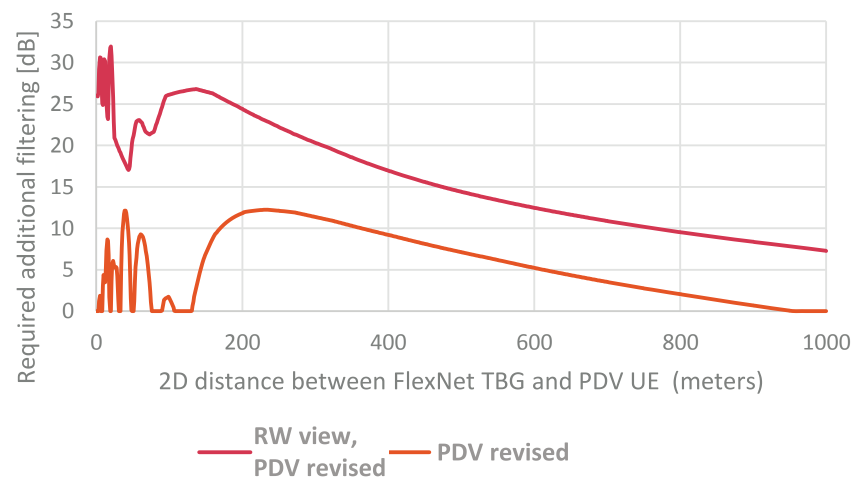
Interpretation B

- The comparison below is based on the PDV proposed emission mask and a protection threshold at -170 dBm/Hz
- The parameters used are compared on the following slide and individually discussed in the remainder of this section

Comparison of interference levels based on PDV and RW challenging parameter sets



Required attenuation (additional to the -170 dBm/Hz threshold)



Our view of parameters indicates that 32 dB of additional attenuation could be required to adequately protect FlexNet Endpoints

Moderate Case - DL

Interpretation B

Moderate case parameters

- The following parameters represent a higher likelihood moderate case

#	Parameter		PDV Parameters	RW Challenging case parameters	RW moderate case parameters
1a	eNodeB boresight gain	dBi	16.0	16	16.0
1b	eNodeB antenna pattern		ARGUS HPX308R (2deg)	Amphenol, BCD-87010-6-25 (6 elec. downtilt)	Kathrein 80010736V01 – (realistic LTE eNB antenna for these frequencies)
1c	eNodeB cable and connector losses		4.0	4	4.0
2	Protection level	dBm/Hz	-160.0	-170	-169.0
3	FlexNet endpoint antenna gain & cable loss	dBi	1.15	0	0.0
4	eNodeB antenna height	feet	98.4'	60’	98.4'
5	Propagation model		W-I LOS	Free space	Free Space
6	Maximum antenna attenuation	dB	Unlimited	20	20.0

Challenging case - DL

PDV and RW challenging case parameters compared

Interpretation B

- The calculations on the previous slide are based on the following parameters
- In the subsequent slides we examine each of the 6 issues flagged here

Issue	Parameter	Symbol	Unit	Value RW view	Comment	Value PDV v7_032215 (-25dB)	Comment
	Base station (eNB) transmit system						
	PDV Tx center frequency	f	MHz	938.5	The correct center frequency	938.0	Incorrectly stated
	OOB attenuation factor		dB	55	+10log(P)	55	+10log(P)
	PDV eNodeB OOB PSD immediately adjacent to channel		dBW/30kHz ERP	-55.0		-55.0	
	as above in dBm/30kHz ERP		dBm/30kHz ERP	-25.0		-25.0	
	as above in dBm/100kHz ERP		dBm/100kHz ERP	-19.8	PDV's proposal	-19.8	25dB
	as above in dBm/100kHz EIRP		dBm/100kHz EIRP	-17.6		-17.6	
	as above in dBm/Hz ERP		dBm/Hz ERP	-69.8		-69.8	
	as above in dBm/Hz EIRP	P_1	dBm/Hz EIRP	-67.6		-67.6	
1	PDV eNodeB antenna gain		dBi	16.0	Irrelevant because licence restriction is in EIRP	16.0	PDV assumes ARGUS HPX308R (2deg), which operates 1525-1710MHz
1	PDV eNodeB cable loss		dB	4.0	Irrelevant because licence restriction is in EIRP	4.0	PDV's assumption
1	PDV eNodeB antenna pattern			6-25 Amphenol	Single Band, Omni, V-Pol, 696-960 MHz, 360°, 1.1 dBd, 3.2 dBi, 0°T, Vertical beamwidth 70 deg	ARGUS HPX308R (2deg)	PDV assumes ARGUS HPX308R (2deg), which operates 1525-1710MHz
1	OOB EIRP density		dBm/Hz	-67.6		-67.6	
	FlexNet endpoint receive system						
	Thermal noise PSD		dBm/Hz	-174		-174	
	FlexNet Endpoint noise figure		dB	4	Input from Sensus: Bob_Notes_Fo	4	No source given
	Thermal noise PSD at Rx input		dBm/Hz	-170		-170	
2	Environmental noise margin		dB	2	Based on Sensus measurements	9.5	TIA-TSB-88.2-D
	Thermal noise PSD at Rx input, incl env. noise		dBm/Hz	-168		-161	
3	FlexNet Endpoint antenna gain		dBi	0	Input from Sensus, email from Bob.	1.15	Equivalent to -1dBd no source given
3	FlexNet Endpoint cable loss		dB	0		1.9	No source given
	Other parameters						
4	PDV eNodeB height		feet	60		98.4	
		h_b	m	18.29		30.00	No source given
	FlexNet Endpoint height	h_m	m	1.5		1.5	
5	Median propagation model			Free space		W-I LOS (slant distance	
	Environment			Urban		Urban	
	PDV eNodeB mechanical downtilt		deg	0		0	PDV's assumption
6	Max attenuation due to V antenna pattern	SLA_v	dB	20	3GPP TR 36.814: multipath fills nulls	999	No consideration of multipath

Details about 6 issues

Interpretation B

- Details about the following issues are available in an earlier section of this sliedeck
  - PDV and RW challenging case parameters compared
  - eNodeB antenna pattern, boresight gain, cable and connector losses
  - Environmental noise margin
  - FlexNet Endpoint antenna gain and cable loss
  - Base station antenna height
  - Propagation model
  - Maximum attenuation due to antenna pattern

Challenging case - DL

Interpretation B

Summary of differences (challenging case)

- We believe PDV has understated the impact of interference due to the following inappropriate parameter choices:

#	Parameter	Comment on PDV assumptions	Impact of each correction on interference:
①	eNodeB antenna pattern, boresight gain, cable and connector losses	Vertical beamwidth has been underestimated	+18dB
②	Environmental noise margin	Assumed 9.5 dB noise rise from reference sources, no measurements	+7.5dB
③	FlexNet Endpoint antenna gain and cable loss	FlexNet Endpoint antenna gain has been underestimated and cable losses have been overestimated	+0.75dB
④	Base station antenna height	PDV cause excessive interference when their antennas are at heights lower than 98.4’	+6dB
⑤	Propagation model	Propagation model for a different environment	+1.4dB
⑥	Maximum attenuation due to antenna pattern	No consideration of impact of real environment on nulls	+8dB
	Overall	**Effects are not simply additive**	**~15 dB**

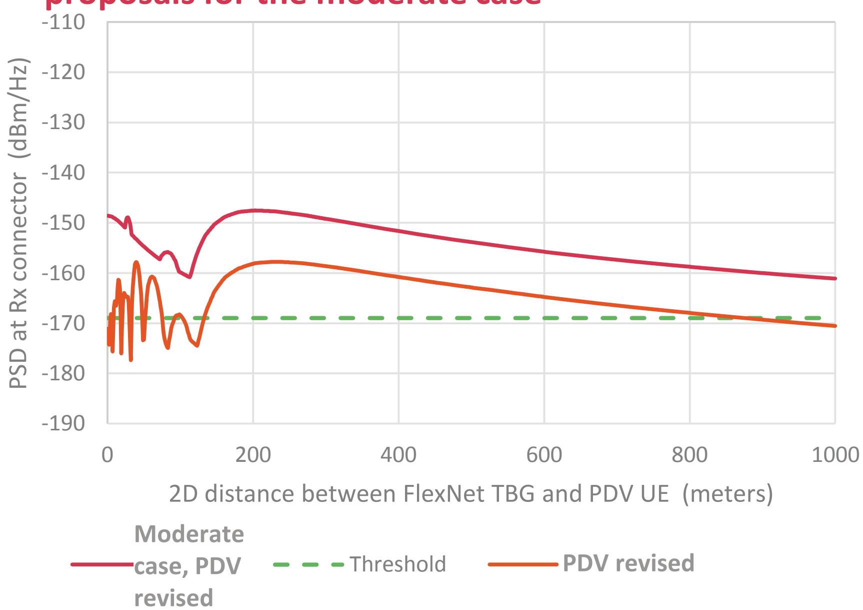
Moderate Case - DL

Interpretation B

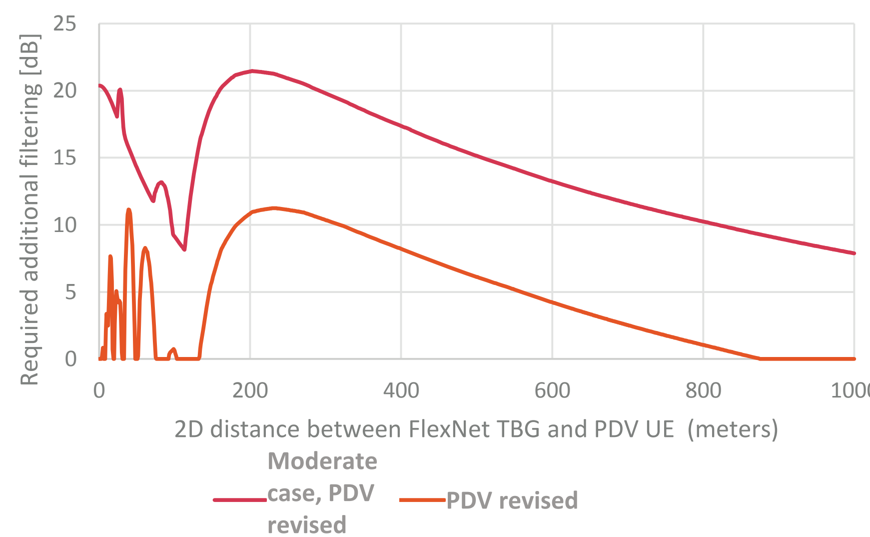
RW moderate cases

- We have considered the proposed moderate case for the interference calculation.
- The parameters used are shown on the previous slide.

Comparison of interference levels between PDV proposals for the moderate case



Required attenuation (additional to the -169 dBm/Hz threshold threshold)



Our view of parameters indicates that 22 dB of additional attenuation could be required to adequately protect FlexNet Endpoints given the revised PDV proposal

10. Summary of findings

Summary of findings

1. Real Wireless has reviewed coexistence calculations and emission specifications proposed by pdvWireless (PDV) to protect adjacent FlexNet systems on behalf of Sensus
2. We have reproduced PDV's calculations using an independent model, **and agree broadly with PDV's calculation methodology**
3. We found that **the interference threshold proposed by PDV is inappropriate**, since it is based on inappropriate noise environment assumptions. Our review of field measurements conducted by Sensus suggests a threshold around **-170dBm/Hz** rather than the -160 dBm/Hz proposed by PDV
4. We have conducted a detailed review of the calculation parameters proposed by PDV and found that in many cases **the parameters are inappropriate**, resulting in a far greater level of interference than PDV has suggested
5. The table below summarises our findings regarding the extra attenuation needed for each: interference mode (uplink, downlink) case (challenging, moderate) and the interpretation of the proposed limits (A or B): Even in moderate cases **tens of dB extra attenuation is needed**
6. Additionally the **test conditions for specifying emission limits need to be properly specified** to account for the measured characteristics of real LTE devices: this could create a 7dB increase in emissions compared with the test conditions specified by PDV

Interference mode				Challenging Case		Moderate Case	
		Rule proposal	Interpretation	A	B	A	B
PDV UE aggressor to Sensus TGB victim (PU2FT)	UL	03-May	PSD dBm/Hz	-116	-114	-141	-139
			Extra attenuation needed (dB)	54	56	27	29
PDV eNodeB aggressor to Sensus endpoint victim (PB2FE)	DL	25-Mar	PSD dBm/Hz	-146		-155	
			Extra attenuation needed (dB)	24		14	
		03-May	PSD dBm/Hz	-128	-138	-138	-147
			Extra attenuation needed (dB)	42	32	31	22

Note: blank cells were not calculated

Annex 1: LTE user equipment out of band emission measurements

Introduction

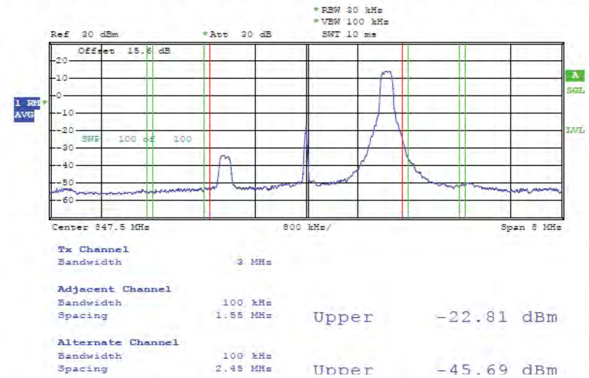
- We have reviewed FCC reports for several LTE devices [1] to determine the practical outcome and test conditions for UE out of band emission measurements
- Results are shown in the next few slides, with a summary of the outcomes at the end

[1] FCC reports from https://apps.fcc.gov/edocs_public/

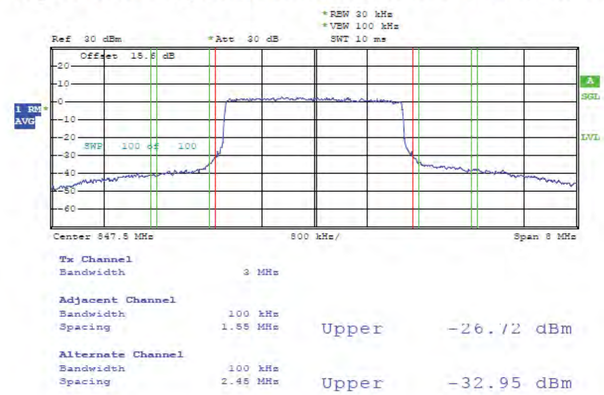
ZTE Z930L 4G Phone FCCID:SRQ-Z930L

- The worse case plot is -22.81 dBm/30 kHz which would relate to -17 dBm/100 kHz.

Higher Band Edge Plot for QPSK-RB Size 1, RB Offset 14

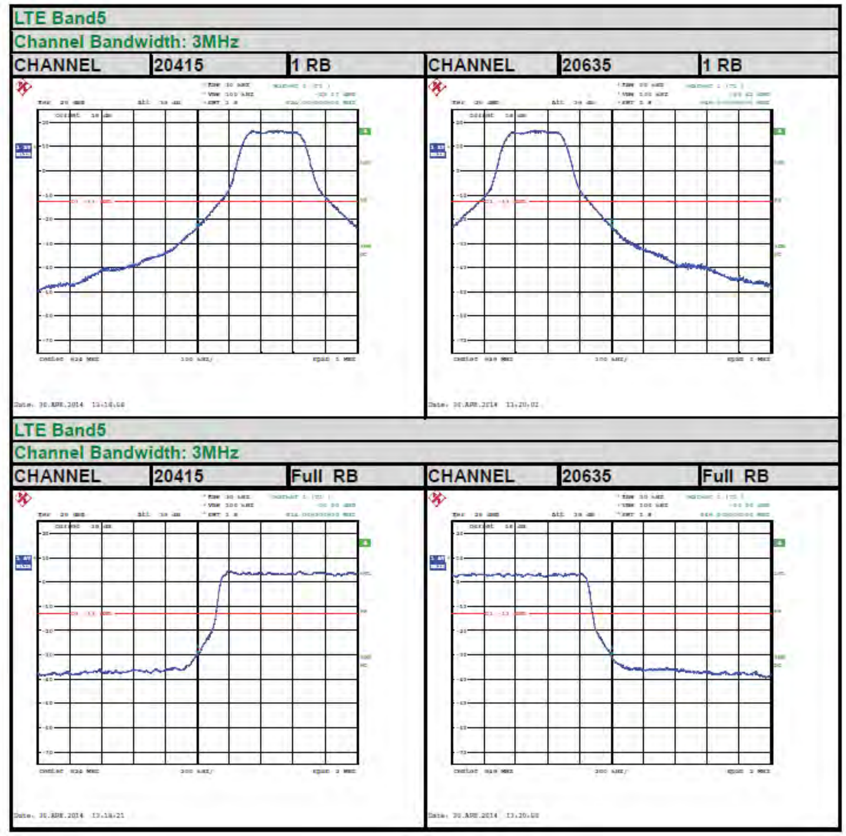


Higher Band Edge Plot for QPSK-RB Size 15, RB Offset 0



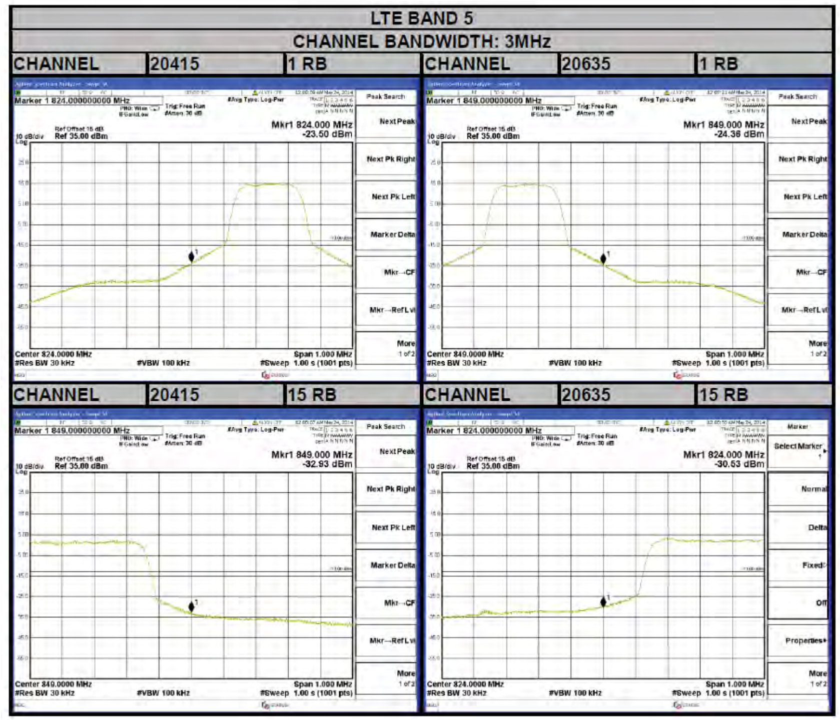
Sonim 4G Phone FCCID:WYPL11V012AA

- Note, the emissions are measured in a 30 kHz bandwidth. The worse case plot is -23.17 dBm/30 kHz which would relate to -18 dBm/100 kHz.



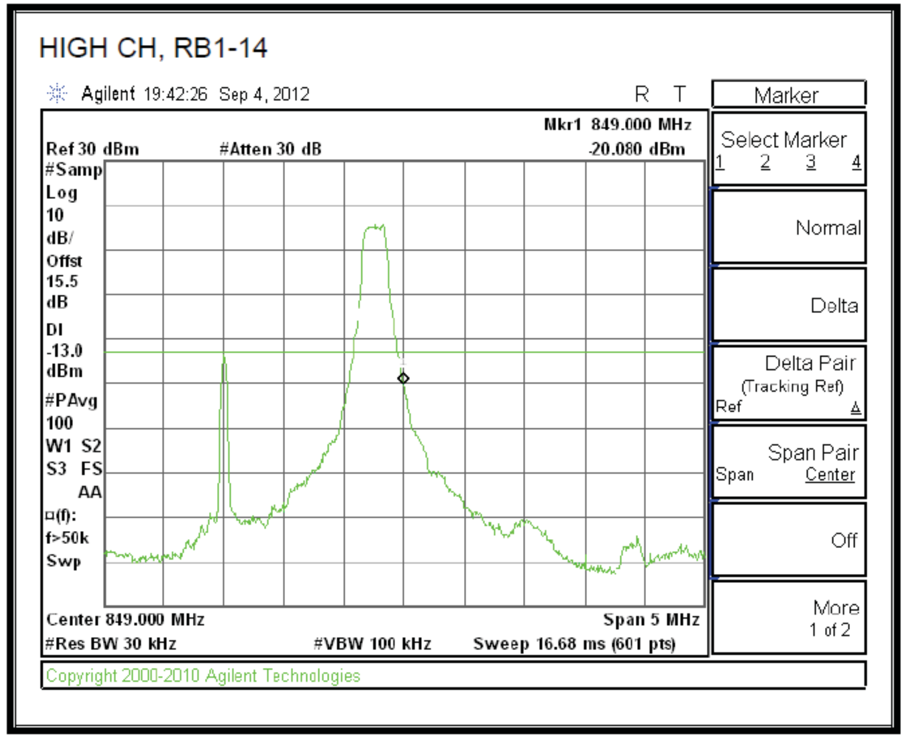
Asus 4G Phone FCCID:MSQT00S

- Note, the emissions are measured in a 30 kHz bandwidth. The worst case plot is -23.50 dBm/30 kHz which would relate to -18.3 dBm/100 kHz.



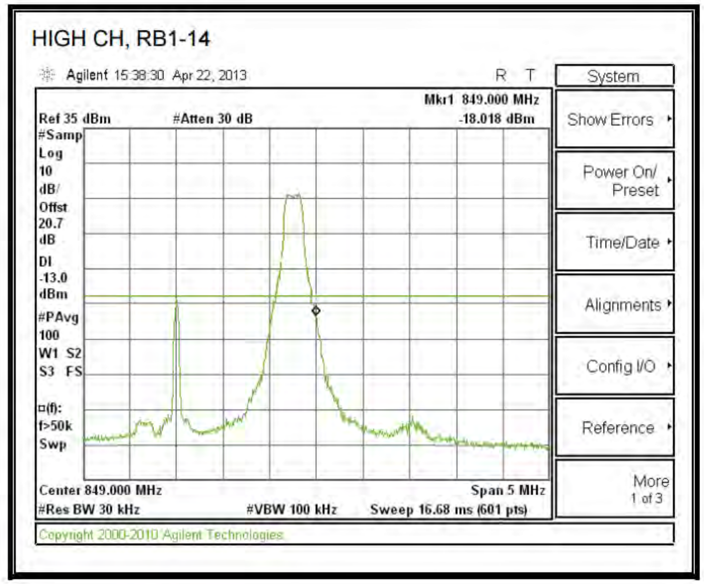
Apple iPad FCCCID:BCGA1460

- QPSK Band 5 3MHz Bandwidth LTE
- Measurement is in 30 kHz bandwidth and shows -20.08 dBm. In 100 kHz bandwidth, this would relate to a reading of -15.5 dBm/100 kHz.



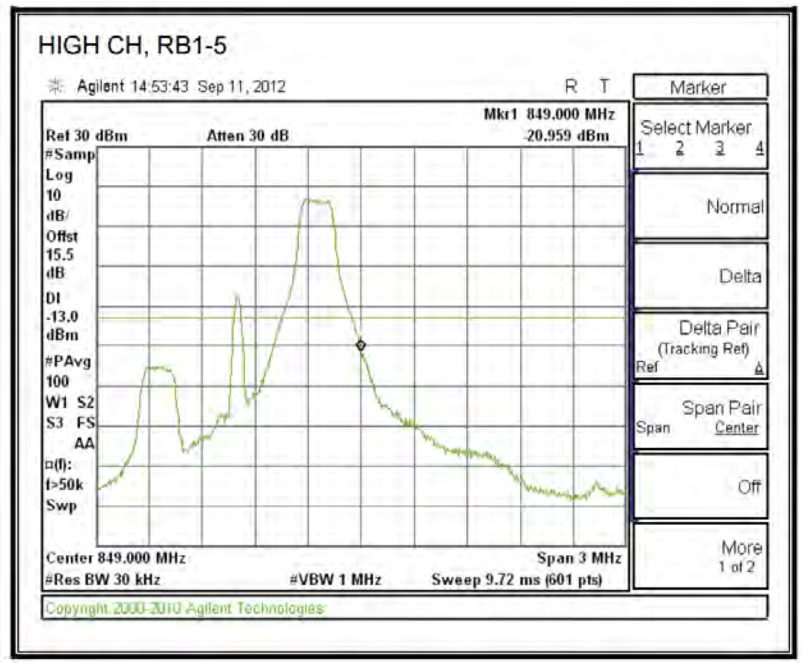
Apple iPad FCCCID:BCG-E2642A (AKA iPhone5)

- QAM Band 5 3MHz Bandwidth LTE
- Measurement is in 30 kHz bandwidth and shows -18.02 dBm.
- In 100 kHz bandwidth, this would relate to a reading of -12.8 dBm/100KHz.



Apple iPad FCCCID:BCGA1455

- QPSK Band 5 3MHz Bandwidth LTE
- Measurement is in 30 kHz bandwidth and shows -20.96 dBm. In 100 kHz bandwidth, this would relate to a reading of -15.6 dBm/100 kHz.



Summary of results

Device	Emissions @ 150kHz from band edge (dBm/ 30 kHz)	
	All resource blocks active	**1 resource block active**
ZTE Z930L 4G Phone FCCID:SRQ-Z930L	-26.7	-22.8
Sonim 4G Phone FCCID:WYPL11V012AA	-30.0	-23.2
Asus 4G Phone FCCID:MSQT00S	-30.5	-23.5
Apple iPad FCCCID:BCGA1460	Not available	-20.1
Apple iPad FCCCID:BCG-E2642A (AKA iPhone5)	Not available	-18.0
Apple iPad FCCCID:BCGA1455	Not available	-21.0

Annex 1 Summary

- PDV has proposed an emission limit for UEs of (55+10 log(*P*)) dB below carrier measured in 30kHz
- For a given UE EIRP *P* this equates to 30-55+10log(100/30) dBm/30 kHz = -25dBm/30 kHz, i.e. 12 dB tighter than the 3GPP specification of -13dBm/30 kHz (assuming 0dBi/0dB UE antenna gain/feeder loss)
- FCC reports for several manufacturers representing widely deployed LTE phones have been reviewed
- Many of the phones tested produce > -20 dBm/100kHz
- The worst case of those reviewed is the iPhone 5, which at -12.8 dBm/100 kHz does exceed PDV's proposed limit by over 7dB
- We find that out of band emission levels depend critically on the test conditions, with emissions being largest when the UE is transmitting in a single resource block rather than over the entire 3 MHz bandwidth, with up to 7dB difference between the two cases

Annex 2: Abbreviations

Abbreviation	Meaning
ACLR	Adjacent Channel Leakage Ratio
ACIR	Adjacent Channel Interference Ratio
ACS	Adjacent Channel Selectivity
CDF	Cumulative Distribution Function
CPE	Customer Premises Equipment
eNB	enhanced NodeB
EIRP	Effective Isotropic Radiated Power
ERP	Effective Radiated Power
FCC	Federal Communications Commission
kHz	Kilohertz
LoS	Line of Sight
LTE	Long Term Evolution
MHz	Megahertz
OOBE	Out of Band Emission
PDV	Pacific DataVision
PEBB	Private Enterprise Broadband – PDV term for its use of the spectrum in scope
PSD	Power Spectral Density
Rx	Receiver
TGB	Tower Gateway Basestation
Tx	Transmitter
UE	User Equipment

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Exhibit 2

FlexNet™ Base Station Noise Floor Measurement Data

Sensus FlexNet™ Deployments in the US

June, 2015

Noise Floor Data

- Readings taken from FlexNet™ base station DSP receivers
  - In bandwidths of 8 or 16 KHz
  - Converted to dBm/Hz, referenced to antenna connector of receiver
- Southern Company data is average since receiver commissioning date
- All other data is average of 15 minute interval data collected during periods in March, 2015

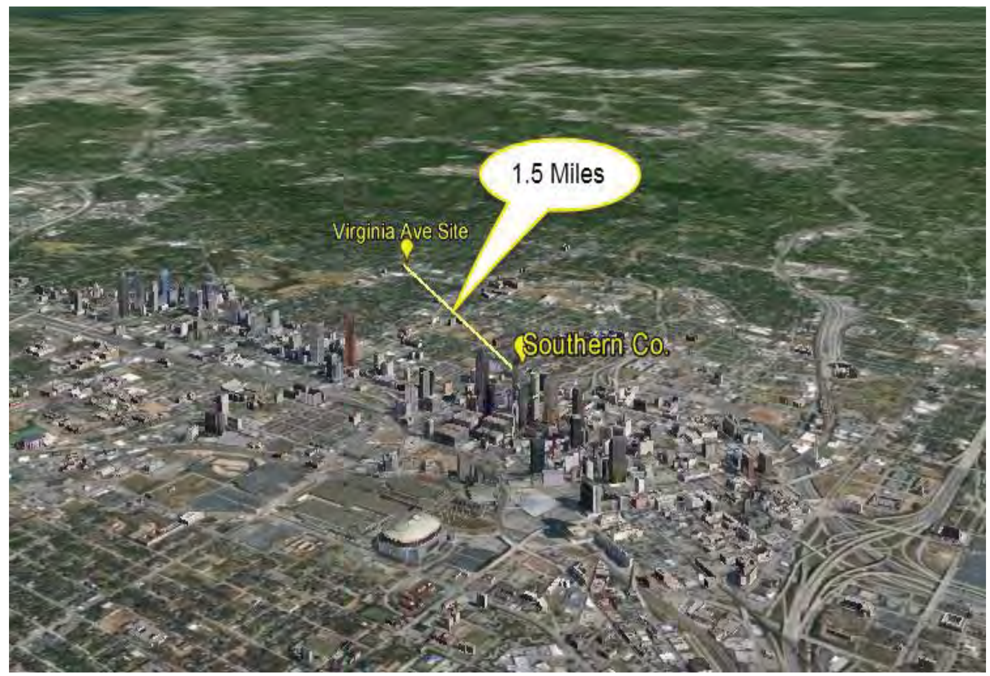
Legend

- (green) <-168.5 dBm/Hz
- (orange) >168.5 dBm/Hz; <-160dBm/Hz
- (red) >-160 dBm/Hz

Noise Floor Data

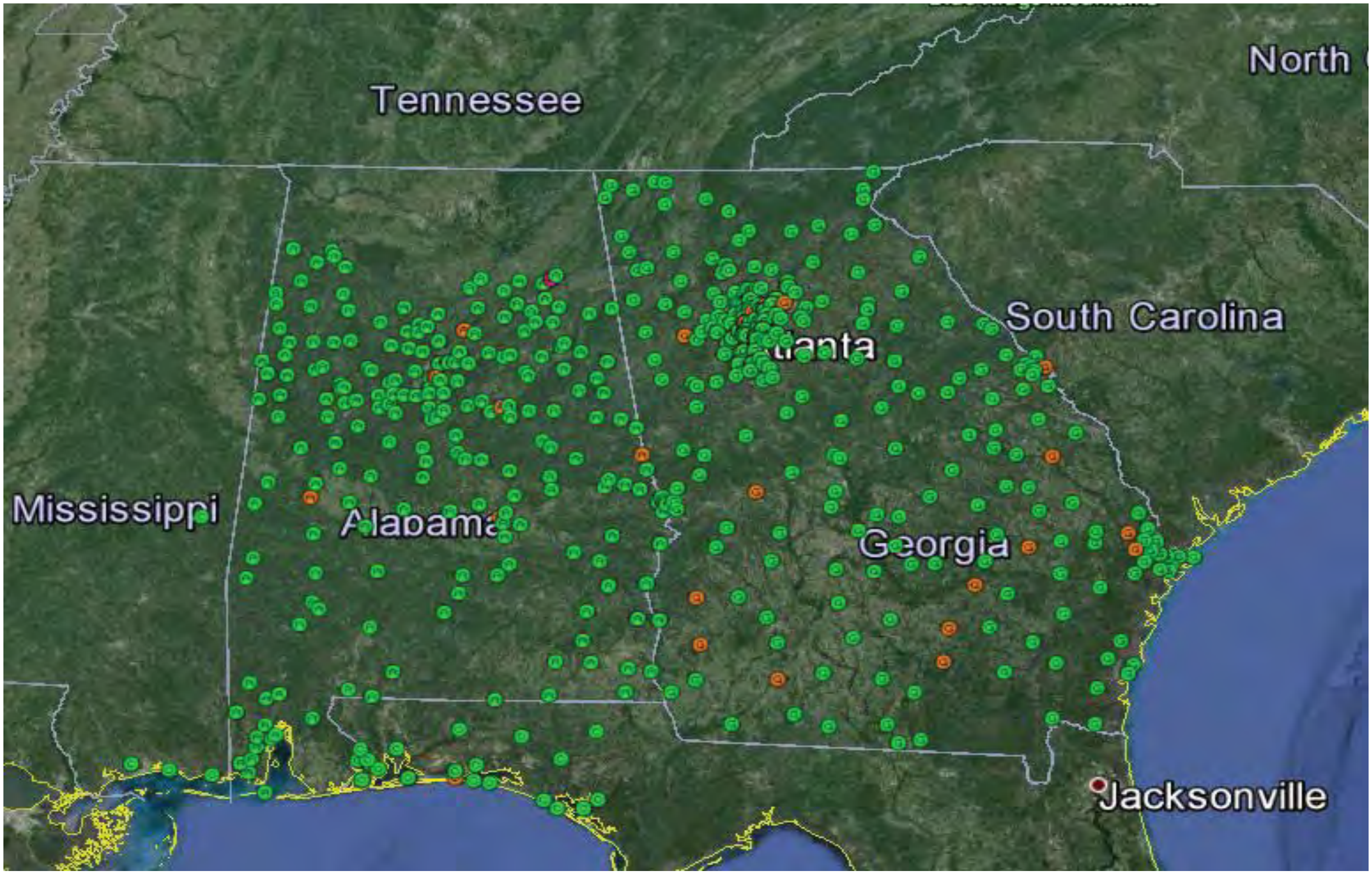
Example: Data from Southern Co. Virginia Ave FlexNet^{TM} base station site in Atlanta, GA

Data from network control system head end

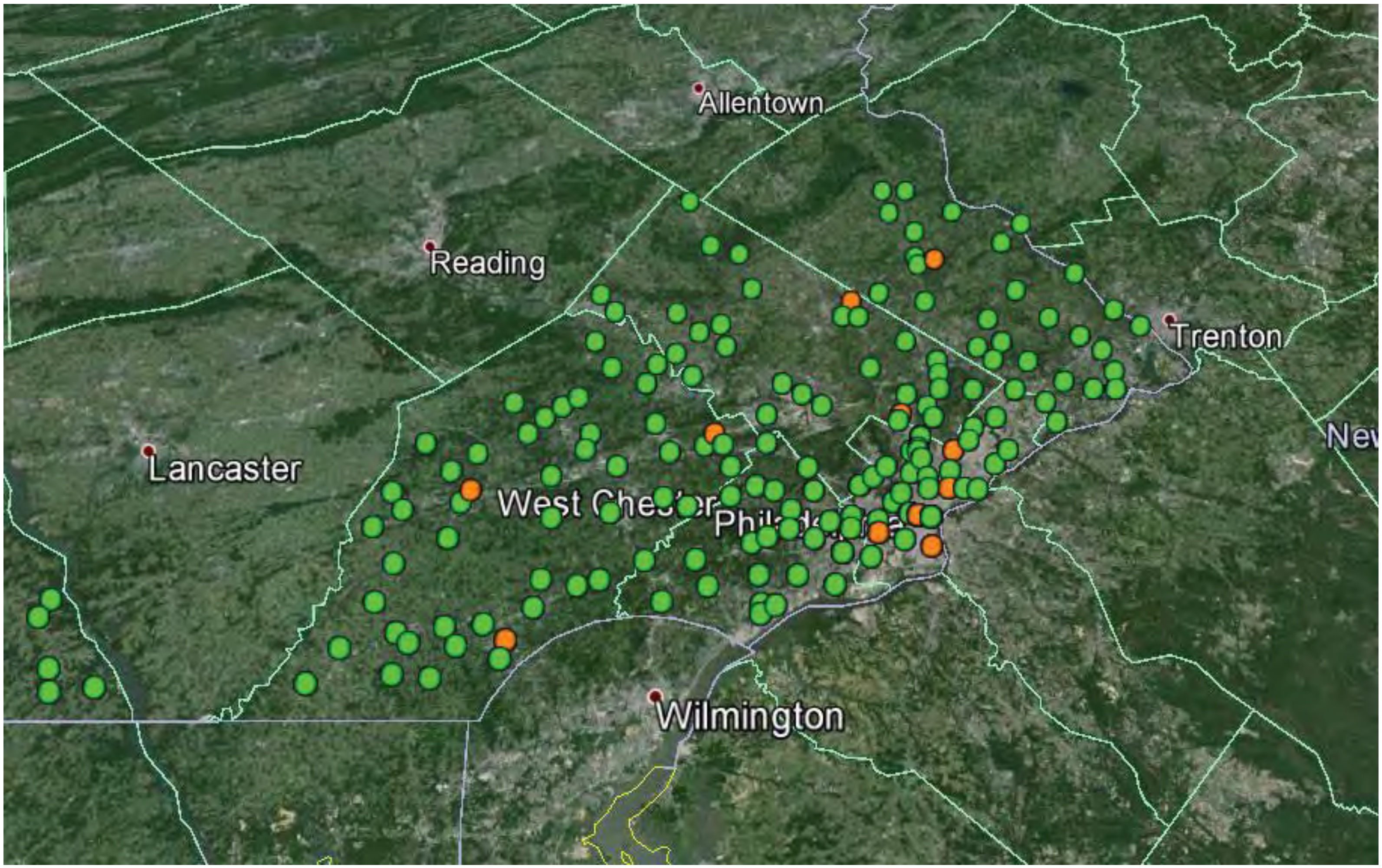


Location in Atlanta, GA

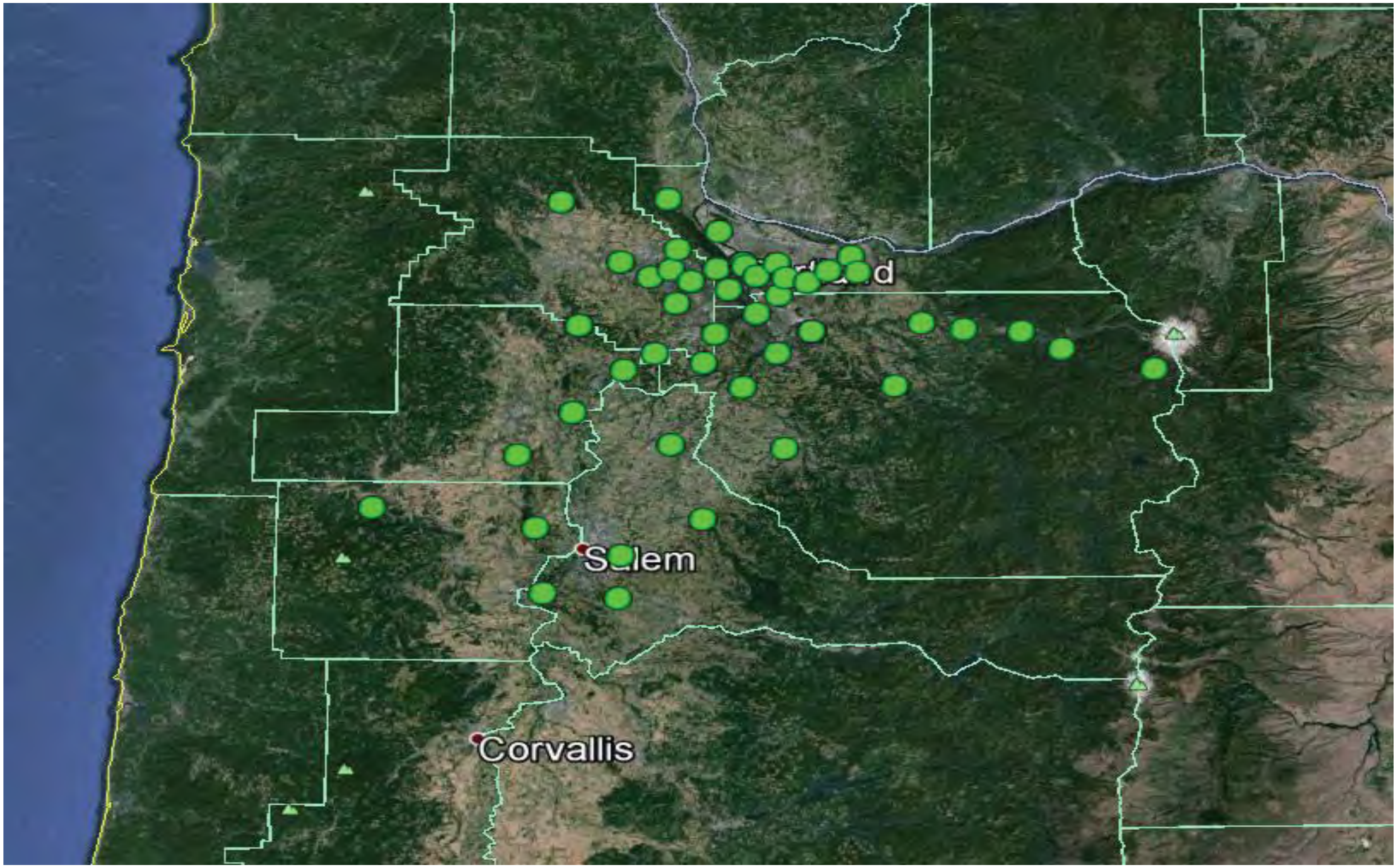
Southern Company FlexNet™ Base Station Noise Readings



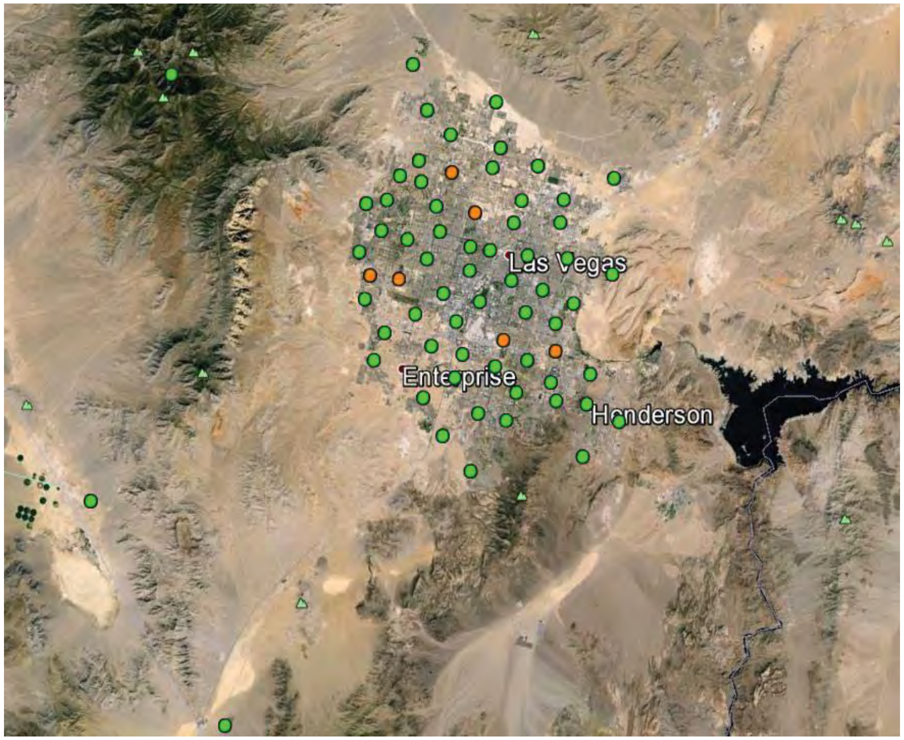
Philadelphia Electric Company FlexNet™ Base Station
Noise Readings



Portland General Electric Company FlexNet^{TM} Base Station
Noise Readings



Sensus Nevada Customer FlexNet^{TM} Deployment - Base Station Noise Readings



Additional US FlexNet^{TM} Deployments - Base Station Noise Floor Data

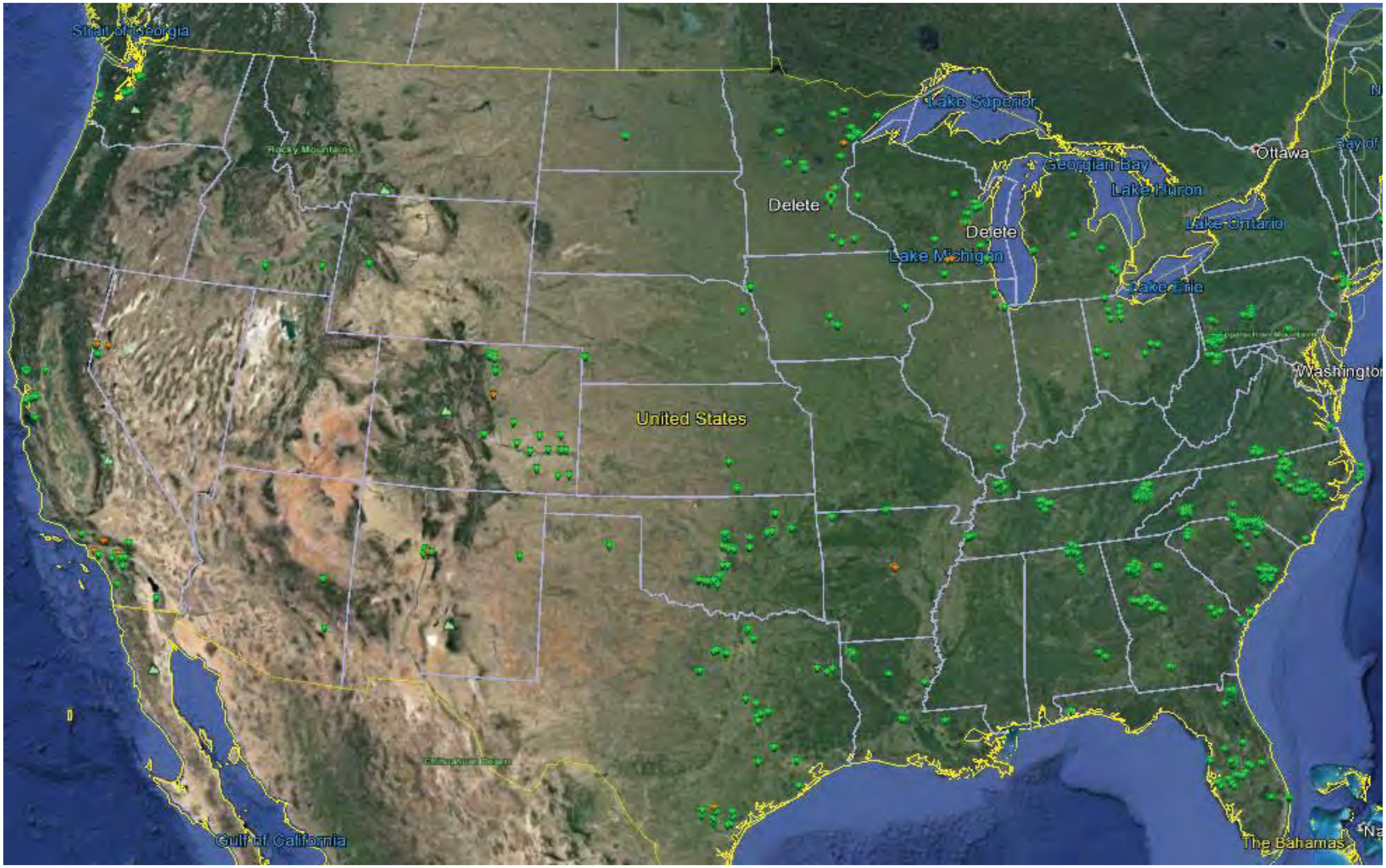
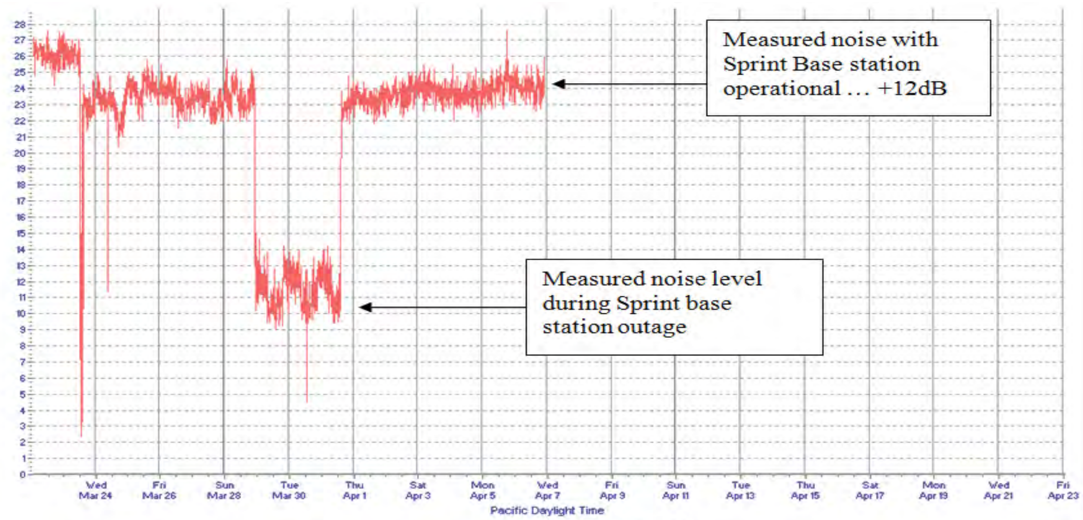
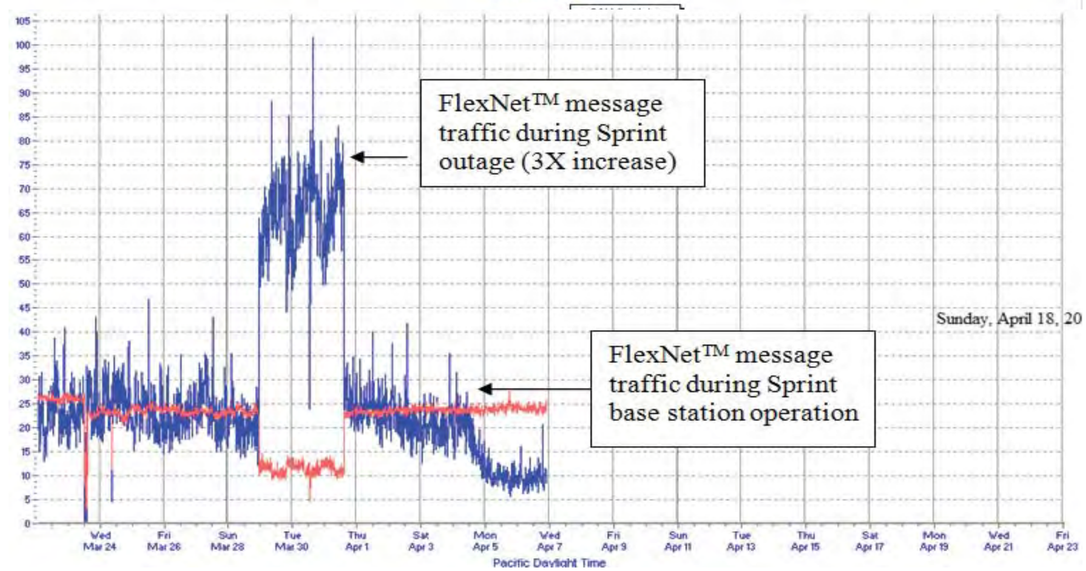


Exhibit 3

Harmful Interference Example At FlexNet^{TM} Base Station in Portland, OR Area

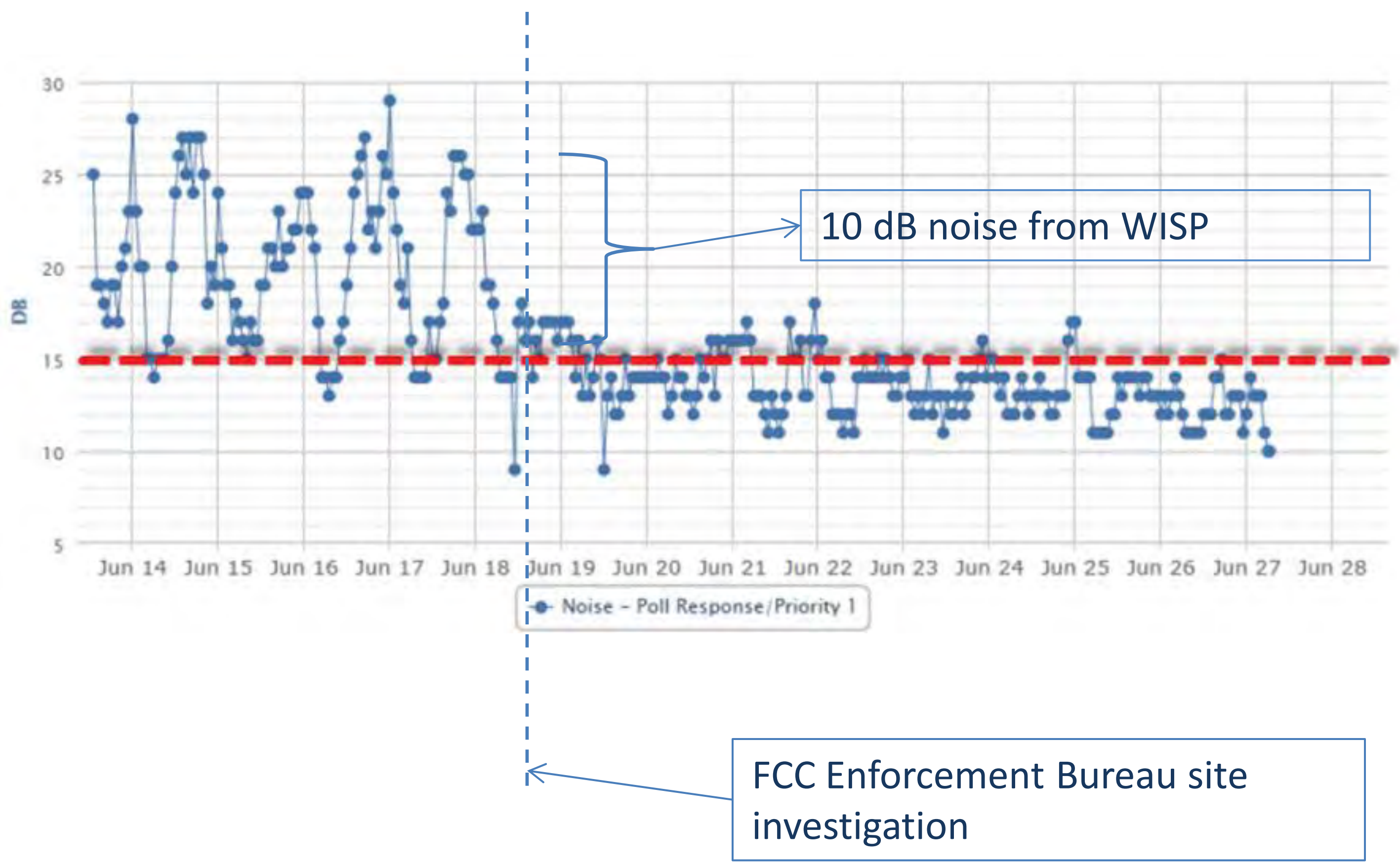




Screenshots of measurement data at FlexNet^{TM} base station from system head end circa April, 2010

Exhibit 4

Interference example from FlexNet™ system in Purcell, OK



Sensus USA
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www.sensus.com

Exhibit 5

Incumbent Part 90 SMR System Impact To Sensus NBPCS Operation

Date: May 13, 2015
Author: Bob Davis

SECTION 1: INTRODUCTION

1.1 SCOPE

The purpose of this document is to provide a summary of how incumbent SMR systems have affected Sensus NBPCS receiver operations in the past.

1.2 BACKGROUND

The FCC has historically grouped like systems together in the SMR and NBPCS bands. These systems have shared similar attributes:

- Narrow band modulations.
    - Part 90 Subpart S uses spectral mask I to insure transmitters with an audio low pass filter adhere to a maximum authorized bandwidth of 12.5 KHz.
    - Part 90 Subpart S uses spectral mask J to insure transmitters without an audio low pass filter adhere to a maximum authorized bandwidth of 13.6 KHz.
- Small channel spacing of 12.5 KHz in the SMR 896-901 band.
- Narrow bandwidth receivers which are highly sensitive.
- Low noise floors at the base station receiver inputs due to narrow band modulations used for transmission.
- The desire for long range, highly sensitive system performance from:
    - Paging transmitters which are located in buildings, worn close to the body, and encounter significant path loss from the transmitter to the base station receiver.
    - Specialized Mobile Radio terminals (which may include voice transmissions) that range from portable, hand-held units to vehicle mounted units. These SMR units are used in buildings and in dense urban areas which encounter significant path loss and fading loss.

The FCC allowed cellular telephone systems to operate in the SMR (NEXTEL) and NBPCS (Space Data and others) bands. A large number of these systems utilized the iDEN network designed by Motorola. iDEN handsets which operated in the 896-901 and 901-902 MHz band were also inherently narrow band in operation due to the mask limitations for operating in these bands. iDEN systems could operate at higher transmit bandwidths if the individual 12.5 KHz channels were aggregated (many operated in 125 KHz channel widths subdivided into 10, 12.5 kHz channels) but the individual handset units were usually kept to narrow band modulations to support as many users as possible in the limited amount of spectrum available for their use.
iDEN mobile units protected the subscribers in the adjacent channel by incorporating high fidelity transmitters which produced very little noise in the adjacent channels. SMR

systems also utilized high fidelity transmitters in most cases to keep from interfering with adjacent channel users.

The technology utilized in the 1990's and 2000's for generating narrow band transmissions was inherently quiet. Modulations were usually generated in narrow loop bandwidth PLLs which utilized high fidelity RF oscillators which further helped the noise levels in the adjacent channels to be low. The narrow loop bandwidths were needed both for modulation containment and to allow the PLL to step in fine frequency increments.

Modulating techniques incorporating I/Q mixers placed between the frequency generation hardware and the transmitter power amplifier or in the reference path to the PLL were commonplace. The modulating signals (phase/frequency/amplitude) applied to the I/Q modulators had narrow band filtering applied to them, which also limited the noise due to modulation in the adjacent channels to be low. Care needed to be used with these I/Q techniques as the hardware could add significant noise to the transmitted signal itself.

SECTION 2: SPECTRAL OCCUPANCY

2.1. SPECTRAL OCCUPANCY AND SPECTRAL MASKS

Three spectral masks will be used for the discussions to follow. Mask J is presently used for all 13.56 KHz authorized bandwidth transmitters in the 896-901 MHz SMR band. Mask J is applied when the transmitting circuitry does not have a low pass filter before the modulator. Usually the types of transmissions generated by equipment which uses Mask J are digital in nature.

Part 24 systems in the 901-902 MHz channel adjacent to the SMR spectrum can use one of two spectral masks constraining their modulations. The narrower mask is for 10 KHz authorized bandwidths. A wider mask is usually set to be 20 KHz wide for 25 KHz channel widths, but may be extended up to the limit usable in a licensee's spectrum depending on the width of the spectrum the licensee holds.

2.2. MASK J

2.2.1. Mask J is defined in CFR 47 Part 90.210(j):

(j) Emission Mask J. For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power of the transmitter (P) as follows:
(1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 2.5 kHz, but no more than 6.25 kHz: At least 53 log (fd/2.5) dB;
(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 6.25 kHz, but no more than 9.5 kHz: At least 103 log (fd/3.9) dB;
(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 9.5 kHz: At least 157 log (fd/5.3) dB, or 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

2.2.2 A plot of emissions Mask J versus displacement from the signal center frequency is shown in FIGURE 1:

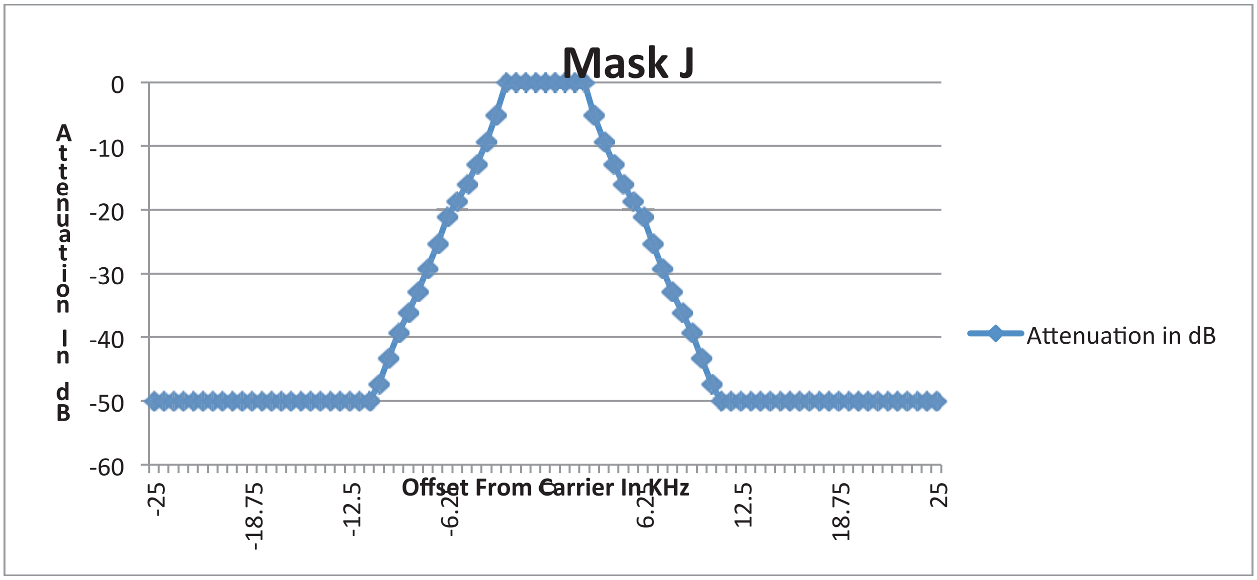


FIGURE 1: Mask J

2.3. PART 24 10 kHz AUTORIZED BANDWIDTH MASK

2.3.1. Part 24 10 kHz authorized bandwidth mask is defined in CFR 47 Part 24.133(2.)

(2) For transmitters authorized a bandwidth of 10 kHz:

(i) On any frequency outside the authorized bandwidth and removed from the edge of the authorized bandwidth by a displacement frequency (f_d in kHz) of up to and including 20 kHz: at least $116 \times Log_{10}((f_d+5)/3.05)$ decibels or $50+10 \times Log_{10}(P)$ decibels or 70 decibels, whichever is the lesser attenuation;

(ii) On any frequency outside the authorized bandwidth and removed from the edge of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 20 kHz: at least $43+10\ Log_{10}(P)$ decibels or 80 decibels, whichever is the lesser attenuation.

(b) The measurements of emission power can be expressed in peak or average values provided they are expressed in the same parameters as the transmitter power.

(c) When an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in this section.

(d) The following minimum spectrum analyzer resolution bandwidth settings will be used: 300 Hz when showing compliance with paragraphs (a)(1)(i) and (a)(2)(i) of this section; and 30 kHz when showing compliance with paragraphs (a)(1)(ii) and (a)(2)(ii) of this section.

2.3.2. A plot of Part 24, 10 kHz authorized bandwidth mask is shown in FIGURE 2:

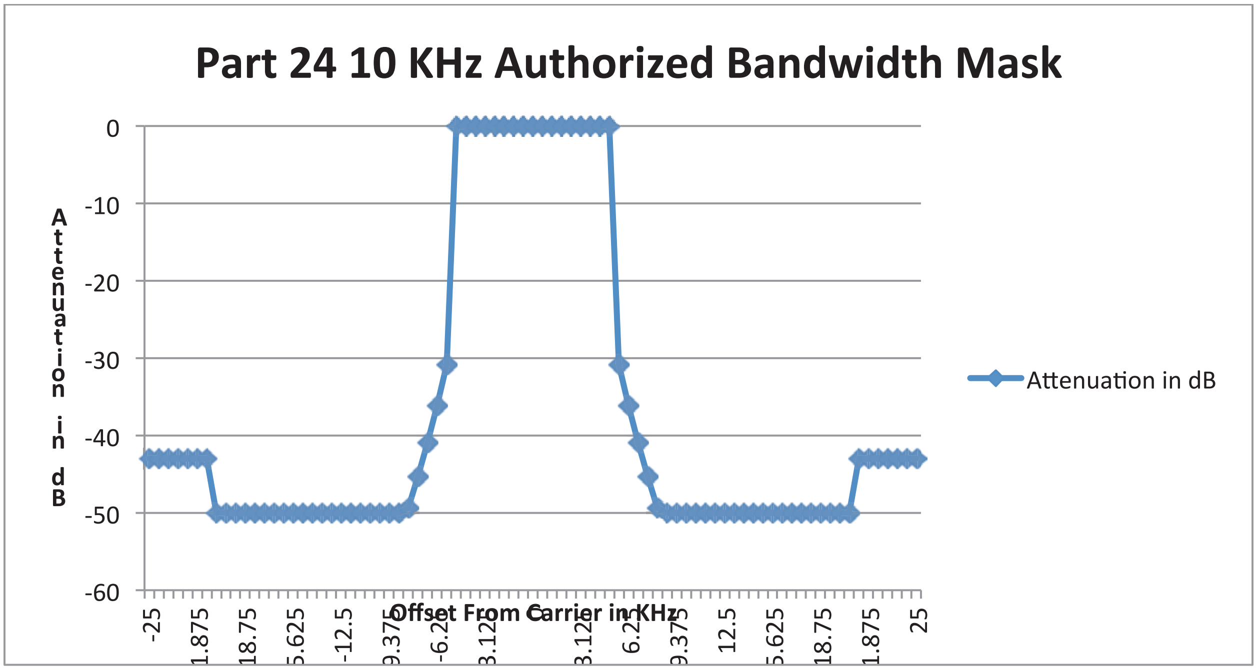


FIGURE 2: Part 24, 10 kHz Authorized Bandwidth Mask

2.4. PART 24 20 kHz AUTORIZED BANDWIDTH MASK

2.4.1. Part 24 10 kHz authorized bandwidth mask is defined in CFR 47 Part 24.133(1.)

(1) For transmitters authorized a bandwidth greater than 10 kHz:

(i) On any frequency outside the authorized bandwidth and removed from the edge of the authorized bandwidth by a displacement frequency (f_d in kHz) of up to and including 40 kHz: at least 116 Log_{10} ((f_d+10)/6.1) decibels or 50 plus 10 Log_{10} (P) decibels or 70 decibels, whichever is the lesser attenuation;

(ii) On any frequency outside the authorized bandwidth and removed from the edge of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 40 kHz: at least 43+10 Log_{10} (P) decibels or 80 decibels, whichever is the lesser attenuation.

2.4.2. Part 24, 10 kHz authorized bandwidth mask is shown in FIGURE 3:

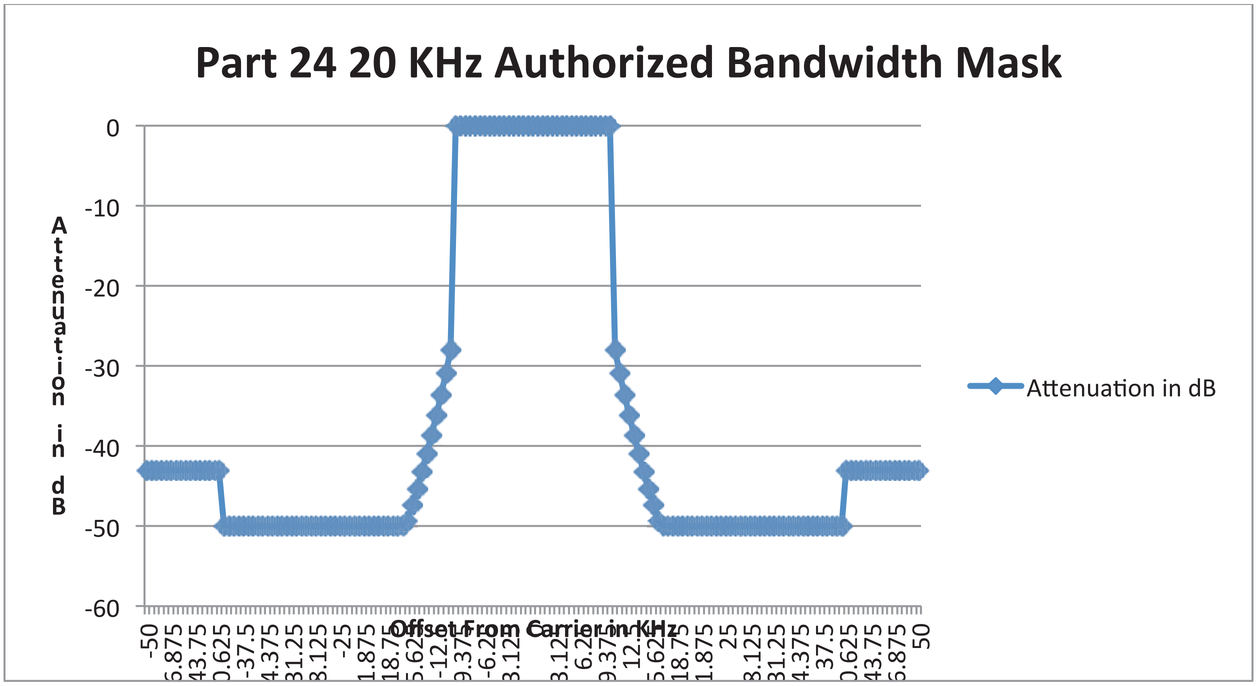


FIGURE 3: Part 24, 20 kHz Authorized Bandwidth Mask

2.5. DISCUSSION OF MEASUREMENTS FOR ALL MASKS

2.5.1. In Band Emissions Measurements

From the center of the authorized bandwidth up to and including the displacement frequency which denotes the out of channel attenuation the measurement bandwidth is usually set between100 Hz and 300 Hz.

2.5.2. Out Of Band Emissions Measurements

The out of band emissions measurements (usually noted as a hard limit plus 10*LOG(P) related to 1 Watt) are measured in a 30 KHz bandwidth. More often than not, compliance to these limits are shown at higher offsets than a few hundreds of kHz for the test reports on the FCC OET site as the intent is usually to show harmonic or spurious emissions from the unit under test not associated with the modulation.

In this author’s experience, the out of channel emissions limits are suspect and worth further scrutiny if emissions closer to the carrier frequency are measured in the 100 Hz bandwidth used for the in-channel measurements and are seen to be “above the out of channel limit line measured in a 100 Hz bandwidth” by over 25 dB (i.e. 10LOG(30,000/100)) then a more stringent measurement may be needed using a 30 KHz measurement bandwidth and filters to reject the carrier frequency.

In other cases the measurement for out of channel emissions may be taken in a 100 Hz bandwidth, translated from dBm/100 Hz to dBm/30KHz and compared against the limits.

For the sake of the following discussions all out of channel measurements will be converted to dBm/Hz and dBm/30 kHz so that a direct relationship to the spectral masks may be made.

SECTION 3: MEASUREMENTS DERIVED FROM ON-LINE FCC OET TEST REPORTS OF LEGACY EQUIPMENT IN SMR AND NBPCS BANDS

3.1. OVERVIEW

3.1.1. Source Of Data Used

The data and plots that follow were collected using the FCC OET Equipment Authorization Web Site. The plots are directly copied from the test reports submitted for the FCCID of the equipment stated in each heading.

3.1.2. Data Manipulation

The original data from the test reports taken from the FCC OET Equipment Authorization Web Site was not altered. If annotation is made to the copied data, it is only intended to clarify the measurements as taken. The data and test results are in no way altered or changed.

3.1.3. Measurement Frequencies

The majority of the measurements below are taken in the 896-901 MHz FCC Part 90 SMR spectrum. The iDEN i475 unit has measurements in both the 896-901 MHz SMR and 901-902 NBPCS spectrum.

3.2. MOTOROLA iDEN i475 FCC ID: IHDT56MG1

3.2.1. Spectral Mask Measurement SMR Band 896-901 MHz

The transmitter spectrum shown in the next Figure shows the modulated output of a Motorola iDEN transmitter subscriber unit operating in the 896-901 MHz band. Modulation is as shown in FIGURE 4.

FCC Filing Package for Motorola i475-Series Transceivers **FCC ID: IHDT56MG1**

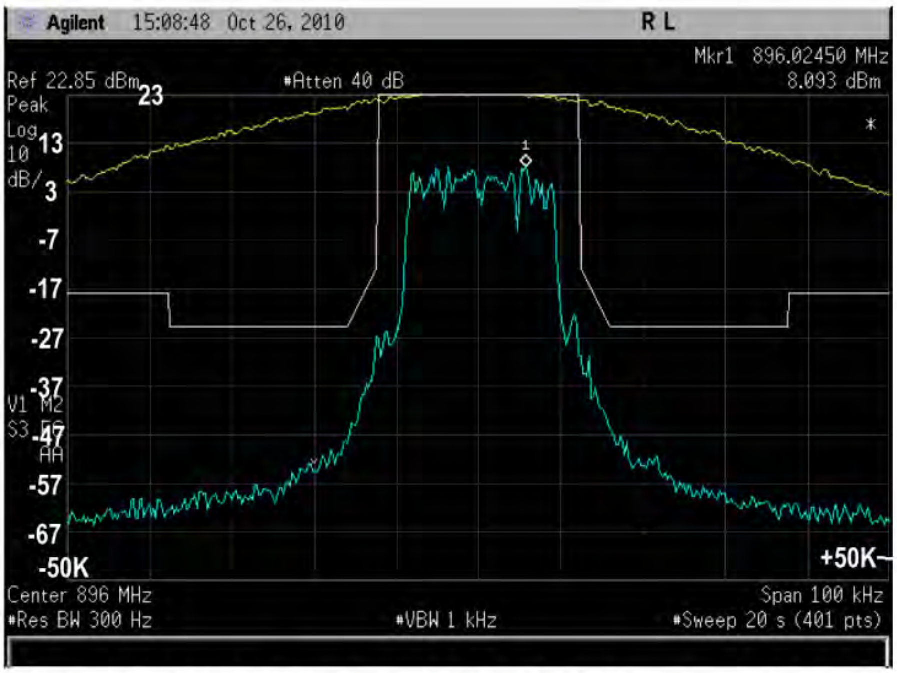


Figure 6a.2.2-11. iDEN 900 MHz Band, Quad-64QAM, Maximum Power, EA Emission Mask

FIGURE 4: Transmitted Spectral Mask From a Motorola i-475 Subscriber Unit. Note the spectral mask varies from Mask J slightly. Motorola used Mask G for the measurements as it is similar to Mask J with the exception that Mask J does not change to 43 + 10 LOG P at 40 KHz. Motorola calls this variance out in their report.

3.2.2. Measurement Detail SMR Band 896-901 MHz

The main power is measured by the yellow trace and is +23 dBm.

The measurement was invoked for 50+10LOG(P) from 23 dBm for the limit for >9.5 KHz from the carrier needed for Mask J. With 23dBm=0.2W : 50+10LOG(0.2)=43dB which is where the limit line is set.

Relating the limit line above to dBm, annotation was added to the left of the measurement to show the level in dBm for each major horizontal line. Relating the 43 dB limit to dBm displayed above puts the limit line at 23dBm-43dB=-20dBm.

3.2.3. Converting The Out Of SMR Band Emission Level to dBm/Hz and dBm/30KHz.

Noting the power measured in the 300 Hz bandwidth at a 50 KHz offset from the carrier and converting to dBm/Hz in FIGURE 4 would yield (interpreting the plot above as closely as possible) would result in -65dBm/300Hz.

- -65 dBm/300Hz converts to -90 dBm/Hz.
- -65 dBm/300Hz converts to -45 dBm/30KHz

3.2.4. Spectral Mask Measurement NBPCS Band 901-902 MHz

The transmitter spectrum shown in the next Figure shows the modulated output of a Motorola iDEN transmitter subscriber unit operating in the 901-902 MHz band. Modulation is as shown in FIGURE 5.

FCC Filing Package for Motorola i475-Series Transceivers | **FCC ID: IHDT56MG1**

6b.2. Modulation Characteristics and Necessary Bandwidth -- Pursuant 47 CFR 2.1033(c)(13), §2.1047(d), §2.1049, §2.202, §24.131, and §24.133(a)(1); RSS-Gen Section 3, RSS-134 Section 6.3.

6b.2.1 Emission Designator 18K3D7W - NBPCS iDEN Measured data

Figure 6b.2.1-1 iDEN NBPCS Band, Occupied Bandwidth, Quad-QPSK, Maximum Power.

50KHz From Carrier -63 dBm / 300 Hz
Relates to -87 dBm / Hz

FIGURE 5: Transmitted Spectral Mask From a Motorola i-475 Subscriber Unit. Measurement is compliant to Part 24, 20 kHz Authorized Bandwidth Mask. Figure is annotated for ease of reading.

3.2.5. Measurement Detail NPBCS Band 901-902 MHz

The main power is measured by the yellow trace and is +23.62 dBm.

The measurement was invoked for 43+10LOG(P) from 23.62 dBm for the out of channel limit. With 23.62dBm=0.23W : 43+10LOG(0.23)=36.71dB : 23.62dBm-36.71dB=-13 dBm which is where the limit line is set at a 50 KHz offset to the center frequency.

3.2.6. Converting The Out Of NBPCS Band Emission Level to dBm/Hz and dBm/30KHz

Noting the power measured in the 300 Hz bandwidth at a 50 KHz offset from the carrier and converting to dBm/Hz in FIGURE 4 (interpreting the plot above as closely as possible) would result in -63dBm/300Hz.

- -63 dBm/300Hz converts to -88 dBm/Hz.
- -63 dBm/300Hz converts to -43 dBm/30KHz

3.3. MOTOROLA iDEN i325 FCC ID: AZ489FT5855

3.3.1. Spectral Mask Measurement

The transmitter spectrum shown in the next Figure shows the modulated output of a Motorola iDEN transmitter subscriber unit operating in the 896-901 MHz band. Modulation is as shown in FIGURE 6.

FCC Filing Package for Motorola i325 Transceiver **FCC ID: AZ489FT5855**

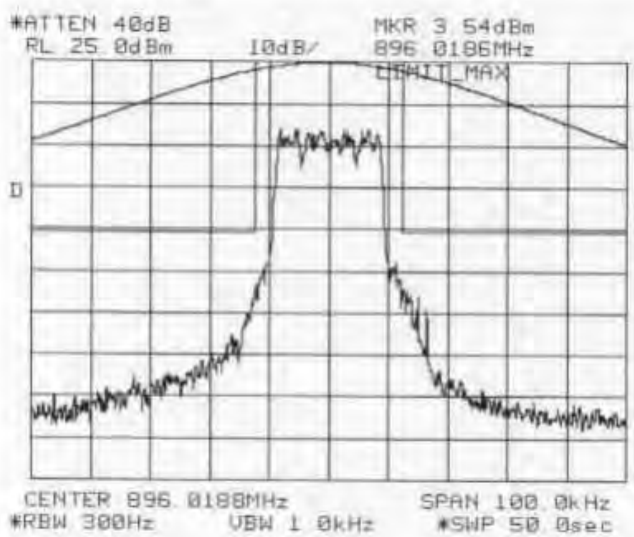


Figure 6-23: Quad-64QAM Modulation performance relative to mask 47 CFR 90.669(a)
(MAXIMUM POWER SETTING)

FIGURE 6: Transmitted Spectral Mask From a Motorola i-325.

3.3.2. Measurement Detail

Note at 50 KHz offsets from the carrier, the noise from the unit is 85 dB below the output power of 25.0 dBm.

3.3.3. Converting The Out Of Band Emission Level to dBm/Hz and dBm/30KHz

The measurement bandwidth in FIGURE 5 is 300 Hz. The measurement at a 50 KHz offset from the center frequency is 25 dBm - 85 dB or -60dBm/300Hz.

- -60 dBm/300Hz converts to -85 dBm/Hz.
- -60 dBm/300Hz converts to -40 dBm/30KHz

3.4. MOTOROLA r750 iDEN Digital Multi-Service Phone FCC ID: AZ489FT5820

3.4.1. Spectral Mask Measurement

The output power of the r750 is lower, presumably for battery life and the fact the unit enjoys some gain from its antenna.

The mask in Figure 7 differs from Mask J slightly, it is based on an MTA mask and the limit line is at 43+10LOG(P), the measurement detail is identical to that used for Mask J as stated earlier.

FCC Filing Package for Motorola r750 Integrated Transceiver **FCC ID:** AZ489FT5820

Figure 6-11: Quad-QPSK Modulation performance relative to mask 47 CFR 90.669(a) 900.99375MHz, MAXIMUM POWER SETTING:

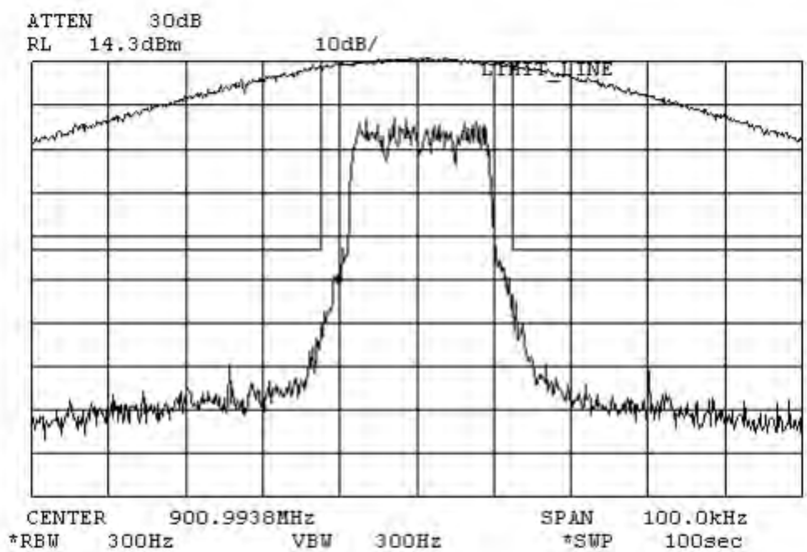


FIGURE 7: Motorola r750 Integrated Transceiver

3.4.2. Measurement Detail

Note at 50 KHz offsets from the carrier, the noise from the unit is 80 dB below the output power of 14.3 dBm.

3.4.3. Converting The Out Of Band Emission Level to dBm/Hz and dBm/30KHz

The measurement bandwidth in FIGURE 6 is 300 Hz. The measurement at a 50 KHz offset from the center frequency is 14.3 dBm - 80 dB or -65.7dBm/300Hz.

- -65.7 dBm/300Hz converts to -90.7 dBm/Hz.
- -65.7 dBm/300Hz converts to -45.7 dBm/30KHz

SECTION 4: DICUSSSION

The data available on the FCC OET Equipment Authorization website for the majority of iDEN SMR subscriber units showed out of channel noise floor conducted levels of better than -85dBm/Hz at 50 KHz separation from the modulated carrier. A number of units were lower than -85dBm/Hz.

Higher power SMR band units used mostly for in-vehicle mobile applications (as their output power levels are quite high and may not pass MPE or SAR FCC limits) show higher noise power in their out of channel spectral measurements. The out of channel noise power remains very low for the units investigated and the low noise power measurements are somewhat masked by the dynamic range of the measuring equipment being used.

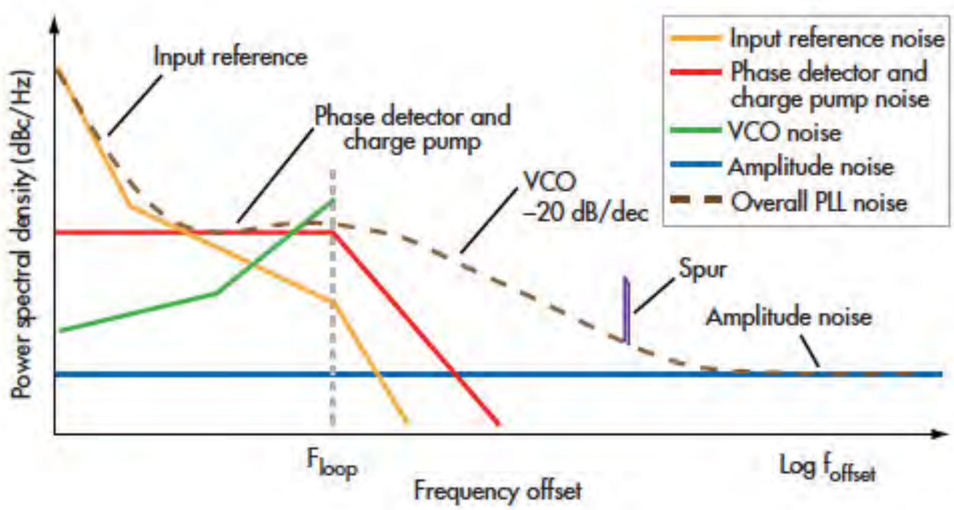
The data available on the FCC OET Equipment Authorization website for the majority of mobile SMR subscriber units at powers less than one Watt showed out of channel noise floor conducted levels of better than -75dBm/Hz at 50 KHz separation from the modulated carrier. A number of units were lower than -75dBm/Hz.

Sensus believes that many units also achieve better noise emissions than their reported -75dBm/Hz reading at 50 KHz offsets, but are limited by the dynamic range of the measuring equipment utilized.

It is our opinion that the RF design of the legacy units in these frequency bands has a tendency to achieve substantial noise emission roll off at offsets closer to the carrier due to:

- High fidelity RF oscillators used in the design of the radios.
- PLL and modulating architectures that are inherently low noise in design.
- Narrow band modulations were required due to narrow authorized bandwidths permitted in the bands.
  - The same point, but referencing data rate limiting on any digital modulations sent in the authorized bandwidths allowed.
  - The narrow authorized bandwidths are regulated by several, narrow band, spectral masks mandated by the FCC for operation in the SMR and NBPCS spectrum (i.e. Mask I, Mask J, Mask H, Mask G, to name a few).
- The need to protect the same user's adjacent channel noise floor 12.5 KHz to 25 KHz from the carrier.
- The fact that if the wider offset noise spectrum of the units tested resides outside the PLL bandwidths of the subscriber units tested, the level of -75 dBm/Hz (and better) will roll off at a slope of 6dB/Octave of frequency separation.

- For example if a level of -75dBm/Hz at a 50 KHz offset from the carrier is measured, the number will increase to -81dBm/Hz at 100 KHz and continue that trend rapidly decreasing to the thermal noise floor.
  - NOTE: Sensus NBPCS channels are only close in proximity to 896-901 MHz upper band edge licensees by less than 100 KHz in a small number of locations.
- A graphic showing the roll off of an RF PLL is supplied for convenience.. The VCO noise rolls off at 20db/decade outside the PLL bandwidth. (From Analog Devices data sheet.)



-
  - 20dB/Decade slope is equal to a slope of 6dB/Octave

Roll-off is given by,

$$\Delta L = 20 \log \left(\frac{\omega_2}{\omega_1} \right) \ \mathrm{dB/interval}_{2,1}$$

For a decade this is;

$$\Delta L = 20 \log 10 = 20 \ \mathrm{dB/decade}$$

and for an octave,

$$\Delta L = 20 \log 2 \approx 20 \times 0.3 = 6 \ \mathrm{dB/8ve}$$

SECTION 5: CONCLUSION

The narrow band nature of the FCC frequency allocations for Specialized Mobile Radio in the 896-901 (935-940) MHz bands and Narrow Band PCS in the 901-902 (930-930.5 and 940-940.5) MHz defined by narrow authorized bandwidths and narrow spectral mask requirements has allowed a multiplicity of users to coexist and operate without significant out of channel emissions.

The low out of channel emissions required by equipment operating in the aforementioned bands has protected the noise floor of all users in these bands allowing for optimal operation of systems in these channels.