BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C.

In the Matter of	)
	)
Requests for Waiver of Section 22.913 of the	)
Commission's Rules to Permit AT&T to Use a PSD	)
Measurement in the Cellular Bands of a Limited	)
Number of Markets	)

PETITION FOR WAIVER FOR LICENSES IN KANSAS

AT&T Services, Inc., on behalf of its subsidiaries (collectively, "AT&T"), pursuant to Federal Communications Commission ("Commission") Rule Section 1.925, requests a waiver of Section 22.913 of the Commission's rules for Cellular licenses in Kansas.[1]

I. BACKGROUND

Commission Rule Section 22.913 sets the effective radiated power ("ERP") limits for Cellular base stations, which has generally been applied *per channel*. On February 29, 2012, AT&T filed a Petition for Rulemaking ("Petition") proposing revisions to Section 22.913 that would authorize the use of a power spectral density ("PSD") model to set an alternative base station ERP limit of 250 W per megahertz ("MHz") in non-rural areas and 500 W/MHz in rural areas.[2] In its Petition, AT&T explained that setting Cellular base station ERP using a PSD model would eliminate unintended penalties on the deployment of advanced digital broadband

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[1] 47 C.F.R. § 22.913.

[2] *In the Matter of Amendment of the Commission's Rules Governing Radiated Power Limits in the Cellular Radio Service Frequency Bands,* Petition for Expedited Rulemaking and Request for Waiver, RM-11660, DA-12-701 (filed February 29, 2012) ("Petition").

modulation schemes in the Cellular bands and allow Cellular licensees to more efficiently deploy Cellular broadband service.

On November 10, 2014, the Commission released a Further Notice of Proposed Rulemaking ("Further Notice") that proposed to allow Cellular licensees to calculate ERP using a PSD model.[3] Pending resolution of this rulemaking, AT&T is seeking license-specific waivers, as needed, of the base station ERP limits by channel in favor of setting base power using a PSD model. Grant of these waivers will allow AT&T to more quickly and efficiently deploy high speed wireless broadband services over Cellular spectrum. In this request, AT&T seeks a waiver of Section 22.913 to allow for base station operations at 250 W/MHz in non-rural areas and 500 W/MHz in rural areas in the following markets:[4]

License	CMA	Block
KNKN465	CMA434	A
KNKN469	CMA433	A
KNKN514	CMA429	A
KNKN516	CMA428	A
KNKN518	CMA438	A
KNKN741	CMA439	A
KNKQ376	CMA440	A

Commission Chairman Wheeler has stated:

> Our role is to harness the power of modern communications to produce social and economic benefits. This we can accomplish in two ways. First, by removing obstacles to progress, whether the obstacles are unnecessary or counterproductive regulations or private arrangements that restrict economic, intellectual, and cultural advancement. And

[3] Amendment of Parts 1 and 22 of the Commission's Rules with Regard to the Cellular Service, Including Changes in Licensing of Unserved Area, *et al*, WT Docket No. 12-40, RM-11510, RM-11660, 29 FCC Rcd 14100, 14135-44 (2014) ("*Further Notice*").

[4] The main counties comprising the Cellular Geographic Service Area (CGSA) for each license are identified in Appendix A. All counties are rural, but in the event there is a change in the classification, AT&T will change to the non-rural power limits.

> second by assuring the availability of the economic inputs we manage which are essential to modern networks. By far the most important of these inputs is spectrum.[5]

The Commission can fulfill this role in both ways by waiving and, ultimately, modifying Section 22.913 to allow Cellular licensees to set base station power limits using PSD. Setting base station ERP using a PSD model will allow AT&T to more efficiently deploy LTE over the same spectrum resources and thus, more effectively meet the data demands of its customers. Further, as explained below, the PSD limits will not increase the risk of interference to public safety entities. Nevertheless, AT&T will continue to adhere to the Commisson's Part 22 and companion Part 90 rules intended to address interference with public safety operations. For all these reasons, as explained more fully below, grant of a waiver is in the public interest and meets all qualifications of Rule Section 1.925.

II. DISCUSSION

Under Section 1.925(b)(3) of its rules, the Commission may grant a request for waiver if the applicant demonstrates that: (i) the underlying purpose of the rule for which the waiver is sought would not be served or would be frustrated by application of the rule, and that the grant of the requested waiver would be in the public interest; or (ii) in view of unique or unusual factual circumstances, application of the rule(s) would be inequitable, unduly burdensome, or contrary to the public interest, or the applicant has no reasonable alternative.[6] As described in this waiver request, permitting AT&T to use a PSD model to set base station ERP in the designated Kansas markets at 250 W/MHz in non-rural areas and 500 W/MHz in

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[5] Prepared remarks of FCC Chairman Tom Wheeler, "Wireless Spectrum and the Future of Technology Innovation" Forum – Brookings Institution, March 24, 2014, http://www.fcc.gov/document/chairman-wheeler-remarks-brookings-institution.

[6] *See*, 47 C.F.R. §1.925; *WAIT Radio v. FCC*, 418 F.2d 1153 (D.C. Cir. 1969).

rural areas is in the public interest because it will foster the deployment of broadband LTE in the Cellular service and will not increase the potential for interference.

A. Grant of the Waiver is in the Public Interest Because it Promotes Broadband LTE Deployment in the Cellular Bands.

Grant of this waiver is in the public interest by removing disparities between radio services that limit Cellular carriers' ability to deploy the most efficient and advanced modulation techniques[7] and by promoting the deployment of mobile broadband services, including in rural areas. Wireless providers have experienced extraordinary increases in the volume of data generated by consumers and businesses as a result of the popularity and ubiquity of smartphones and other data-enabled devices. Having pioneered devices like the iPhone and aggressively promoted the latest technologies and applications, AT&T has borne the brunt of a substantial amount of this newly generated traffic. Over the last eight years, data traffic over AT&T's wireless network has increased an astounding 100,000 percent.[8] To help meet that demand, AT&T has invested nearly $140 billion in capital, spectrum, and other assets over the last six years to build and enhance its networks, including increasing its LTE build-out in the 1900 MHz Personal Communications Services (PCS) bands.[9]

Notwithstanding that massive investment, AT&T remains critically constrained by access to spectrum, while data usage continues to soar. To maintain high-quality service for its customers, AT&T must continue to rapidly and aggressively roll-out more efficient LTE services over other spectrum bands, notably 850 MHz Cellular. Deploying LTE over existing 850 MHz

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[7] *See*, Petition at 9–12.

[8] AT&T Inc. 2014 Annual Report at 2, http://www.att.com/Investor/ATT_Annual/2014/downloads/att_ar2014_annualreport.pdf.

[9] *Id.* at 6.

infrastructure and frequencies would provide significant operational and spectrum efficiencies. Unfortunately, as the Commission has observed:

> The . . . current [base station power] limits apply to each emission or channel, so that a licensee using narrow emissions can transmit more total power per MHz than a licensee using wideband emissions. For example under the current rules, a Cellular licensee using a 5 MHz LTE emission in a non-rural area would be limited to 500 W in those 5 MHz (100 W/MHz), while a licensee in the same 5 MHz could deploy four CDMA channels with an aggregate power of 2000 W ERP (400 W/MHz), or 12 GSM channels with an aggregate power of 6000 W ERP (1200 W/MHz).[10]

This penalty on wideband emissions dilutes and potentially precludes deployment of the most up-to-date, efficient wideband technologies to the broadest population.

To this end, it is in the public interest to authorize AT&T to use the PSD model to calculate ERP at 250 W/MHz in non-rural areas and 500 W/MHz in rural areas in the above-referenced Kansas markets pending resolution of the Further Notice. This conclusion is supported by the Commission's grant of similar waiver requests to operate using the PSD model in certain Florida and Vermont markets.[11] In those matters, the Commission examined the data provided by AT&T, which is identical to the data provided for this waiver request, and concluded that allowing the use of the PSD model "better serves the public interest than strict application of the current Cellular radiated power rule."[12] The same rationale applies to the Kansas markets listed above, warranting grant of the waiver.

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[10] *Further Notice* at 14138-39.

[11] Interim Waiver of 47 C.F.R. § 22.913 to Permit the Use of a Power Spectral Density Model for Certain Cellular Service Operations in Three Florida Markets, WT Docket No. 13-202, 29 FCC Rcd 11638 (2014) ("Florida Waiver"); Interim Waiver of 47 C.F.R. § 22.913 to Permit the Use of a Power Spectral Density Model for Certain Cellular Service Operations for Cellular Market 248 – Burlington, VT, WT Docket No. 14-10, 29 FCC Rcd 11632 (2014) ("Vermont Waiver").

[12] Florida Waiver at 11643; Vermont Waiver at 11636.

B. Grant of the Waiver Would Not Increase the Interference Risk in Adjacent Bands.

One of the Commission's core missions is to manage spectrum effectively and ensure that licensees do not interfere with each other.[13] To reduce the potential for interference with licensees operating in adjacent bands, the Commission establishes power limits within each wireless service, such as Section 22.913. Grant of the waiver requested herein would not undermine the purpose of Section 22.913, as the interference environment using a PSD calculation at the ERP limits proposed by AT&T remains relatively the same as (or better than) the current ERP measure.

1. Use of PSD Keeps the Status Quo with Public Safety.

Attached hereto as Appendix B is a study prepared by AT&T demonstrating that the use of a PSD model for calculating ERP at 250 W/MHz in non-rural areas and 500 W/MHz in rural areas will not increase the potential for interference with public safety systems in any of the markets for which a waiver is requested.[14] In this study, AT&T compared the potential interference effects of various wireless network arrangements on public safety receivers. The test cases in the study represent AT&T's past, present, and future wireless networks—various configurations of GSM, UMTS and/or LTE (with 2x2 MIMO[15]) systems in the Cellular band. The study addressed three near/far interference mechanisms common in the public safety

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[13] 47 U.S.C. §302.

[14] The findings are identical to those in the study attached as Appendix A to AT&T's Petition.

[15] To increase spectral efficiency and throughput of a radio link, multiple transmitters using the same frequency and multiple antennas or multiple elements of the same antenna are used to create multiple distinct spatial channels between the transmitters and antenna(s). With the aid of a multipath environment and signal processing, multiple channels are created using the same frequency at each transmitter. This technology is referred to as MIMO (Multiple Input Multiple Output).

interference environment – intermodulation, out-of-band emissions ("OOBE"), and receiver overload. The benchmarks used to measure significant interference were a rise in the receiver's noise floor greater than 1 dB for intermodulation and OOBE and a received interference level higher than the overload limit of the affected receiver for receiver overload. Public safety receiver performance was based upon current models with relatively wide open front-end filtering encompassing the range from 851-869 MHz, with receiver bandwidths of 12.5 and 25 KHz.

AT&T's study confirms the absence of any significant effects upon public safety services in the Kansas markets arising from operating at ERP limits based upon a PSD model—finding, for example, that AT&T's future LTE deployments in the Cellular bands under a PSD limit would maintain the *status quo* with public safety services. With respect to intermodulation interference, at the three distances from the Cellular base station site (40 meters, 200 meters, and 1000 meters) for all migration paths, the noise floor rise for LTE deployments with MIMO and PSD rules relief were significantly less than technology deployments allowed under current Commission rules. For OOBE at the three distances from the Cellular base station site for all migration paths, all noise floor rises were below 1 dB. This rise in the interference floor is insignificant in practice and is still well under the 1 dB degradation in the noise floor of the public safety mobile receiver. Finally, for overload interference, the study showed LTE deployments did not increase the number of possibilities of such interference above that of existing deployments.

Moreover, the risk of interference from the use of PSD is further reduced by existing Commission rules, namely Cellular Rule Sections 22.970–22.973 and their companion public safety service Rule Sections 90.672–90.675.[16] Under those rules, the wireless industry established an 800 MHz Interference Notification Website with 24 hour response to public safety requests for interference mitigation.[17] Using this website and the procedures established under the Part 22 and Part 90 rules, Cellular licensees and public safety agencies have worked together for years to resolve the few interference incidents that have arisen and will continue to do so. As evidence of their effectiveness, the Association of Public-Safety Communications Officials-International, Inc. ("APCO") and the National Public Safety Telecommunications Council ("NPSTC") tout the necessity of these rules.[18] The availability of these Part 22 and Part 90 remedies will resolve any remaining concerns about interference into public safety systems arising from AT&T's use of a PSD model.[19]

2. Use of PSD Does not Increase the Risk of Interference to Adjacent CGSAs.

In its Petition, AT&T proposed ERP limits per megahertz based on existing transmit power levels at AT&T's sites, which would maintain the status quo in the RF environment vis-a-vis not only neighboring public safety systems, but also the Cellular Geographic Service Areas ("CGSAs") of neighboring Cellular licensees. Consequently, with the PSD limits proposed,

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[16] 47 C.F.R. §§ 22.970-22.973, 90.672-90.675.

[17] The 800 MHz Interference Notification Website can be found at http://www.publicsafety800mhzinterference.com/CTIAWeb/index.aspx.

[18] Reply Comments of The Association of Public-Safety Communications Officials-Int'l, Inc., WT Docket No. 12-40 at 3 (filed Feb. 20, 2015); The National Public Safety Telecommunications Council, WT Docket No. 12-40 at 4 (filed Feb. 20, 2015).

[19] The Commission has noted the value of the 24-hour response to public safety currently required by Section 90.674. *Improving Spectrum Efficiency Through Flexible Channel Spacing and Bandwidth Utilization for Economic Area-based 800 MHz Specialized Mobile Radio Licensees, et al*, Report and Order, WT Docket No, 12-64, WT Docket No. 11-110, 27 FCC Rcd 6489, 6497 (2012).

AT&T's power levels into adjacent public safety areas and CGSAs would be the same as before. AT&T will not inject increased signal energy into or increase the noise level in these bordering areas until it acquires any necessary approvals. The effect on neighboring and co-located systems – both public safety and Cellular services – is minimal.

Verizon Wireless and United States Cellular Corporation, two of the three non-AT&T licensees of Cellular A Block CGSAs bordering the licenses for which waiver is sought, both support AT&T's Petition.[20] In fact, Verizon Wireless has proposed PSD limits higher than proposed by AT&T.[21] The other bordering Cellular A Block licensee, NE Colorado Cellular, Inc. did not file comments in response to AT&T's Petition or the Further Notice. Verizon Wireless holds all adjacent channel licenses. The absence of objections to AT&T's PSD rule change Petition from its neighbor licensees suggests that these licensees would anticipate no harmful effects from the grant of this waiver request. AT&T will also comply with all existing Cellular rules governing power levels at the neighbors' borders and coordination of channel usage with those neighbors.[22] Hence, there is no increased risk of harmful effect to neighboring systems in either Cellular band.

C. AT&T'S Planned LTE Deployment Using PSD.

AT&T needs to deploy LTE carriers on its Cellular spectrum in the Kansas markets using the proposed PSD power limits as soon as possible to meet the demand for data that continues unabated. AT&T has demonstrated that allowing the alternative PSD ERP limit maintains or

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[20] Comments of United States Cellular Corp., RM-11660 (June 1, 2012); Reply Comments of Verizon Wireless, RM-11660, DA 12-701 (June 18, 2012).

[21] Reply Comments of Verizon Wireless at 4-6. *See also* Comments of Verizon, WT Docket No. 12-40, RM No. 11510 at 2-3 (filed Jan. 21, 2015).

[22] *See* 47 C.F.R. §22.907.

improves the interference environment that the Commission found to be reasonable when it established Section 22.913. Moreover, the waiver—conditioned on the outcome of the pending rulemaking—would not undermine the deliberative process relative to adopting PSD limits for Cellular carriers more broadly. The Commission has previously concluded that granting AT&T a waiver to operate at an alternative ERP using the PSD model in Florida, "strikes an appropriate balance in the public interest by enabling AT&T to deploy LTE using the Cellular . . . Stations and allowing it to make more effective use of the spectrum by providing enhanced product offerings to consumers, while also protecting public safety licensees and neighboring Cellular licensees from increased risk of harmful interference."[23] Likewise, allowing AT&T to operate using a PSD model at Cellular base stations in Kansas would serve the public interest.

CONCLUSION

For the foregoing reasons, AT&T respectfully requests that the Commission waive section 22.913 of the rules to permit AT&T's Cellular base stations in the Kansas markets described herein to operate at 250 W/MHz in non-rural areas and 500 W/MHz in rural areas.

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Respectfully submitted,

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[23] Florida Waiver Grant, 29 FCC Rcd at 11643-44.

Appendix A

License[24]	CMA	Block	Counties
KNKN465	CMA434	A	Trego, Ellis, Russell, Ness, Rush, Barton, Pawnee, Stafford
KNKN469	CMA433	A	Wallace, Logan, Gove, Greeley, Wichita, Scott, Lane, Sheridan
KNKN514	CMA429	A	Norton, Phillips, Smith, Graham, Rooks, Osborne
KNKN516	CMA428	A	Cheyenne, Rawlins, Decatur, Sherman, Thomas, Sheridan
KNKN518	CMA438	A	Hamilton, Kearny, Finney, Stanton, Grant, Haskell, Morton, Stevens, Seward
KNKN741	CMA439	A	Hodgeman, Gray, Ford, Meade, Clark
KNKQ376	CMA440	A	Barber, Comanche, Kiowa, Pratt, Stafford, Edwards

[24] This waiver should apply to all base stations providing service in the CGSA for each license, including minor extensions into CMAs and counties adjacent to those listed in this table.

Appendix B

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Radio Access and Devices – Wireless Technology Strategies

Date: **November 19, 2014**

Subject: **A Further Comparison of the Impacts on Public Safety Receivers from the Various Wireless Technologies used in AT&T's Migration from Narrowband GSM to Broadband LTE in the 850 MHz CMRS Cellular Band in Kansas Markets**

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Abstract

The FCC Rules for the 850 MHz band were designed to accommodate first generation AMPS (Advanced Mobile Phone System) analog cellular service. Over the years, carriers deployed digital services in the 850 MHz bands, and eventually sunset analog services. Carriers currently use the 850 MHz band for technologies that support mobile broadband, such as UMTS. As the industry moves toward fourth generation LTE (Long Term Evolution) technology coupled with the use of MIMO (Multiple Input Multiple Output) techniques for spectral efficiency improvements, it is appropriate to consider whether the rules for this band relating to power measurement, which were adapted for technology deployed almost 30 years ago, should be revised to accommodate LTE. In band plans adopted more recently to accommodate mobile broadband deployment, the Commission has adopted a Power Spectral Density approach. This paper presents the results of a further study that considers whether making such a change to the 850 MHz rules to accommodate contemporary commercial mobile broadband deployments would increase the likelihood of interference to adjacent users of Public Safety bands in a Kansas market.

The study addressed the interference impacts on Public Safety receivers under five different cases that are representative of AT&T's past, present, and future network comprising GSM, UMTS and LTE systems in various configurations in the cellular band. Results of this "real world" study again leads AT&T to conclude that a power limit based on a Power Spectral Density measure will not increase the possibility of harmful interference to adjacent bands and would maintain the "status quo" with respect to the potential impact on users of adjacent spectrum, such as the Public Safety Radio Service. The "real world" study results also supported a Power Spectral Density limit of 250 Watts/MHz in non-rural areas and 500 Watts/MHz in rural areas. As a result of this study, AT&T will file a petition at the FCC proposing to supplement the current per-emission ERP limits for cellular base stations with ones restated to include power spectral density limits.

1. Introduction

The FCC Rules for the 850 MHz band were designed to accommodate first generation AMPS (Advanced Mobile Phone System) analog cellular service. Over the years, carriers deployed digital services in the 850 bands, and eventually sunset analog services. Carriers currently use the 850 MHz band for technologies that support mobile broadband, such as UMTS (Universal Mobile Telecommunications System). As carriers migrate their wireless networks to fourth generation (4G) LTE (Long Term Evolution) technology and use MIMO (Multiple Input Multiple Output) techniques for spectral efficiency improvements, the FCC Rules governing the radiated power of transmitters in the Cellular Radiotelephone Service have come into question. MIMO uses multiple antennas or multiple antenna elements at both the transmitter and receiver to create multiple distinct spatial channels between the transmitter and the receiver using the same radio channel. AT&T plans to use 2x2 MIMO in its 850 MHz LTE deployments. 2x2 MIMO uses two transmitters operating on the same carrier channel but carrying two different information streams to create two separate spatial channels. Since two spatial channels are created using a single radio carrier, spectral efficiency is increased. The current FCC Rule governing radiated power in the Cellular Radiotelephone Service (Section 22.913) states - *the effective radiated power of base transmitters and cellular repeaters must not exceed 500 watts*. Since this power limit was enacted prior to the development and use of MIMO techniques, it was generally understood that a single transmitter used a single carrier frequency and the power requirement was related to this carrier frequency. A 2x2 MIMO deployment, which employs a single carrier channel on two transmitters, must split the maximum radiated power given in the FCC Rules between the two MIMO transmitters. This power split reduces the service coverage area of the transmitters operating in the MIMO mode compared to that of a single transmitter deployment.

In 2004, recognizing the problem posed by the then current power limitation rules, CTIA offered a technologically neutral proposal to modify base station power limits for PCS licensees. Subsequently, the Commission expanded this proposal to include not only PCS, but also cellular radio service and other service bands. In 2008, following comments on the proposal, the FCC revised the radiated power rules for certain services, notably PCS and AWS, but declined to extend the revision to cellular radio service because the frequencies immediately adjacent to the 850 MHz cellular band were undergoing significant restructuring and "until [it could] better assess the impact of additional power limit changes" on the possibility of harmful interference to adjacent bands. Since then, re-banding of services adjacent to the cellular band is almost complete and there has been adequate time to understand the interference concerns, if any, due to the adoption of Power Spectral Density (PSD) rules in PCS and AWS bands. Such a PSD limit would allow the use of MIMO techniques in the 850 MHz band without requiring a reduction in the service coverage area, and would be more consistent with FCC broadband power limit rules in other bands. A PSD limit specifies the amount of power that is distributed with frequency and, in the case of the cellular radiotelephone service, it is the amount of power distributed over a radio channel. If the maximum radiated power in a 5 MHz channel is 1500 watts, the PSD would be 300 watts/MHz (1500 watts/5 MHz).

Believing that a PSD measure should now be adopted for the cellular bands, AT&T conducted a technology interference comparison analysis of its third generation (3G) UMTS and 4G LTE technologies to show that a power limit based on a Power Spectral Density measure will not increase the possibility of harmful interference to adjacent bands and would also maintain the "status quo" with respect to the potential impact on users of adjacent spectrum, such as the Public Safety Radio Service. The results of the technology interference comparison supported AT&T's belief. The study results also supported a Power Spectral Density limit greater than 100 Watts/MHz.

To further bolster AT&T's belief that a power limit based on a Power Spectral Density measure will not increase the possibility of harmful interference to adjacent bands, AT&T completed a second "real world" study which determined the interference impacts on users of adjacent spectrum as a result of its technology migration through the years – from second generation (2G) GSM (Global Systems for Mobile Communications) to 4G LTE with MIMO. AT&T's technology migration study commences with the deployment of 2G GSM technology employing a tri-sectored frequency reuse pattern of N=12 that typically allowed on average up to five GSM carriers per sector. With the migration to broadband 3G UMTS technology, some GSM carriers were replaced with a single UMTS carrier. A typical sector in an initial 3G network would include one UMTS and three GSM carriers. As broadband demand increased, the spectrum for a second UMTS carrier was again re-farmed from existing GSM carriers. A typical congested metro market deploys two UMTS carriers along with two GSM carriers per sector. As the data traffic demand increased, a migration to 4G LTE in the cellular bands will be necessary. LTE deployments will precede by replacing one of the UMTS carriers with a 5 MHz LTE carrier employing 2X2 MIMO. Initial deployments of LTE will include a 5 MHz UMTS carrier, a 5 MHz LTE carrier, and two GSM carriers in the cellular band. The final migration will be to replace the remaining UMTS and GSM carriers and to upgrade the 5 MHz LTE carrier to a 10 MHz LTE carrier. The LTE deployments will be with two transmitters per carrier/sector as compared to a single transmitter per carrier/sector with UMTS. This paper documents the final results of that study.

1. Modeling the Interference Environment

Modeling the interference environment consisted of the following five steps:

1. Model the interference path
2. Determine the transmitter and receiver characteristics
3. Model the interference mechanisms
4. Calculate the interference levels and determine their impacts

1.1 Modeling the Interference Path

Since the interference network environment is that of a standard cellular architecture, two propagation loss models were used to calculate path loss. These two propagation loss models were the HATA loss models and the modified Friis Transmission Loss model. The HATA models are the most widely used radio frequency propagation models for predicting the behavior of cellular transmissions. Since the HATA models are accurate for link distances between 1 and

20 kilometers, another model was needed for paths closer to the cell site. The Friis Transmission Loss model is ideal for paths between two isotropic antennas in free space (Line-of-Sight) and can be modified for paths other than free space (Non-Line-of-Sight). All loss models were incorporated into the Friis Transmission Equation which relates received power, transmit power, antenna gains and path loss in order to calculate interference levels. For line-of-sight paths a propagation constant of 2 was used and for non-line-of-sight paths, a propagation constant of 2.4 was used. Cellular antenna heights for non-rural areas of Kansas used the average antenna height in the Kansas market - 30 meters. For rural areas of Kansas where antenna heights are generally higher, antenna heights of 47 and 92 meters were used. The average antenna height for the Kansas rural markets in this study was 86 meters.

1.2 Determining the Transmitter and Receiver Characteristics

The transmitter and receiver characteristics were:

- Maximum transmit power
- Base station antenna gains and discrimination
- Transmission line loss
- Transmitter sideband emission levels
- Public Safety receiver noise floor
- Minimum mobile Adjacent Channel Rejection Ratio
- Minimum portable Adjacent Channel Rejection Ratio
- Public Safety mobile antenna gain: From an Internet site on Public Safety equipment
- Public Safety portable antenna gain: From an Internet site on Public Safety equipment
- Public Safety Receiver Overload level
- Third Order Intercept Point calculation: From *Motorola paper by Bruce Oberlies – "Public Safety Interference Environment – Raising Receiver Performance Requirements"*
- Third Order Interference Level calculation: From Aeroflex Application Note on Intermodulation Distortion on the website www.aeroflex.com.

1.3 Modeling the Interference Mechanism

The three near/far interference mechanisms common in Public Safety interference environments were modeled in the following manner:

1. Intermodulation – The receive interference level at the input to the Public Safety receiver's front end was calculated using the appropriate Friis Transmission Equation. The study assumed that the GSM channels were transmitting at 500 Watts, UMTS channels were transmitting at 500 Watts, and LTE at 500 Watts/transmitter-antenna for a 5 MHz channel and 1000 Watts/transmitter-antenna for a 10 MHz channel. Since Effective Radiated Power level is the power level radiating from the base station's antenna, no transmission line loss or base station antenna gain was included in this calculation. It was assumed that these levels were the levels of the two interfering signals creating the intermodulation product. The third order intercept point was calculated using the formula in the Motorola paper and this value was used in the Aeroflex equation with

the interference levels calculated from the Friis Transmission Equation to obtain the level of the third order product in the receiver.

2. Transmitter Sideband Emissions - The transmitter sideband emission level at the input to the Public Safety receiver's front end was calculated using the appropriate Friis Transmission Equation. The sideband transmit power level at the output of the transmitter used in this equation was the measured spurious emissions level given by the manufacturer. For this calculation in the Friis Transmission Equation, transmission line loss and base station antenna gain were included.

3. Receiver Overload - The received interference level at the input to the Public Safety receiver's front end was calculated using the appropriate Friis Transmission Equation. The cellular base station transmit power level used in this equation was the maximum Effective Radiated Power level specified in the FCC Rules for Cellular services in the 850 MHz cellular band for 2G and 3G technologies (GSM channels were transmitting at 500 Watts, UMTS channels were transmitting at 500 Watts, and LTE at 500 Watts/transmitter-antenna for a 5 MHz channel and 1000 Watts/transmitter-antenna for a 10 MHz channel). Since Effective Radiated Power level is the power level radiating from the base station's antenna, no transmission line loss or base station antenna gain was included in this calculation.

1.4 Interference Levels and Their Impacts

An Excel spreadsheet was developed to make the above mentioned calculations and determine the impacts of the various interference mechanisms. For the intermodulation interference calculation and the transmitter sideband emission interference calculation, the criteria used to determine impact was a rise in the receiver's noise floor. For Receiver Overload interference calculations, the criteria used to determine impacts was that any interfering level that was less than the specified overload point of the receiver is an acceptable interfering level. For this study only the relative levels of the interference environments are compared. Only in situations where a technology's interference environment level is no worse than the existing technology's interference environment level can the interference level be deemed acceptable (Status Quo).

The study addresses the interference impacts on Public Safety receivers under five different cases that are representative of AT&T's past, present, and future network comprising GSM, UMTS and LTE systems in various configurations in the cellular band. Case one represents an initial 2G GSM deployment of five GSM carriers. Case two addresses the migration to one UMTS carrier and three GSM carriers. Case three represents the migration to two UMTS carriers along with two GSM carriers per sector. Case four represents a migration to 4G LTE with a 5 MHz UMTS carrier, a 5 MHz LTE carrier with MIMO, and two GSM carriers. The final migration, Case five, will be to a single 10 MHz LTE carrier with MIMO.

2. Study Results

With a single GSM channel's transmit power level set to 500 Watts, a single UMTS channel set to 500 Watts, and a LTE channel set to 500 Watts/transmitter-antenna for a 5 MHz channel and

1000 Watts/transmitter-antenna for a 10 MHz channel, the results of the Excel spreadsheet calculations of interference into Public Safety receivers with bandwidths of 25 and 12.5 KHz from the five migration cases for non-rural and rural environments are shown in Tables 1 through 12. Bracketed numbers in the overload tables are received overload interference levels in dBm.

2.1 Intermodulation Interference Impacts

	PS RECEIVER BANDWIDTH = 25 KHz				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	9.4362	9.4362	9.4362	9.4362	0.0173
200	6.4700	6.4700	6.4700	6.4700	0.0076
>1000	0.0482	0.0482	0.0482	0.0482	0.0000

	PS RECEIVER BANDWIDTH = 12.5 KHz				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	18.0114	18.0114	18.0114	18.0114	0.1363
200	14.5468	14.5468	14.5468	14.5468	0.0607
>1000	0.3717	0.3717	0.3717	0.3717	0.0002

TABLE 1. Non-Rural Mobile Intermodulation Impacts

	PS RECEIVER BANDWIDTH = 25 KHz				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0043	0.0043	0.0043	0.0043	0.0000
200	0.0019	0.0019	0.0019	0.0019	0.0000
>1000	0.0482	0.0482	0.0482	0.0482	0.0000

	PS RECEIVER BANDWIDTH = 12.5 KHz				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0339	0.0339	0.0339	0.0339	0.0000
200	0.0104	0.0104	0.0104	0.0104	0.0000
>1000	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE 2. Non-Rural Portable Intermodulation Impacts

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 47 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.5766	0.5766	0.5766	0.5766	0.0000
200	8.9790	8.9790	8.9790	8.9790	0.0019
>1000	1.0994	1.0994	1.0994	1.0994	0.0001

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 47 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	3.2957	3.2957	3.2957	3.2957	0.0003
200	17.5004	17.5004	17.5004	17.5004	0.0076
>1000	5.1913	5.1913	5.1913	5.1913	0.0006

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 92 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0000	0.0000	0.0000	0.0000	0.0000
200	0.0076	0.0076	0.0076	0.0076	0.0000
>1000	3.3683	3.3683	3.3683	3.3683	0.0003

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 92 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0003	0.0003	0.0003	0.0003	0.0000
200	0.0601	0.0601	0.0601	0.0601	0.0000
>1000	10.1597	10.1597	10.1597	10.1597	0.0026

TABLE 3. Rural Mobile Intermodulation Impacts

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 47 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0001	0.0001	0.0001	0.0001	0.0000
200	0.0038	0.0038	0.0038	0.0038	0.0000
>1000	0.0002	0.0002	0.0002	0.0002	0.0000

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 47 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0006	0.0006	0.0006	0.0006	0.0000
200	0.0301	0.0301	0.0301	0.0301	0.0153
>1000	0.0013	0.0013	0.0013	0.0013	0.0000

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 92 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0001	0.0001	0.0001	0.0001	0.0000
200	0.0038	0.0038	0.0038	0.0038	0.0000
>1000	0.0006	0.0006	0.0006	0.0006	0.0000

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 92 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0000	0.0000	0.0000	0.0000	0.0000
200	0.0000	0.0000	0.0000	0.0000	0.0000
>1000	0.0051	0.0051	0.0051	0.0051	0.0000

TABLE 4. Rural Portable Intermodulation Impacts

The results above show that for intermodulation interference at the three distances from the cellular base station site (40 meters, 200 meters, and 1000 meters) for all migration paths, the noise floor rise for LTE deployments with MIMO were below 1 dB and were significantly less than present technology deployments. The higher and consistently uniform interference level for those cases involving GSM are driven only by much higher PSD of the GSM carrier. Thus this worst case interference effect remains the same regardless of the number of GSM carriers that are present. In practice where interference cases have been identified, judicious shuffling of the GSM carriers amongst various frequencies has allowed IM interference to be mitigated.

Tables 1 through 4 show Case 4, which is represented by each sector deploying one UMTS carrier transmitting at 500 W, one 5 MHz LTE carrier transmitting at 1000 W and two GSM carriers transmitting 500 watts each, will not cause any additional interference from intermodulation (IM) into Public Safety receivers as compared to existing UMTS or GSM systems.

2.2 Sideband Interference Impacts

	PS RECEIVER BANDWIDTH = 25 KHz				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed by FCC Rules	Yes	Yes	Yes	No	No
40	0.0271	0.0216	0.0216	0.0271	0.0271
200	0.0207	0.0164	0.0164	0.0207	0.0207
>1000	0.0024	0.0019	0.0019	0.0024	0.0031

	PS RECEIVER BANDWIDTH = 12.5 KHz				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed by FCC Rules	Yes	Yes	Yes	No	No
40	0.0271	0.0216	0.0216	0.0271	0.0271
200	0.0207	0.0164	0.0164	0.0207	0.0207
>1000	0.0024	0.0019	0.0019	0.0024	0.0031

TABLE 5. Non-Rural Mobile Sideband Impacts

	PS RECEIVER BANDWIDTH = 25 KHz				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0136	0.0108	0.0108	0.0136	0.0136
200	0.0104	0.0082	0.0082	0.0104	0.0104
>1000	0.0012	0.0010	0.0010	0.0012	0.0015

	PS RECEIVER BANDWIDTH = 12.5 KHz				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0136	0.0108	0.0108	0.0136	0.0136
200	0.0104	0.0082	0.0082	0.0104	0.0104
>1000	0.0012	0.0010	0.0010	0.0012	0.0015

TABLE 6. Non-Rural Portable Sideband Impacts

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 47 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0036	0.0028	0.0028	0.0036	0.0036
200	0.0131	0.0104	0.0104	0.0131	0.0065
>1000	0.0045	0.0036	0.0036	0.0045	0.0045

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 47 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0036	0.0216	0.0216	0.0036	0.0036
200	0.0131	0.0104	0.0104	0.0131	0.0131
>1000	0.0045	0.0036	0.0036	0.0045	0.0045

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 92 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0001	0.0001	0.0001	0.0001	0.0001
200	0.0008	0.0007	0.0007	0.0008	0.0008
>1000	0.0072	0.0057	0.0057	0.0072	0.0072

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 92 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0001	0.0001	0.0001	0.0001	0.0001
200	0.0008	0.0007	0.0007	0.0008	0.0008
>1000	0.0072	0.0057	0.0057	0.0072	0.0072

TABLE 7. Rural Mobile Sideband Impacts

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 47 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0018	0.0014	0.0014	0.0018	0.0018
200	0.0065	0.0052	0.0052	0.0065	0.0033
>1000	0.0023	0.0018	0.0018	0.0023	0.0023

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 47 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0018	0.0014	0.0014	0.0018	0.0018
200	0.0065	0.0052	0.0052	0.0065	0.0065
>1000	0.0029	0.0018	0.0018	0.0029	0.0023

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 92 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0001	0.0001	0.0001	0.0001	0.0001
200	0.0004	0.0003	0.0003	0.0004	0.0004
>1000	0.0036	0.0029	0.0029	0.0036	0.0036

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 92 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	0.0001	0.0001	0.0001	0.0001	0.0001
200	0.0004	0.0003	0.0003	0.0004	0.0004
>1000	0.0036	0.0029	0.0029	0.0036	0.0036

TABLE 8. Rural Portable Sideband Impacts

Similarly, for Sideband emissions at the three distances from the cellular base station site (40 meters, 200 meters, and 1000 meters) for all migration paths, all noise floor rises were below 1 dB. The tables show a slight increase in interference from Sideband emissions between some scenarios deploying LTE with increased power and less cable loss (Case 4 and Case 5) than existing GSM and UMTS systems as represented by Case 1, 2 and 3. This rise in the interference floor is insignificant in practice and is still well under the 1 dB degradation in the noise floor of the Public Safety mobile receiver.

2.3 Overload Interference Impacts

	PS RECEIVER BANDWIDTH = 25 KHz				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	YES (-21.1)	YES (-22)	YES (-22)	YES (-21.1)	YES (-22)
200	YES (-22.2)	YES (-23.2)	YES (-23.2)	YES (-22.2)	YES (-23.2)
>1000	NO	NO	NO	NO	NO

	PS RECEIVER BANDWIDTH = 12.5 KHz				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	YES(-21.1)	YES(-22.0)	YES (-22)	YES(-21.1)	YES (-22)
200	YES(-22.2)	YES(-23.2)	YES (-23.2)	YES(-22.2)	YES (-23.2)
>1000	NO	NO	NO	NO	NO

TABLE 9. Non-Rural Mobile Overload Impacts

	PS RECEIVER BANDWIDTH = 25 KHz				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	YES(-24.1)	YES(-25)	YES (-25)	YES(-24.1)	YES(-25)
200	YES(-25.2)	YES(-26.2)	YES (-26.2)	YES(-25.2)	YES(-26.2)
>1000	NO	NO	NO	NO	NO

	PS RECEIVER BANDWIDTH = 12.5 KHz				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	2500 W	2000 W	2000 W	2500 W	2000 W
Allowed Now	YES	YES	YES	NO	NO
40	YES(-24.1)	YES(-25)	YES (-25)	YES(-24.1)	YES(-25)
200	YES(-25.2)	YES(-26.2)	YES (-26.2)	YES(-25.2)	YES(-26.2)
>1000	NO	NO	NO	NO	NO

TABLE 10. Non-Rural Portable Overload Impacts

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 47 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	YES(-26.8)	YES(-27.8)	YES(-27.8)	YES(-26.8)	NO
200	YES(-21.2)	YES(-22.2)	YES(-22.2)	YES(-21.2)	YES(-25.2)
>1000	YES(-25.8)	YES(-26.8)	YES(-26.8)	YES(-25.8)	YES(-29.8)

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 47 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	YES(-26.8)	YES(-27.8)	YES(-27.8)	YES(-26.8)	NO
200	YES(-21.2)	YES(-22.2)	YES(-22.2)	YES(-21.2)	YES(-25.2)
>1000	YES(-25.8)	YES(-26.8)	YES(-26.8)	YES(-25.8)	YES(-29.8)

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 92 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	NO	NO	NO	NO	NO
200	NO	NO	NO	NO	NO
>1000	YES(-23.8)	YES(-24.8)	YES(-24.8)	YES(-23.8)	YES(-27.8)

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 92 m)				
DISTANCE TO MOBILE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	NO	NO	NO	NO	NO
200	NO	NO	NO	NO	NO
>1000	YES(-26.8)	YES(-27.8)	YES(-27.8)	YES(-26.8)	NO

TABLE 11. Rural Mobile Overload Impacts

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 47 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	YES(-29.8)	NO	NO	YES(-29.8)	NO
200	YES(-24.2)	YES(-25.2)	YES(-25.2)	YES(-24.2)	YES(-28.2)
>1000	YES(-28.8)	Yes(-29.8)	Yes(-29.8)	YES(-28.8)	NO

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 47 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	YES(-29.8)	NO	NO	YES(-29.8)	NO
200	YES(-24.2)	YES(-25.2)	YES(-25.2)	YES(-24.2)	YES(-28.2)
>1000	YES(-28.8)	YES(-29.8)	YES(-29.8)	YES(-28.8)	NO

	PS RECEIVER BANDWIDTH = 25 KHz (Ant Height = 92 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	NO	NO	NO	NO	NO
200	NO	NO	NO	NO	NO
>1000	YES(-26.8)	Yes(-27.8)	Yes(-27.8)	YES(-26.8)	NO

	PS RECEIVER BANDWIDTH = 12.5 KHz (Ant Height = 92 m)				
DISTANCE TO PORTABLE RECEIVER (METERS)	CASE 1 5 GSM CXRS (dB)	CASE 2 1 UMTS & 3 GSM CXRS (dB)	CASE 3 2 UMTS CXRS & 2 GSM CXRS (dB)	CASE 4 1 FIVE MHz LTE CXR, 1 UMTS CXR & 2 GSM CXRS (dB)	CASE 5 1 TEN MHz LTE CXR (dB)
Power/Sector	5000 W	4000 W	4000 W	5000 W	4000 W
Allowed Now	YES	YES	YES	NO	NO
40	NO	NO	NO	NO	NO
200	NO	NO	NO	NO	NO
>1000	YES(-26.8)	YES(-27.8)	YES(-27.8)	YES(-26.8)	NO

TABLE 12. Rural Portable Overload Impacts

For overload interference, the tables show that such interference is possible close to the cellular base station sites, but LTE deployments did not increase the number of possibilities of such interference above that of existing deployments. The small difference in the overload levels for the near site calculations can be attributed to the path loss difference and the base station antenna discrimination. The tables also show that such cases of overload interference into Public Safety receivers could be reduced with the use of newer Public Safety receivers with overload limits around – 20 dBm (well within present design even at the current wider front end bandwidths) or the incorporation of front end filtering.

2.4 The PSD Limit

Reviewing the above tables lead to the conclusion that overload is the controlling interference mechanism. Based on this conclusion the highest PSD that can be implemented and still maintain the *status quo* in the interference environment can be determined. A PSD of 250 watts/MHz for non-rural areas and 500 watts/MHz for rural areas was determined to be the highest PSD limit that would not cause any additional interference into bands adjacent to the 850 MHz cellular band.

3. Conclusions

This study addressed the interference impacts on Public Safety receivers under five different cases that are representative of AT&T's past, present, and future network comprising GSM, UMTS and LTE systems in various configurations in the cellular band in a Kansas market. The study used the operating parameters of Public Safety portable and mobile units which were considered poor by present industry standards. The study results in Tables 1 through 12 suggest that the interference environment into Public Safety portable and mobile units from 2X2 MIMO LTE cellular deployments is not appreciably different than that from existing technologies in the cellular band.

Results of this "real world" study support AT&T's belief that a power limit based on a Power Spectral Density measure will not increase the possibility of harmful interference to adjacent bands and would maintain the "status quo" with respect to the potential impact on users of adjacent spectrum, such as the Public Safety Radio Service. The "real world" study results also supported a Power Spectral Density limit of 250 Watts/MHz in non-rural areas and 500 Watts/MHz in rural areas. As a result of this study, AT&T will file a petition at the FCC proposing to supplement the current per-emission ERP limits for cellular base stations with ones restated as power spectral density limits.