FREQUENZ
RF Technical Services

Antenna Site Conformity FCC RF Assessment and Report

prepared for FCC Licensee
New Cingular Wireless PCS, LLC

The new at&t
Your world. Delivered.

Site ID "MI-144X"

Site address

5 Lindsey Drive
North Brunswick, NJ 08902

January 13, 2021

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Contents

Introduction and Summary

At the request of AT&T Wireless ("AT&T"), Frequenz, LLC has performed an independent expert analysis of radiofrequency (RF) environment and associated FCC compliance for proposed installation on a proposed wireless antenna operation on a proposed monopole located at 5 Lindsey Drive North Brunswick, NJ 08902. AT&T refers to the antenna site by the Site ID "MI-144X", the proposed installation will facilitate a service and transmission in the 700, 850, 1900, 2100 and 2300 MHz frequency bands licensed to it by the FCC.

The FCC requires all wireless antenna operators to perform an assessment of potential human exposure to radiofrequency (RF) fields emanating from all the transmitting antennas at a site whenever antenna operations are added or modified, and to ensure compliance with the Maximum Permissible Exposure (MPE) limit in the FCC's regulations. Note that FCC regulations require any future antenna collocators to assess and assure continuing compliance based on the RF effects of all proposed and then-existing antennas at the site.

This report describes a mathematical analysis of RF levels resulting around the site in areas of unrestricted public access, that is, at ground level around the site. The compliance analysis employs a standard FCC formula for calculating the effects of the antennas in a very conservative manner, in order to overstate the RF levels and to ensure "safe-side" conclusions regarding compliance with the FCC limit for safe continuous exposure of the general public.

The results of a compliance assessment can be explained in layman's terms by describing the calculated RF levels as simple percentages of the FCC MPE limit. If the reference for that limit is 100 percent, then calculated RF levels higher than 100 percent indicate the MPE limit is exceeded, while calculated RF levels consistently lower than 100 percent serve as a clear and sufficient demonstration of compliance with the MPE limit.

We can (and will) also describe the overall worst-case result via the "plain-English" equivalent "times-below-the-limit" factor.

The result of the FCC RF compliance assessment in this case is as follows:

- At street level around the site, the conservatively calculated maximum RF level from the proposed antenna operations is ***1.3583*** percent of the FCC general population MPE limit – well below the 100-percent reference for compliance. In other words, the worst-case RF level around the site is more than 70 times below the limit established as safe for continuous human exposure to the RF emissions from antennas.
- The results of the calculations provide a clear demonstration that the RF levels from the proposed antenna operation is in compliance with the applicable FCC regulations and MPE limit. Moreover, because of the conservative methodology and operational assumptions incorporated in the calculations, RF levels actually caused by the antennas will be even less significant than these calculations indicate.

The remainder of this report provides the following:

- relevant technical data on the AT&T antenna operations, as proposed to be installed, at the site;
- a description of the applicable FCC mathematical model for assessing MPE compliance, and application of the relevant data to those models; and
- an analysis of the results, and a compliance conclusion for the antenna operations at this site.

In addition, Four Appendices are included. Appendix A provides background on the FCC MPE limit, as well as that of the State of New Jersey.

Appendix B provides a list of FCC references on MPE compliance. Appendix C provides a comparison of exposures from consumer products with those from a nearby mobile telephone base station. Appendix D provides a summary of the qualifications of the expert certifying compliance for the subject antenna operations.

We recognize that the State of New Jersey also has its own MPE limit, embodied in the *Radiation Protection Act*. However, the State's limit is actually *less protective* of the general public (by a factor of five) than the FCC MPE limit. Thus, it is more appropriate to apply in the exposure assessment the more protective FCC limit. Compliance with the FCC's limit automatically ensures compliance with the State's limit, in this case by a factor of 350.

Site Specific Antenna and Transmission Data

Relevant compliance-related data for the AT&T antenna operation, as proposed to be installed, is provided in the table that follows.

Site Specific Data	
Wireless Frequency Bands	700 MHz, 850 MHz, 1900 MHz, 2100 MHz and 2300 MHz
Service Coverage Type	Sectorized (4 sectors)
Antenna Type	Directional Panel
Antenna Centerline Height	178ft. AGL
Antenna Line Loss	Conservatively ignored (assumed 0 dB)
700 MHz Data	
Antenna Models (Max Gain)	CCI OPA45R-BU5CA-K (15.4 dBi) Commscope NNHH-65B-R4 (14.6 dBi)
Total Input Power Per Sector	400 watts
850 MHz Data	
Antenna Models (Max Gain)	CCI OPA45R-BU5CA-K (15.8 dBi) Commscope NNHH-65B-R4 (15.0 dBi)
Total Input Power Per Sector	160 watts
1900 MHz Data	
Antenna Models (Max Gain)	CCI OPA45R-BU5CA-K (18.8 dBi) Commscope NNHH-65B-R4 (17.3 dBi)
Total Input Power Per Sector	320 watts
2100 MHz Data	
Antenna Models (Max Gain)	CCI OPA45R-BU5CA-K (19.2 dBi) Commscope NNHH-65B-R4 (17.5 dBi)
Total Input Power Per Sector	160 watts
2300 MHz Data	
Antenna Models (Max Gain)	CCI OPA45R-BU5CA-K (18.9 dBi) Commscope NNHH-65B-R4 (17.9 dBi)
Total Input Power Per Sector	100 watts

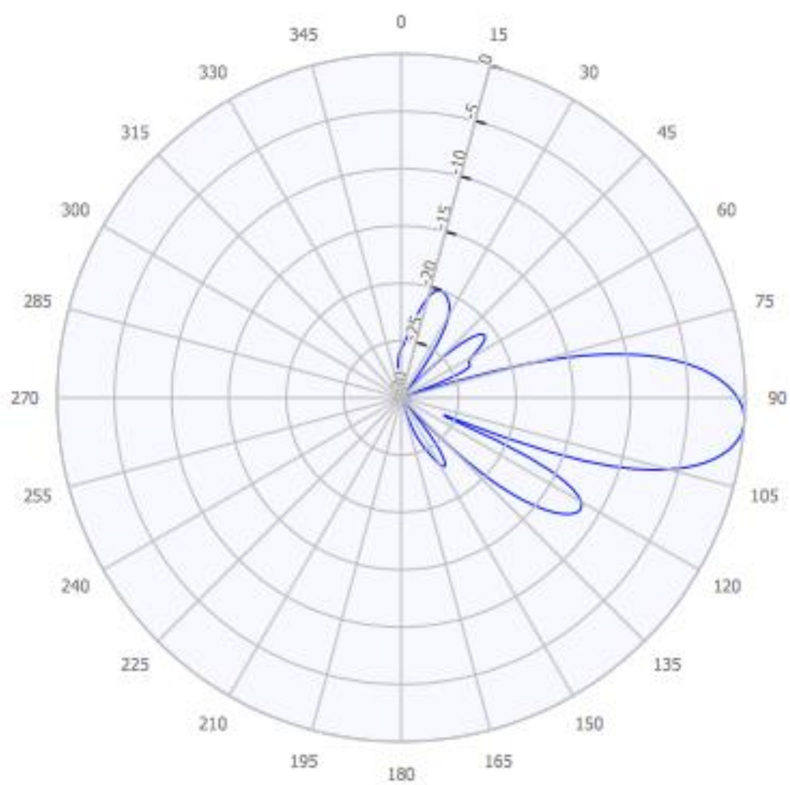
The area below the antennas, at street level, is of interest in terms of potential "uncontrolled" exposure of the general public, so the antenna's vertical-plane emission characteristic is used in the compliance calculations, as it is a key determinant in the relative level of RF emissions in the "downward" direction. By way of illustration, Figure 1 on the next page shows the vertical-plane radiation pattern of the CCI OPA45R-BU5CA-K proposed AT&T antenna model to be used in the 700 MHz band.

In this type of antenna radiation pattern diagram, the antenna is effectively pointed at the nine o'clock position (the horizon) and the pattern at different angles is described using decibel units.

Note that the use of a decibel scale in the diagrams incidentally visually understates the relative directionality characteristic of the antenna in the vertical plane. Where the antenna pattern reads 20 dB, the relative RF energy emitted at the corresponding downward angle is 1/100th of the maximum that occurs in the main beam (at 90 degrees); at 30 dB, the energy is 1/1000th of the maximum. Note that the automatic pattern-scaling feature of our internal software may skew side-by-side visual comparisons of different antenna models, or even different parties' depictions of the same antenna model.

Figure 1. OPA45R-BU5CA-K Antenna –700 MHz Vertical-plane Pattern

90 deg Horizon – 5dB/division



Compliance Analysis

FCC Office of Engineering and Technology Bulletin 65 ("OET Bulletin 65") provides guidelines for mathematical models to calculate the RF levels at various points around transmitting antennas. At street-level around an antenna site (in what is called the "far field" of the antennas), the RF levels are directly proportional to the total antenna input power and the relative antenna gain in the downward direction of interest – and the levels are otherwise inversely proportional to the square of the straight-line distance to the antenna. Conservative calculations also assume the potential RF exposure is enhanced by reflection of the RF energy from the intervening ground. Our calculations will assume a 100% "perfect", mirror-like reflection, the worst-case approach.

The formula for street-level compliance assessment for any given antenna operation is as follows:

$$MPE\% = (100 * Chans * TxPower * 10^{(Gmax-Vdisc/10)} * 4) / (MPE * 4\pi * R^2)$$

where

MPE%	=	RF level, expressed as a percentage of the MPE limit applicable to continuous exposure of the general public
100	=	factor to convert the raw result to a percentage
Chans	=	maximum number of RF channels per sector
TxPower	=	maximum transmitter power per channel, in milliwatts
$10^{(GmaxVdisc/10)}$	=	numeric equivalent of the relative antenna gain in the downward direction of interest; data on the antenna vertical-plane pattern is taken from manufacturer specifications

4	=	factor to account for a 100-percent-efficient energy reflection from the intervening ground, and the squared relationship between RF field strength and power density ($2^2 = 4$)
MPE	=	FCC general population MPE limit
R	=	straight-line distance from the RF source to the point of interest, centimeters

The MPE% calculations are performed out to a distance of 600 feet from the facility to points 6.5 feet (approximately two meters, the FCC-recommended standing height) off the ground, as illustrated in Figure 2 below.

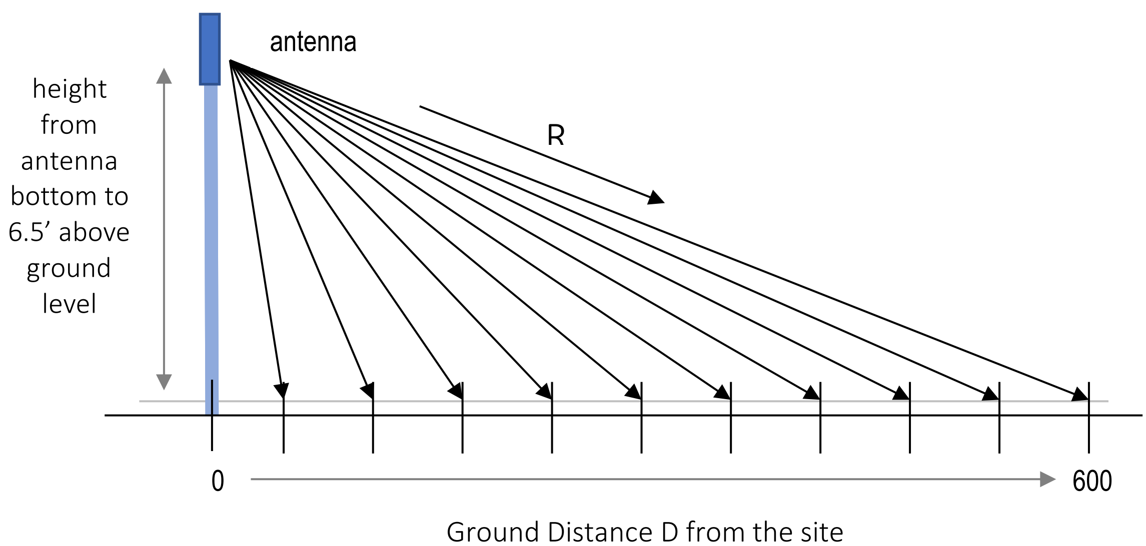


Figure 2. Ground-Level MPE% Calculation Geometry

It is popularly understood that the farther away one is from an antenna, the lower the RF level – which is generally but not universally correct. The results of MPE% calculations fairly close to the site will reflect the variations in the vertical-plane antenna pattern as well as the variation in straight-line distance to the antennas. Therefore, RF levels may actually increase slightly with increasing distance within the range of zero to 600 feet from the site.

As the distance approaches 600 feet and beyond, though, the antenna pattern factor becomes less significant, the RF levels become primarily distance-controlled, and as a result the RF levels generally decrease with increasing distance, and are well understood to be in compliance.

Street-level FCC compliance for a collocated antenna site is assessed in the following manner. At each distance point along the ground, an MPE% calculation is made for each antenna operation, and the sum of the individual MPE% contributions at each point is compared to 100 percent, the normalized reference for compliance with the MPE limit. We refer to the sum of the individual MPE% contributions as "total MPE%", and any calculated total MPE% result exceeding 100 percent is, by definition, higher than the FCC limit and represents non-compliance and a need to mitigate the potential exposure. If all results are consistently below 100 percent, on the other hand, that set of results serves as a clear and sufficient demonstration of compliance with the MPE limit.

Note that according to the FCC, when directional antennas and sectorized coverage arrangements are used, the compliance assessments are based on the RF effect of a single (facing) sector, as the RF effects of directional antennas facing generally away from the point of interest are insignificant.

The following conservative methodology and assumptions are incorporated into the MPE% calculations on a general basis:

1. The antennas are assumed to be operating continuously at maximum power and maximum channel capacity.
2. The power-attenuation effects of shadowing or other obstructions to the line-of-sight path from the antenna to the point of interest are ignored.

3. The calculations intentionally minimize the distance factor (R) by assuming a 6’6” human and performing the calculations from the bottom (rather than the centerline) of each operator’s lowest-mounted antenna, as applicable.
4. The potential RF exposure at ground level is assumed to be 100-percent enhanced (increased) via a “perfect” field reflection from the intervening ground.

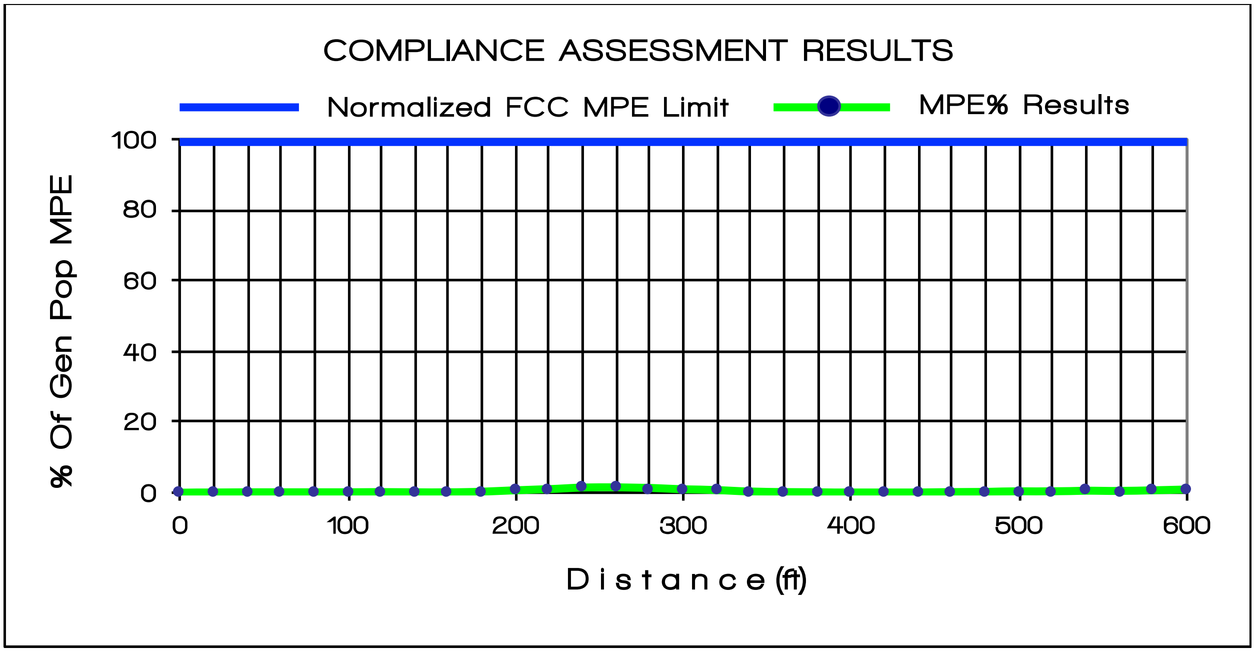
The net result of these assumptions is to significantly overstate the calculated RF exposure levels relative to the levels that will actually occur – and the purpose of this conservatism is to allow very “safe-side” conclusions about compliance.

The table that follows on the next page provides the results of the MPE% calculations for each frequency band, with the maximum calculated “total MPE%” result highlighted in bold in the last column.

Ground Distance (ft)	AT&T 700 MHz MPE%	AT&T 850 MHz MPE%	AT&T 1900 MHz MPE%	AT&T 2100 MHz MPE%	AT&T 2300 MHz MPE%	Total MPE%
0	0.0055	0.0109	0.0002	0.0008	0.0091	0.0265
20	0.0104	0.0151	0.0008	0.0037	0.0313	0.0612
40	0.0164	0.0293	0.0050	0.0118	0.0226	0.0852
60	0.0271	0.0314	0.0160	0.0124	0.0015	0.0884
80	0.0502	0.0112	0.0159	0.0032	0.0100	0.0904
100	0.0830	0.0062	0.0048	0.0116	0.0041	0.1098
120	0.0546	0.0414	0.0393	0.0044	0.0017	0.1414
140	0.0046	0.0674	0.0240	0.0173	0.0002	0.1135
160	0.0280	0.0409	0.0064	0.0262	0.0000	0.1015
180	0.2246	0.0044	0.0295	0.0042	0.0016	0.2643
200	0.4767	0.0124	0.1041	0.0250	0.0077	0.6258
220	0.6119	0.0380	0.1811	0.0885	0.0001	0.9196
240	0.7435	0.1038	0.2440	0.1885	0.0346	1.3144
260	0.7147	0.1506	0.1783	0.1711	0.1436	**1.3583**
280	0.6114	0.1824	0.0816	0.1126	0.2261	1.2141
300	0.4488	0.1815	0.0188	0.0392	0.1981	0.8864
320	0.3374	0.1592	0.0077	0.0145	0.1304	0.6492
340	0.1595	0.1126	0.0080	0.0005	0.0227	0.3034
360	0.0816	0.0805	0.0067	0.0032	0.0026	0.1745
380	0.0285	0.0514	0.0036	0.0053	0.0025	0.0913
400	0.0026	0.0271	0.0033	0.0041	0.0115	0.0486
420	0.0055	0.0097	0.0085	0.0016	0.0158	0.0411
440	0.0373	0.0007	0.0175	0.0014	0.0101	0.0671
460	0.0971	0.0022	0.0245	0.0042	0.0019	0.1299
480	0.1827	0.0155	0.0232	0.0081	0.0005	0.2299
500	0.2919	0.0411	0.0137	0.0096	0.0059	0.3622
520	0.2720	0.0383	0.0127	0.0089	0.0055	0.3375
540	0.3926	0.0736	0.0043	0.0060	0.0113	0.4877
560	0.3674	0.0689	0.0040	0.0056	0.0105	0.4564
580	0.4935	0.1114	0.0076	0.0009	0.0111	0.6246
600	0.6297	0.1614	0.0289	0.0013	0.0061	0.8273

As indicated, the maximum calculated result is 1.3583 percent of the FCC MPE limit – well below the 100-percent reference for compliance.

A graph of the overall calculation results, provided on the next page, provides perhaps a clearer visual illustration of the relative compliance of the calculated RF levels. The line representing the overall calculation results shows an obviously clear, consistent margin to the FCC MPE limit.



Compliance Conclusion

According to the FCC, the MPE limit has been constructed in such a manner that continuous human exposure to RF fields up to and including 100 percent of the MPE limit is acceptable and safe.

The conservative analysis in this case shows that the maximum calculated RF level from the proposed antenna operations at the site is 1.3583 percent of the FCC general population MPE limit. In other words, the worst-case RF level around the site is more than 70 times below the FCC MPE limit (and, correspondingly, 350 times below the related MPE limit in the New Jersey Radiation Protection Act).

The results of the calculations provide a clear demonstration of FCC compliance. Moreover, because of the conservative calculation methodology and operational assumptions applied in the analysis, the RF levels actually caused by the antennas at the site will be even less significant than the calculations indicate.

Certification

The undersigned certifies as follows:

1. I have read and fully understand the FCC regulations concerning RF safety and the control of human exposure to RF fields (47 CFR 1.1301 et seq).
2. To the best of my knowledge, the statements and information disclosed in this report are true, complete and accurate.
3. The results of the analysis of RF compliance provided herein is consistent with the applicable FCC regulations, additional guidelines issued by the FCC, and industry practice.
4. The results of the analysis show that the maximal levels of RF energy of the antenna operations at the subject site will be in clear compliance with the FCC regulations concerning the control of potential human RF exposure.

Daniel Penesso
Chief Technical Officer
Frequenz, LLC
January 13, 2020

Appendix A. The FCC and State of New Jersey MPE Limits

FCC Regulations and the State of New Jersey MPE Limits

As directed by the Telecommunications Act of 1996, the FCC has established limits for maximum continuous human exposure to RF fields.

The FCC maximum permissible exposure (MPE) limits represent the consensus of federal agencies and independent experts responsible for RF safety matters. Those agencies include the National Council on Radiation Protection and Measurements (NCRP), the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), the American National Standards Institute (ANSI), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA). In formulating its guidelines, the FCC also considered input from the public and technical community – notably the Institute of Electrical and Electronics Engineers (IEEE).

The FCC's RF exposure guidelines are incorporated in Section 1.301 et seq of its Rules and Regulations (47 CFR 1.1301-1.1310). Those guidelines specify MPE limits for both occupational and general population exposure.

The specified continuous exposure MPE limits are based on known variation of human body susceptibility in different frequency ranges, and a Specific Absorption Rate (SAR) of 4 watts per kilogram, which is universally considered to accurately represent human capacity to dissipate incident RF energy (in the form of heat). The occupational MPE guidelines incorporate a safety factor of 10 or greater with respect to RF levels known to represent a health hazard, and an additional safety factor of five is applied to the MPE limits for general population exposure. Thus, the general population MPE limit has a built-in safety factor of more than 50. The limits were constructed to appropriately protect humans of both sexes and all ages and sizes and under all conditions – and continuous exposure at levels equal to or below the applicable MPE limits is considered to result in no adverse health effects or even health risk.

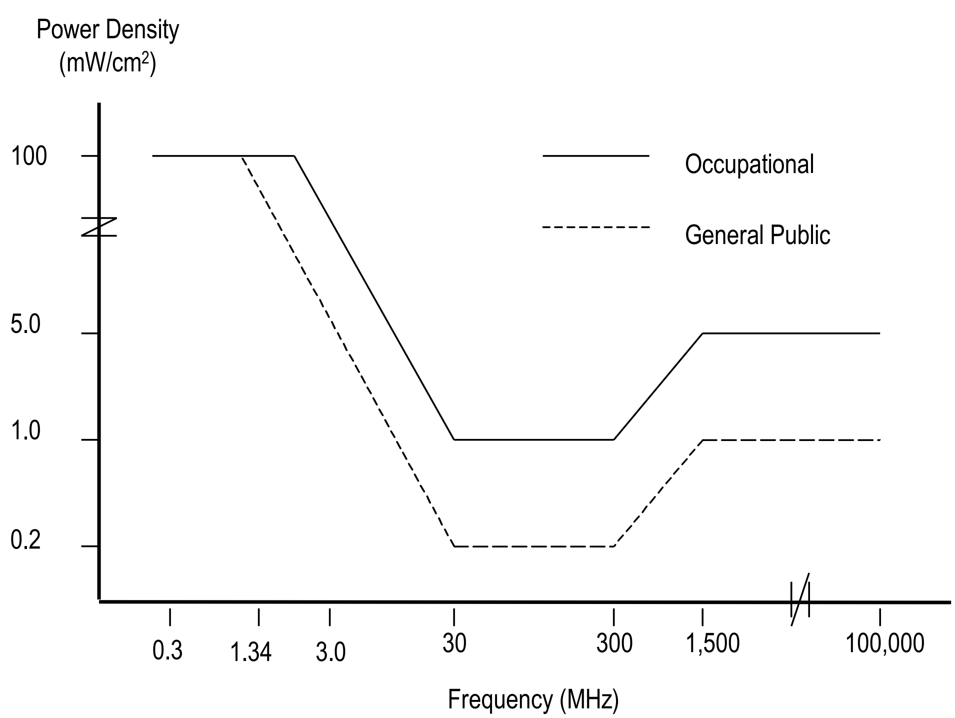
The reason for two tiers of MPE limits is based on an understanding and assumption that members of the general public are unlikely to have had appropriate RF safety training and may not be aware of the exposures they receive; occupational exposure in controlled environments, on the other hand, is assumed to involve individuals who have had such training, are aware of the exposures, and know how to maintain a safe personal work environment.

The FCC's RF exposure limits are expressed in two equivalent forms, using alternative units of field strength (expressed in volts per meter, or V/m), and power density (expressed in milliwatts per square centimeter, or mW/cm^2).

The table below lists the FCC limits for both occupational and general population exposures, using the mW/cm^2 reference, for the different radio frequency ranges.

Frequency Range (F) (MHz)	Occupational Exposure (mW/cm^2)	General Public Exposure (mW/cm^2)
0.3 - 1.34	100	100
1.34 - 3.0	100	180 / F^2
3.0 - 30	900 / F^2	180 / F^2
30 - 300	1.0	0.2
300 - 1,500	F / 300	F / 1500
1,500 - 100,000	5.0	1.0

The diagram below provides a graphical illustration of both the FCC's occupational and general population MPE limits.



Because the FCC's RF exposure limits are frequency-shaped, the exact MPE limits applicable to the instant situation depend on the frequency range used by the systems of interest.

The most appropriate method of determining RF compliance is to calculate the RF power density attributable to a particular system and compare that to the MPE limit applicable to the operating frequency in question. The result is usually expressed as a percentage of the MPE limit.

For potential exposure from multiple systems, the respective percentages of the MPE limits are added, and the total percentage compared to 100 (percent of the limit). If the result is less than 100, the total exposure is in compliance; if it is more than 100, exposure mitigation measures are necessary to achieve compliance.

State of New Jersey – The "Radiation Protection Act"

The State of New Jersey's radiation Protection Act (N.J.S.A 26:2D et seq) includes virtually identical language to the FCC's regulations regarding potential human exposure to RF fields.

There is, however, one critical difference between the respective MPE limits describe in each source. While the FCC describes two tiers of MPE limits – one for "uncontrolled" exposure of the general population, and one five times less strict for "controlled" occupational exposure – the New Jersey Radiation Protection Act only describes one limit, applicable to all circumstances, and that limit is identical to the FCC's "controlled" occupational exposure.

Therefore, since the limit chosen in New Jersey matches the FCC's occupational limit but applies to exposure of the general public as well, the New Jersey limit is less protective of the general public by a factor of five, relative to the FCC's limit for the general public.

Appendix B. FCC References on Radio Frequency Compliance

47 CFR, FCC Rules and Regulations, Part 1 (Practice and Procedure), Section 1.1310 (Radiofrequency radiation exposure limits).

FCC Second Memorandum Opinion and Order and Notice of Proposed Rulemaking (FCC 97-303), In the Matter of Procedures for Reviewing Requests for Relief From State and Local Regulations Pursuant to Section 332(c)(7)(B)(v) of the Communications Act of 1934 (WT Docket 97-192), Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation (ET Docket 93-62), and Petition for Rulemaking of the Cellular Telecommunications Industry Association Concerning Amendment of the Commission's Rules to

Preempt State and Local Regulation of Commercial Mobile Radio Service Transmitting Facilities, released August 25, 1997.

FCC First Memorandum Opinion and Order, ET Docket 93-62, In the Matter of Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation, released December 24, 1996.

FCC Report and Order, ET Docket 93-62, In the Matter of Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation, released August 1, 1996.

FCC Office of Engineering and Technology (OET) Bulletin 65, “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields”, Edition 97-01, August 1997.

FCC Office of Engineering and Technology (OET) Bulletin 56, “Questions and Answers About Biological Effects and Potential Hazards of RF Radiation”, edition 4, August 1999.

[B1] Croft, R., Mckenzie, R., and Leung, S., “EME in Homes Survey: Final Report,” *Australian Centre for Radio-Frequency Bioeffects Research, July 2009*.

Appendix C. Radiofrequency (RF) in the Home

A Comparison of Exposures from Consumer Products with Those from a Nearby Mobile Telephone Base Station

Numerous measurements of typical radiofrequency (RF) exposure levels in the home have been carried out by various researchers and agencies throughout the world. For example, Croft, et al., carried out detailed measurements of typical exposures associated with consumer electronics in 20 homes in Australia [B1]. Included were microwave ovens, WiFi routers, cordless telephones, wireless computer keyboards, etc. Their results are summarized in the figures below. As seen in figure 3 below, most exposures are below 10% of the safety limits, with the microwave oven being the major contributor. The predicted maximal exposure values for all sectors of the proposed AT&T installation are less than 1.5% of the FCC safety guidelines at 6.5 ft. above grade, respectively. These values would occur *outside* of nearby homes and buildings, - *not inside*. Because of the attenuation of building materials and the directionality of the antenna patterns, the corresponding levels form the AT&T installation would be far lower inside any structure.

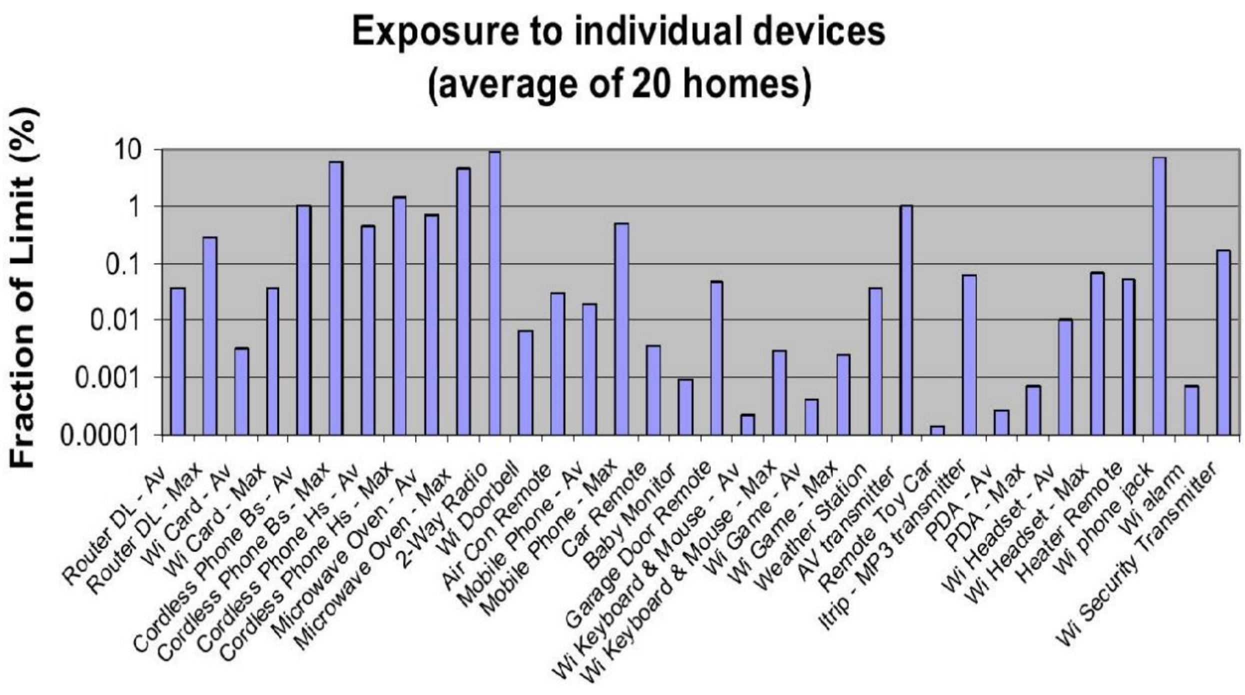


Figure 3. Exposure to individual devices – average of 20 homes (from Croft, et al., [B1]

Appendix D. Summary of Expert Qualifications

Daniel Penesso, Chief Technical Officer, Frequenz, LLC

Synopsis:	• 23 years of experience in all aspects of wireless RF engineering, including network design and implementation, interference analysis, FCC and FAA regulatory matters, and antenna site compliance with FCC RF exposure regulations • Have performed RF engineering and FCC compliance work for all the major wireless carriers – AT&T, Verizon Wireless, Sprint, T-Mobile, and MetroPCS, as well as Crown Castle • Have served as an expert witness on RF engineering and/or FCC RF compliance more than 100 times before municipal boards in New Jersey and New York
Education:	• Bachelor of Science in Electrical Engineering, DeVry Institute of Technology, Chicago, IL, 1987
Current Responsibilities	• Manages Frequenz's staff work involving FCC RF compliance for wireless antenna sites, including the provision of math- and measurements-based site compliance reports, related expert testimony in municipal hearings, and compliance-related support in client meetings with prospective site landlords and in town meetings • Provides math-based FCC compliance assessments and reports for Frequenz's wireless clients, including AT&T, Verizon Wireless, T-Mobile, Sprint, MetroPCS, and Crown Castle • Responsible for providing client consulting and in-house training on FCC and OSHA RF safety compliance
Prior Experience:	• Have served as senior RF engineer for four of the five national wireless carriers – AT&T, T-Mobile, Sprint, and MetroPCS – in the New York and New Jersey markets • Served as an RF engineer for Metricom, Triton PCS, Alltel Communications, and Western Wireless • Have worked as an RF engineer for several engineering services companies, including Sublime Wireless, Amirit Technologies, Celcite, and Wireless Facilities Incorporated