C Squared Systems, LLC
65 Dartmouth Drive
Auburn, NH 03032
(603) 644-2800
support@csquaredsystems.com

Calculated Radio Frequency Emissions Report

Cotuit Relo MA

414 Main Street, Cotuit, MA 02635

July 14, 2017

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1. Introduction

The purpose of this report is to investigate compliance with applicable FCC regulations for the proposed installation of T-Mobile, Sprint and AT&T antenna arrays on the monopole tower to be located at 414 Main Street in Cotuit, MA. The coordinates of the tower will be 41° 37' 47.93" N, 70° 26' 30.72" W.

T-Mobile is proposing the following:

1) Install three antennas for their 731 MHz LTE network (one per sector);
2) Install three antennas for their 1900 MHz GSM/UMTS networks (one per sector);
3) Install three antennas for their 2100 MHz LTE network (one per sector).

Sprint is proposing the following:

1) Install three dualband antennas for their 865/1900 MHz CDMA/ LTE networks (one per sector);
2) Install three antennas for their 2500 MHz LTE network (one per sector).

AT&T is proposing the following:

1) Install three dualband antennas for their 739/1900 MHz LTE networks (one per sector);
2) Install three antennas for their 2100 MHz LTE network (one per sector);
3) Install three antennas for their 2300 MHz LTE network (one per sector).

This report uses the planned antenna configurations for each carrier to derive the resulting cumulative % MPE, once the proposed configurations have been installed.

2. FCC Guidelines for Evaluating RF Radiation Exposure Limits

In 1985, the FCC established rules to regulate radio frequency (RF) exposure from FCC licensed antenna facilities. In 1996, the FCC updated these rules, which were further amended in August 1997 by OET Bulletin 65 Edition 97-01. These new rules include Maximum Permissible Exposure (MPE) limits for transmitters operating between 300 kHz and 100 GHz. The FCC MPE limits are based upon those recommended by the National Council on Radiation Protection and Measurements (NCRP), developed by the Institute of Electrical and Electronics Engineers, Inc., (IEEE) and adopted by the American National Standards Institute (ANSI).

The FCC general population/uncontrolled limits set the maximum exposure to which most people may be subjected. General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

Public exposure to radio frequencies is regulated and enforced in units of milliwatts per square centimeter (mW/cm^2). The general population exposure limits for the various frequency ranges are defined in the attached "FCC Limits for Maximum Permissible Exposure (MPE)" in Attachment B of this report.

Higher exposure limits are permitted under the occupational/controlled exposure category, but only for persons who are exposed as a consequence of their employment and who have been made fully aware of the potential for exposure, and they must be able to exercise control over their exposure. General population/uncontrolled limits are five times more stringent than the levels that are acceptable for occupational, or radio frequency trained individuals. Attachment B contains excerpts from OET Bulletin 65 and defines the Maximum Exposure Limit.

Finally, it should be noted that the MPE limits adopted by the FCC for both general population/uncontrolled exposure and for occupational/controlled exposure incorporate a substantial margin of safety and have been established to be well below levels generally accepted as having the potential to cause adverse health effects.

3. RF Exposure Prediction Methods

The emission field calculation results displayed in the following figures were generated using the following formula as outlined in FCC bulletin OET 65:

$$\text{Power Density} = \left(\frac{EIRP}{\pi \times R^2} \right) \times \text{Off Beam Loss}$$

Where:

EIRP = Effective Isotropic Radiated Power

R = Radial Distance = $\sqrt{\left(H^2 + V^2\right)}$

H = Horizontal Distance from antenna in meters

V = Vertical Distance from radiation center of antenna in meters

Off Beam Loss is determined by the selected antenna patterns

Ground reflection factor of 2.0

These calculations assume that the antennas are operating at 100 percent capacity, that all antenna channels are transmitting simultaneously, and that the radio transmitters are operating at full power. Obstructions (trees, buildings, etc.) that would normally attenuate the signal are not taken into account. The calculations assume even terrain in the area of study and do not take into account actual terrain elevations which could attenuate the signal. As a result, the predicted signal levels reported below are much higher than the actual signal levels will be from the final site configuration.

The percent of MPE values presented in this report reflect levels that one may encounter from one sector of each carrier's antennas. Most carriers use 3 sectors per site with azimuths approximately 120 degrees apart, therefore one could not be standing in the main beam of all 3 sectors at the same time. Although carriers are free to orient their antennas in whichever direction necessary to support their network coverage objectives, this report assumes that all carriers are using the same azimuth for each sector. In cases where downtilt and antenna models are not uniform across all 3 sectors, the downtilt and antenna model with the highest gain was used for the calculations. This results in a conservative or "worst case" assumption for percent of MPE calculations.

4. Antenna Inventory

Table 1 below outlines each operator's proposed antenna configuration for this site. The associated data sheets and antenna patterns for these specific antenna models are included in Attachments C, D & E.

Operator	Sector/ Azimuth	TX Freq (MHz)	Power at Antenna (Watts)	Ant Gain (dBi)	Power EIRP (Watts)	Antenna Model	Beam Width	Mech. Tilt	Length (ft)	Antenna Centerline Height (ft)
T-Mobile	Alpha/ 0	1900	45	17.5	2531	AIR 21 B2A B4P_2	65	0	4.7	167
		731	60	16.7	2806	LNX-6515DS-A1M_0	65	0	8.1	167
		2100	120	17.5	6748	AIR 21 B2A B4P_2	65	0	4.7	167
	Beta/ 120	1900	45	17.5	2531	AIR 21 B2A B4P_2	65	0	4.7	167
		731	60	16.7	2806	LNX-6515DS-A1M_0	65	0	8.1	167
		2100	120	17.5	6748	AIR 21 B2A B4P_2	65	0	4.7	167
	Gamma/ 240	1900	45	17.5	2531	AIR 21 B2A B4P_2	65	0	4.7	167
		731	60	16.7	2806	LNX-6515DS-A1M_0	65	0	8.1	167
		2100	120	17.5	6748	AIR 21 B2A B4P_2	65	0	4.7	167
Sprint	Alpha/ 80	865	56	15.5	1987	APXVSPP18-C_0_0	65	0	6.0	156
		1900	160	18.0	10095		65			
		2500	80	18.0	5048	APXVTM14-C_0	65	0	4.7	156
	Beta/ 180	865	56	15.5	1987	APXVSPP18-C_0_0	65	0	6.0	156
		1900	160	18.0	10095		65			
		2500	80	18.0	5048	APXVTM14-C_0	65	0	4.7	156
	Gamma/ 320	865	56	15.5	1987	APXVSPP18-C_0_0	65	0	6.0	156
		1900	160	18.0	10095		65			
		2500	80	18.0	5048	APXVTM14-C_0	65	0	4.7	156
AT&T	Alpha/ 20	2100	160	17.4	8793	HPA-65R-BUU-H8_2	64	0	7.7	147
		2300	80	17.7	4711	HPA-65R-BUU-H8_2	60	0	7.7	147
		739	80	15.3	2711	HPA-65R-BUU-H8_2_2	65	0	7.7	147
		1900	160	17.1	8206		62			
	Beta/ 150	2100	160	17.4	8793	HPA-65R-BUU-H8_2	64	0	7.7	147
		2300	80	17.7	4711	HPA-65R-BUU-H8_2	60	0	7.7	147
		739	80	15.3	2711	HPA-65R-BUU-H8_2_2	65	0	7.7	147
		1900	160	17.1	8206		62			
	Gamma/ 270	2100	160	17.4	8793	HPA-65R-BUU-H8_2	64	0	7.7	147
		2300	80	17.7	4711	HPA-65R-BUU-H8_2	60	0	7.7	147
		739	80	15.3	2711	HPA-65R-BUU-H8_2_2	65	0	7.7	147
		1900	160	17.1	8206		62			

Table 1: Proposed Antenna Inventory[1] [2]

[1] Antenna heights are in reference to the Chappell Engineering Associates, LLC, Zoning Drawings, dated July 6, 2017.

[2] Transmit power assumes 0 dB of cable loss.

5. Calculation Results

The calculated power density results are shown in Figure 1 below (one composite line is shown for each operator for clarity). For completeness, the calculations for this analysis range from 0 feet horizontal distance (directly below the antennas) to a value of 3,000 feet horizontal distance from the site. In addition to the other worst case scenario considerations that were previously mentioned, the power density calculations to each horizontal distance point away from the antennas was completed using a local maximum off beam antenna gain (within ± 5 degrees of the true mathematical angle) to incorporate a realistic worst-case scenario.

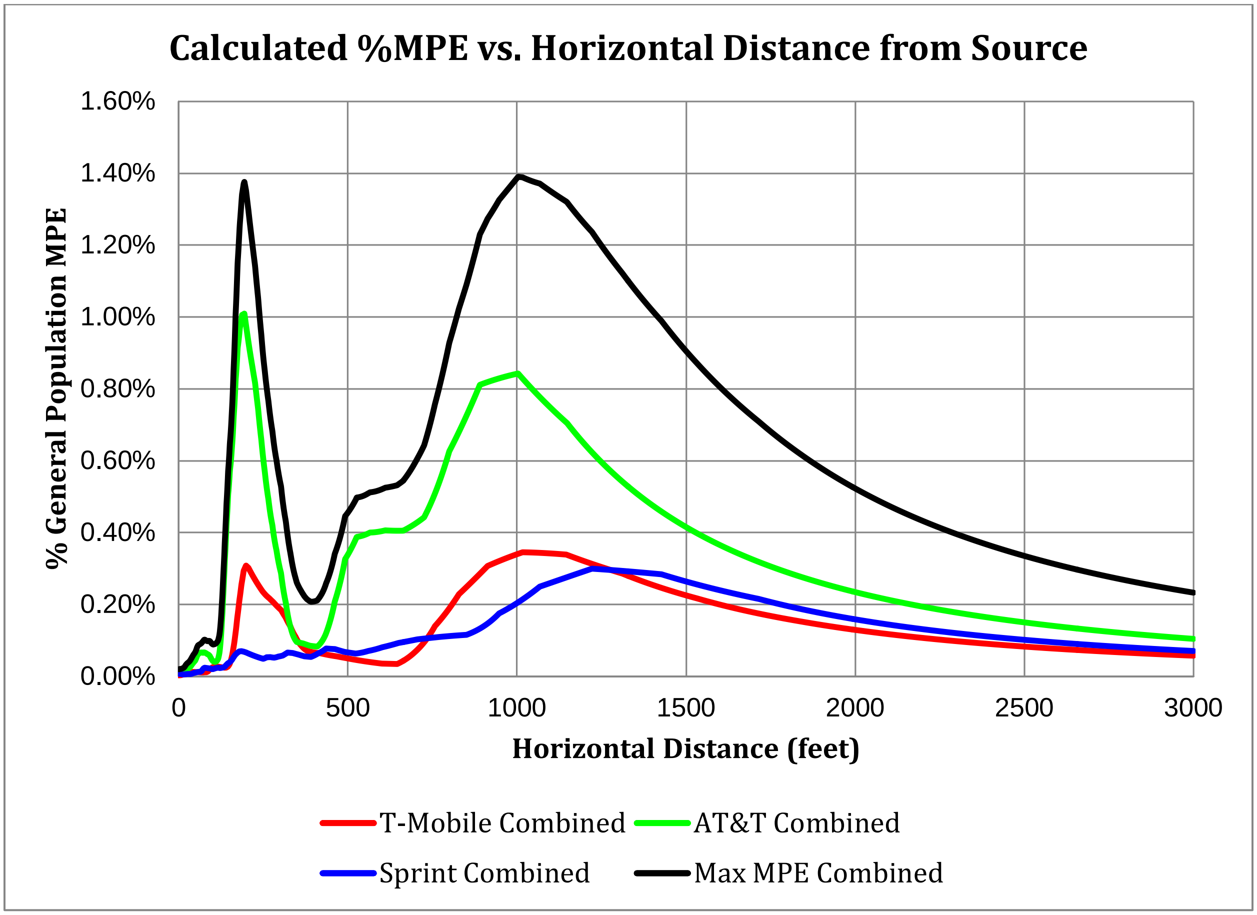


Figure 1: Graph of Percent of General Population MPE vs. Distance

The highest cumulative percent of MPE (1.39% of the General Population limit) was calculated to occur at a horizontal distance of 1,004 feet from the site. Please note that the percent of MPE calculations close to the site take into account off beam loss, which is determined from the vertical pattern of the antenna used. Therefore, RF power density levels may increase as the distance from the site increases. At distances of approximately 1,500 feet and beyond, one would now be in the main beam of the antenna patterns and off beam loss is no longer considered. Beyond this point, RF levels become calculated solely on distance from the site and the percent of MPE decreases significantly as distance from the site increases.

Table 2 below lists percent of MPE values as well as the associated parameters that were included in the calculations. The highest percent of MPE value was calculated to occur at a horizontal distance of 1,004 feet from the site (reference Figure 1).

As stated in Section 3, all calculations assume that the antennas are operating at 100 percent capacity, that all antenna channels are transmitting simultaneously, and that the radio transmitters are operating at full power. Obstructions (trees, buildings etc.) that would normally attenuate the signal are not taken into account. In addition, 6 feet was subtracted from the height of the antennas for this analysis to account for average human height. As a result, the predicted signal levels are significantly higher than the actual signal levels will be from the final configuration.

Carrier	Number of Trans.	Power out of Base Station Per Transmitter (Watts)	Antenna Height (Feet)	Distance to the Base of Antennas (Feet)	Power Density (mW/cm^2)	Limit (mW/cm^2)	%MPE	Composite %MPE
AT&T LTE 1900MHz	4	40.0	147.0	1004	0.002542	1.000	0.25%	0.84%
AT&T LTE 2100MHz	4	40.0	147.0	1004	0.002675	1.000	0.27%	
AT&T LTE 2300MHz	4	20.0	147.0	1004	0.001391	1.000	0.14%	
AT&T LTE 739MHz	2	40.0	147.0	1004	0.000893	0.493	0.18%	
Sprint CDMA 1900MHz	5	16.0	157.0	1004	0.000392	1.000	0.04%	0.21%
Sprint CDMA 865MHz	1	16.0	157.0	1004	0.000143	0.577	0.02%	
Sprint LTE 1900MHz	2	40.0	157.0	1004	0.000392	1.000	0.04%	
Sprint LTE 2500MHz	4	20.0	157.0	1004	0.000412	1.000	0.04%	
Sprint LTE 865MHz	2	20.0	157.0	1004	0.000359	0.577	0.06%	
T-Mobile GSM 1900MHz	1	15.0	167.0	1004	0.000212	1.000	0.02%	0.34%
T-Mobile LTE 2100MHz	2	60.0	167.0	1004	0.001610	1.000	0.16%	
T-Mobile LTE 731MHz	2	30.0	167.0	1004	0.000569	0.487	0.12%	
T-Mobile UMTS 1900MHz	1	30.0	167.0	1004	0.000425	1.000	0.04%	
						Total	**1.39%**	

Table 2: Maximum Percent of General Population Exposure Values[3] [4] [5]

[3] Transmit power assumes 0 dB of cable loss.

[4] Frequencies listed in Table 2 are representative of the operating band of each carrier and are not the carriers' specific operating frequencies.

[5] The total %MPE listed is a summation of each unrounded contribution. Therefore, summing each rounded value may not reflect the total value listed in the table.

6. Conclusion

The above analysis verifies that cumulative RF exposure levels from the proposed antenna configurations will be well below the maximum levels as outlined by the FCC in the OET Bulletin 65 Ed. 97-01. Using the conservative calculation methods and parameters detailed above, the maximum percent of MPE calculated at 6 feet above ground level is **1.39% of the FCC General Population limit**. This maximum percent of MPE value is calculated to occur 1,004 feet away from the base of the tower.

7. Statement of Certification

I certify to the best of my knowledge that the statements in this report are true and accurate. The calculations follow guidelines set forth in ANSI/IEEE Std. C95.3, ANSI/IEEE Std. C95.1 and FCC OET Bulletin 65 Edition 97-01.

July 14, 2017

Daniel L. Goulet
C Squared Systems, LLC

Date

Attachment A: References

OET Bulletin 65 - Edition 97-01 - August 1997 Federal Communications Commission Office of Engineering & Technology

IEEE C95.1-2005, IEEE Standard Safety Levels With Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz IEEE-SA Standards Board

IEEE C95.3-2002 (R2008), IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Exposure to Such Fields, 100 kHz-300 GHz IEEE-SA Standards Board

Attachment B: FCC Limits for Maximum Permissible Exposure (MPE)

(A) Limits for Occupational/Controlled Exposure[6]

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (E) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	$(900/f^2)$*	6
30-300	61.4	0.163	1.0	6
300-1500	-	-	f/300	6
1500-100,000	-	-	5	6

(B) Limits for General Population/Uncontrolled Exposure[7]

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (E) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	$(180/f^2)$*	30
30-300	27.5	0.073	0.2	30
300-1500	-	-	f/1500	30
1500-100,000	-	-	1.0	30

f = frequency in MHz * Plane-wave equivalent power density

Table 3: FCC Limits for Maximum Permissible Exposure

[6] Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

[7] General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

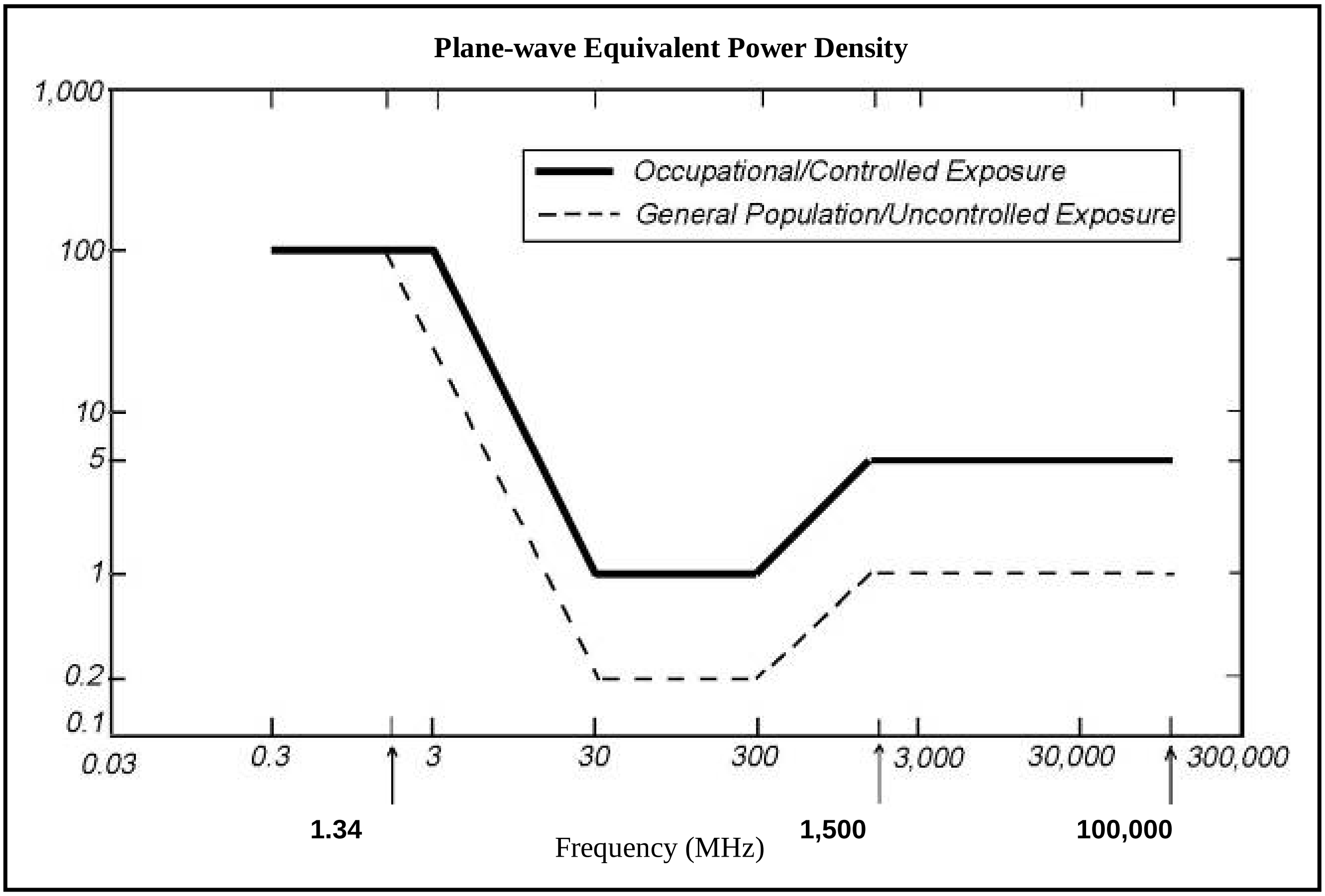
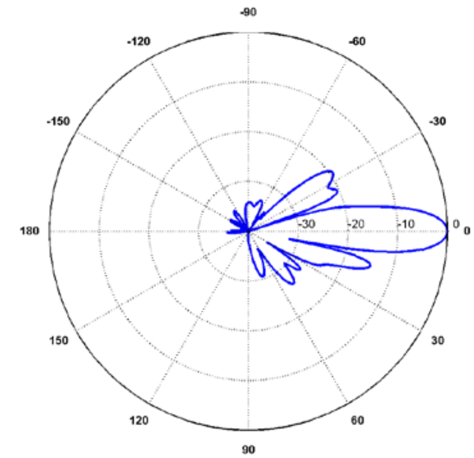


Figure 2: Graph of FCC Limits for Maximum Permissible Exposure

Attachment C: T-Mobile's Antenna Model Data Sheets and Electrical Patterns

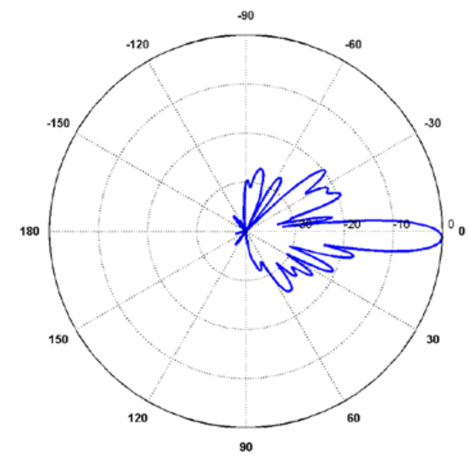
731 MHz LTE

Manufacturer:	Commscope
Model #:	LNX-6515DS-A1M_0
Frequency Band:	698-806 MHz
Gain:	16.7 dBi
Vertical Beamwidth:	9.7°
Horizontal Beamwidth:	65°
Polarization:	± 45°
Size L x W x D:	96.6" x 11.9" x 7.1"



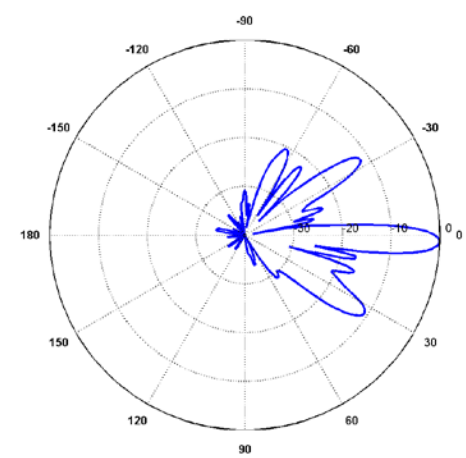
1900 MHz GSM/UMTS

Manufacturer:	Ericsson
Model #:	AIR 21 B2A B4P_2
Frequency Band:	1850-1990 MHz
Gain:	17.5 dBi
Vertical Beamwidth:	7°
Horizontal Beamwidth:	65°
Polarization:	± 45°
Size L x W x D:	56.0" x 12.1" x 7.9"



2100 MHz LTE

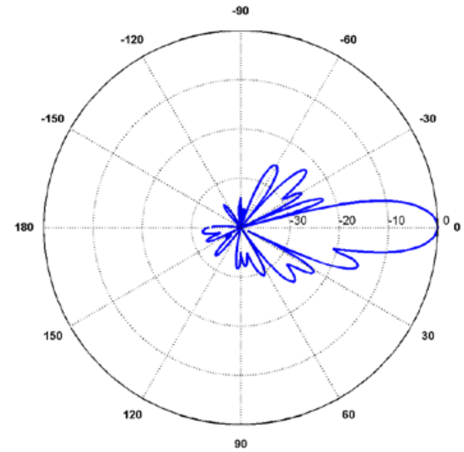
Manufacturer:	Ericsson
Model #:	AIR 21 B4A B2P_2
Frequency Band:	1710-2155 MHz
Gain:	17.5 dBi
Vertical Beamwidth:	7°
Horizontal Beamwidth:	65°
Polarization:	± 45°
Size L x W x D:	56.0" x 12.1" x 7.9"



Attachment D: Sprint's Antenna Model Data Sheets and Electrical Patterns

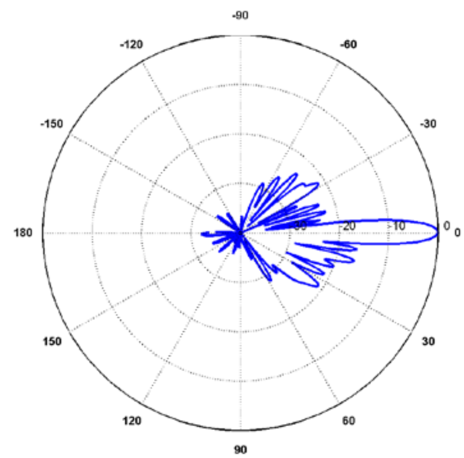
865 MHz CDMA/LTE

Manufacturer:	RFS
Model #:	APXVSPP18-C_0
Frequency Band:	806-869 MHz
Gain:	15.5 dBi
Vertical Beamwidth:	11.5°
Horizontal Beamwidth:	65°
Polarization:	Dual Pol ± 45°
Size L x W x D:	72.0" x 11.8" x 7.0"



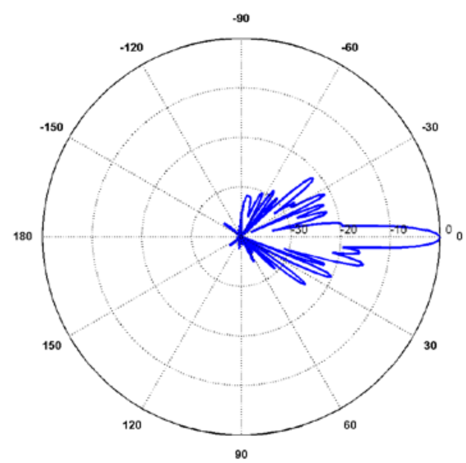
1900 MHz CDMA/LTE

Manufacturer:	RFS
Model #:	APXVSPP18-C_0
Frequency Band:	1850-1995 MHz
Gain:	18.0 dBi
Vertical Beamwidth:	5.5°
Horizontal Beamwidth:	65°
Polarization:	Dual Pol ± 45°
Size L x W x D:	72.0" x 11.8" x 7.0"



2500 MHz LTE

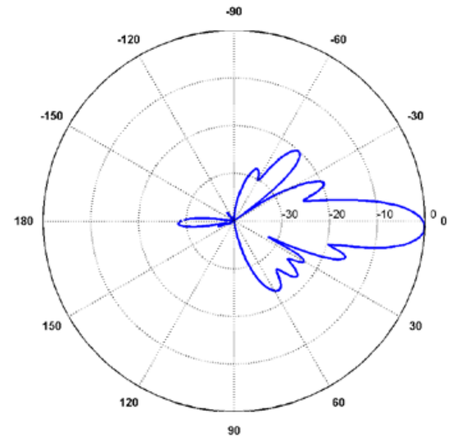
Manufacturer:	RFS
Model #:	APXVTM14-C_0
Frequency Band:	2490-2600 MHz
Gain:	18.0 dBi
Vertical Beamwidth:	5°
Horizontal Beamwidth:	65°
Polarization:	Dual Pol ± 45°
Size L x W x D:	56.3" x 12.6" x 6.3"



Attachment E: AT&T's Antenna Model Data Sheets and Electrical Patterns

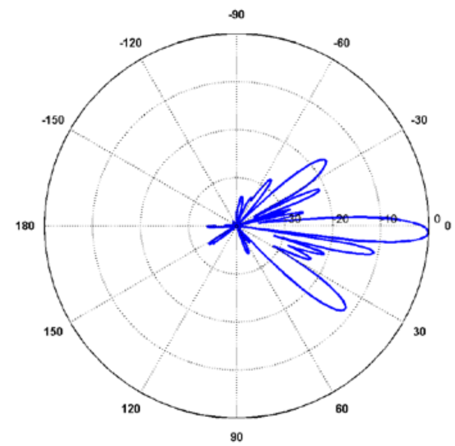
739 MHz LTE

Manufacturer:	CCI
Model #:	HPA-65R-BUU-H8_2
Frequency Band:	698-806 MHz
Gain:	15.3 dBi
Vertical Beamwidth:	10.1°
Horizontal Beamwidth:	65°
Polarization:	Dual Pol ± 45°
Size L x W x D:	92.4" x 14.8" x 7.4"



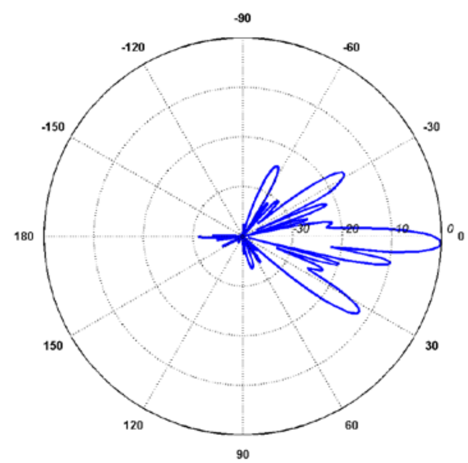
1900 MHz LTE

Manufacturer:	CCI
Model #:	HPA-65R-BUU-H8_2
Frequency Band:	1850-1990 MHz
Gain:	17.1 dBi
Vertical Beamwidth:	5.6°
Horizontal Beamwidth:	62°
Polarization:	Dual Pol ± 45°
Size L x W x D:	92.4" x 14.8" x 7.4"



2100 MHz LTE

Manufacturer:	CCI
Model #:	HPA-65R-BUU-H8_2
Frequency Band:	2110-2170 MHz
Gain:	17.4 dBi
Vertical Beamwidth:	5°
Horizontal Beamwidth:	64°
Polarization:	Dual Pol ± 45°
Size L x W x D:	92.4" x 14.8" x 7.4"



2300 MHz LTE	
Manufacturer:	CCI
Model #:	HPA-65R-BUU-H8_2
Frequency Band:	2305-2360 MHz
Gain:	17.7 dBi
Vertical Beamwidth:	4.5°
Horizontal Beamwidth:	60°
Polarization:	Dual Pol ± 45°
Size L x W x D:	92.4” x 14.8” x 7.4”