An Investigation of the 800MHz Band Interference between the Public Safety and CMRS Radio Systems

Presented to

CTIA

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I. Acknowledgements

WFI has worked closely with a number of CTIA members, namely Nextel Communication (Nextel), Motorola, AT&T Wireless Services (AT&T Wireless), Verizon Wireless (Verizon), Cingular Wireless (Cingular) who have helped us tremendously not only to understand the nature of issues, but also shared their best practices to respond accordingly. We have also received valuable reference documentation from Motorola and Nextel, as well as specific market case studies. We do appreciate their efforts to facilitate a progress of this report.

II. Executive Summary

Wireless Facilities, Inc (www.wfinet.com) has been tasked with providing a report to the CTIA making recommendations on the means to mitigate the 800 MHz interference experienced between Public Safety Radio Systems and the Commercial Mobile Radio Service (CMRS) systems operated by CTIA's carrier members, namely Nextel, Cingular, AT&T Wireless, Verizon. WFI has communicated with the members to discuss the cases, which they have worked and/or are working on.

As in all wireless consulting projects, we emphasize the importance of combining market, technical, and business considerations to create a cohesive snapshot of the issue at hand. Given the short timeframe involved in our due diligence as well as the limited availability of data, it has not been possible to perform certain areas of analysis in a complete manner. These limitations are highlighted in this report, as well as some suggested follow-up measures.

There are also a number of supplementary documents captured in the attachments to this report. The first is Technical Solutions Comparison. This table represents a comparative analysis of effectiveness and specific attributes of possible technical solutions to the interference issues. The second is Market Analysis Commentary, developed to illustrate the magnitude of impact of interference conditions in different representative BTAs. The third is Business Analysis Introduction, presented to instigate follow-up discussions important to fully understand financial modeling required to devise a reasonable mitigation strategy.

III. Introduction to the Interference Issues

The interference issues between CMRS providers and Public Safety (PS) Operators have been recorded for a number of years. Some of the earlier cases were documented in 1998. In April 2000, FCC has responded with arranging a development of " A best practices Guide" to discuss this problem and define some mitigation strategies.

It is clear that most recent proliferation of networks by CMRS providers, using digital technology coupled with aggressive frequency reuse strategies have effectively brought renewed urgency to addressing this challenge. At the same time, one should not overlook a potential of PS systems out-of-band emissions interfering with CMRS systems.

It is important to note that all the parties involved do follow the rules and regulations of their respective license agreements. The fundamental root cause of this problem is a difficulty of managing a coexistence for two very diverse network architectures (noise limited in case of PS and interference limited for CMRS) operating in closely spaced radio band allocations.

While discussing this issue, it is important to understand the distinctive characteristics of system architecture of networks involved. Typical attributes of PS system would be high elevation base stations transmitter installations with little if any frequency reuse practices to provide a greater area coverage with minimal capital investment. It is common to use multiple simulcast towers to achieve required degree of reliability. As a result there are conditions in place, under which one could experience a wide dynamic range of signal strength levels throughout the coverage footprint with distinctive extremes between placements close to the transmitter and on the edge of coverage. Under originally envisioned objectives (1974), these arrangements were reasonable as long as the information signal was sufficiently strong to overcome the thermal noise present in the area (noise limited conditions).

Due in large to the explosive growth of wireless communication services, CMRS systems are designed to operate in a different manner. They do deploy a large number of transceivers or base stations in a " cellular"-like pattern to effectively reuse the same frequency channels multiple number of times throughout network. As a result, system performance is limited by the interference from other base stations within a network deploying the same frequency (interference-limited system).

Taken into consideration points mentioned, condition clearly exist for two systems that happened to be geographically (PS subscriber unit in an immediate vicinity of high-powered CMRS base station) or spatially (adjacent or close channels deplored) to interfere with each other, with PS system being a more "troubled" party.

IV. Technical Assessment

Based on our experience in field deployments as well as information received from parties involved, we believe there are several contributors to the issue in order of impact.

First, it is Intermodulation (IM) Interference, which is a form of interference that results from the "mixing" of several carrier frequencies. The frequencies mix to form new frequencies that might affect other receivers in close proximity. This phenomenon could be seen in both transmitter and receiver. It is especially harmful for a PS receiver unit that could be overwhelmed with total power coming throughout its band.

Second, there is a Wide Band (WB) Noise, a type of interference that introduces additional undesired energy from a transceiver to the noise from other sources to unintended receiver to the point where the latter is not able to perform properly. Digital transmitters have a higher WB noise emissions in comparison to analog systems.

Third, we should look at Spurious Response Interference, an interference to a desired signal due to an interfering transmitter signal being processed at the receiver, because of some equipment failure to discriminate between different sources and as a result developing a degradation in performance.

Last, we are aware of so-called Front End Overload Interference (not a significant contributor, especially with modern solid state electronics that mitigate this issue effectively) – Interference to a desired signal due to other transmitter/transmitters overloading the Front end of a Receiver.

There are several differentiation points that separate the degree of exposure some of CMRS operators might have to these problems. They are driven in large by the band of operation, radio channelization and access protocol deployed. For example, it is generally believed that CDMA as a technology performs better (interfere less) in comparison to TDMA based systems by deploying effective power control mechanisms as well as by virtue of wide band spreading. It is also important to note that even with new generation of wireless mobility systems, based on CDMA technology, there are potential areas of concern with deploying of adaptive beam-forming (“ smart antenna”) technology or supporting very high data transmissions rates.

At the same time, PS operators do not envision any revolutionary adjustments to their system architecture. Same of the more recent developments were focused on adding additional simulcast towers or adjusting radio configuration of existent legacy infrastructure.

There are a number of solutions that might be applied to address the interference issue. It is important to understand their benefits and limitations. All of them should be thought of as tools to be deployed conjointly, based on a particular circumstances of interference reported.

One of the more effective strategies to this point has been better frequency planning by CMRS as well as PS operators. It is possible to address the issue of interference by adjusting both cellular and enhanced SMR operators channel deployment schedules. It is customary to strive for 1.5 MHz or more of separation to substantially resolve the problem. It is worth to notice that this strategy is costly from Operational Expenditure (OpEx) prospective, while also limiting deployment options of CMRS carriers to use advanced automatic frequency planning and other features to support capacity demands of their networks.

Another idea is based on Verification/Modification of CMRS Radio Equipment characteristics. There is potentially a wide array of options that could be explored by CMRS carriers such as adjustments to transmit power levels, antenna characteristics (gain, orientation, beam width, etc.). In our opinion, these options while useful in case-by-case circumstances, result in limitations on the spectrum usage performance by affected carriers and possibly limiting their service level agreements guarantees.

One other option that has been explored successfully at times is collocation or strategic location of PS and CMRS base stations. This strategy is commonly used to ensure a gap in power level between desired and interfering signal from an adjacent system at the subscriber unit. The solution is a subject to a number of constraints that dramatically limit its feasibility.

There are always opportunities to be explored in the area of System Design Improvements for both CMRS and PS equipment (base station/transmitters and handheld/portable receivers).

There are a number of adjustments that could be introduced to the CMRS base station transmitters to respond to some of the issues reported. There is a definite possibility of deploying additional filtering to combat wide-band noise. The solution while costly if deployed system-wide is effective to address some of the problem contributing components.

One of the first steps to respond to the interference issue from PS infrastructure prospective, was an introduction of better performing PS handsets. It is our understanding that they are reported to perform at very reasonable levels of intermodulation specifications (75 dB for on the street coverage). There is important gating item to consider while analyzing this option. Some of the latest system specification for PS handsets are calling for very wide band of operation (700/800 MHz) while adheres to the

accepted physical dimensions and functionality. As a result with a broader roll off characteristics, these units will be most definitely limited in their ability to effectively filter/combat the interference discussed in this report. We feel that the latest generation of PS handsets will add a few dB of improved performance but will fall short of mitigating the issue of intersystem interference as a whole.

In other words, while improvements to transmitter and mobile and portable radio receiver performance specifications should be introduced, the net gains from that innovation are not expected to be sufficient enough.

One of the more complete strategies is Frequency Swaps/Realignments in a band of contention. While most of previously mentioned strategies address individual contributors to the problem, frequency realignment/swaps in the affected band is the best answer to the issue as a whole. It would not only pave the way to better network engineering for carriers, but also simplify functional requirements for the systems designs of affected infrastructure components (both handsets and base station radios).

IV. Conclusions and overall recommendation

The interference issues in the 800 MHz band between Public Safety and CMRS Radio Systems are complex in nature. Any proposed long term solution has to be sound in a number of different, sometimes contradictory aspects (technical, regulatory, financial) properly adjusted to time dimension. Based on our industry experience as well as information provided by CTIA members, it is our belief the most effective way to tackle this problem is a combination of efforts in all the areas mentioned.

WFI feel strongly that frequency rebanding with new contiguous allocations and adequate (2MHz appears to be reasonable) guard band is a required system solution to the issue. At the same time, it is important to focus on a number of crucial initiatives CTIA members could pursue. Our opinion has been developed with focus on long term horizon, associated costs and ease of implementation. In our view, some of the key solutions in order of magnitude are:

1. We recommend CTIA advocate a need for improvements in PS Equipment Designs, such as better IM rejections characteristics (faster roll-off performance) by PS handhelds.

2. WFI believes it is important to strive for better system coverage characteristics of PS networks by deploying additional multicast cell sites/repeaters and designing the system for in-building coverage requirements for all new installations.

3. We find it is very important for all CMRS carriers to have IM analysis as an integral part of their general engineering practices for all in band/out of band studies, collocation installation, etc.

4. It is also important, in our opinion, to increase PS users awareness of potential limitations in system performance and best practices to respond appropriately.

5. We would also suggest a thorough study of possibilities to request the FCC waivers on the conditions of incumbent license agreements held by Nextel as well as clear communication on a recent filing between Nextel and other affected parties.

Appendix A. Technical Solutions Comparison

Proposed Solutions	Interference component to be addressed	Pros	Cons	Implications	Comments
Frequency band realignment/FCC waivers	All	Effective ultimate solution, Consideration for next generation of technologies for both PS and CMRS	Dramatic costs, Careful scheduling is required, Difficult to build a consensus between parties involved	Could be very expensive (billions of dollars in the extreme case)	The fact of diverse systems deployed within close frequency spacing and significant difference in performance objectives needs to be addressed in a most direct manner. Contiguity of new allocations is another key element.
Improved Public Safety Receiver Specifications Improving of PS IMR	IM, WB, Overload	This option has been explored for same time now: trade-offs are well understood, Competition between vendors to drive performance improvements	Many performance gains are offset by required "concessions" in functionality/specifications	Refer to Motorola	Per Motorola: current IM performance is good (75dB), difficulty in improving specs and satisfying PS requirements: power, reliability, size, etc. Per Motorola 3dB improvement in IMR reduces interference by half. According to Nextel, there is a clear roll-off problem particularly at the higher end of a band (851-869 MHz)
PS architecture adjustments Larger multicast installation Deployment of repeaters Improvements in radio interface protocol	IM	Easy to implemented as required, Good cost control option, Proven in a field	Cumulative financial impact is sizable, Requires constant monitoring, and seems to be far behind the pace of CMRS deployments, Zoning Restrictions	Large relative to budgets available (hundreds of thousands for new towers, tens of thousands for repeaters)	Faced with budgetary constraints, high performance requirements, and high visibility/importance as well as having incumbent status, PS operators have shown certain degree of resistance to test additional solutions, as per CMSR carriers. PS operators have limited visibility into new generation upgrades of their current architecture.
Improvements of CMSR carriers transmitters performance Introduction of Cavity Filters	WB and TX IM	Proven technology, Availability of hardware	Cost for equipment and labor	Refer to Vendors	Deployment of cavity filtering at the CMRS base station transmitters should clearly address the issue. It is important to meet FCC requirements
Increase Frequency Spacing Careful frequency planning Deployment of guard spacing Avoidance of continuous transmissions, other then on control channels	All	Effective technique, Could be automated, Straightforward to control, Proven in field deployments	Sub-optimal band usage, Difficult to implement with new features like dynamic frequency allocation	Significant time and costs of up to thousands of dollars per site affected	1.5 MHz of frequency spacing is shown to significantly reduce interference.
Cell site configuration adjustments Antennae Reorientation/Reconfiguration Collocation of PS and CMRS transmitters	All	Easy to implement Flexibility Simplified site acquisition	Additional requirements for Operational Expenditures	Fair in terms of costs and time requirements	Collocation (or repeater use) is generally recommended to improve desired signal level in a presence of interference. General physical spacing is not practical to implement
Improvements of CMSR carriers transmitters performance Power Adjustments at the CMSR transmitter	IM, Overload	Easy to control	Network performance degradation	Inexpensive, but costly in lost revenues due to performance degradation, fair in terms of time requirements	There is 3 dB of IM reduction for every 1dB decrease in power from one of the contributors; Potential interference cut in half by lowering cell power by 3dB, per Motorola
PS transmitter adjustments Power increase	IM	Possible to introduce where required	Limitations imposed by FCC limit the range	Inexpensive to implement	As per Motorola 39% interference area reduction for 3dB of TX power increase

Appendix B. Market Analysis Commentary

In undertaking this assignment, WFI conducted an analysis of three markets. For the purpose of this study, these three markets represent a sample of the geographic and population sizes of license areas. The markets selected were the Chicago IL, Charlotte-Gastonia NC and Tuscaloosa AL BTAs. These markets were selected based on their varying geographic size, density of population and urban sprawl.

Specifically, this study is targeted at quantifying degree of potential for the interference issues by producing specific examples for these three markets. As explained in the technical section of this document, there are several factors affecting the interference between Public Safety and CMRS transmissions. The two that will be studied in the market analysis section will proximity and height.

This study will analyze the distance between all registered towers filed with the FCC and all Public Safety towers filed with the FCC. Additionally, this study will segregate the towers by height. Towers whose AGL (Above Ground Level) is low tend to have a larger impact on interference issues. Therefore, the towers have been delineated by the following categories: below 50 ft, 50 – 99 ft and 100-149 ft. WFI has also analyzed three of the individual carriers within these three markets. This was accomplished by segmenting the tower records further by analyzing those towers owned by Nextel, AT&T and Cingular.

Several caveats should be noted in reviewing these statistics. First, this does not represent all of the radios currently operating within each market by these carriers. In order to minimize capital expenditure on tower builds many carriers opt to co-locate on other towers not owned by them. As this information is proprietary in nature, WFI is not able to locate and analyze all of the radios operating in the 800 MHz band. Therefore, the statistics represented below assume that each of these carriers is only operating on the towers owned by them. Due to the quantity of towers not owned by these three carriers, as well as the strategic locations of many of these towers, it is our opinion that these statistics represent only a percentage of the interference issues currently in effect. The second note is that all of the tower location data was derived from the most recent FCC data available, effective February 5, 2002.

While assessing the statistical samplings provided, it is important to note that the interference is most severe then an intended PS subscriber is within 0.25 to 0.5 miles within low placed transmitter of offending cell. In general, with other contributors being equal, the larger the distance between transmitter and receiver, the lower the signal level is, i.e. the signal level will double if a subscriber unit distance to a base station reduced in half.

The following statistics represent the study results. These results were completed within a very short time line. A more comprehensive analysis could be completed given additional time to complete the study.

	Total Public Safety Towers	Total Registered Towers	Nextel Owned Towers	AT&T Owned Towers	Cingular Owned Towers
Charlotte-Gastonia, NC	192	735	10	31	59
Chicago, IL	336	1,490	80	287	17
Tuscaloosa, AL	91	200	1	0	13

* The total carrier owned towers shown here vary from those figures listed below. This is because the tower totals within the search radius of the following spreadsheets include multiple entries for the same tower, if that tower is within the search radius of multiple PS towers.

This study shows that most of the major operators have focused on markets considered to be tier one and two, based upon population. As is shown in Tuscaloosa, most operators are either not currently providing extensive coverage in these markets, or the have chosen to co-locate on other towers in these areas. Additionally, within the major cities, like Chicago, there are almost five times as many CRMS towers below 100 feet than there are PS towers. In the tier two market, the ratio was reduced to double the tower count. And this ratio is similar within the tier three market studied as well.

Charlotte-Gastonia, NC

Analysis of Towers with an AGL Below 50 ft

	Search Radius	Public Safety Towers	All Registered Towers	Ratio of Registered Towers to Public Safety
Market Totals	0.25	0	0	0.0
	0.50	4	4	1.0
	0.75	8	9	1.1
	1.00	15	16	1.1
	1.50	31	35	1.1
	2.00	42	54	1.3
	3.00	62	122	2.0
	Totals	*162*	*240*	1.5

	Search Radius	Public Safety Towers	Nextel Owned Towers	Percent Towers Owned by Nextel	Percent of Public Safety Towers Affected
Nextel	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	1	1	11.11%	12.50%
	1.00	1	1	6.25%	6.67%
	1.50	1	1	2.86%	3.23%
	2.00	1	1	1.85%	2.38%
	3.00	6	6	4.92%	9.68%

	Search Radius	Public Safety Towers	AT&T Owned Towers	Percent Towers Owned by AT&T	Percent of Public Safety Towers Affected
AT&T	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	0	0	0.00%	0.00%
	2.00	1	2	3.70%	2.38%
	3.00	4	5	4.10%	6.45%

	Search Radius	Public Safety Towers	Cingular Owned Towers	Percent Towers Owned by Cingular	Percent of Public Safety Towers Affected
Cingular	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	0	0	0.00%	0.00%
	2.00	1	1	1.85%	2.38%
	3.00	8	10	8.20%	12.90%

Chicago, IL

Analysis of Towers with an AGL Below 50 ft

	Search Radius	Public Safety Towers	All Registered Towers	Ratio of Registered Towers to Public Safety
Market Totals	0.25	50	70	0.0
	0.50	84	229	2.7
	0.75	123	454	3.7
	1.00	170	746	4.4
	1.50	235	1,410	6.0
	2.00	277	2,089	7.5
	3.00	316	3,615	11.4
	Totals	*1,255*	*8,613*	6.9

	Search Radius	Public Safety Towers	Nextel Owned Towers	Percent Towers Owned by Nextel	Percent of Public Safety Towers Affected
Nextel	0.25	2	2	0.00%	0.00%
	0.50	5	5	2.18%	5.95%
	0.75	15	19	4.19%	12.20%
	1.00	30	38	5.09%	17.65%
	1.50	68	91	6.45%	28.94%
	2.00	111	190	9.10%	40.07%
	3.00	168	345	9.54%	53.16%

	Search Radius	Public Safety Towers	AT&T Owned Towers	Percent Towers Owned by AT&T	Percent of Public Safety Towers Affected
AT&T	0.25	24	27	0.00%	0.00%
	0.50	46	69	30.13%	54.76%
	0.75	69	137	30.18%	56.10%
	1.00	98	203	27.21%	57.65%
	1.50	157	376	26.67%	66.81%
	2.00	208	520	24.89%	75.09%
	3.00	277	970	26.83%	87.66%

	Search Radius	Public Safety Towers	Cingular Owned Towers	Percent Towers Owned by Cingular	Percent of Public Safety Towers Affected
Cingular	0.25	0	0	0.00%	0.00%
	0.50	1	1	0.44%	1.19%
	0.75	2	2	0.44%	1.63%
	1.00	2	2	0.27%	1.18%
	1.50	10	10	0.71%	4.26%
	2.00	15	15	0.72%	5.42%
	3.00	28	28	0.77%	8.86%

Tuscaloosa, AL

Analysis of Towers with an AGL Below 50 ft

	Search Radius	Public Safety Towers	All Registered Towers	Ratio of Registered Towers to Public Safety
Market Totals	0.25	4	4	1.0
	0.50	7	7	1.0
	0.75	14	14	1.0
	1.00	20	21	1.1
	1.50	32	44	1.4
	2.00	36	73	2.0
	3.00	42	124	3.0
	Totals	*155*	*287*	1.9

	Search Radius	Public Safety Towers	Nextel Owned Towers	Percent Towers Owned by Nextel	Percent of Public Safety Towers Affected
Nextel	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	0	0	0.00%	0.00%
	2.00	0	0	0.00%	0.00%
	3.00	0	0	0.00%	0.00%

	Search Radius	Public Safety Towers	AT&T Owned Towers	Percent Towers Owned by AT&T	Percent of Public Safety Towers Affected
AT&T	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	0	0	0.00%	0.00%
	2.00	0	0	0.00%	0.00%
	3.00	0	0	0.00%	0.00%

	Search Radius	Public Safety Towers	Cingular Owned Towers	Percent Towers Owned by Cingular	Percent of Public Safety Towers Affected
Cingular	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	1	1	7.14%	7.14%
	1.00	2	2	9.52%	10.00%
	1.50	7	7	15.91%	21.88%
	2.00	18	18	24.66%	50.00%
	3.00	23	23	18.55%	54.76%

Charlotte-Gastonia, NC

Analysis of Towers with an AGL of 50 - 99 ft

	Search Radius	Public Safety Towers	All Registered Towers	Ratio of Registered Towers to Public Safety
Market Totals	0.25	32	39	1.2
	0.50	54	88	1.6
	0.75	69	138	2.0
	1.00	92	193	2.1
	1.50	132	334	2.5
	2.00	154	511	3.3
	3.00	184	930	5.1
	Totals	*717*	*2,233*	3.1

	Search Radius	Public Safety Towers	Nextel Owned Towers	Percent Towers Owned by Nextel	Percent of Public Safety Towers Affected
Nextel	0.25	3	3	7.69%	9.38%
	0.50	10	10	11.36%	18.52%
	0.75	12	12	8.70%	17.39%
	1.00	15	15	7.77%	16.30%
	1.50	17	17	5.09%	12.88%
	2.00	22	24	4.70%	14.29%
	3.00	24	30	3.23%	13.04%

	Search Radius	Public Safety Towers	AT&T Owned Towers	Percent Towers Owned by AT&T	Percent of Public Safety Towers Affected
AT&T	0.25	2	2	5.13%	6.25%
	0.50	5	5	5.68%	9.26%
	0.75	6	6	4.35%	8.70%
	1.00	6	6	3.11%	6.52%
	1.50	11	12	3.59%	8.33%
	2.00	24	30	5.87%	15.58%
	3.00	47	74	7.96%	25.54%

	Search Radius	Public Safety Towers	Cingular Owned Towers	Percent Towers Owned by Cingular	Percent of Public Safety Towers Affected
Cingular	0.25	1	1	2.56%	3.13%
	0.50	8	8	9.09%	14.81%
	0.75	10	10	7.25%	14.49%
	1.00	13	13	6.74%	14.13%
	1.50	26	26	7.78%	19.70%
	2.00	42	45	8.81%	27.27%
	3.00	74	87	9.35%	40.22%

Chicago, IL

Analysis of Towers with an AGL of 50 - 99 ft

	Search Radius	Public Safety Towers	All Registered Towers	Ratio of Registered Towers to Public Safety
Market Totals	0.25	51	55	1.1
	0.50	106	168	1.6
	0.75	143	300	2.1
	1.00	170	465	2.7
	1.50	255	831	3.3
	2.00	288	1,259	4.4
	3.00	320	2,139	6.7
	Totals	*1,333*	*5,217*	3.9

	Search Radius	Public Safety Towers	Nextel Owned Towers	Percent Towers Owned by Nextel	Percent of Public Safety Towers Affected
Nextel	0.25	2	2	3.64%	3.92%
	0.50	19	19	11.31%	17.92%
	0.75	29	30	10.00%	20.28%
	1.00	35	36	7.74%	20.59%
	1.50	55	59	7.10%	21.57%
	2.00	66	82	6.51%	22.92%
	3.00	79	135	6.31%	24.69%

	Search Radius	Public Safety Towers	AT&T Owned Towers	Percent Towers Owned by AT&T	Percent of Public Safety Towers Affected
AT&T	0.25	4	4	7.27%	7.84%
	0.50	20	21	12.50%	18.87%
	0.75	51	55	18.33%	35.66%
	1.00	71	77	16.56%	41.76%
	1.50	103	150	18.05%	40.39%
	2.00	129	219	17.39%	44.79%
	3.00	219	397	18.56%	68.44%

	Search Radius	Public Safety Towers	Cingular Owned Towers	Percent Towers Owned by Cingular	Percent of Public Safety Towers Affected
Cingular	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	1	1	0.33%	0.70%
	1.00	3	3	0.65%	1.76%
	1.50	11	11	1.32%	4.31%
	2.00	14	14	1.11%	4.86%
	3.00	34	35	1.64%	10.63%

Tuscaloosa, AL

Analysis of Towers with an AGL of 50 - 99 ft

	Search Radius	Public Safety Towers	All Registered Towers	Ratio of Registered Towers to Public Safety
Market Totals	0.25	10	10	1.0
	0.50	27	31	1.1
	0.75	36	50	1.4
	1.00	43	82	1.9
	1.50	54	141	2.6
	2.00	65	216	3.3
	3.00	75	409	5.5
	Totals	*310*	*939*	3.0

	Search Radius	Public Safety Towers	Nextel Owned Towers	Percent Towers Owned by Nextel	Percent of Public Safety Towers Affected
Nextel	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	0	0	0.00%	0.00%
	2.00	0	0	0.00%	0.00%
	3.00	0	0	0.00%	0.00%

	Search Radius	Public Safety Towers	AT&T Owned Towers	Percent Towers Owned by AT&T	Percent of Public Safety Towers Affected
AT&T	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	0	0	0.00%	0.00%
	2.00	0	0	0.00%	0.00%
	3.00	0	0	0.00%	0.00%

	Search Radius	Public Safety Towers	Cingular Owned Towers	Percent Towers Owned by Cingular	Percent of Public Safety Towers Affected
Cingular	0.25	1	1	10.00%	10.00%
	0.50	1	1	3.23%	3.70%
	0.75	1	1	2.00%	2.78%
	1.00	3	3	3.66%	6.98%
	1.50	7	7	4.96%	12.96%
	2.00	10	10	4.63%	15.38%
	3.00	15	15	3.67%	20.00%

Charlotte-Gastonia, NC

Analysis of Towers with an AGL of 100 - 149 ft

	Search Radius	Public Safety Towers	All Registered Towers	Ratio of Registered Towers to Public Safety
Market Totals	0.25	13	13	1.0
	0.50	18	19	1.1
	0.75	23	26	1.1
	1.00	36	41	1.1
	1.50	55	85	1.5
	2.00	72	143	2.0
	3.00	92	248	2.7
	Totals	*309*	*575*	1.9

	Search Radius	Public Safety Towers	Nextel Owned Towers	Percent Towers Owned by Nextel	Percent of Public Safety Towers Affected
Nextel	0.25	1	1	7.69%	7.69%
	0.50	2	2	10.53%	11.11%
	0.75	2	2	7.69%	8.70%
	1.00	4	4	9.76%	11.11%
	1.50	9	9	10.59%	16.36%
	2.00	10	10	6.99%	13.89%
	3.00	18	18	7.26%	19.57%

	Search Radius	Public Safety Towers	AT&T Owned Towers	Percent Towers Owned by AT&T	Percent of Public Safety Towers Affected
AT&T	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	0	0	0.00%	0.00%
	2.00	0	0	0.00%	0.00%
	3.00	0	0	0.00%	0.00%

	Search Radius	Public Safety Towers	Cingular Owned Towers	Percent Towers Owned by Cingular	Percent of Public Safety Towers Affected
Cingular	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	0	0	0.00%	0.00%
	2.00	0	0	0.00%	0.00%
	3.00	0	0	0.00%	0.00%

Chicago, IL

Analysis of Towers with an AGL of 100 - 149 ft

	Search Radius	Public Safety Towers	All Registered Towers	Ratio of Registered Towers to Public Safety
Market Totals	0.25	5	6	1.2
	0.50	8	10	1.3
	0.75	11	15	1.4
	1.00	18	25	1.4
	1.50	34	42	1.2
	2.00	56	69	1.2
	3.00	128	168	1.3
	Totals	*260*	*335*	1.3

	Search Radius	Public Safety Towers	Nextel Owned Towers	Percent Towers Owned by Nextel	Percent of Public Safety Towers Affected
Nextel	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	4	4	16.00%	22.22%
	1.50	4	4	9.52%	11.76%
	2.00	4	4	5.80%	7.14%
	3.00	21	21	12.50%	16.41%

	Search Radius	Public Safety Towers	AT&T Owned Towers	Percent Towers Owned by AT&T	Percent of Public Safety Towers Affected
AT&T	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	0	0	0.00%	0.00%
	2.00	0	0	0.00%	0.00%
	3.00	1	1	0.60%	0.78%

	Search Radius	Public Safety Towers	Cingular Owned Towers	Percent Towers Owned by Cingular	Percent of Public Safety Towers Affected
Cingular	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	0	0	0.00%	0.00%
	2.00	0	0	0.00%	0.00%
	3.00	0	0	0.00%	0.00%

Tuscaloosa, AL

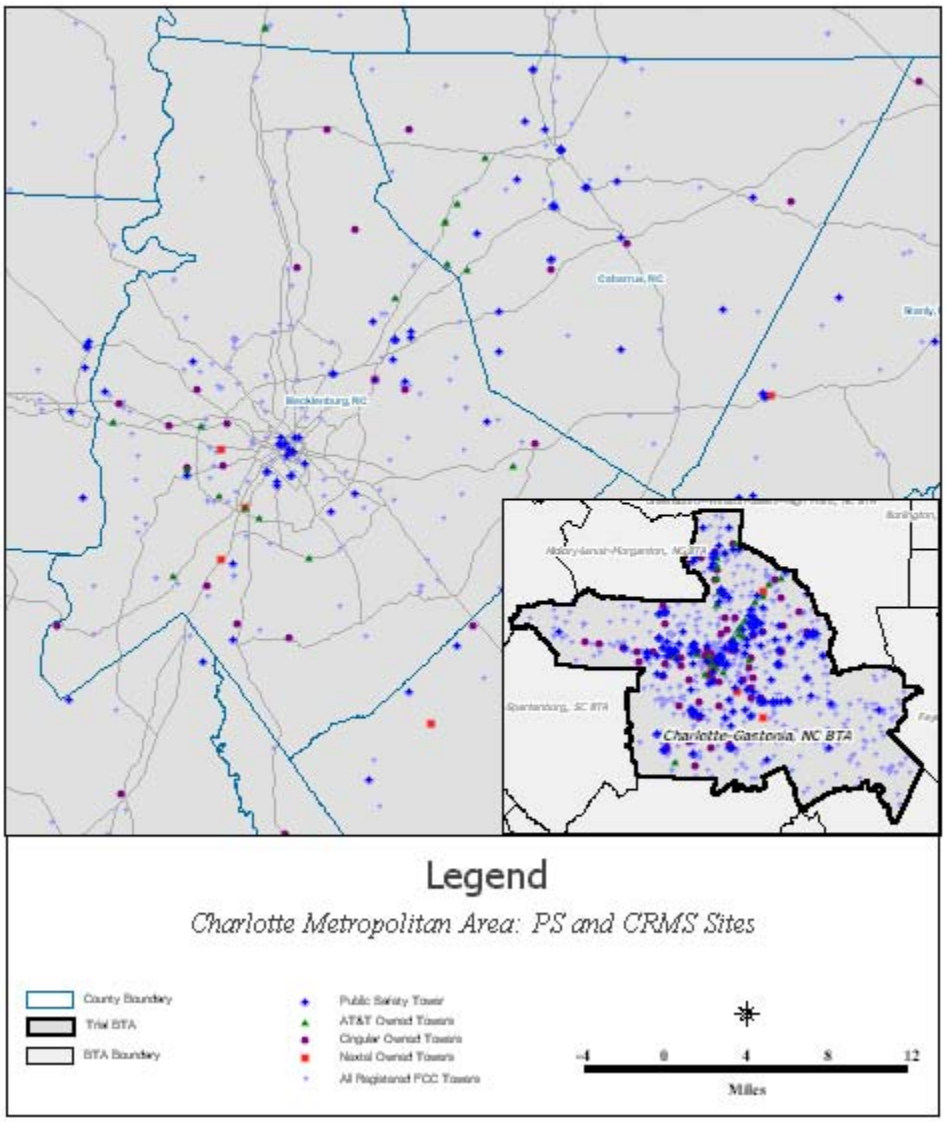
Analysis of Towers with an AGL of 100 - 149 ft

	Search Radius	Public Safety Towers	All Registered Towers	Ratio of Registered Towers to Public Safety
Market Totals	0.25	4	4	1.0
	0.50	7	7	1.0
	0.75	10	10	1.0
	1.00	15	15	1.0
	1.50	20	20	1.0
	2.00	29	30	1.0
	3.00	54	58	1.1
	Totals	*139*	*144*	1.0

	Search Radius	Public Safety Towers	Nextel Owned Towers	Percent Towers Owned by Nextel	Percent of Public Safety Towers Affected
Nextel	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	4	4	26.67%	26.67%
	1.50	4	4	20.00%	20.00%
	2.00	4	4	13.33%	13.79%
	3.00	21	21	36.21%	38.89%

	Search Radius	Public Safety Towers	AT&T Owned Towers	Percent Towers Owned by AT&T	Percent of Public Safety Towers Affected
AT&T	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	0	0	0.00%	0.00%
	2.00	0	0	0.00%	0.00%
	3.00	0	0	0.00%	0.00%

	Search Radius	Public Safety Towers	Cingular Owned Towers	Percent Towers Owned by Cingular	Percent of Public Safety Towers Affected
Cingular	0.25	0	0	0.00%	0.00%
	0.50	0	0	0.00%	0.00%
	0.75	0	0	0.00%	0.00%
	1.00	0	0	0.00%	0.00%
	1.50	1	1	5.00%	5.00%
	2.00	1	1	3.33%	3.45%
	3.00	1	1	1.72%	1.85%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Mecklenburg, NC
Charlotte-Gastonia, NC BTA
Legend
Charlotte Metropolitan Area: PS and CRMS Sites
County Boundary
Trial BTA
BTA Boundary
Public Safety Tower
AT&T Owned Towers
Cingular Owned Towers
Nextel Owned Towers
All Registered FCC Towers
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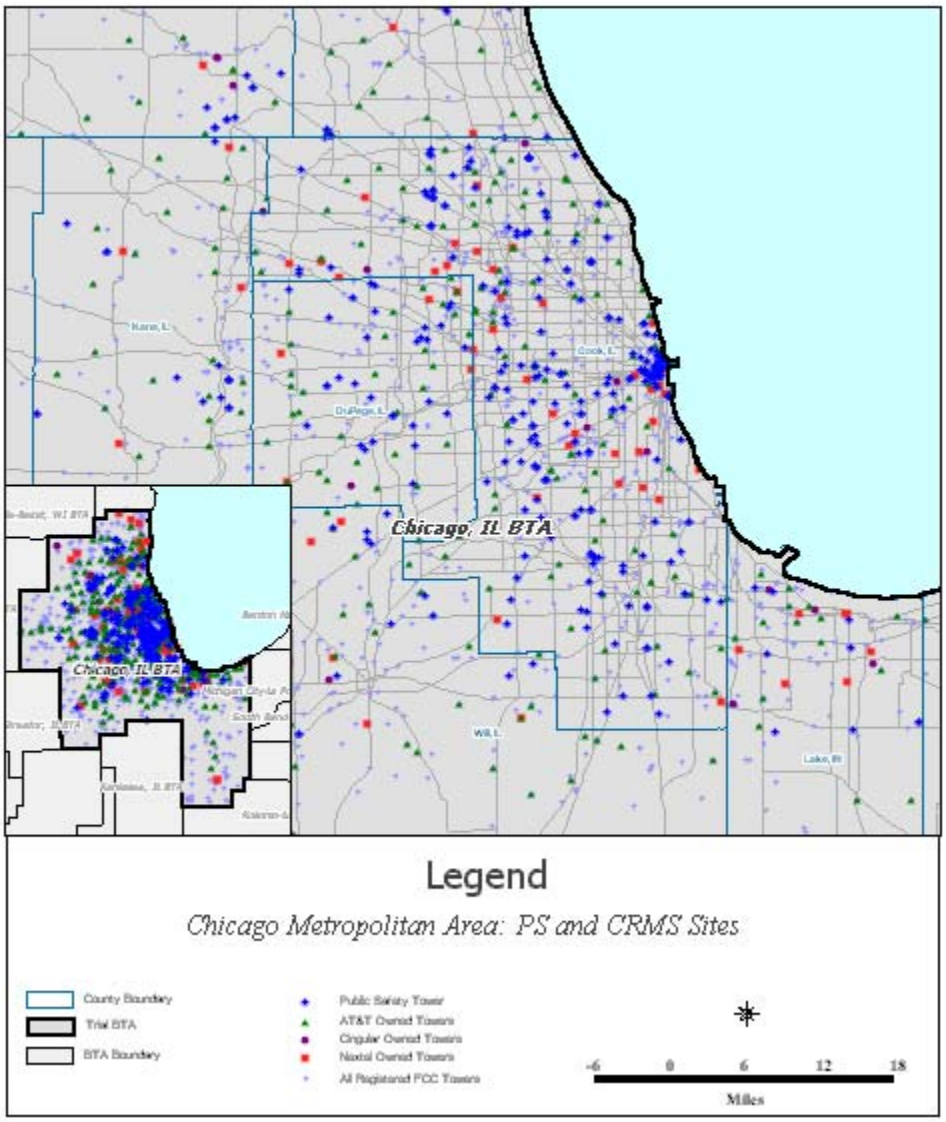
0
4
8
12
Miles


Chicago, IL BTA
Chicago, IL BTA
Legend
Chicago Metropolitan Area: PS and CRMS Sites
County Boundary
Trial BTA
BTA Boundary
Public Safety Tower
AT&T Owned Towers
Cingular Owned Towers
Nextel Owned Towers
All Registered FCC Towers
-6
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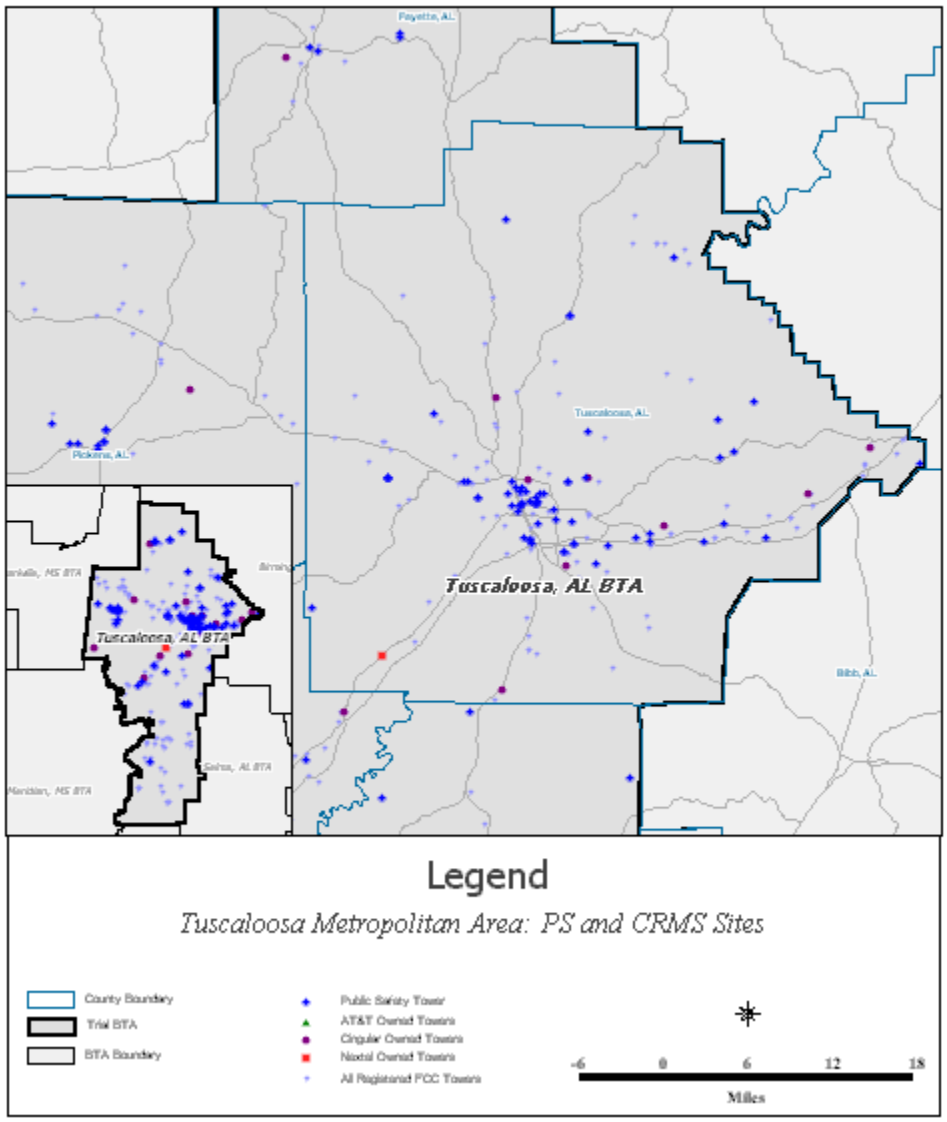
18
Miles


Fayette, AL
Pickens, AL
Tuscaloosa, AL
Tuscaloosa, AL BTA
Tuscaloosa, AL BTA
Bibb, AL
Legend
Tuscaloosa Metropolitan Area: PS and CRMS Sites
County Boundary
Trial BTA
BTA Boundary
Public Safety Tower
AT&T Owned Towers
Cingular Owned Towers
Nextel Owned Towers
All Registered FCC Towers
-6
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6
12
18
Miles

Appendix C. Business Analysis Introduction

Resolving the interference issues discussed in this document will require substantial capital commitments and a detailed action plan. As in all adjustments and/or improvements to network infrastructure, the complexities can be immense, time consuming, and difficult to quantify. One of the key strategic initiatives explored by WFI over the past year has been the need to migrate networks in a time- and cost-effective fashion. Just as transitioning from second to third generation networks requires careful planning if existing and new subscribers are to remain satisfied, so too will resolution of the shift to new contiguous blocks of spectrum in the 800MHz band. In both situations, it is necessary to correctly estimate requirements for capital, currently a resource nearly as scarce as spectrum itself.

Shifting among alternative spectrum bands, however near in proximity, will require new infrastructure and additional expenses associated with optimizing modified networks. To accurately quantify the cost of this transition, a combination of market, technical, and business expertise is essential.