Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington, D.C. 20554

In the matter of	)	
	)	
Interference Immunity Performance Specifications for Radio Receivers	)	ET Docket No. 03-65
	)	
Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television	)	MM Docket No. 00-39

COMMENTS OF

Statewide Wireless Network

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Contents

I. INTRODUCTION

1. These comments from the Statewide Wireless Network, under the New York State Office for Technology (NYS-OFT), present the thoughts and concerns of the State of New York in response to the Commission's Notice of Inquiry ("NOI") regarding "Interference Immunity Performance Specifications for Receivers" in the above-captioned proceeding. The NOI addresses the potential for incorporating receiver interference immunity performance specifications into spectrum policy on a broader basis[1]. We applaud the Commission for creating a forum to address these issues and the future impacts that such matters will have on spectrum policies.

2. The New York State Office for Technology, on behalf of the State of New York, is in the process of procuring a new Statewide Wireless Network (SWN) for State, Federal and Local Governmental entities that operate within New York State's geographic borders. SWN will provide an integrated mobile radio communications network that will be utilized by both Public Safety and Public Service agencies in New York State. It will provide a digital, trunked architecture that will offer both voice and data capabilities. SWN will be used in day-to-day operations, as well as for disaster and emergency situations, to more effectively and efficiently coordinate the deployment of all levels of government resources to such incidents. It will also enhance international coordination along the US/Canadian border, and will play a critical role in supporting the homeland defense efforts of the State of New York.

3. The State of New York has a large stake in the outcome of any current or future spectrum policy decisions, especially where these affect the performance, capability, capacity, cost, or

construction timeline of the SWN system. The NOI has provided many starting points for discussion and we thank the Commission for the opportunity to contribute to this process by including our comments on the needs of Public Safety, who have very unique requirements and extremely limited resources available.

II. RECEIVER AND TRANSMITTER PERFORMANCE GRADING CRITERIA.

4. The Commission states in the NOI that from "a technical standpoint, a radio receiver's susceptibility to interference is largely dependent on the interference immunity of the device, particularly with regard to its rejection of undesired radio frequency (RF) signals."[2] The Commission also requests "comment on the possible approaches by which desired levels of receiver immunity or tolerances could be achieved, including incentives for improving performance, voluntary industry standards, mandatory standards, or a combination of these or other approaches." Furthermore, the Commission recognizes in the NOI "that receivers can contribute as much as transmitters to the existence of perceived interference, there may be benefits to the adoption of guidelines, labeling rules, or even mandatory standards for certain classes of receivers."

5. In keeping with the spirit of the NOI, the Commission should consider establishing grading criteria based upon both receiver and transmitter performance, as well as spectrum allocation. We recommend that transmitter system and receive devices receiving Type-Acceptance be rated to a specific grade consistent with performance parameters affecting interference immunity (and interference propagation) based on the current state-of-the-art. We believe

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[1] ET Docket No., 03-65, MM Docket No. 00-39, Notice of Inquiry, Introduction.
[2] ET Docket No. 03-65, MM Docket No. 00-39, Notice of Inquiry, page 1-2.

the simplest and most cost effective means of classifying receivers and transmit systems is to have a graduated rating. Classes of receivers could be categorized as:

a. Class A – Very high immunity to interference (i.e. IM and adjacent channel rejection, and selectivity), with high sensitivity (i.e. low internal receiver noise floor). It is important to note that highly sensitive receivers are made from the highest quality components, meet specific communications needs, and are deserving of full protection[3].

b. Class B – Moderate immunity to interference, with moderate sensitivity

c. Class C – Standard moderate immunity to interference with standard sensitivity. Consistent with current rules.[4]

d. Class D – (Exempt) Experimental receiver technology.

6. Furthermore, classes of transmitter systems[5] could be categorized as:

a. Class A – Very low RF "pollution", i.e. low out-of-band-emissions (OOBE), high adjacent channel attenuation, tight frequency stability, and low power level at companion receiver locations (i.e. combined path loss and OOBE result in low out-of-band intercepted power at a victim receiver)

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[3] Note that the Commission has been requiring the use of increasingly spectrally efficient technologies in the land mobile radio and Public Safety allocations. This often leads to more sensitive receivers. For example, the Project 25 Standard that is embedded in the 700 MHz interoperability requirements has an equivalent noise bandwidth at the IF filter of only about 6 kHz, leading to a thermal noise floor of lower than -136 dBm. With a typical noise Figure of less than 10dB, a mobile receiver noise floor can easily fall lower than -126 dBm

[4] For instance, §90.548(a)(1) specifies for 700 MHz Public Safety interoperability: "Project 25 FDMA Common Air Interface--New Technology Standards Project--Digital Radio Technical Standards, approved April 15, 1998, Telecommunications Industry Association, ANSI/TIA/EIA-102.BAAA-1998". It is therefore implied that the standard for receiver performance is specified in a companion standard of that series of standards: Land Mobile Radio Transceiver Performance Recommendations – Project 25 – Digital Radio Technology, C4FM/CQPSK Modulation, approved September 6, 2002, Telecommunications Industry Association, ANSI/TIA 102.CAAB-A-2002..

[5] Transmitter systems consist of all components in the transmission system, i.e. base stations, combiners and duplexers, transmit filters, antennas, etc. In a System of Class X, all components of the system must be of Class X of higher, in other words the class of the transmitter system depends on its lowest class component.

b. Class B – Moderate RF "pollution", i.e. moderate OOBE, moderate adjacent channel attenuation, moderate frequency stability, and moderate power levels at companion receiver locations.

c. Class C – High RF "pollution", i.e. high OOBE, low adjacent channel attenuation, "loose" frequency stability, and high power levels at companion receiver locations. Consistent with current rules.[6]

d. Class D – Experimental (Exempt).

We also concur with the Commission that it possesses the necessary statutory authority to promulgate transceiver standards and guidelines[7].

7. In order to keep current with advances in technology, the Commission should perform a periodic review of these performance ratings (e.g. every five years). Transmitter system and receiver performance specifications should always reflect the present state-of-the-art, and prevent to the greatest extent possible stagnation of the rules by incorporating the realities of modern day spectrum policy.

III. EQUIPMENT PERFORMANCE BASED INTERFERENCE RESOLUTION

8. We recommend that the Commission also consider supplementing existing rules to specify which party(s) is (are) responsible for resolving interference complaints. The Commission should consider creating an "accountable party" procedure for rectification of interference matters that considers the performance levels of both the interfering transmitter system and

[6] For instance, §90.548(a)(1) specifies for 700 MHz Public Safety interoperability: "Project 25 FDMA Common Air Interface--New Technology Standards Project--Digital Radio Technical Standards, approved April 15, 1998, Telecommunications Industry Association, ANSI/TIA/EIA-102.BAAA-1998". It is therefore implied that the standard for transmitter performance is specified in a companion standard of that series of standards: Land Mobile Radio Transceiver Performance Recommendations – Project 25 – Digital Radio Technology, C4FM/CQPSK Modulation, approved September 6, 2002, Telecommunications Industry Association, ANSI/TIA 102.CAAB-A-2002.

the victim receiver - provided all parties are operating in compliance with the rules. An alleged interfering party would not be responsible for interference resolution unless it is operating a transmitter system grade lower than the receiving device used by the victim. Any transmitter system that interferes with a higher-class device would be required to resolve the issue. In cases where existing or legacy devices are causing interference to established classes, resolution will depend upon how their specifications compare. Responsibility of action for legacy devices would occur if they fail to meet or exceed specifications of an established class. Likewise when an established class interferes with a legacy device action is only required when an established class's performance is below that of the legacy receiver. An example of a joint transmitter and receiver performance-based interference resolution procedure is shown in Table 1.

Table 1: Example of Receiver Ratings and Interference Accountability

Interfering Device	Receiving Device	Responsibility for Action
Class A	Class A	Class A interferer
Class A	Class B	No action
Class A	Class C	No action
Class B	Class A	Class B interferer
Class B	Class B	Class B interferer
Class B	Class C	No action
Class C	Class A	Class C interferer
Class C	Class B	Class C interferer
Class C	Class C	Class C interferer
Legacy transmitter	Class A, B, or C	Legacy interferer[8]
Class A, B, or C	Legacy receiver	Class A, B, C[9]

9. It is important to note that the actual performance of a given receiver or transmitter **<u>system</u>** may not match its class. This is especially true is cases where systems are assembled

[7] ET Docket No., 03-65, MM Docket No. 00-39, Notice of Inquiry page 4.

[8] Action necessary if Legacy device's transmitter specifications do not meet or exceed the receiving device experiencing interference.

incorrectly or interact adversely with their environment[10]. In such cases an interference study may need to be performed to ensure that both receiver and transmitter system classes match their expected performance; and, where interference resolution issues arise, to determine accountability from the results of the interference study.

IV. PROTECTION OF PUBLIC SAFETY SPECTRUM

10. We are concerned that the Commission wishes to follow the recommendations of the SPTF report with regard to establishment of a regionalized "Interference Temperature" metric. We respectfully urge the Commission to use any subsequent noise floor studies or measurements to identify areas of "high RF-noise pollution" that should be further addressed - not for specifying an interference temperature to measure licensed operations against where mission critical systems are involved.

11. Likewise, we are concerned with the Commission's statement in the NOI that "more robust receiver performance would help to facilitate more flexible use of the spectrum. Such robust performance would allow receivers to tolerate changes in operating systems, services and frequency loading that are expected to occur under flexible use of the spectrum." Our concern is that the NOI seems to suggest that improved receiver performance would promote greater spectrum sharing, and that such sharing might include spectrum used by public safety and mission-critical systems in general. The Commission issued a Notice of Inquiry recently on the *Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*[11], where we objected to sharing of Public Safety spectrum with such uses and pointed out the possible negative impacts that such an initiative would have on clearing of the upper

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[9] Action from Class A, B, or C if device specifications do not meet or exceed the legacy device, otherwise no action is required.

[10] For example passive intermodulation products produced from a rusty bolt located near a transmit antenna system, unexpected transmitted intermodulation products, etc.

700 MHz band that has been allocated to Public Safety[12]. We respectfully urge that the Commission under no circumstances require other services to share spectrum allocations with mission-critical Public Safety[13]. While we applaud the Commission for investigating new and alternative technologies to more efficiently use the limited spectrum resources, the need to provide adequate interference protection to Public Safety and other mission-critical services is paramount and must remain a priority.

V. TWO-TIERED APPROACH FOR ENSURING RECEIVER INTERFERENCE IMMUNITY PERFORMANCE

12. We believe that the Commission should consider taking a two-tiered approach to the labeling and validation of receiver interference immunity specifications. We applaud the Commission for consistently taking a voluntary approach to technology and testing, and relying primarily on programs supported and managed by industry[14]. However, the Commission may want to investigate requiring the identification of compliance with advertised manufacture specifications (in order to ensure accurate and standardized labeling) - as well as the use of standardized test methods. Accurate labeling would protect the consumer by guaranteeing the receiver will meet the performance expectations appropriate for their class. Receiver specifications also need to be consistently reported to allow the buyer to make comparisons and select the best product for their needs. Standardized test methodologies would be utilized to ensure performance requirements are consistently validated. Both labeling and test methods will require regulatory action from the Commission. However, this process

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[11] ET Docket No. 02-380 In the Matter of Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band.

[12] Reply Comments from the Statewide Wireless Network New York State Office for Technology State Capital, ESP, Dated May 16, 2003.

[13] i.e used in the protection of it's citizens and for defense of this country

[14] ET Docket No. page 7-8, 03-65, MM Docket No. 00-39, Notice of Inquiry.

does not need to be complicated. The regulatory requirements could be as simple as documentation filed with the Commission identifying the labeling and standardized test methodology used. This approach will provide the consumer with accurate performance data and provide the manufacturer with traceability[15].

13. To provide the buyer consistent and accurate information, the Commission should require the reporting of receiver performance specifications similar to the reporting requirements of other government agencies such as the Food and Drug Administration (FDA). Receiver performance specifications should be consistent for all devices, use common units of measurement, and methodologies to obtain each parameter. This information should be accessible by the consumer, and would be a subset of the information provided with the equipment. An example of a standardized table listing receiver parameters for an idealized Public Safety Receiver is shown in Table 2. This table provides data for all channel bandwidths the device is capable of operating. Also included is a hypothetical test method used to derive the example specification. Specifications could easily be tailored for any electronic device in order to reflect the most pertinent performance parameters.

14. Industry should also be required to provide additional information that is necessary in order to effectively and efficiently manage spectrum allocations. This should include overall receiver noise figure, receiver IF filter equivalent noise bandwidth, receiver IF filter model, and transmit waveform power spectral density characteristics.

[15] Ibid. page 9 – In keeping with the spirit of what the Commission asks requesting comment on how the public should be informed.

Table 2: Example of Possible Standardized Receiver Specifications and Labeling

RECEIVER SPECIFICATIONS			
Parameter	Specification	Constraint	Test Method
Class	A	Not Applicable	Method C
Frequency Range	136-174 MHz	Not Applicable	Method Z
Channel Spacing	12.5 kHz	Not Applicable	Method M
	25 kHz	Not Applicable	Method M
Frequency Stability	1 PPM	-30 C to +60 C	Method V
RF Input Impedance	50 Ohms	Not Applicable	Method L
Sensitivity (for 12 dB SINAD)	-120 dBm	12.5 kHz BW	Method X
	-118 dBm	25 kHz BW	Method X
Digital Sensitivity	-100 dBm	1% BER 12.5 kHz BW	Method U
	-120 dBm	5% BER 12.5 kHz BW	Method U
Adjacent channel Rejection	90 dB	12.5 kHz BW	Method Y
	80 dB	25 kHz BW	Method Y
Intermodulation Rejection	75 dB	12.5 kHz BW	Method A
	73 dB	25 kHz BW	Method A
Spurious response Rejection	85 dB	12.5 kHz BW	Method R
	85 dB	25 kHz BW	Method R
Squelch Sensitivity (dB SINAD)	8 dB	12.5 kHz	Method B
	8 dB	25 kHz	Method B
Hum and noise	-50 dB	12.5 kHz	Method T
	-50 dB	25 kHz	Method T
Audio power	3 Watts	8 ohm load	Method P
	5% distortion	8 ohm load	Method P
Audio response	300-3000 Hz	Not Applicable	Method Q

VI. PROTECTION OF CURRENTLY LICENSED SERVICES

15. Before the Commission recommends rule changes affecting receiver performance and immunity they should consider utilizing their regulatory authority to ensure that interference levels do not increase in protected spectrum. As bands become more crowded and receiver performance increases, spectral purity will become even more critical. Interference protection to licensed services from unlicensed devices must remain intact and unchanged. The Commission must ensure that all type accepted electronics devices, which fall under

their jurisdiction, are required to conform to current rules for OOBE and spurious emissions. The State urges the Commission to resist any move to relax rules (e.g. Part 15) that would permit higher levels for spurious emissions. Expending time, money, and resources to improve receiver performance and immunity from interference, while at the same time neglecting spurious emissions, will negate any progress in improved receiver performance and may compound the problem.

VII. LIMITING IN-BAND POWER IN GEOGRAPIC AREAS AND THE IMPACT ON SYSTEM DESIGN.

16. The Commission is correct in its assertion that limiting in-band power and spillover into adjacent bands and areas, along with definition of these band and areas, will provide substantial characterization of the interference environment to which other licensees can design their systems[16]. In particular, specifying maximum allowable aggregate in-band power at the receiver (i.e. at ground level) in conjunction with OOBE limits can completely define the maximum interference power that can be expected within any operational environment. In our Spectrum Policy Task Force comments[17], we discussed the often-overlooked solution to the near-far problem by the shaping of antenna patterns to provide uniform flux density over the service area[18]. These types of uniform flux radiation patterns can provide reliable communications - without the need for high in-band power levels at receiver locations that are in close proximity to the transmitter.

17. We strongly disagree with the concept of requiring minimum signal strength levels corresponding to operation at levels greater than would be required when considering only

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[16] ET Docket No. page 9, para. 22, 03-65, MM Docket No. 00-39, Notice of Inquiry.

[17] ET Docket No. 02-135, January 24, 2003 Comments of the Statewide Wireless Network - New York State Office For Technology, para 9.

the victim receiver noise floor (kTB + NF). Such noise limited operations are typical of Public Safety mission critical systems. The specification of minimum signal levels as a criterion for interference protection must be applied carefully; such that noise limited system designs can operate with interference protection.

18. The State believes that the Commission must not adopt rules or policies that have the effect of requiring public safety systems to be based upon an interference-limited design model. Such an approach would have serious ramifications. In the Appendix we reiterate some material originally presented with our Spectrum Policy Task Force Comments. In this Appendix we discuss the near-far issue that frequently results in interference (A), examine the necessary signal levels necessary to mitigate interference under various scenarios (B), illustrate typical coverage range degradation due to interference and noise floor increases 0, translate this to system siting effects (D), and conclude with a discussion on how interference-limited designs actually prove to be spectrally inefficient with regard to Public Safety operations (E).

19. Another serious issue with interference-limited designs is restrictions on tower siting, which are becoming more and more problematic in many areas of the country. In urban areas many options are available for locating antennas such as building rooftops, but cost and zoning approvals are often an issue. In rural areas spacing of tower sites can be much greater. Thus, we believe an interference-limited design may be more practical in higher population areas than in rural areas. Other areas where interference-limited design would be prohibitive are in protected areas throughout the country (e.g., State and National Parks, ecological sanctuaries, etc). The Commission should not consider a blanket approach, but rather one more flexible

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[18] Ibid. page 5.

and adaptable to the many issues facing tower siting. We urge the Commission to proceed carefully in this matter.

20. We continue to agree with the same recommendations presented in a previous filing in ET Docket No. 02-135, which are just as pertinent today[19]. The recommendations that the State supports are those that enable both users and regulators to better understand the spectrum environment, and its noise and interference levels. These include:

- Obtaining better characterization of the noise floor, and adopting a standard method for measuring this noise floor[20],
- Creating a public/private partnership for a long term noise monitoring network, and archiving the resulting data for use by both the FCC and the public[21],
- Awarding a contractual study to evaluate receiver performance in these current environments[22],
- Promoting voluntary receiver performance requirements through industry groups[23],
- Considering incentives for the use of advanced receivers[24],
- Promoting transmitter enhancements for interference control, such as[25]
  - Fostering technologies that enhance uniform signal levels throughout a service area;
  - Promoting greater use of automated transmitter control systems; and
  - Considering tightening out-of-band emission limits over time.

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19 19 Comments of Statewide Wireless Network New York State Office for Technology, Submitted January 7, 2003, pages 8-10.

20 SPECTRUM POLICY TASK FORCE REPORT, Federal Communications Commission ET Docket No. 02- 135, November 2002, see § IX-B-10 (p. 64) and § VI

21 *Ibid.*, § IX-B-11 (p. 64)

22 *Ibid.*, § IX-B-15 (p. 65)

23 *Ibid,* § IX-B-16 (p. 65)

24 *Ibid,* § IX-B-17 (p. 65)

25 *Ibid,* § IX-B-18 (p. 65)

- Improving communications on interference issues with the public, such as[26]:
  - Harmonizing interference language in FCC and related International rules,
  - Ensuring consistent and appropriate use of interference terminology,
  - Developing technical bulletins that explain interference rules for all radio services,
  - Developing an "FCC Best Practices Handbook".

21. These steps will enable the Commission and the general public to better understand both the noise and *pollution* levels that exist in the radio spectrum, as functions of time, space, and frequency. This will assist system designers, regulators and technologists, while also clearly illustrating the need to reduce or eliminate out of band interference and spurious emissions that pollute much of the Public Safety spectrum landscape. The need to clean up this environment is critical in order to sustain and allow large-scale Public Safety systems to be developed at fiscally achievable costs.

VIII. ESTABLISHING HIGHER RECEIVER PERFORMANCE STANDARDS SPECIFIC TO PUBLIC SAFETY SERVICES.

22. We generally agree with the commission that Public Safety should utilize high performance receivers in order to ensure better interference immunity. Such performance requirements are necessary given the highly mobile nature of Public Safety users, which require that a unit may have to operate in areas of both high and low spectrum utilization[27]. However, we do not believe that requiring Public Safety receivers to meet high performance requirements is the only solution, nor should it be the ultimate goal.

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[26] *Ibid,* § IX-B-19 (p. 65)

23. A holistic approach could also be taken that addresses issues associated with deploying different technologies in a given Public Safety band. The Task Force notes that the Commission should consider grouping future allocations based on mutually compatible technical characteristics, and require improvements in the out-of-band interference performance of transmitters and receivers so as to reduce the need for such grouping[28]. The State feels that, at a minimum, the FCC should consider grouping allocations for similar designs together (i.e. segregating noise-limited and interference-limited designs). This will reduce interference to noise limited services, and would allow sharper transmitter filters and lower out of band emissions (OOBE) for all services. In our filing submitted in Spectrum Policy, ET Docket No. 02-135, we stated how this type of policy decision was being examined as the main solution to mitigating inter-service interference at 800 MHz[29]. The State also submitted further discussion and analysis regarding the importance of reducing OOBE to ensure the survival of noise-limited systems[30].

IX. BAND SPECIFIC PROPOSALS FOR ESTABLISHING TECHNICAL STANDARDS

24. The State supports the creation of receiver standards policies through a National Public Safety committee process, such as the National Coordination Committee. We applaud the Commission giving consideration to such a process, as it has proved to be very successful in the past. A National committee is most beneficial for capturing and incorporating the

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[27] Areas that could severely affect receiver performance

[28] SPECTRUM POLICY TASK FORCE REPORT, Federal Communications Commission ET Docket No. 02- 135, November 2000, § IX-A-6 (p. 64), as well as § V

[29] ET Docket No. 02-135, January 24, 2003 Comments of the Statewide Wireless Network - New York State Office For Technology, para 7.

[30] See Appendix

requirements and concerns of a large diverse group of users, such as Public Safety agencies. A committee is also a pertinent forum for the generation of data, amassing of statistics, and dissemination of information pertaining to matters of interest to their respective jurisdictions. For example in the Public Safety community, a (funded) National committee could be responsible for the gathering of information on noise floor levels, licensing activity, interference reports and interference resolutions. This information could reside on a National database and be accessible to all interested parties. We further believe that the interests of the Public Safety community and those of government and industry would be better served through a more uniform application of receiver standards based upon open access to the information gathered in the field.

X. CONCLUSIONS

25. The State is cautiously optimistic regarding the use of Receiver Standards as a tool for the development and enforcement of spectrum policy. There are clear benefits to the joint application of receiver and transmitter standards, as well as other policies that could reduce interference and allow for more efficient utilization of our limited spectrum resources. However, any attempt to standardize receiver performance must not cause the forced migration of Public Safety into interference-limited designs. This would be both fiscally irresponsible and spectrally wasteful, and Public Safety (Local, State, and Federal) cannot shoulder the additional financial burdens that would result from such ineffectual and ill-conceived policies.

Respectfully Submitted,

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APPENDIX - INTERFERENCE EFFECTS ON PUBLIC SAFETY SYSTEMS

(A) The Near/Far Problem

The infamous near/far problem occurs when users are relatively far from their base transmitters, and relatively close to an interference source. This interfering source radiates power that is being coupled into the filters of the victim receiver. This interfering power may be due to near or far adjacent channel interference, strong out-of-band-emission (OOBE) levels, transmitter-generated intermodulation products, and even high level far out-of-band signals generating intermodulation products within the victim receiver. The interfering source can emanate from a base station, mobile or portable transmitter.

Figure 1 and Figure 2 illustrate a typical near/far scenario that results in interference to subscriber receivers. In these figures, notice that there are two types of locations where interference becomes much more likely. The most common is when a subscriber unit is far from its associated base station, and close to an interfering source. In this case, the loss experienced by the desired signal at the subscriber unit is greater than the loss of the undesired signal. Therefore, even though the undesired signal is not co-channel with the desired signal, interference may still result. The other case seen here is when cellular subscribers are operating on the edge of their service area, where their power output is at its highest. If this occurs in tandem with a low-level desired signal (i.e. the victim being relatively far from its base transmitter), again, interference will result.

Not shown, but also a frequent cause of interference is when the undesired signal is being used by a subscriber near the desired base receiver, at the same time that the victim receiver is trying to receive its distant mobile. This situation results in interference at the base receiver, where the undesired signal degrades the reception of the desired signal.

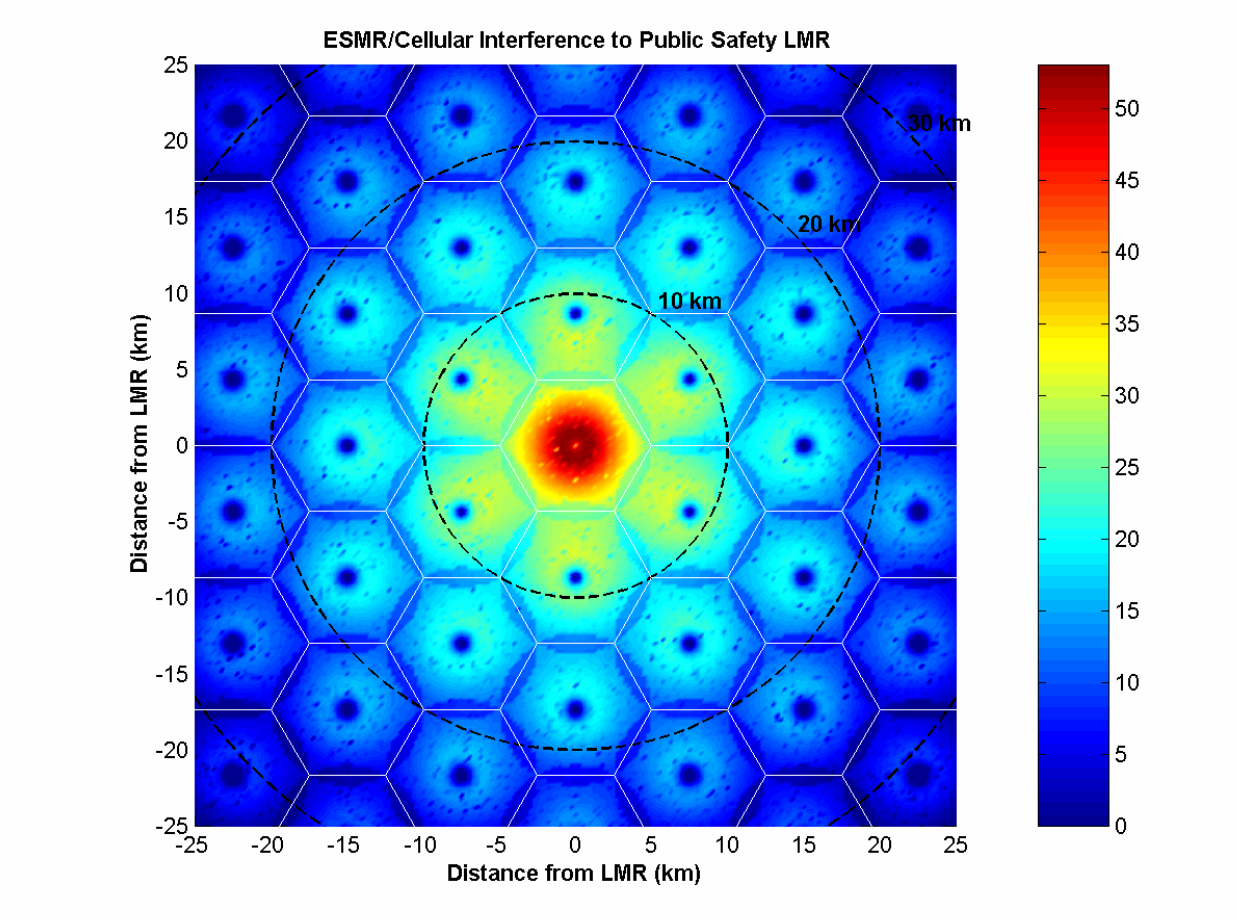

Figure 1: S/(ΣI+N) Distribution in Near/Far Problem

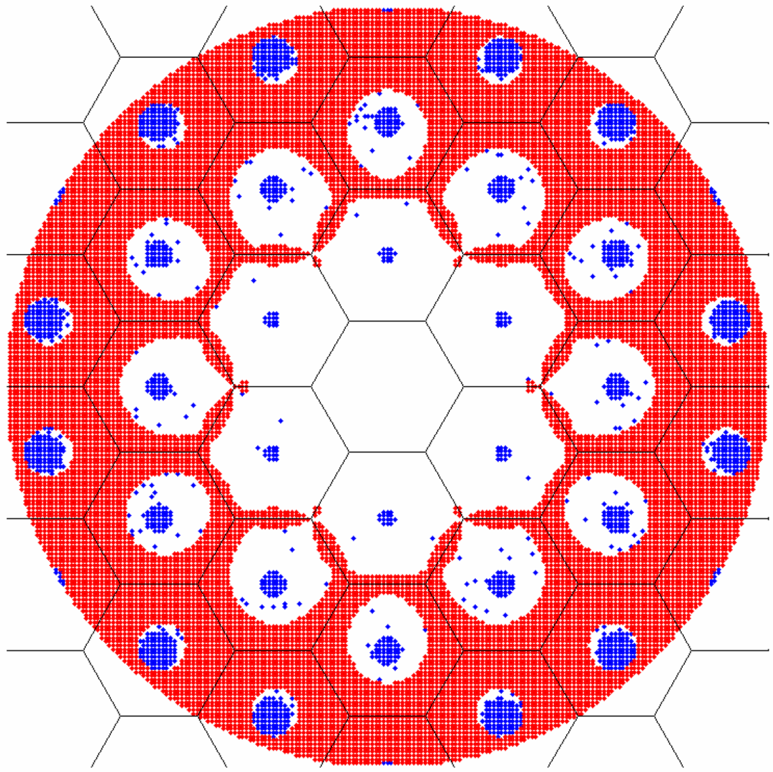

Figure 2: Locations of Interference Due to the Near/Far Problem

(B) Necessary Increase in Signal Required for Interference Mitigation

In this section, Table 3 illustrates the effect that both interference levels, and noise floor degradation have upon the necessary desired signal level, in order to ensure that a system design can maintain a fixed communications reliability. These tables use the following parameters:

- *Receiver Noise Floor:* *-126.32 dBm (ENBW = 6 kHz, NF = 10 dB)*
- *Mean Interferer Level:* *-128.0 dBm in Desired IF of Victim Receiver (this interferer will experience antenna loss/gain)*
- *Lognormal Variance:* *5.8-dB and 8-dB*
- *Faded S/(I+N) Requirement:* *17-dB (Delivered Audio Quality of 3.0 for C4FM)*
- *Uncorrelated Signal and Interference Level(s)*
- *Where Applicable, Portable Antenna Losses of 10-dB (relative to 1/2 wave dipole)*

And correspond to the following cases:

- *N:* *Noise Only.*
- *N+I:* *Noise and a Single Interferer.*
- *N+2I:* *Noise and Two Equal Interferers.*
- *N+OOBE3:* *A 3-dB Degradation of Noise Floor due to OOBE of equal power Level. (this degradation is independent of antenna loss/gain)*
- *N+I+OOBE3:* *A Single Interferer, along with a 3-dB Noise Floor Degradation due to OOBE, etc.*
- *N+I OOBE5:* *A Single Interferer, along with a 5-dB Degradation of Noise Floor due to OOBE, etc.*

Table 3: Necessary Power Increase due to Interference Effects

Noise Floor	-126.22 dBm
Sigma	5.8 dB

	Signal (dBm) For Reliability Target				**Increase (dB) From Noise Limited Case**		
	Case	**90%**	**95%**	**97%**	**90%**	**95%**	**97%**
Mobile	***N***	-101.8	-99.7	-98.4	*N/A*	*N/A*	*N/A*
	N+I	-96.5	-93.6	-91.6	5.3	6.2	6.8
	N+2I	-94.3	-91.4	-89.5	7.5	8.4	9.0
	N+OOBE3	-98.8	-96.7	-95.4	3.0	3.0	3.0
	N+I+OOBE3	-94.5	-91.5	-89.6	7.3	8.2	8.8
	N+I+OOBE5	-92.9	-89.9	-88.0	8.9	9.8	10.4
Portable	***N***	-91.8	-89.7	-88.3	*N/A*	*N/A*	*N/A*
	N+I	-91.5	-89.4	-88.0	0.3	0.3	0.3
	N+2I	-87.8	-84.9	-82.9	4.0	4.9	5.4
	N+OOBE3	-88.8	-86.7	-85.3	3.0	3.0	3.0
	N+I+OOBE3	-88.7	-86.6	-85.2	3.1	3.1	3.1
	N+I+OOBE5	-86.7	-84.6	-83.2	5.1	5.1	5.1

Noise Floor	-126.22 dBm
Sigma	8.0 dB

	Signal (dBm) For Reliability Target				**Increase (dB) From Noise Limited Case**		
	Case	**90%**	**95%**	**97%**	**90%**	**95%**	**97%**
Mobile	***N***	-99.0	-96.1	-94.2	*N/A*	*N/A*	*N/A*
	N+I	-92.6	-88.4	-85.8	6.4	7.7	8.4
	N+2I	-90.4	-86.3	-83.7	8.6	9.8	10.5
	N+OOBE3	-96.0	-93.1	-91.2	3.0	3.0	3.0
	N+I+OOBE3	-90.5	-86.4	-83.7	8.5	9.8	10.5
	N+I+OOBE5	-88.8	-84.8	-82.2	10.1	11.3	12.0
Portable	***N***	-89.0	-86.1	-84.2	*N/A*	*N/A*	*N/A*
	N+I	-88.7	-85.8	-83.9	0.3	0.3	0.3
	N+2I	-83.8	-79.7	-77.1	5.2	6.4	7.1
	N+OOBE3	-86.0	-83.1	-81.2	3.0	3.0	3.0
	N+I+OOBE3	-85.8	-82.9	-81.1	3.1	3.1	3.1
	N+I+OOBE5	-83.9	-81.0	-79.1	5.1	5.1	5.1

> 40 dBu (yellow) **> 50 dBu** (red) **> 3 dB** (blue)

Note that the current 40-dBu typical[31] field strength limits at the edge of a service area are insufficient to mitigate *most* cases of noise floor degradation and interference that involve mobile operations, and *all* cases involving portable operations. Further note that in many cases the 50-dBu contour levels that have been discussed[32] by the Commission are also insufficient for many cases.

[31] The level at which 800 MHz Public Safely co-channel protection is based upon

[32] see for example PETITION FOR RECONSIDERATION OF THE SECOND MEMORANDUM OPINION AND ORDER, SERVICE RULES FOR THE 746-764 AND 776-794 MHZ BANDS AND REVISIONS TO PART 27 OF THE COMMISSIONS RULES, 17 FCC Rcd 13985, July 12, 2002

(C) Coverage Range Degradation due to Interference

Table 4, below, illustrates the effect that increased signal levels have upon the range and coverage area of Public Safety systems. The increased power levels are due to interference and/or noise floor degradation, and are necessary to ensure that a system design can maintain reliable communications.

Table 4: Typical Range and Coverage Losses due to Necessary Power Increases

EOC = Edge of Coverage

EOC Level (dBm)	EOC Level Increase (dB)	Distance Reduction Open	Distance Reduction Suburban	Distance Reduction Urban	Area Reduction Open	Area Reduction Suburban	Area Reduction Urban
-102	**0**	100%	100%	100%	100%	100%	100%
-101	**1**	96%	95%	93%	93%	90%	87%
-100	**2**	93%	90%	87%	86%	82%	76%
-99	**3**	89%	85%	81%	79%	71%	66%
-98	**4**	86%	79%	76%	73%	63%	58%
-97	**5**	82%	74%	71%	67%	54%	50%
-96	**6**	79%	69%	67%	62%	48%	44%
-95	**7**	76%	65%	62%	58%	42%	38%
-94	**8**	73%	60%	58%	53%	36%	34%
-93	**9**	70%	56%	54%	49%	32%	29%
-92	**10**	67%	52%	50%	45%	27%	25%
-91	**11**	64%	49%	47%	41%	24%	22%
-90	**12**	61%	46%	44%	38%	21%	19%
-89	**13**	59%	43%	41%	35%	18%	17%
-88	**14**	56%	40%	38%	32%	16%	15%
-87	**15**	54%	37%	36%	29%	14%	13%
-86	**16**	51%	35%	33%	26%	12%	11%
-85	**17**	49%	32%	31%	24%	10%	9%
-84	**18**	47%	30%	29%	22%	9%	8%
-83	**19**	44%	28%	27%	20%	8%	7%
-82	**20**	42%	26%	26%	18%	7%	7%
-81	**21**	40%	25%	24%	16%	6%	6%
-80	**22**	37%	23%	22%	14%	5%	5%
-79	**23**	35%	21%	21%	12%	5%	4%
-78	**24**	32%	20%	19%	10%	4%	4%
-77	**25**	30%	19%	18%	9%	3%	3%

(D) System Siting Effects due to Interference

This section illustrates the effect that the parameters presented in Sections (B) and 0 of this Appendix have upon large system designs. Figure 3 shows an example of the number of hexagonal cells[33] required to provide coverage for New York State[34], assuming that there is no terrain blockage or diffractive effects. In this figure, it is seen that for a noise-limited design the state could be covered with 364 cells. However, when the noise floor and interference degradation rises, so does the number of sites required to maintain reliable communications. A 3-dB increase in required signal levels almost doubles the number of transmitter locations, and a 10-dB increase multiplies the number of required sites by a factor of five. The number of sites is proportional to the cost of a Public Safety (or any) system, and Public Safety does not have a market case for increasing both siting and system costs. It is clear why large Public Safety systems require that noise and interference levels are as low as possible.

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[33] This accounts for the cell overlap that is present for circular coverage cells.

[34] Since there is a New York Statewide system currently under procurement, it must be noted that this is an illustrative example only. This does not imply that the number of sites presented here is representative of the final system design.

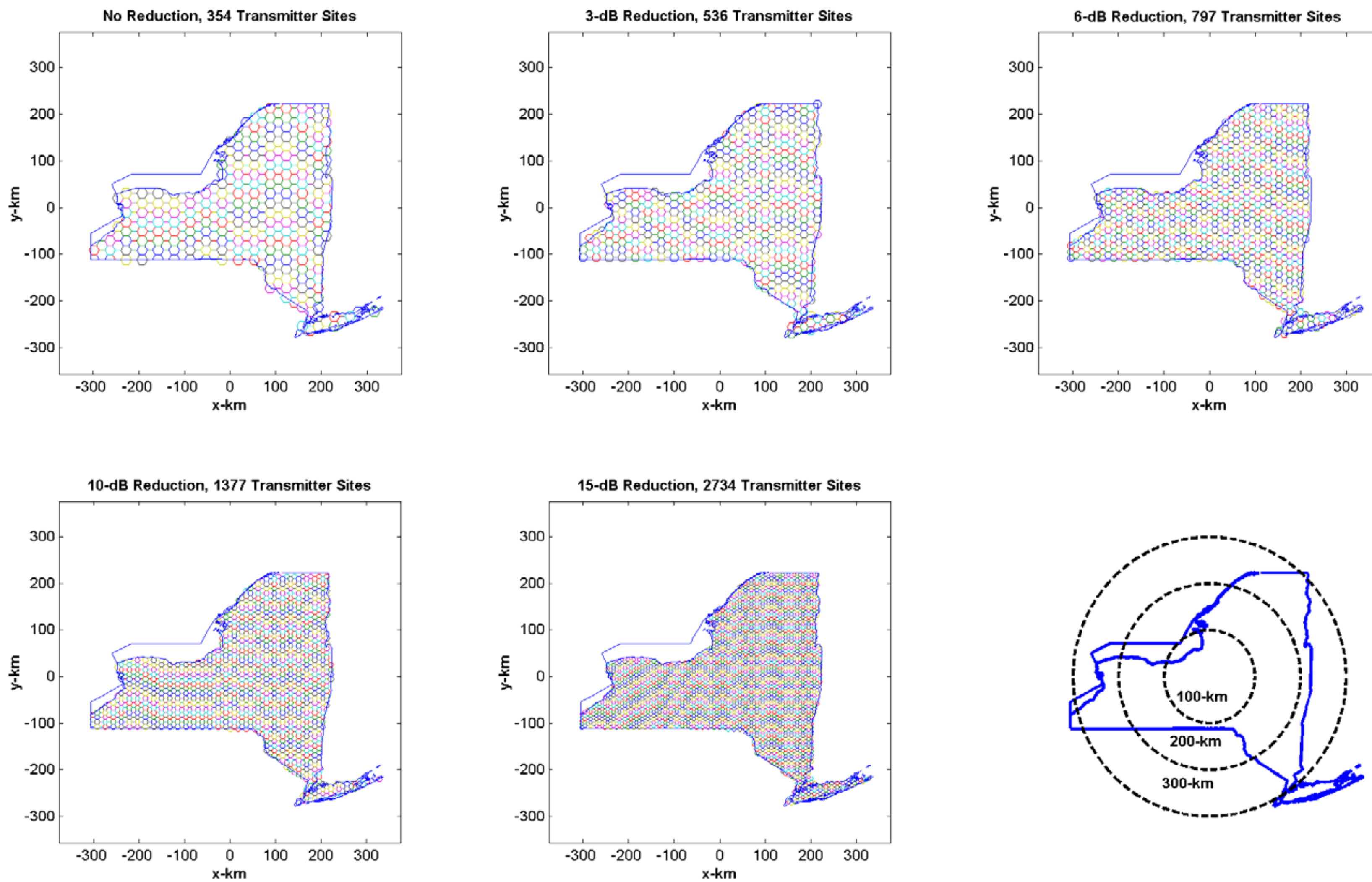

Figure 3: Example of Increased Statewide Siting Requirements due to Interference Degradation

(E) System Capacity Effects due to Interference-Limited Designs

The explosive growth of the wireless communications industry in the 1980's was a direct result of the concept of "cellular design". It was seen that if base transmitters were located in a cellular (or other tessellated type) grid, and co-channel frequencies were assigned in specific repeating patterns, then geographic capacity could be enhanced by reducing the size of the representative cells. Furthermore, this increased capacity could occur while maintaining consistent and adequate signal to interference (S/I) levels, always meeting a minimum Quality of Service level. These came to be called "interference-limited" systems, since the limiting factor for communications reliability was only the interference level, which was much higher than the thermal noise level of the system receivers. These days, nearly all cellular and PCS systems exploit the concept of interference-limited system designs in order to enjoy maximum capacity from a fixed set of channels or frequency blocks. However, this expansion in capacity does not hold for Public Safety systems.

The cellular, interference-limited design exploits the fact that as more spectrum is reused, more capacity is made available. This however, is based upon the notion that all communications are point-to-point within the system, and that each call can load at most two transmitter cells. Public Safety voice communications do not meet this criterion. A very high percentage of Public Safety communications are point-to-multipoint within a talkgroup structure. Because of this, every cell not only experiences all the traffic of a particular *user* registered within the cell, but also *all* of the traffic from the associated members of the talk group (or talkgroups) corresponding to the user located within the cell. While this at first glance seems wasteful, it clearly corresponds to the notion of providing Public Safety services. In other words, in order to protect and serve the public over a given area, it is necessary to coordinate Public Safety personnel *simultaneously over the entire area*.

For purposes of discussion let's assume that we have a countywide Public Safety communications system. Because each site within the system will experience nearly identical traffic loading[35], each site must essentially have enough channel resources to handle all the users within the county. Lets set a fixed channel requirement of *N*-Channels in order to provide a sufficiently low blocking probability for accessing the system. If the system has *M* transmitter sites, then the total number of channels required by the county is *MN*. It is clear that the channel requirements increase linearly with the number of transmitter sites. Furthermore, most counties (at least in the Northeastern U.S.) are not large enough to allow co-channel reuse within their border; therefore *MN* distinct channels are required. This is the reason that simulcast systems are popular; they return the channel requirement back to *M* channels, a number that is attainable in most localities[36].

The moral of the story is that, for Public Safety operations, increasing the number of sites actually increases the amount of channels required, which is equivalent to reducing the geographic spectral efficiency of the system. Although simulcast designs can help mitigate this, simulcast is extremely difficult to implement for a large number of transmitter sites and is not expected to be available with TDMA and other spectrally efficient[37] technologies.

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[35] This assumes that at least one member of each talk group can be found within each site footprint or coverage area.

[36] In most populated areas there is only a very limited amount of spectrum that can be made available.

[37] Measured in terms of voice-paths/Hz. Note that what is really important is voice-paths/Hz/km^2

In terms of the parameters and examples illustrated in (B) through (D), lets look at the overall spectrum efficiency reduction that results from moving toward interference-limited designs. Figure 4 portrays two simple cases; both corresponding to a system that requires 10, 25-kHz channels in order to adequately support its operations. In the case on the left, we see what happens to the system when an increase of 6-dB is required to mitigate elevated noise and/or interference levels within a noise-limited system. The dotted black line shows the original coverage, with the red solid hexagons showing the increased siting necessary to support the increase in signal levels. Assuming that simulcasting is not an option, in this case a system that required 250 kHz of total spectrum would now require 1 MHz of spectrum to support the same operations. In the case on the right, the degradation is now 10 dB, and the result is a seven-fold increase in spectrum required to support the same operations. It is clear that when point-to-multipoint communications are required, interference-limited designs actually decrease the resulting spectrum efficiency.

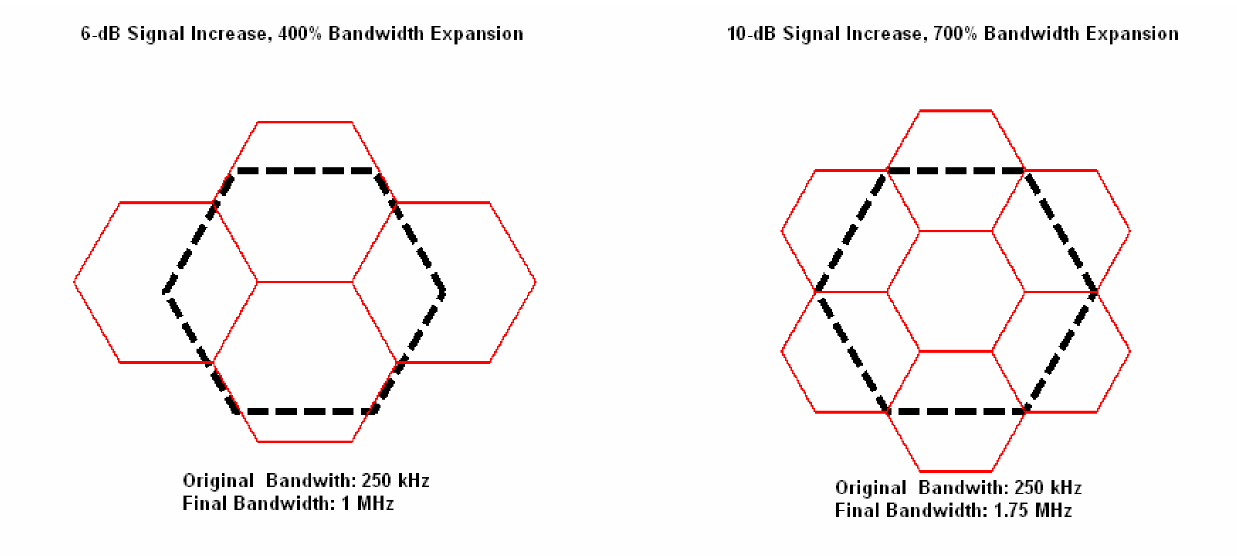

Figure 4: Bandwidth Expansion due to Interference Degradation