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October 22, 2003

BY ELECTRONIC FILING

Marlene H. Dortch, Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, D.C. 20554

Re: WT Docket No. 02-55
Ex Parte Presentation

Dear Ms. Dortch:

On Tuesday, October 21, 2003, Lawrence Krevor, Vice President – Government Affairs, Nextel Communications, Inc. ("Nextel"), Dave Maples, Nextel's Senior RF Operations Engineer, and I met with Catherine Seidel, Deputy Bureau Chief, Wireless Telecommunications Bureau ("WTB"); David Furth, Associate Bureau Chief, WTB; Walter Strack, Chief Economist, WTB; D'Wana Terry, Chief, Public Safety and Private Wireless Division, WTB; Shellie Blakeney, Legal Advisor, WTB; Aaron Goldberger, WTB; Sarah Mechanic, WTB; Ziad Sleem, WTB; and Michael Wilhelm, WTB, regarding the Commission's above-captioned rulemaking on public safety communications in the 800 MHz band. During our meeting, we addressed the urgent need to adopt the Consensus Plan as a means of resolving CMRS – public safety interference and providing additional spectrum for public safety communications. In particular, we discussed the potential costs and benefits of Consensus Plan implementation, as well as the costs and benefits associated with other proposals submitted in this proceeding. Attached to this letter is a copy of a document entitled "How to Respond to Reports of Interference," which was developed for use by Nextel employees in the investigation and resolution of CMRS – public safety interference. This document was discussed with WTB staff at the meeting.

Pursuant to section 1.1206(b)(2) of the Commission's rules, 47 C.F.R. § 1.1206(b)(2), this letter and this attachment are being filed electronically for inclusion in the public record of the above-referenced proceeding.

Sincerely,

/s/ Regina M. Keeney
Regina M. Keeney

Attachment

cc: Catherine Seidel
David Furth
Walter Strack
D'Wana Terry
Shellie Blakeney
Aaron Goldberger
Sarah Mechanic
Ziad Sleem
Michael Wilhelm

Nextel Communications
How to Respond to Reports of Interference

Release 10.06

August 20, 2002

RF Operations Department

This document was prepared and developed for use by Nextel Communications ("Nextel") employees for the investigation and resolution of alleged interference between commercial mobile radio service ("CMRS") providers and public safety communications systems. This document may be made available to assist other CMRS providers in investigating and resolving incidents of interference with public safety entities.

Nextel Communications
How to Respond to Reports of Interference
R.10.06 / August 20, 2002

REVISION HISTORY

Item	Revision	Date	Author	Comments
1	R.01.00	03/17/99	J. Margolis, J. Goldstein	Original Draft
2	R.02.00	12/29/99	D. Maples	Added test procedures
3	R.03.00	08/01/01	D. Maples	Rewritten to reflect current understanding of problem
4	R.04.00	10/02/01	D. Maples	Revised Figure 1
5	R.08.00	01/22/02	D. Maples	Revised equations and added requirements for gathering spurious response data
6	R.10.00	04/01/02	D. Maples, M. Elhag, D. Lee	Major revisions to document
7	R.10.01	04/05/02	D. Lee	Corrected equations
8	R.10.03	04/24/02	D. Lee	Minor edits; expanded RBW discussion
9	R.10.04	06/07/02	D. Maples	Added data on spurious responses and cellular noise rolloff
10	R.10.05	06/10/02	J. Goldstein	Clarified several sections.
11	R.10.06	08/07/02	D. Mohr	Revised document to include Interference Workbook V5

RELATED DOCUMENTS

Interference Complaint Workbook (Excel Workbook): A set of data sheets to be used as described in this procedures document for tracking activity related to interference complaints and a set of tools for performing most of the calculations described in this document. For easy record-keeping, one workbook can be used for each complaint (or set of related complaints). It is recommended that descriptive file names be used (*e.g.* **Fairfax County PD workbook updated 3-1-02.xls**)

ATTACHMENTS TO THIS DOCUMENT

ADDITIONAL REFERENCES

TIA/EIA-603-A (Revision of TIA/EIA-603), "Land Mobile FM or PM Communications Equipment Measurement and Performance Standards", August 2001

A. INITIAL RESPONSE

1. After receiving a complaint, **call the complainant back within 1 day**. Assure them that Nextel is concerned about the interference problem and is interested in working with the complainant to resolve it. Obtain from them the information shown on the **Initial Response** tab of the Interference Complaint Workbook available on the NHQ Public Safety Web Page. Request a meeting to observe the interference and get some details. Ask for the contact information of a technical point of contact (POC) who will work with Nextel on examining and testing the problem.

2. Notify NHQ RF Engineering, Corporate Strategy, and Government Affairs of the complaint immediately after talking to the complainant by sending e-mail to the public safety mailbox (publicsafety@nextel.com). Attach the Interference Complaint Workbook with the filled-out **Initial Response** tab to the e-mail.

If the call is urgent, escalated from an earlier complaint, or from an FCC staffer, follow the e-mail with a telephone call (numbers are listed in Appendix 1). Do NOT use a telephone call as a substitute for the e-mail. Do NOT leave only one voice mail; if the situation is urgent enough to require a telephone call, then it is urgent enough to continue calling both an employee's desk phone and mobile phone if necessary, until a person answers the telephone.

3. Contact the complainant's technical POC on the telephone. Advise them of the conversation with the complainant and schedule the on-site meeting. Advise the technical POC that you are sending them the **Affected System** tab and ask them to fill it out if they have not done so previously on another complaint. Ask them to return this to you before the meeting if possible via e-mail (you will need that data for the initial meeting). If they do not have e-mail, obtain a fax number, print the tab, fax it to them, and ask them to send it back to you via fax.

Require the technical POC to bring an affected radio to the test session with the affected frequencies programmed as **conventional (non-trunked) channels**. Explain to him that this will allow you and him to evaluate the interference on a frequency-by-frequency basis in the field.

4. Prepare for the meeting with the technical POC as follows:

a. Gather the following measurement equipment:

1. Spectrum analyzer with mobile power cord or inverter
2. Mobile antenna (make note of the antenna gain; this will be needed in later analysis)
3. Step attenuator
4. Cables and adapters as required (spares are useful here)

b. Analyze the location in question and determine the closest Nextel site(s) that could be contributing to the problem.

c. Complete the Interference Complaint Workbook up through **Nextel Site Data** tab.

d. Examine the Nextel and complainant's frequencies. If this is a suspected co-channel interference problem, do the following:

1. IF NEXTEL IS TRANSMITTING ON THE CO-CHANNEL, TURN OFF THE OFFENDING BR IMMEDIATELY AND ***LEAVE IT OFF UNTIL THE ISSUE IS RESOLVED***. Send a message to publicsafety@nextel.com identifying the issue and asking for Legal Department help in resolution.
2. If Nextel is not transmitting on the co-channel, it is possible that another SMR operator is, in which case notify the complainant immediately. Send a message to publicsafety@nextel.com identifying the issue.

If this is a suspected adjacent channel problem, do the following:

1. If a Nextel BR (or BRs) is transmitting on one (or both) of the adjacent channels, attempt to retune the BR (or BRs). If this is not possible, turn of the offending BR (or BRs) until another solution is determined. In either case, send a message to publicsafety@nextel.com identifying the issue, and request for possible Engineering Department help in resolution.
2. If Nextel is not transmitting on either of the adjacent channels, it is possible that another operator is, in which case notify the complainant immediately. Send a message to publicsafety@nextel.com identifying the issue.

e. Run an IM study on the site to determine the frequencies of IM products that could fall in the receive band. Presence of IM products falling in the receive band is a good indication that there may be lower-order products falling in the transmit band as well.

f. Request that the Nextel site(s) be inspected to check for the following:

1. Any open maintenance items.
2. Combiner schemes installed as documented, and BR transmitter power levels are at appropriate settings
3. There is a duplexer or bandpass filter in line between each transmitter and its associated antenna (this step seems obvious, but check anyway)
4. There are no IM products from the transmitters that are falling in the mobile receive band (check this by attaching a spectrum analyzer to the receiver multicoupler and looking on frequencies projected in (e))

If the site is not ready for the test session, delay it until the site is ready.

B. INITIAL MEETING

5. Go to the test session. At the test session do the following:

a. Measure and record in the **Initial Meeting-Nextel** tab of the Interference Complaint Workbook the strength and the resolution bandwidth (RBW) setting used of the Nextel signals in the area. Be sure to take multiple measurements of signals from all 3 sectors. Insert attenuation in the line as required to ensure that the analyzer is not overloaded.

b. Measure and record in the **Initial Meeting-Complainant** tab of the Interference Complaint Workbook the strength and RBW setting used of the complainant's signal at multiple locations around the Nextel site, taking care to pick locations where the Nextel signal does not overload the analyzer (*i.e. are* below –50 dBm). Average these readings to arrive at an average complainant signal level. Measure as many of the complainant's signals as possible. Insert attenuation in the line as required to ensure that the analyzer is not being overloaded.

Listen to each of the complainant's frequencies with the radio that is configured for non-trunked operation. Evaluate what you hear:

1. Is the reception noisy or broken up?
2. Can you understand what is being said without difficulty, or would you have to ask for the transmission to be repeated?
3. What else do you hear besides the desired signal (lots of noise, sounds like a buzz saw, etc.)?

Record these evaluations in the **Initial Meeting-Complainant** tab of the Interference Complaint Workbook as Delivered Audio Quality.

c. Measure and record in the **Initial Meeting-Others** tab of the Interference Complaint Workbook the strength, center frequencies, the RBW setting used, and bandwidths of other signals (*i.e.* non-Nextel and non-complainant) in the 851-894 MHz range. Insert attenuation in the line as required to ensure that the analyzer is not being overloaded.

If any of these signals are above about -50 dBm then the carriers for those signals MUST be brought into the mitigation activity **by the technical POC**. Explain this to the technical POC and require the other carriers be brought into the solution.

d. **IMPORTANT NOTE**. If the resolution bandwidth (RBW) is adjustable on the spectrum analyzer, use a RBW less than or equal to the bandwidth for the type of signals being measured. Remember that measurements must be normalized to the channel bandwidth of interest.

1. **Agilent (HP) ESA series spectrum analyzers**. For all models, the RBW can be set to $M \times 10^N$ Hz, where M={1, 3} and N={3, 4, 5, 6}. If Option 1DR is installed, N={1, 2, ..., 6}. If Option 1D5 is installed (requires Option 1DR), N={0, 1, ..., 6}.
2. **Motorola R-2660 service monitors**. There are two RBW settings: narrowband (10 kHz) and wideband (200 kHz).
3. **Other models of spectrum analyzers**. Check with the product manual or spec sheet for available RBW settings.

The following table indicates some suggested RBW settings for different channel types to be measured.

	Suggested Resolution Bandwidth					
Channel Type	**3 kHz[1]**	**10 kHz[1,2]**	**30 kHz[1]**	**100 kHz[1]**	**200 kHz[2]**	**300 kHz[1]**
IDEN, Public Safety, SMR	✓	✓				
AMPS, TDMA	✓	✓	✓			
GSM	✓	✓	✓	✓	✓	
CDMA	✓	✓	✓	✓	✓	✓
[1] – Agilent (HP) ESA series spectrum analyzer						

[2] – Motorola R-2660 service monitor

C. DATA EVALUATION

6. In order to perform a valid comparison of average received power of carriers with 25 kHz channel bandwidths and those without (*e.g. cellular*), the average received power of the non-25kHz channels (P_r, in dBm) must be normalized to a 25 kHz channel average received power (P_{25}, in dBm) as follows:

$$P_{25} = P_r - 10\log_{10}\left(\frac{BW_r}{25}\right) \text{ where}$$

BW_r = channel bandwidth of the received carrier, in kHz

7. Do an IM study using the Interference Complaint Workbook and CommSite Pro on all the frequencies at the site, examining those products and levels that are created on or adjacent to the desired channel(s). Get 3rd-order products first. Use the IM Hitlist Summary report in CommSite Pro to rank the contributors by determining which ones contribute to the most products. This is the most severe cause of interference after co-channel interference, **but may not be the entire cause of the problem.**

8. The Interference Complaint Workbook uses the measured signal strength (not the normalized power, since the power spectrum of the IM product is a function of the occupied bandwidths of the contributors) of each carrier to quantify the level of the IM products (P_{im}, in dBm) formed as follows:

a. For two-carrier, 3rd-order products (these products take the form 2**a**-**b**):

$$P_{im} = 2(P_a + AG) + (P_b + AG) - 3(IMR + RS) + (RS - CN_s) \text{ where}$$

P_a = measured signal strength of the contributor in the 2nd harmonic (2**a**) term, in dBm
P_b = measured signal strength of the contributor in the 1st fundamental (**b**) term, in dBm
AG = antenna gain and feed line loss, in dB (assume -4 if no data is available)
IMR = IM rejection spec of the receiver, in dB
RS = reference sensitivity of the receiver, in dBm
CN_S = static carrier-to-noise ratio of the receiver, in dB (typically 4 or 5)

b. For three-carrier, 3rd-order products (these products take the form **a**+**b**-**c**):

$$P_{im} = (P_a + AG) + (P_b + AG) + (P_c + AG) - 3(IMR + RS) + (RS - CN_s) + 6 \text{ where}$$

P_a = measured signal strength of the contributor in the fundamental **a** term, in dBm
P_b = measured signal strength of the contributor in the fundamental **b** term, in dBm
P_c = measured signal strength of the contributor in the fundamental **c** term, in dBm
AG = antenna gain and feed line loss, in dB (assume -4 if no data is available)
IMR = IM rejection spec of the receiver, in dB
RS = reference sensitivity of the receiver, in dBm

CN_S = static carrier-to-noise ratio of the receiver, in dB (typically 4 or 5)

c. The Interference Complaint Workbook adds up the total composite power delivered to each of the complainant's frequencies from all the products. Note that the power spectral density of an IM product is a function of the bandwidth and amplitude of its contributors, so adding the power of multiple products and normalizing the interfering power to the desired channel bandwidth may be challenging. However, the formulas above are useful for understanding the mechanism behind IM interference.

9. Use the Interference Complaint Workbook to calculate the estimated power of aggregate noise from all Nextel BRs (P_{nn}, in dBm) by using the measured average power of each individual i^{th} BR from Step 5a (P_{ni}, in dBm) and the following equation:

$$P_{nn} = 10\log_{10}\left[\sum_{i=1}^{x} 10^{\frac{(P_{ni}-70)}{10}}\right] \quad \text{where}$$

x = total number of BRs

10. Use the Interference Complaint Workbook to calculate the adequacy of the complainant's signal in the area of interference (CN_0, in dB) using the following formula:

$CN_0 = (P_c + AG) - (RS - CN_S)$ where

P_c = average power of complainant signal in area with Nextel BRs turned off, in dBm
AG = antenna gain and feed line loss, in dB (assume -4 if no data is available)
RS = reference sensitivity of receiver, in dBm
CN_S = static carrier-to-noise ratio of the receiver, in dB (typically 4 or 5)

Remember that P_c is to be an average of multiple measurements taken at several discrete locations around the problem area, **not a single measurement with a spectrum analyzer**.

Assuming FM modulation, if CN_0 is less than approximately 17 dB, there is insufficient complainant signal in the area of interference to provide reliable operation, even with the Nextel equipment turned off. If the system uses digital modulation, the minimum required carrier-to-noise ratio for that modulation scheme will have to be obtained from the manufacturer.

11. Use the Interference Complaint Workbook to calculate the estimated power of aggregate noise from all other non-Nextel and non-complainant transmitters (P_{no}, in dBm) by using the measured average power of each individual j^{th} transmitter from Step 5c (P_{oj}, in dBm) and the following equation (remember to normalize the power as needed):

$$P_{no} = 10\log_{10}\left[\sum_{j=1}^{x} 10^{\frac{(P_{oj}-A_{oobj})}{10}}\right] \quad \text{where}$$

x = total number of transmitters

A_{oobj} is the out-of-band attenuation of each j^{th} transmitter, in dB. This figure represents the level of wideband noise in relation to the transmitted on-channel power. The FCC required attenuation for cellular systems is 60 dBc. Note that this approach may overstate the level of wideband noise since (a) actual transmitter performance may exceed the FCC requirement and (b) for cellular systems, actual power outside the cellular band is also a function of duplexer / filter rolloff. **To most accurately determine the aggregate noise power for cellular systems, obtain the duplexer / filter rolloff for the cellular system in question at the target frequencies.**

12. Use the Interference Complaint Workbook to calculate the estimated total power of spurious responses due to all unwanted signals (P_{st}, in dBm) by using the measured average power of each k^{th} BR/transmitter from Step 5 (P_{uk}, in dBm) and the following equation (remember to normalize the power as needed):

$$P_{st} = 10\log_{10}\left[\sum_{k=1}^{x} 10^{\frac{(P_{uk}-SRR)}{10}}\right] \text{ where}$$

x = total number of BRs/transmitters
SRR = spurious response rejection of the receiver, in dB

Note that this approach assumes every undesired signal triggers a spurious response across the desired spectrum, at a power level equal to the RSSI of each undesired channel minus the spurious response rejection figure. **This is more conservative than is typically the case, unless the potential contributors are less than 500 kHz away from the target frequency.**

13. Use the Interference Complaint Workbook to calculate the carrier-to-noise ratios (in dB) due to each interference mechanism by using the previously measured and calculated values and the following formulas:

$CN_{im} = P_c - P_{im}$
$CN_{nn} = P_c - P_{nn}$
$CN_{no} = P_c - P_{no}$
$CN_{nt} = P_c - (P_{nn} + P_{no})$ [remember to convert to watts or milliwatts before adding]
$CN_{st} = P_c - P_{st}$

Calculate these for co-channel as well as adjacent channel. (Remember to apply adjacent channel rejection for adjacent channel calculations.) If CN_{im}, CN_{nn}, CN_{no}, CN_{nt}, or CN_{st} is less than the required carrier-to-noise ratio for the type of modulation being used by the complainant (*e.g.* 17 dB for FM), then that interference mechanism may be the source of interference. **Note that problems with IM interference can mask problems with interference from noise.**

14. Review the data gathered to this point, develop hypotheses as to the cause(s) of interference, and select possible courses of action to follow to mitigate the interference. A typical scenario could be that the carrier-to-noise ratio from IM is less than 17 dB AND simultaneously the total aggregate noise from Nextel and the A-band carrier reduces the aggregate carrier-to-noise ratio in the absence of IM to below 17 dB as well. It may also be possible that on-channel carrier-to-noise is acceptable, but strong IM products on an adjacent channel are affecting receiver performance. The next round of testing will put these hypotheses to the test.

Contact the technical POC and request to arrange a follow-up test session **to include all suspect carriers.** The test session should occur during the maintenance window as transmitters will need to be turned off.

D. ON/OFF TESTS

15. A series of on/off tests must be conducted in the manner described as follows.

a. With all BRs at the site turned off or de-keyed and with all other licensees' transmitters disabled or de-keyed make multiple signal strength measurements in the area immediately around the complaint area, measuring the average signal strength of as many of the complainant's signals that are being interfered with as possible. Ask the complainant to ensure that they are keyed up. This will capture the effects of clutter and potential problems at the complainant's site on the complainant's signals better than a stationary measurement with a spectrum analyzer. Use one of the complainant's conventionally programmed radios to do an assessment of the complainant's radio system at the site, including ability to access the system and audio quality.

With each licensee's transmitters keyed up in turn, make multiple signal strength measurements in the area immediately around the complaint area, measuring the average signal strength of as many of the complainant's signals that are being interfered with as possible. As with the previous test ask the complainant to ensure that they are keyed up. This will capture the effects of clutter and potential problems at the complainant's site on the complainant's signals better than a stationary measurement with a spectrum analyzer. Use one of the complainant's conventionally programmed radios to do an assessment of the complainant's radio system at the site, including ability to access the system and audio quality.

Continue the measurements and assessments in this manner until all combinations of licensee's transmitters are keyed up. The number of combinations will be 2^n, where n is the number of licensees (excluding any public safety licensees, because public safety systems will never be turned off).

b. Repeat the process from Step 15a, only this time the hypotheses from Step 13 will be tested. For example, if it is believed that specific transmitters are creating IM products, ask the contributors to de-key only those suspected transmitters during this round of on/off testing.

c. As an outcome of Step 15b, note the results of the testing and recommended mitigation actions on the **On-Off Testing** tab of the Interference Complaint Workbook. Email this to publicsafety@nextel.com.

E. SHORT-TERM MITIGATION

The techniques used for short-term mitigation and long-term correction (discussed in the next section) of an interference problem may well be different. The following rules MUST be adhered to WITHOUT EXCEPTION:

a. **If there are multiple instances of interference all locations need to be analyzed for other carrier's contribution(s) before any mitigation is implemented.**

b. **All mitigation recommendations need to be analyzed to determine the impact on Nextel's service (blocks and/or drops).**

Additionally, for each change undertaken it is important to:

a. CHANGE ONLY ONE THING AT A TIME in order to properly identify what, if anything, corrected the problem. It is likely that several iterations of mitigation testing and evaluation will be required.

b. DOCUMENT the change made.

c. TAKE DATA to document the results of the change.

IM-based interference. If the interference is caused by IM products generated in the complainant's receiver, there is no filter that can be installed at the contributor's transmitter to remove the problem. The only solutions available to correct this kind of problem are to (a) change the frequencies of the contributors, (b) reduce their power to the point that the IM products formed do not decrease the required carrier-to-noise ratio for the complainant's system below the required minimum, or (c) increase the complainant's signal level.

Noise-based interference. If the interference is caused by residual noise from the Nextel transmitters, it can be coped with by (a) filtering the products or (b) raising the complainant's signal level in the area. **The user MUST be certain that there are no IM-based issues left to deal with before going after noise-based interference, because the changes that improve noise-based interference will do little or nothing to correct IM-based interference.**

The chart below summarizes the appropriate techniques that may be used to mitigate the aforementioned types of interference. These may be used as short-term mitigation measures to resolve acute instances of interference, but may not be useful as long-term mitigation techniques. A discussion of each action follows.

Short-Term Mitigation Technique	Interference Mechanism			
	IM-based	Adj Chan	WB Noise	Spurious
a. RETUNE THE SITE	✓	✓[1,2]		
b. REDUCE POWER	✓	✓[2]	✓	✓
c. REORIENT ANTENNAS	✓	✓[2]	✓	✓
d. REPLACE ANTENNAS	✓	✓[2]	✓	✓
e. CHANGE COMBINERS			✓	
f. BANDSTOP FILTERS			✓	✓
g. TURN OFF BRs	✓	✓[1,2]	✓	✓
h. RAISE COMPLAINANT'S SIGNAL LEVEL	✓	✓[2]	✓	✓
i. PULL ANTENNAS FROM ROOF EDGE	✓	✓[2]		

[1] – Applicable to transmitted adjacent channel issues
[2] – Applicable to IM products formed on adjacent channels

a. RETUNE THE SITE. If the site can be retuned to be IM-free in the complainant's system, this is an effective short-term mitigation approach because no other changes to the site are required. Care must be taken, however, if there are other systems like the complainant's system in the area, because the retuning process may cause IM products to be created on one of the other systems' frequencies instead of the complainant's system.

b. REDUCE POWER. This is also an effective short-term method to reduce acute IM-based interference, because the strength of the IM products goes down 3 dB for every 1 dB reduction in the contributor levels. A 3 dB change may make the difference between a completely non-functional complainant radio and one that functions at least reasonably well. For noise-based interference, if the amount of improvement required is small, a reduction in power may be sufficient to accomplish the needed reduction.

c. REORIENT ANTENNAS. Repositioning (*e.g.* raising the radiation center) or reorienting antennas (*e.g.,* reducing downtilt) may decrease the RF level at the interference location without adverse effects to the Nextel network. This should be undertaken only after study to ensure that co-channel interference to other Nextel sites is not raised to an adverse level.

d. REPLACE ANTENNAS. Replacing antennas with equipment having narrower vertical beamwidths can help mitigate near-field interference. Replacing antennas with equipment that DOES NOT incorporate null fill may also help reduce near-field interference by reducing the near-field on-ground signal level. In some cases, there has been some success with inverting the existing antennas (however, be cognizant of the location of drainage holes to prevent the antennas from filling with water).

e. CHANGE COMBINERS. Replacing hybrid combiners with Autotune cavity combiners (ATCs) will reduce out-of-band emissions to some extent. Study is required, however, to verify that (a) the additional sideband noise reduction offered by the ATC is sufficient to solve the interference problem and (b) the additional frequency spread at the site does not create new IM issues. **It is vital that if hybrid combiners are replaced with ATCs that the BR powers be readjusted downward to compensate for the reduced combining losses.**

f. BANDSTOP FILTERS. Some work has been done on a bandstop filter for the 866-869 MHz range to work in conjunction with an ATC. These filters will provide an additional 20 dB rejection in the range 866-869 MHz, which may be enough to solve the interference problem without other effort. This filter is not suitable for use with a hybrid combiner.

g. TURN OFF BRs. This immediately reduces the number of possible IM products, reduces out-of-band noise power, and reduces consumed electricity at the site for both direct BR support and for HVAC support. However, this solution is of very limited utility in a noise-based problem, since the aggregate noise decreases as $10*\log_{10}n$, where n is the number of BRs present.

h. RAISE COMPLAINANT'S SIGNAL LEVEL. It may be possible to raise the complainant's signal level in the area either by modifying its original site or by adding either a unidirectional amplifier with donor and contributor antennas at the Nextel site or adding another complete public safety transmitter site. The practicality of these options may vary largely depending on the affected public safety provider's financial and technical resources and the design of the system (e.g. implementing a unidirectional amplifier can result in new interference issues further from the site in question). One must also consider the large increase in signal level required to guarantee an adequate carrier-to-noise ratio as the IM products grow. However, if no other solution can be found, such an arrangement may have to be implemented. Since modifications to the complainant's system or adding a unidirectional amplifier outside an enclosed area may affect FCC filings for the system, consult Government Affairs and the Legal Department for assistance first.

i. PULL ANTENNAS FROM ROOF EDGE. In some cases for rooftop sites it may be possible to mount antennas closer in towards the center of the roof, along a windwall or penthouse, etc. This reduces the amount of RF energy radiated on the street in an area immediately around the site, while not impacting the overall coverage objective of the site. Depending on where the antennas are mounted, an RF emissions study may need to be performed, and the Compliance Department should be notified first.

F. LONG-TERM RESOLUTION

Long-term correction of an interference problem is generally more complex than simple short-term mitigation. This is because:

a. The number of Nextel sites involved is usually larger

b. The willingness of the complainant to accept a less-than-adequate solution usually extends for only a brief period of time.

c. Infrastructure changes usually have to reflect not only the complainant but, if the complainant is a public-safety agency, similar agencies in adjacent jurisdictions.

d. The long-term correction should be proactive (to cover Nextel's future requirements) rather than reactive (to cover today's problem).

Nextel has proposed a long-term interference mitigation plan to the FCC. On November 21, 2001, Nextel submitted a "White Paper" which proposed a realignment of the 800 MHz band to remove the interleaving of public safety providers and other incumbents from CMRS providers, including Nextel. In February 2002, the FCC released a Notice of Proposed Rulemaking ("NPRM") to address Nextel's proposal and others that had been submitted for consideration. Nextel and various members of the wireless industry have filed comments in that proceeding which remains pending. Nextel believes that 800 MHz realignment is the essential step to long-term resolution of interference. Therefore, any proposed long-term solution that could be implemented prior to an FCC decision must be justified and submitted to the NHQ.

Appendix 1: NHQ Interference Contacts
Nextel Communications
How to Respond to Reports of Interference
R.10.06 / August 20, 2002

James Goldstein, Senior Attorney
Government Affairs POC for Interference issues
Main: 703-433-4000
Direct: 703-433-4212

Robert McNamara, Senior Counsel-Regulatory
Legal Department POC for interference Issues
Main: 703-433-4000
Direct: 703-433-4222

Len Cascioli, Vice President, RF Engineering
Engineering Department POC for Interference issues
Main: 703-433-4000
Direct: 703-433-8193

Sandy Edwards, Vice President, Public Safety
Corporate Strategy POC for Interference issues
Main:
Direct: 678-405-8442

Note: If the situation is such that a phone call is warranted, please make sure to speak with a live person. **Keep trying to reach the POC via desk phone and mobile phone until you make contact.**

Appendix 2: Background Information on Interference
Nextel Communications
How to Respond to Reports of Interference
R.10.06 / August 20, 2002

Nextel is becoming involved in an increasing number of interference issues. As the number of interference reports grows, Nextel is learning valuable new lessons to facilitate a quick and effective response to these reports. This memo provides an overview of the causes of interference and recommends procedures for handling all interference issues in the future.

It is most important that when interference issues of any kind arise they be quickly examined. For cases involving Public Safety entities, interference concerns should be resolved as quickly as possible. Critical to a resolution is the collaboration between local Nextel engineering, Nextel headquarters engineering and the Public Safety organization. In addition, communication to other Nextel entities will be a part of the resolution efforts, *e.g.* interference strategy managers, government affairs, government accounts, and public safety initiative communications personnel. Finally, collaboration with equipment manufacturers, other cellular carriers, public safety consultants and others may be required for a comprehensive resolution. Clearly, the problems of interference are too important and too complex for any one organization to solve alone.

There have been times when a public safety operator has escalated an interference issue to the Federal Communications Commission (FCC), the Association of Public Safety Communications Officials (APCO) and/or a local public safety coordinator. The escalation of these reports, generally an indication of the frustration experienced by the Public Safety entity, can bring undue attention to Nextel and increase the risk of Nextel's exposure to regulatory and other liabilities.

Your immediate action can begin the process for positive mitigation of interference problems. Particularly in cases involving Public Safety entities, disputes in the Canadian or Mexican border areas, and in cases where the FCC has become involved, your communication to the right parties at Nextel sets the framework for solutions. The POC will bring in other appropriate resources as necessary.

I. OVERVIEW OF FCC RULES GOVERNING INTERFERENCE

FCC rules in Part 90 govern Nextel's operations. Section 90.7 of the FCC's rules sets forth the definition of harmful interference: "For the purposes of resolving conflicts between stations operating under this part, any emission, radiation, or induction which specifically degrades, obstructs, or interrupts the service provided by such stations" is harmful interference. As you can see, this definition is drafted to include the broadest possible scope of all types of interference.

The common types of harmful interference are:

a. Co-channel interference — interference to a desired signal caused by another transmitter (usually licensed to another entity) on the same frequency as the desired signal. This type of interference is rare but does happen occasionally.

b. Adjacent channel interference — interference to a desired signal caused by another transmitter (usually licensed to another entity) on the frequency above or below the desired signal. This type of interference may be more common than co-channel interference, but receiver performance determines the severity of problems, if any, experienced by the receiver.

c. Intermodulation (IM) interference — interference to a desired signal caused by mixing of two or more transmitted signals other than the desired signal. If the mixing products fall on or close to the frequency of the desired signal, interference can occur. This mixing can take place in the transmitting infrastructure, some other piece of hardware or **in the affected receiver or receivers**. The fact that the mixing can take place outside the transmitter infrastructure means that the transmitters involved can be completely compliant with FCC regulations and can still be the source of an interference complaint. Intermodulation products of commercial signals forming in the front-end of public safety receivers is the dominant cause of CMRS-public safety interference in the 800 MHz band.

d. Wideband (WB) noise interference — interference to a desired signal caused by WB noise from a transmitter adding to the noise from other sources at an affected receiver or receivers to the point that the energy ratio between the desired signal and the cumulative noise (the signal-to-noise ratio) is no longer sufficient to allow the affected receiver or receivers to properly receive the desired signal. Because all transmitters generate WB noise, it is possible for a transmitter that is completely compliant with FCC regulations to still be a possible cause of WB noise interference to a receiver or receivers.

e. Spurious response interference — interference to a desired signal caused by an interfering transmitter or transmitters being "mapped" in the affected receiver or receivers to the frequency of the desired signal as a result of some unidentified component of the receiver. This is usually, but not always, caused by the phase noise of the receiver first local oscillator; where this is the case, it generally is a problem only if the contributor is within about 500 kHz of the target frequency..

f. Front-end overload interference — interference to a desired signal caused by a transmitter or transmitters overloading the first stage or stages (the "front end") of a receiver, causing them to fail to operate in a linear fashion. The transmitter or transmitters may be operating properly and may or may not be on channels adjacent to the receiver channel.

While there are specific FCC rule sections concerning co-channel interference, the FCC's rules do not specifically address the other types of interference. The following sections describe the FCC's rules and Nextel's procedures to resolve all of these types of interference issues.

In all cases of interference, it is vital to DOCUMENT the nature of the complaint as completely and accurately as possible using calibrated test equipment. In one complaint, the complainant indicated that the Nextel site "reduced the strength of the control channel" on a public-safety trunked radio system at a particular location. While this is physically impossible, Nextel was unable to refute the claim because no measurements had been made of the control channel signal strength at the interference location.

The "How to Respond to Reports of Interference" document is a general procedure for responding to interference complaints.

II. FCC INVESTIGATORS AND CONTACTS WITH LOCAL NEXTEL PERSONNEL

On occasion, representatives from the FCC's local Compliance and Information Bureau Offices contact Nextel's local field offices regarding an interference complaint. If you receive a call, a letter, or a visit from the FCC, call the Government Affairs or Legal Department POC listed in Appendix 1. The POC will help form our response.

III. CO-CHANNEL INTERFERENCE

Section 90.621(b) of the FCC's rules governs SMR operations and the use of co-channel facilities requiring compliance with certain co-channel separation distance criteria, such as distance, power and antenna height, for co-channel licensees. These factors are taken into account when Nextel applies for and licenses its facilities. The standard co-channel separation distance is 70 miles but could be as close as 55 miles under certain circumstances. On occasion parties have claimed Nextel or a competitor has placed facilities into operation, which violate the FCC's co-channel separation rules. As described below, these situations can typically be resolved quickly without FCC involvement. In summary, the FCC does not guarantee non-interference; it merely promulgates rules (such as the co-channel separation rules) which if followed predict non-interference. Thus, if Nextel operates its stations in compliance with their licensed parameters, it should remain safe from liability.

A. Procedures to Resolve Co-Channel Interference

Co-channel interference is usually a result of impermissible short-spacing between two co-channel stations. Once Nextel field personnel are made aware of such a licensing/operational conflict, typically through a phone call to Nextel, they must immediately bring it to the attention of the Government Affairs or Legal Department POC at the NHQ so they can quickly evaluate who has superior FCC rights to the subject channels. If necessary, the POC may ask the Nextel field office to mitigate the interference until a resolution can be reached. In these situations, acting promptly to mitigate the interference can reduce animosity towards Nextel and reduce the risk of litigation before the FCC.

Should a co-channel interference issue arise, make sure the following actions take place:

a. Contact the Legal Department POC. Be prepared to provide the call signs involved. The Legal Department POC will help determine whether the Nextel station is operating within its licensed parameters by comparing the actual coordinates, height and power values with the figures authorized for the call signs on the FCC database. They will also help determine whether the competitor's station is operating within its licensed parameters, again using the FCC database. Finally, they will determine whether both parties have primary interference protection on the channels.

b. Once a determination of "fault" is established, typically one party or the other must turn down its power or discontinue its use of the facilities immediately. In some cases, the Legal Department POC may recommend temporary discontinuance so more information can be gathered.

c. If the dispute can be resolved informally, the local market contact or the Legal Department POC can simply document this with an internal memo. Otherwise, the Legal Department may send the competitor a demand letter or notify the FCC.

d. If co-channel interference arises within 55 miles of FCC-defined regions along the Canadian and Mexican border, which require special frequency coordination, it is particularly important to contact the Legal Department POC because the dispute may trigger unique and complicated FCC licensing rules.

B. Nextel Must Continue to Maintain Accurate Licenses for Its Sites

An important consideration in co-channel interference disputes is the completeness and accuracy of the license Nextel holds for its facilities. It is important that licensing information for all Nextel sites be kept current, complete, and accurate.

IV. OTHER TYPES OF INTERFERENCE

Nextel has encountered five other types of interference, two of which have become significant challenges. As noted above, these are (a) adjacent channel interference, (b) IM interference, (c) WB noise interference, (d) spurious response interference and (e) receiver overload interference. Of these five, receiver overload is the LEAST significant. The following describes the nature of all five types of interference and provides guidance on how to resolve them.

A. Adjacent Channel Interference

The presence of a strong transmitted adjacent channel can interfere with a desired signal in two ways:

1. Insufficient roll-off of one or more receiver filters can allow adjacent channel energy to be "seen" by the receiver.
2. Insufficient roll-off of the adjacent channel signal can allow off-channel energy to "bleed" over into the desired channel.

In most cases, adjacent channel interference is only a serious problem when the desired signal level is low.

B. IM Interference

Any time two or more RF signals (*e.g.* Nextel transmitters) are present in or pass through a device that has a non-linear response to RF signals, the RF signals will be mixed together such that new signals (called intermodulation or IM products) are generated. The device generating the IM products can be a radio receiver, transmitter, amplifier, some other component or assembly, a connector, or even something as simple as a rusty bolt or fence. These IM products have four important characteristics:

1. The frequencies of the IM products generated in the device are mathematically related to those of the original RF signals but do not have to be the same. As a result it is

possible for transmitters operating properly on their assigned frequencies to contribute to an IM product that interferes with another service on a completely different frequency.

2. The strength of the IM products generated by a device is a function of the strengths of the original RF signals and the non-linear characteristics of the device.

3. **The IM products grow in strength <u>faster than the original signals do</u>**. If the original signals grow in strength by a factor of 2 (3 dB), the IM products may grow by a factor of 8 (9 dB), 32 (15 dB), or even some higher multiple of 2. This means that a small change in the strength of the original signals can mean the difference between an IM product that causes a problem to another service and one that does not.

4. **The bandwidth of the IM products is larger than the bandwidth of the original signals**. The IM product formed by two Nextel signals or two cellular signals can cause destructive interference to 3, 5, or even 7 or more adjacent channels.

The strength of a signal from a transmitter at a radio receiver is dependent in part on the distance between the receiver and the transmitter antenna. In the absence of other variables, the strength will double every time the distance between receiver and transmitter antenna is halved.

Putting all this together, IM interference typically becomes a problem for a CMRS carrier when radio receivers belonging to some other service, tuned to other frequencies, are operated close (100'- 250' or more) to CMRS sites. This problem is made worse when the CMRS site has a low radiation center because in this situation the receiver is located somewhere close to or in the main radiation lobe of the transmitting antenna and as such is receiving very strong signals from the CMRS site. The small distance between the receiver and the CMRS site means that a small change in distance between the two can cause a substantial change in the strength of the original signals in the receiver. This in turn can cause large changes in the strength of the IM products formed. Since the IM products can in turn affect multiple adjacent channels, a small change in distance from the CMRS site to the receiver can take the affected receiver from essentially no impact to complete impairment.

Repeated tests by Nextel and others both in the laboratory and in the field have shown that IM-related interference is the most likely mechanism for interference to 800 MHz public safety communications systems.

C. Wideband (WB) Noise Interference

All transmitters generate energy on frequencies other than the assigned frequency. This energy usually takes the form of random noise covering a wide band of frequencies (hence the name wideband noise). The wideband nature of the noise makes it likely that it will be present on the assigned frequencies of other services in the area. The FCC requires that this noise be attenuated below the strength of the signal on the assigned frequency by a substantial amount. Tests by Nextel and others indicates that the Nextel transmitting equipment outperforms the FCC requirement for attenuation of wideband noise (measured at approximately –70 dBc for a single BR). Even this amount of noise, however, can still cause interference to desired signals in a receiver if the receiver is located very close to a Nextel site and if the desired signal is weak.

D. Spurious Response Interference

Off-channel signals that are not related through intermodulation can still be "mapped" by phase noise in the first oscillator to resemble on-channel signals at a lower level. The spurious-response rejection specification indicates how much lower the worst-case on-channel responses will be. If this specification is insufficient (*e.g.* below –70 dB) and the potential interferers are strong, the responses can still be sufficient to interfere with a relatively weak desired signal. As noted earlier, this is usually but not always a function of impurities in the local oscillator signal, and is usually most significant if the contributor is within about 500 kHz of the target frequency.

E. Receiver Overload Interference

If the signals applied to a receiver are extremely strong, it is possible to overload the first stage or stages (the "front end") of a receiver, causing them to cease operating in a linear fashion. When this occurs, desired signals are not reproduced properly. The amount of signal necessary to produce this effect varies according to receiver design. Tests by Motorola and others have shown that this is very unlikely with receivers of modern design, occurring only when signal levels exceed approximately –10 dBm. This possibility should be considered only after IM and WB noise interference have been checked for and eliminated as possibilities.

Figure 1 shows the relationship between IM interference and WB noise interference at a typical Nextel site for a typical public-safety receiver (reference sensitivity –120 dBm, IM rejection specification 70 dB). The lower line indicates the maximum level of on-frequency interference for a given desired signal in the receiver (for this example, 17 dB in all cases). The other two lines show the maximum RSSI per BR power allowed at the receiver to not exceed the maximum allowable interference level for a given desired signal level. Note that at approximately –90 dBm the per-BR power required to produce a 3-carrier IM product at the maximum interference level becomes lower than that required to produce the same level of interference from BR noise only. The point of this chart is that at fairly low desired signal levels (for this example, about –90 dBm) IM products become the predominant concern from an interference-control standpoint.

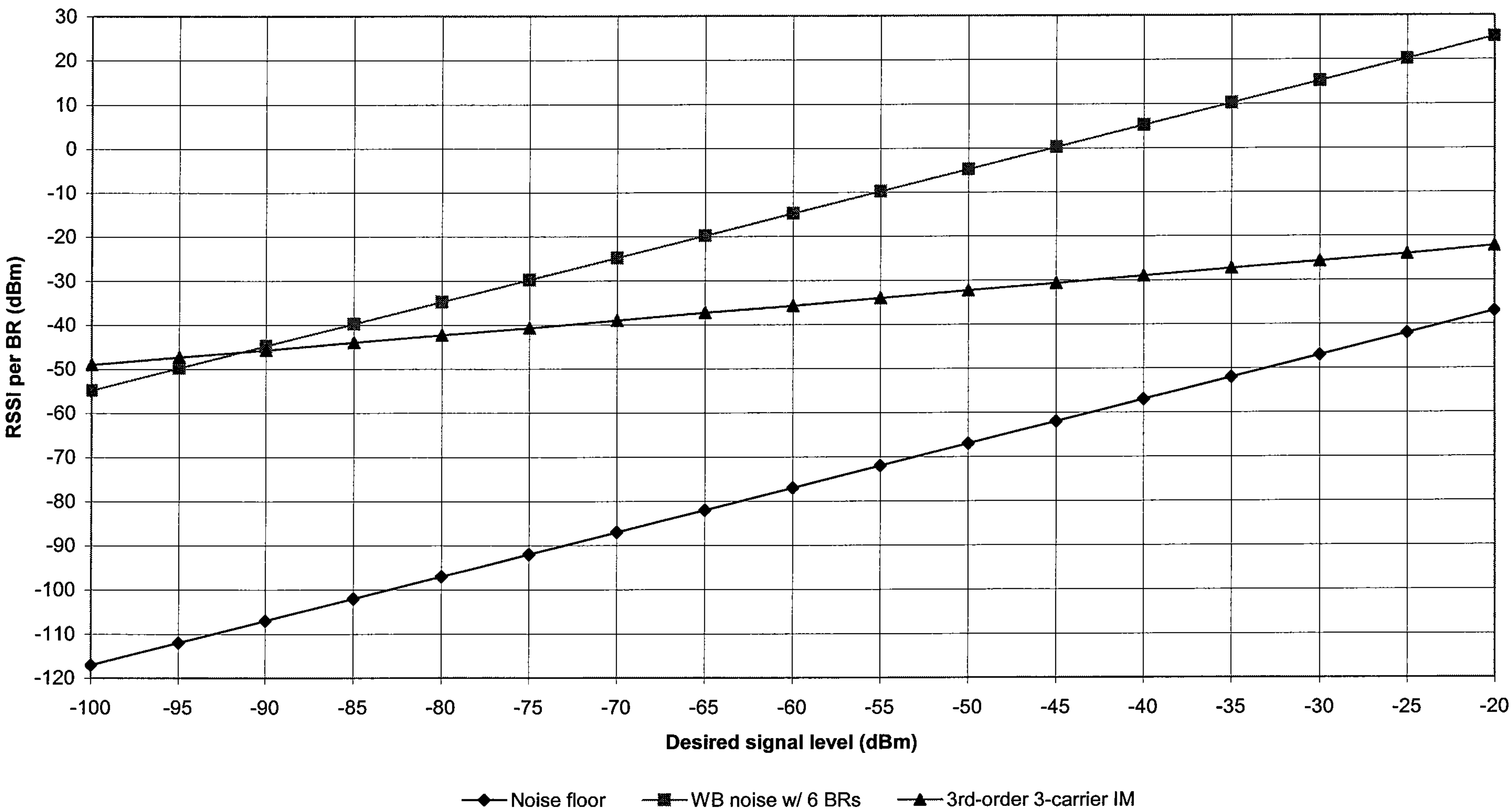
F. Procedures to Resolve Other Types of Interference

The "How to Respond to Reports of Interference" document outlines steps to follow to identify the source of and mitigate the types of interference discussed above. It is important to note that one mechanism of interference may mask another, so it is important to evaluate for all mechanisms of interference rather than assuming that one type or another is the only mechanism.

V. CONCLUSION

Nextel personnel must be made aware of the potential for interference problems and the menu of possible solutions. Therefore, please distribute this document and discuss it with your staff. In addition, the NHQ personnel listed in Appendix 1 are available to discuss any of the interference issues discussed.

Figure 1. Maximum RSSI for Interference Mechanisms @ 17 dB required C/N



Appendix 3: Summary of Interference Procedures
Nextel Communications
How to Respond to Reports of Interference
R.10.06 / April 24, 2002

Summary of Interference Procedures	Reference Section	Reference Pages
INITIAL RESPONSE		
After receiving the complaint, call the complainant back within 1 day. Request sufficient information for the **Initial Response** tab and a technical POC.	A1	3
Complete the **Initial Response** tab. Email the workbook to publicsafety@nextel.com.	A2	3
Contact the technical POC, request information for the **Affected System** tab, schedule an Initial Meeting.	A3	3
Prepare for the Initial Meeting: gather measurement gear, complete the **Nextel Site Data** tab, inspect Nextel sites, check datafill, determine if co-channel or adjacent channel is an issue.	A4	3-4
INITIAL MEETING		
Measure Nextel signals and record in the **Initial Meeting-Nextel** tab. Measure complainant signals, observe audio quality and record in the **Initial Meeting-Complainant** tab. Measure other carriers signals and record in the **Initial Meeting-Others** tab. Email the workbook to publicsafety@nextel.com.	B5	4-5
DATA EVALUATION		
Do an IM study on all frequencies found at the problem site, and determine composite power of IM products.	C7-C8	6-7
Calculate C/N on the complainant's signal: in the absence of noise; due to Nextel wideband noise; due to wideband noise of other carriers; due to spurious responses; due to intermod.	C9-C13	7-8
Based on analysis, determine possible solutions to the problem. Contact the technical POC and schedule On/Off Test to include all carriers involved.	C14	8-9
ON/OFF TESTS		
Do on/off tests for the system as is, then with the proposed fixes. Observe complainant's audio quality the whole time. Record the results on the **On-Off Testing** tab. Email the workbook to publicsafety@nextel.com.	D15	9
MITIGATION	E	9-12
LONG-TERM RESOLUTION	F	12

The example in this Appendix follows the methodology for Data Analysis as presented in the "How to Respond to Reports of Interference" document. This is a simplified example intended to be easy to follow and comprehend. However, it should be understood that some, if not most, cases of interference in real life will be more complex.

Complainant Receiver Data

The affected receiver for this example is the Motorola MTS-2000 portable. The published specs for the 800 MHz model are as follows:

Receiver Sensitivity	-118 dBm
Intermodulation Rejection	72 dB
Adjacent Channel Rejection	72 dB
Spurious Response Rejection	78 dB
Required C/N	17 dB

Additionally, a static C/N figure of 5 dB and an antenna gain / line loss of -4 dB shall be assumed. The average measured signal level of the complainant's affected control channel (860.3875 MHz) in the problem area is -80 dBm.

From these values, the C/N ratio of the complainant's signal in the absence of external noise (CN_0) can be determined. Using the equation in Step 10 (pg. 7) CN_0 is calculated to be 39 dB. Since the required C/N is 17 dB, CN_0 is not an issue.

Nextel Site Data

The problem area for this example is a major street intersection in the coverage area of Sector 1 of a nearby 3-sector Nextel site. The site has 4 BRs per sector going through a hybrid combiner. There is a dedicated transmit antenna for each sector so no duplexers are present. The frequency plan for the site is as follows:

Sector 1	BR 1	864.7375 MHz
	BR 2	861.1375 MHz
	BR 3	861.3375 MHz
	BR 4	851.5625 MHz
Sector 2	BR 1	865.4625 MHz
	BR 2	864.5875 MHz
	BR 3	863.9125 MHz
	BR 4	859.5625 MHz
Sector 3	BR 1	864.5125 MHz
	BR 2	864.8875 MHz
	BR 3	862.9625 MHz
	BR 4	861.1625 MHz

Note there are no co-channels or adjacent channels as possible interferers to the complainant's control channel. However, this does not exclude the possibility of IM products being created on an adjacent channel.

The average measured RSSI in the problem area is -30 dBm for Sector 1 BRs and -35 dBm for Sector 2 and Sector 3 BRs. For this example, there are no cellular sites within 1 mile of the problem area, so none will be considered as possible interferers.

IM Study

Running an intermod study of the 12 BRs shows that three third-order IM products may be produced on-channel in the receiver as follows:

$$864.7375 - 863.9125 + 859.5625 = 860.3875$$
$$861.3375 - 865.4625 + 864.5125 = 860.3875$$
$$861.3375 - 863.9125 + 862.9625 = 860.3875$$

Note that one BR from every sector is a contributor to each product. Also note that 861.3375 MHz (Sector 1, BR 3) is a contributor to the second and third products above, and 863.9125 MHz (Sector 2, BR 3) is a contributor to the first and third products above. This is significant because during the On/Off Testing phase these 2 BRs can be turned off (eliminating all on-channel intermod products from being formed) to test for intermod as an interference mechanism. Also, if intermod is indeed determined to be an interference mechanism, this is a short-term mitigation technique which may be applied until those BRs can be retuned.

Using the equation in Step 8b (pg. 6), P_{im} for each product is calculated to be -91 dBm. Summing the power of the three products (in watts or milliwatts) reveals a composite IM power of -86.2 dBm. The C/N ratio due to intermod (CN_{im}) is thus 6.2 dB so intermod must be considered an interference mechanism.

Because CN_{im} is about 10.8 dB below the required C/N ratio, and because the power of IM products increases 3 dB for every 1 dB increase in power of each contributor, then reducing the power of the contributors by 3.6 dB may be considered as an On/Off Testing and mitigation technique (as is increasing the power of the complainant's signal by 10.8 dB, or some combination of the two, of course).

Wideband Noise

Using the equation in Step 9 (pg. 7), the composite power of wideband noise from the Nextel BRs (P_{nn}) is calculated to be -91.9 dBm. The C/N ratio due to wideband noise from Nextel BRs (CN_{nn}) is thus 11.9 dB so wideband noise must be considered an interference mechanism.

Because CN_{nn} is about 5.1 dB below the required C/N ratio, reducing the power of all BRs by about 5.1 dB may be considered as an On/Off Testing and mitigation technique (as is increasing the power of the complainant's signal by 5.1 dB, or some combination of the two, of course).

Spurious Responses

Using the equation in Step 12 (pg. 8), the composite power of spurious responses generated in the receiver (P_{st}) is calculated to be -99.9 dBm. The C/N ratio due to spurious responses (CN_{st}) is thus 19.9 dB so spurious responses should not be a significant interference mechanism. Note that this is the worst-case composite; typical responses would be lower.