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December 21, 2001

Via Hand Delivery
Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: *Ex Parte* Presentation
IB Docket No. 95-91

Dear Ms. Salas:

XM Radio Inc. hereby files the attached technical response to a November 2, 2001 joint submission from various Wireless Communications Services ("WCS") licensees concerning alleged interference from DARS repeaters. *See* Letter from BeamReach Networks, Inc., BellSouth Corporation, Verizon Wireless, and Wordcom to Ms. Magalie Roman Salas, FCC, IB Docket No. 95-91 (Nov. 2, 2001).

Please direct any questions regarding this matter to the undersigned.

Very truly yours,

David S. Konczal

cc: Saj Durrani
Bob Eckert
Bruce Franca
Julius Knapp
Ronald Netro
John J. O'Connor
Bruno Pattan
Rockie Patterson
Ronald Repasi
Randall Schwartz, BeamReach
Karen Possner, BellSouth
Donald Brittingham, Verizon Wireless
Mary N. O'Connor, Worldcom

2300 N Street, NW Washington, DC 20037-1128 | 202.663.8000 Fax: 202.663.8007 | www.shawpittman.com | Washington, DC
Northern Virginia
New York
Los Angeles
London

Reply to WCS Parties' November 2, 2001 Ex Parte Filing

On November 2, 2001, the WCS Parties (BeamReach Networks, Inc., BellSouth Corporation, Verizon Wireless, Inc., and WorldCom, Inc.) submitted a set of three technical analyses that purport to demonstrate that RF AGC will not prevent overload and intermodulation (IM) interference from SDARS repeaters to WCS customer premise equipment (CPE). As discussed below, the WCS Parties analyses are based on significant errors that dramatically overstate the potential for interference between SDARS and WCS. The analysis below provides additional evidence supporting XM's position that RF AGC is a cost effective solution available to the WCS entities to mitigate the potential for SDARS interference at the CPE.

The two critical errors in the WCS Parties analyses are:

- making unrealistically worst-case and asymmetrical assumptions concerning the propagation characteristics of the SDARS and WCS systems

- using an IM threshold of –60 dBm instead of –40dBm (resulting in a power gap of 20 dB instead of a more accurate 40 dB)

When these two sets of errors are corrected, it is evident that even in the most extreme cases presented by the WCS Parties analyses, the use of front-end RF AGC will be sufficient to protect WCS CPE from both overload and IM interference.

Propagation characteristics. In each of the three studies presented, the WCS Parties used propagation parameters that are unrealistic or inaccurate and have the effect of radically skewing the results.

In the first of the three studies presented (BellSouth Study I), the stated assumptions include a line-of-sight propagation constant of 2 for the SDARS signal and a non-line-of-sight propagation constant of 3 for the WCS signal. In addition, a fade margin of 10 dB was added for the WCS signal but not for the line-of-sight SDARS signal. This theoretical exercise has no relationship to a real world situation at the distances analyzed. WCS Parties, p. 16.

In the second study (BellSouth Study II), the analysis arbitrarily assigned a 10 dB confidence factor to the WCS signal source and a 0 dB confidence factor to the SDARS signal source. This effectively adds 10dB to the required WCS signal in the model. While it is normal to include a confidence factor in a system coverage analysis, to apply this factor to the desired signal and not the interfering signal dramatically increases the number of interference bins flagged. However, the probability that actual interference will be found in any flagged bin is extremely low. It is important to remember that the intermodulation interference threshold itself is already set very low at 6 dB below the receiver noise threshold. The analysis also assigns a 99% time variability factor to the WCS signal source and only a 50% factor to the SDARS signal source. (Some of this

may have been based on a mistaken reading of the SDARS repeater antenna height; the analysis apparently misread the repeater antenna heights as being in meters rather than feet.) The difference in variability tells the simulation program that a higher signal level is required to receive the WCS signal than the XM signal.[1] The analysis also models the XM antenna height at 1750 feet AGL, some 1150 feet higher than indicated in the STA.

BellSouth Study II also uses a WCS base station transmit power of only 2 watts, far less than the 2 kW that is permitted in the WCS rules. While this design criteria is within the WCS licensee's discretion as it designs its system and has the effect of increasing the power differential between WCS and SDARS, the analysis we present herein does not rely on any increase in WCS base station transmit power, even though the use of a 2 KW Base Station would narrow the differential by a further 30 dB. In other words, our analysis shows that, even using the parameter of WCS base stations operating at 2 watts, the use of RF AGC is effective to eliminate any concern about overload or IM interference.

In the third study (WorldCom Study), the analysis repeats the BellSouth Study II assumptions by arbitrarily assigning a 10 dB confidence factor to the WCS signal source and a 0 dB confidence factor to the SDARS signal source. Similar to the BellSouth study II, the analysis also assigns a 99% time variability factor to the WCS signal source and only a 50% factor to the SDARS signal source.

Intermodulation. All three studies base their analysis on an intermodulation threshold of –60dBm at the receiver input, whereas a more accurate threshold is

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[1] The following parameter definitions are provided in the EDX Users Manual:

Prediction Confidence Margin
For any prediction of signal level, including predictions for given time and location percentages, you may increase your confidence that the predicted signal levels are indeed above the indicated levels by adding a confidence margin to all the predictions. For example, if you set the prediction confidence margin at 0 dB, then the signal levels used for the study will be exactly the signal levels predicted by the program.

Time Variability

Time variability is the variability in signal level as a function of time that is observed at a fixed receiver with the other physical parameters of the environment also fixed. Time-varying signal levels only occur because of time-dependent changes in the atmosphere, primarily changing atmospheric refractivity. These changes can result in effective misalignment of the antennas that affects the directly received signal energy. This is often called a "power fade," and results from long term variability derived from hourly median signal level measurements that average out short term fast fading time variability.

computed to be –40 dBm. The threshold figure used by the WCS Parties is apparently derived from the Verizon Wireless' Reply Comments (August 30, 2001) in which BeamReach disclosed its receiver's intermodulation threshold as –60dBm in field strength at the face of the antenna. This is consistent with a further filing by the WCS Entities on September 7, 2001. The error is that it fails to take into account the receiver antenna gain. This is immediately evident with a simple intermodulation calculation.

BeamReach provided the following information about its receiver in the Reply Comments of Verizon Wireless dated August 30, 2001.

Parameter	Symbol	Value
Input Intercept Point	IIP3	-7dBm
Intermodulation Noise Floor Threshold	IMD_{NF}	-113.9 dBm
Antenna Gain	G	18 dBi
Intermodulation Threshold (Face of Antenna)	IMD_{ANT}	-60 dBmi

Table 1. BeamReach Receiver Intermodulation Parameters for Equal Power Repeaters

The intermodulation threshold at the face of the antenna (IMD_{ANT}) is related to the intermodulation threshold at the receiver input (IMD_{RCV}) by the equation:

$$IMD_{RCV} = IMD_{ANT} + G \qquad (1)$$

For third order intermodulation products, the following relationship is valid [1]:

$$URr = 2/3\ [\ IPi - Pi\ ] \qquad (2)$$

Where

URr = IMD_{RCV} - IMD_{NF} = undesired response rejection ratio at input (in dB)
IPi = IIP3 = receiver input intercept point (in dBm)
Pi = IMD_{NF} = input noise threshold level for blocking (in dBm)

Equation (2) can be rewritten as:

$$IMD_{RCV} = 2/3\ [IIP3 - IMD_{NF}\ ] + IMD_{NF} \qquad (3)$$

The intermodulation threshold at the receiver input (IMD_{RCV}) was not explicitly provided by Verizon Wireless but is easily computed with equation (1) and verified with equation (3).

From equation (1),

$$IMD_{RCV} = (-60) + (18) = -42 \text{ dBm}$$

Verifying the result with equation (3) yields:

IMD_{RCV} = 2/3 [(-7) – (-113.9)] + (-113.9) = -42.6 dBm

The results are within the round off error of the provided intermodulation threshold.

Next, consider the theoretical receiver parameters provided by BellSouth for their analysis. The intermodulation noise floor threshold is taken from the Comments of BellSouth dated August 21, 2001.

Parameter	Symbol	Value
Input Intercept Point	IIP3	-
Intermodulation Noise Floor Threshold	IMD_{NF}	-107.8 dBm
Antenna Gain	G	17 dBi
Intermodulation Threshold (Face of Antenna)	IMD_{ANT}	-
Intermodulation Threshold (Receiver Input)	IMD_{RCV}	-60 dBm

Table 2. BellSouth Receiver Intermodulation Parameters for Equal Power Repeaters

While BellSouth did not provide the third order input intercept point for their theoretical receiver, it is easily computed with equation (3)

$$IMD_{RCV} = 2/3\ [IIP3 - IMD_{NF}] + IMD_{NF} \qquad (3)$$

Rearranging (3) yields:

$$IIP3 = 3/2\ [IMD_{RCV}] – 1/2\ [IMD_{NF}] \qquad (4)$$

From Table 2,

IIP3 = 3/2[-60] – 1/2 [-107.8] = -36.1 dBm

Referring back to Table 1, it should be noted that the BeamReach third order input intercept point is –7 dBm, which is average linearity performance for a low cost linear receiver. The -36 dBm third order intercept point of the theoretical BellSouth receiver would require a significant engineering effort focused on performance degradation and is clearly a mistake.

If the BellSouth theoretical receiver were to operate with a third order intercept point equivalent to the BeamReach receiver, the intermodulation threshold at the input to the receiver would be:

IMD_{RCV} = 2/3 [(-7) – (-107.8)] + (-107.8) = -40 dBm

Corrected Analysis. When the propagation paremeters are unbiased and a more realistic intermodulation threshold at the receiver input is modeled, the results change dramatically.

BellSouth Study I

XM repeated the analysis done in BellSouth Study I after correcting it by applying a –40 dBm intermodulation threshold and attenuating both the WCS and SDARS signal with a worst-case propagation constant of 2. In addition, a fade margin of 10 dB was applied to each signal. The results of the calculations are presented in Table 3. In summary, the revised analysis shows that for every case presented RF AGC works to protect against SDARS interference without impacting WCS performance.

SDARS EIRP (WATTS)	WCS EIRP (WATTS)	WCS CELL SIZE (Mi)	WCS RCVR DISTANCE FROM BASE (Mi)	SDARS INTERFERING PATH LENGTH (Mi)	WCS RECEIVE LEVEL (dBm)	WCS EXCESS LINK MARGIN (dB)	SDARS SIGNAL AT RECEIVER (dBm)	DIFFERENCE BETWEEN SDARS AND WCS (dB)	AGC WORKS FOR OVERLOAD WITHOUT IMACTING PERFORMANCE	AGC WORKS FOR IM WITHOUT IMACTING PERFORMANCE
40,000	3.6	5	5	5	-61	19	-25.0	35.5	YES	YES
		5	2	2	-53	27	-17.0	35.5	YES	YES
		5	1	1	-47	33	-11.0	35.5	YES	YES
		5	5	15	-61	19	-34.5	26.0	YES	YES
		5	1	11	-47	33	-31.8	14.7	YES	YES
		5	5	65	-61	19	-47.3	13.3	YES	YES
		5	2	62	-53	27	-46.9	5.7	YES	YES
		5	1	61	-47	33	-46.7	-0.2	YES	YES
		5	5	75	-61	19	-48.5	12.0	YES	YES
		5	3	73	-56	24	-48.3	7.8	YES	YES
		5	2	72	-53	27	-48.2	4.4	YES	YES
		5	5	285	-61	19	-60.1	0.4	YES	YES
20,000	3.6	5	5	5	-61	19	-28.0	32.5	YES	YES
		5	2	2	-53	27	-20.0	32.5	YES	YES
		5	1	1	-47	33	-14.0	32.5	YES	YES
		5	5	15	-61	19	-37.5	23.0	YES	YES
		5	5	65	-61	19	-50.3	10.3	YES	YES
		5	2	62	-53	27	-49.9	2.7	YES	YES
		5	5	205	-61	19	-60.3	0.3	YES	YES
10,000	3.6	5	5	5	-61	19	-31.0	29.5	YES	YES
		5	2	2	-53	27	-23.0	29.5	YES	YES
		5	1	1	-47	33	-17.0	29.5	YES	YES
		5	5	65	-61	19	-53.3	7.3	YES	YES
		5	2	62	-53	27	-52.9	-0.3	YES	YES
		5	5	145	-61	19	-60.2	0.3	YES	YES
5,000	3.6	5	5	5	-61	19	-34.0	26.5	YES	YES
		5	2	2	-53	27	-26.0	26.5	YES	YES
		5	5	15	-61	19	-43.5	17.0	YES	YES
		5	1	11	-47	33	-40.8	5.7	YES	YES
		5	5	105	-61	19	-60.4	0.1	YES	YES
2,000	3.6	5	5	5	-61	19	-38.0	22.5	YES	YES
		5	1	1	-47	33	-24.0	22.5	YES	YES
		5	5	15	-61	19	-47.5	13.0	YES	YES
		5	1	11	-47	33	-44.8	1.7	YES	YES
		5	5	65	-61	19	-60.3	0.3	YES	YES

Table 3. Corrected Results of Calculations of AGC Solution

BellSouth Study II

BellSouth Study II presents a variety of cases in which it purports to show some inability of RF AGC to prevent interference from SDARS repeaters. For the reasons already described, that analysis is invalid. To demonstrate this, XM resimulated a worst case presented in the study, Problem Demonstration 10, in which BellSouth reported a 100% loss in coverage. The propagation parameters in Table 4 were used. All radio parameters provided by BellSouth were used with the exception of the intermodulation threshold at the receiver input, which was corrected to –40 dBm. The results of the XM simulation are depicted in Figure 1.

Signal Source	Ant . Height AGL (feet)	Confidence Factor (dB)	Time Variability (%)	Location (%)
WCS	257	10	99	50
XM	600	10	99	50

Table 4. XM Study - EDX Propagation Parameters

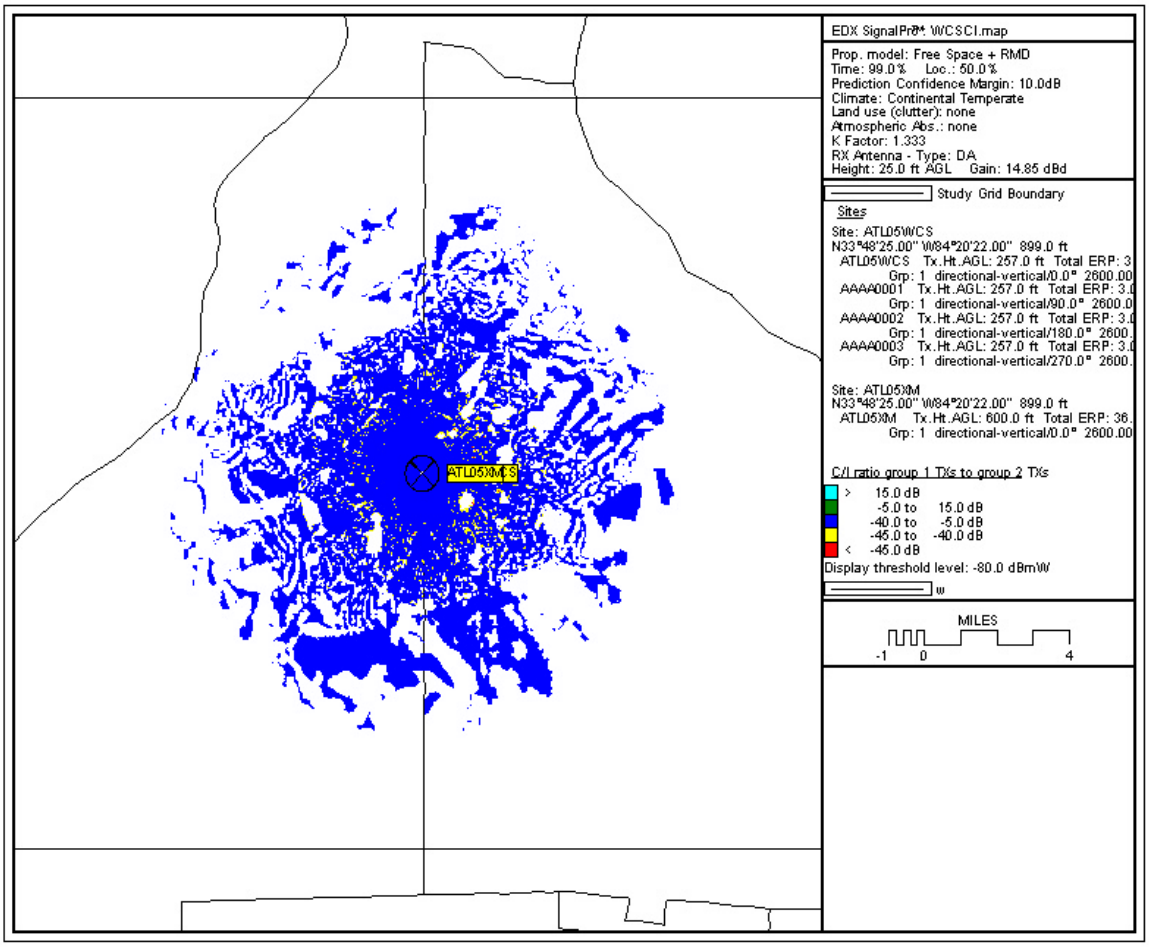

Figure 1. EDX Simulation for Problem Demonstration 10 with Correct IMD

Referencing the results shown in Figure 1, the areas colored by yellow are the areas where a potential exists for intermodulation interference and the areas colored by red are the areas where a potential exists for overload interference. The area study indicates the following statistics:

Good Coverage	97.2%
Potential Intermodulation	2.8%
Potential Overload	0.0%

The fact that a 2.8% potential still exists for overload is largely due to the signal processing in the Bellsouth theoretical receiver. Table 5 compares the BeamReach receiver parameters to the BellSouth receiver parameters.

WCS Equipment	Noise Floor (dBm)	Minimum Signal (dBm)	Intermodulation (dBm)	Blanketing Interference (dBm)
BeamReach (18 dBi Antenna)	-108	-93	-42	-31
BellSouth (17 dBi Antenna)	-102	-80	-60	-35

Table 5. Performance Parameters of WCS Theoretical Receivers

According to Table 5, the minimum signal required for the BellSouth theoretical receiver is 13 dB greater than that for the BeamReach receiver. A significant portion of this difference is the BellSouth receiver does not yet contain FEC or channel coding, which is common practice in the industry for digital receivers. When the simulation in Figure 1 is repeated with the BeamReach receiver power gaps for intermodulation and overload interference, the results in Figure 2 are achieved.

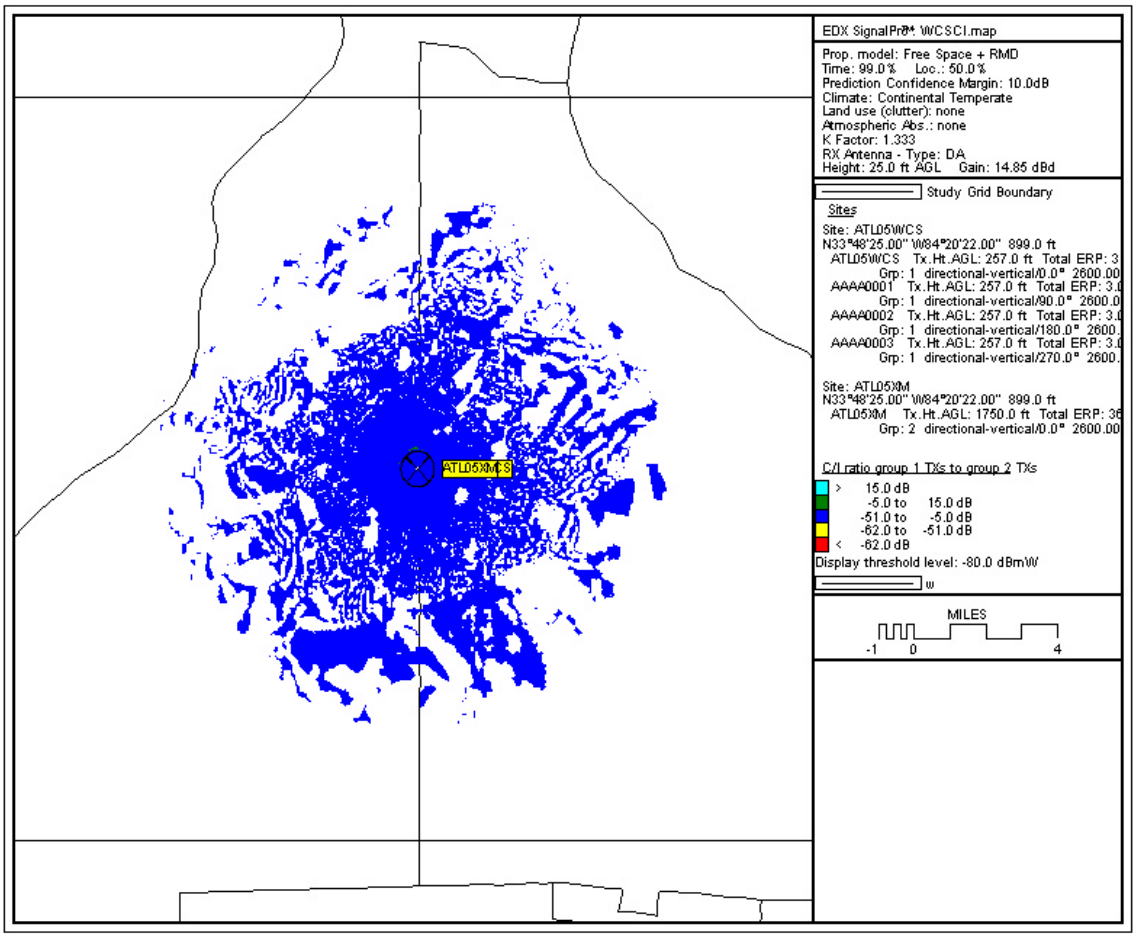

Figure 2. EDX Simulation for Problem Demonstration 10 with BeamReach Receiver

Referencing the results shown in Figure 2, the areas colored by yellow are the areas where a potential exists for intermodulation interference and the areas colored by red are the areas where a potential exists for overload interference. The area study indicates the following statistics:

Good Coverage	100%
Potential Intermodulation	0.0%
Potential Overload	0.0%

XM resimulated Problem Demonstration 10, which models the interference of a theoretical collocated 40 kW SDARS repeater into the WCS cell, with the Beamreach receiver power gaps. The results are depicted in Figure 3.

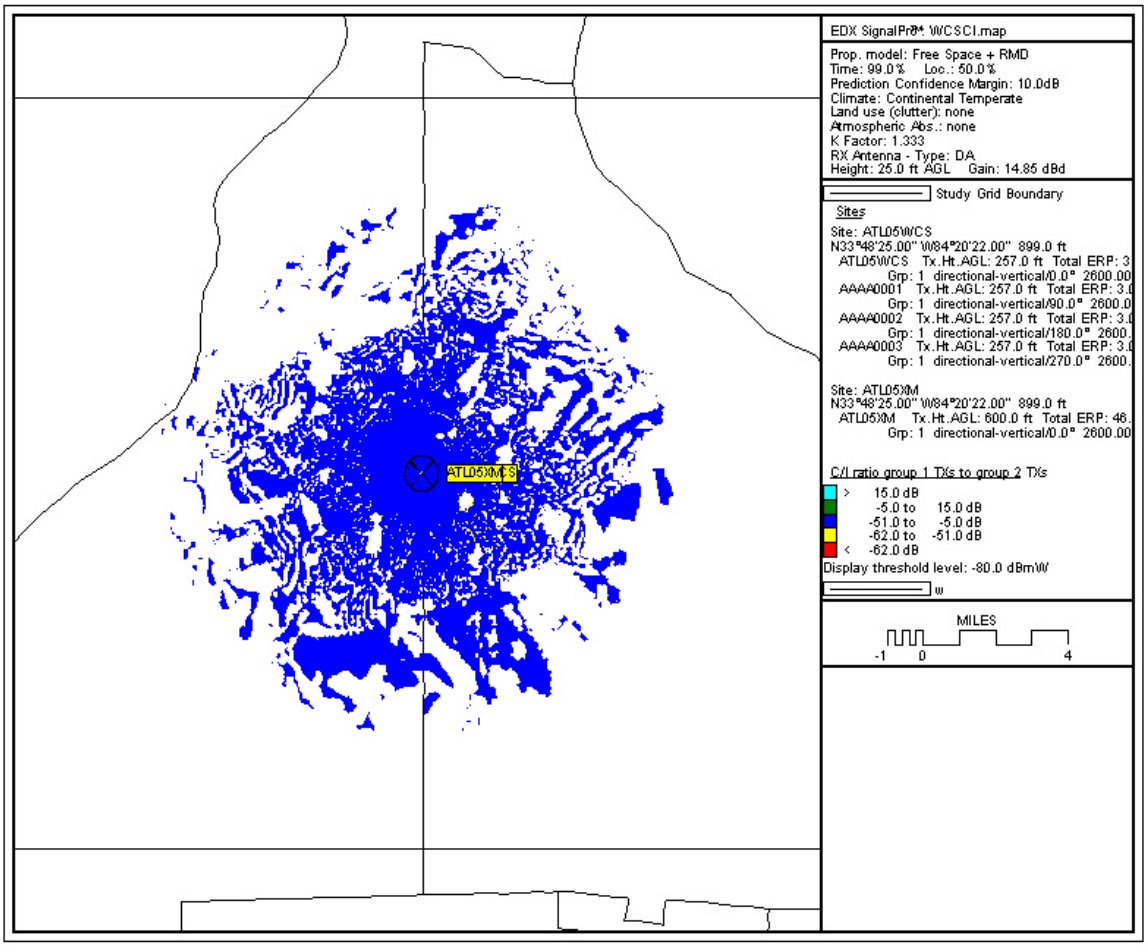

Figure 3. EDX Simulation for Problem Demonstration 9 with BeamReach Receiver

Referencing the results shown in Figure 3, the areas colored by yellow are the areas where a potential exists for intermodulation interference and the areas colored by red are the areas where a potential exists for overload interference. The area study indicates the following statistics:

Good Coverage	99.0%
Potential Intermodulation	1.0%
Potential Overload	0.0%

As a reminder, these results are achieved with a 2 watt WCS base transmitter and under a worst-case freespace propagation environment.

WorldCom Study

The WorldCom Study is similar to BellSouth Study II in that it presents a variety of cases in which it purports to show some inability of RF AGC to prevent interference from SDARS repeaters. For the reasons already described, the WorldCom analysis is also invalid. To demonstrate this, XM resimulated the RF coverage area of WCS base station DAL08 presented in Figure 21 of the study, in which WorldCom reported a significant loss in coverage. The propagation parameters in Table 6 were used. All radio parameters provided by WorldCom were used with the exception of the intermodulation threshold at the receiver input, which was corrected to –40 dBm. The results are depicted in Figure 4.

Signal Source	Confidence Factor (dB)	Time Variability (%)	Location (%)
WCS	10	99	50
XM	10	99	50

Table 6. XM Study - EDX Propagation Parameters

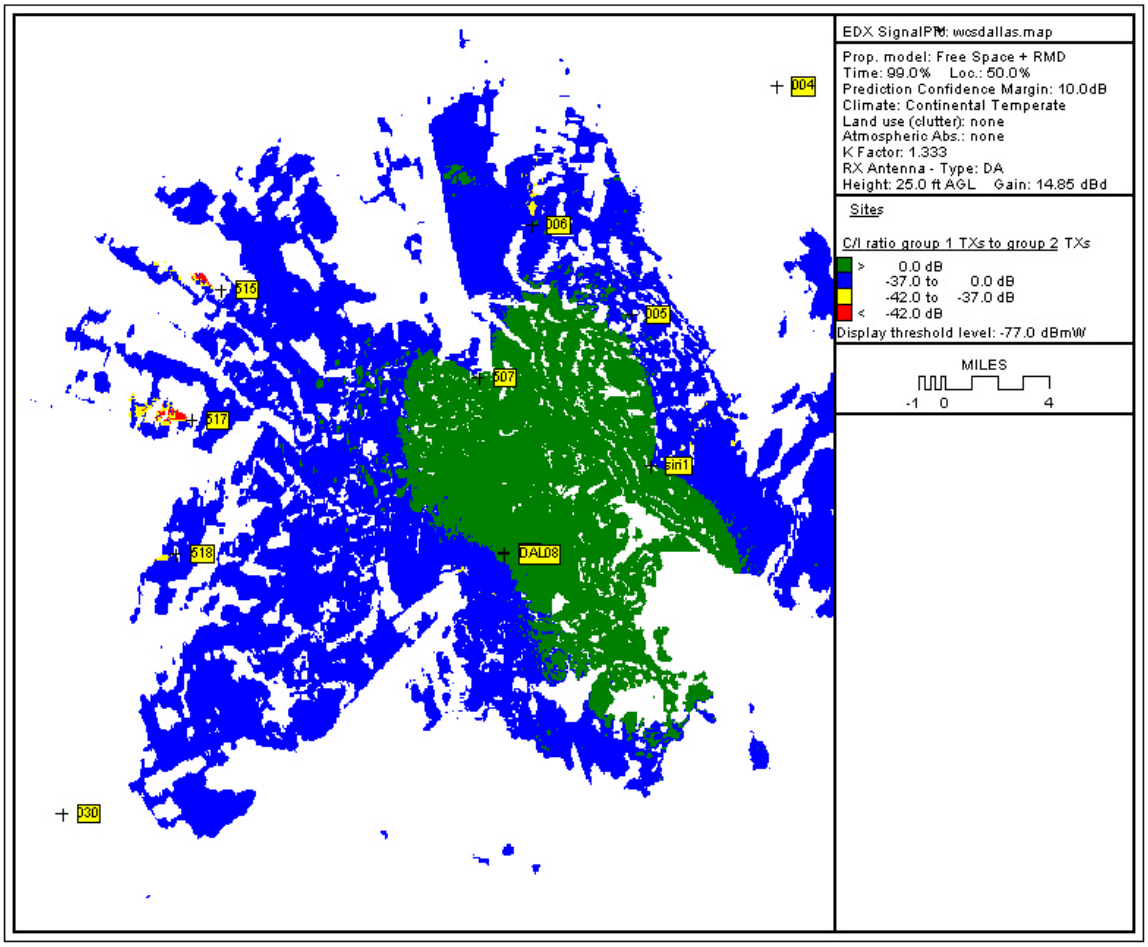

Figure 4. EDX Simulation for WorldCom Base Station DAL08

Referencing the results shown in Figure 4, the areas colored by yellow are the areas where a potential exists for intermodulation interference and the areas colored by red are the areas where a potential exists for overload interference. The area study indicates the following statistics:

Good Coverage	99.5%
Potential Intermodulation	0.4%
Potential Overload	0.1%

Closer scrutiny of the theoretical Bellsouth System raises further questions of the level of system engineering applied to the numbers used in the analysis. BeamReach, WorldCom and BellSouth all claim to be using similar systems. Each system uses roughly equivalent base and CPE antenna heights and cell sizes range from 2-7 miles, with 5 miles typical. Similar systems such as these, which operate in the same environment and in the same frequency band, normally have equivalent link budgets. System engineers normally design the RF network with a link budget, which is based on the total available system gain. The total available system gain is defined as the gap

between the transmitter EIRP and the receiver sensitivity at the face of the antenna. Based on the data provided in the record, a snapshot of the system gains of the BeamReach, WorldCom and BellSouth systems have been tabulated in Table 7.

System	CPE Sensitivity Receiver Input (dBm)	CPE Antenna Gain (dBi)	CPE Sensitivity Antenna Face (dBm)	Base Transmit EIRP (dBm)	Total System Gain (dB)
BeamReach	-93	18	-111	33	144
WorldCom	-77	17	-94	51	145
BellSouth	-80	17	-97	33	130

Table 7. System Gains for Similar WCS Theoretical Systems

Evident from Table 7, both BeamReach and WorldCom systems operate over the 5-mile cell with 144-145 dB of system gain. BellSouth, however, purports their system is designed to operate over the 5-mile cell with 130 dB of system gain[2]. Any competent system engineer would immediately raise the question of what unique aspect of BellSouth's system allows it to provide equivalent service with 15 dB less system gain than the BeamReach and WorldCom systems. Simply put, the numbers presented for these theoretical systems do not add up.

One purpose of the White Paper was to educate the Commission and WCS Entities of the cost effective RF techniques successfully deployed in existing equipment to mitigate interference from strong adjacent signals. If these cost effective techniques are shown to solve the theoretical potential for interference from SDARS high power transmitters in one WCS Service Provider's equipment, others could easily follow suit. XM believes the analysis of the BeamReach and WorldCom CPEs presented here is further evidence the SDARS interference potential can be eliminated with these cost effective techniques.

[2] In the WCS Entities November 2 Ex Parte, BellSouth provides interference results for 5-mile cell with 3.6 watts EIRP in Table 1 analysis and 2.0 watts in EDX analysis.

Additional errors. Several other errors and misstatements in the WCS Parties' filing bear correction.

- The WCS Parties claim (at p. 3) that front-end AGC is already incorporated in most well-designed WCS receivers. This is belied by the block diagrams of WCS receivers that have been submitted and by the parameters chosen in the WCS analyses.

- The WCS Parties claim (at p. 3) that the power disparities between SDARS repeaters and WCS base stations are substantially greater than those that apply in the environment in which the Qualcomm patent is used. This claim is excessively exaggerated and irrelevant. The WCS parties compare a single users power under RF AGC control to the composite power of the adjacent system. A similar exaggeration could be made comparing a CDMA phone's transmit power at full cutback to a TDMA phone's peak power. The critical aspect is the difference in signal level present at the receive antenna in which the system has to operate. The dynamic range encountered in a PCS environment is actually greater than that at issue in this proceeding, due to handset-to-handset proximity.

- The WCS Parties claim (at p. 3) that XM erred by assuming an average WCS base station power of 2 kW. As shown above, even using a base station power of 2 watts, front-end RF AGC is sufficient to protect WCS receivers from overload and IM interference. Nonetheless, XM should not be criticized for the effects of design choices that WCS licensees may make. WCS licensees are permitted to operate at up to 2 kW and they have not shown that they cannot operate at 2 kW.

- The WCS Parties claim (at p. 4) that XM erred by assuming that WCS would use a single cell deployment strategy. In fact, any such assumption is irrelevant to our analysis, as the potential SDARS interference to each WCS cell has to be analyzed independently.

- The WCS Parties claim (at p. 4) that XM erred by assuming that WCS receivers would have a minimum receive level of –101 dBm. The fact that WCS receivers, through design choices of the WCS licensees, operate at somewhat less than –101 dBm sensitivity does not detract from the technical goals of the example or change the resulting conclusion, which was to further explain the RF AGC concept and to show more than adequate link margin is available for RF AGC to overcome SDARS interference.

- The WCS Parties claim (at p. 4) that XM erred by assuming that WCS would operate with excess link margin. The fact that WCS operates with excess link margin is indisputable. The worst performing theoretical WCS system to date is the system disclosed in BellSouth Study II, which uses a base transmit power of 2 watts EIRP and a receive sensitivity at the face of the antenna of –97 dBmi. The signal available at the face of the CPE antenna from the 2-watt base at the edge of the 5-mile cell is –81 dBmi using freespace propagation. This is 16 dB excess link margin, which is available to overcome propagation impairments and/or attenuation introduced by RF

AGC. Obviously, the WCS Entities are free to improve CPE sensitivity through modulation or channel coding design choices and are also free to raise base station power in order to increase the excess link margin.

REFERENCES

[1] Richard C. Sagers, "Intercept Point and Undesired Responses," *IEEE Transactions on Vehicular Technology*, February 1983.

Document #: 1198025 v.1

Technical Certification

I, Phillip Barsky, Spectrum Management/Regulatory System Engineer for XM Radio Inc., certify under penalty of perjury that:

I am the technically qualified person responsible for the preparation of the technical information contained in the above "Reply to WCS Parties' November 2, 2001 Ex Parte Filing." The information contained in this document is true and correct to the best of my belief.

Phillip Barsky

Dated: December 21, 2001