September 24, 2001

By Electronic Filing
Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

Re: **Ex Parte Communication**
Establishment of Rules and Policies for the Satellite Digital Audio Radio Service in the 2310-2360 MHz Band, IB Docket No. 95-91
XM Radio Request for STA, File No. SAT-STA-20010712-00063
Sirius Request for STA, File No. SAT-STA-20010724-00064

Dear Ms. Salas:

The attached supplement to XM Radio Inc.'s White Paper of August 29, 2001 provides additional technical information and analysis relevant to the debate regarding potential interference from DARS repeaters to WCS licensees. The supplement focuses on ways in which the WCS licensees can make their systems immune to potential interference without significantly increasing the cost of WCS deployment.

If one thing has remained clear throughout the debate over alleged problems that DARS repeaters will cause WCS licensees it is that there is absolutely no practical impediment to the WCS licensees doing exactly what the DARS licensees did and what paging and cellular companies have done -- designing and building a consumer service with affordable equipment that is immune to the interference concerns that the WCS licensees insist are inevitable. Putting aside the inequity of WCS licensees having been silent on these issues for so many months after the record was supposed to have closed, that the DARS licensees have shown that the "solution" proposed by the WCS licensees would create worse problems for the WCS licensees, and that the WCS licensees will need to fix these problems to prevent causing interference to themselves, the simple question the WCS licensees have yet to answer is: what is unique about WCS that prevents them from doing what the DARS licensees and others have done?

XM Radio is also compelled to respond to the request by AT&T Wireless Services that the Commission prolong this rulemaking still more. XM Radio respectfully submits that it is time to resolve this matter now. The chiefs of the International Bureau and Wireless Telecommunications Bureau assured the parties at the end of August that the proceeding would be concluded within days. Over the past four years, the WCS licensees have had ample opportunity to make known their views, there can be no question that the scope of the rulemaking encompassed the issues the WCS licensees have only recently been raising, and they should not be rewarded by their delay in doing so.

Very truly yours,

/s/

Lon C. Levin

cc: Don Ableson
Tom Sugrue
Bruce Franca
Rosalee Chiara
Saj Durrani
Bob Eckert
Rick Engleman
Alexandra Field
Bruce Franca
David Furth
Anna Gomez
Keith Larson
Chris Murphy
Ron Netro
Rockie Patterson
Bruno Pattan
Ron Repasi
Cathy Seidel
Tom Stanley
Don Brittingham, Verizon
Carl Frank, Counsel for Sirius
Michael Hamra, Metricom
Karen Possner, BellSouth
Mary Nordberg O'Connor, Worldcom
Randall Schwartz, Beam Reach Networks
Paul Sinderbrand, Counsel for WCA
William M. Wiltshire, Counsel for AT&T Wireless

XM Radio
Supplement to August 29, 2001 White Paper

This paper supplements XM Radio's August 29 White Paper, in response to two filings on September 7, 2001, by AT&T Wireless Services, Inc. ("AWS") and by various other WCS licensees, including BellSouth, Metricom, Verizon, and Worldcom (collectively, the "WCS Entities"). Among other things, XM attempts to correct certain mischaracterizations of the White Paper. The supplement includes the following:

1. XM's proposal for the use of filters and RF automatic gain control is described again in order to eliminate confusion and reiterate that XM is not proposing the use of filters for typical consumer equipment.

2. The use of a properly designed filter at the WCS Base Station is described further, including the need of WCS licensees to have such filter-based solutions in order to protect WCS base stations from interference in the presence of WCS operations on adjacent frequencies.

3. The use of front-end RF AGC for the WCS consumer equipment is described in further detail, including the ability to retrofit already-deployed equipment and to dynamically adjust the level of attenuation. A system example is provided and it is demonstrated that in line of sight cases, where the need for attenuation may be required, the use of attenuation will not affect the WCS system's coverage. The use of increased power at the WCS base station is described further, as one additional alternative for improving the WCS interference environment if necessary.

4. XM corrects the WCS Entities analysis of the XM repeater link budget. If repeater power is reduced, additional repeaters will have to be added at additional expense to XM. As demonstrated in the White Paper, this action will not reduce the overall area of the potential WCS exclusion zones.

5. XM responds to questions raised concerning the White Paper's analysis of the impact on WCS exclusion zones if XM were to replace its higher power repeaters with many low power repeaters.

1. RF System Design

The system concept presented by XM to protect WCS systems against blanketing interference or interference due to intermodulation distortion is depicted in Figure 1.

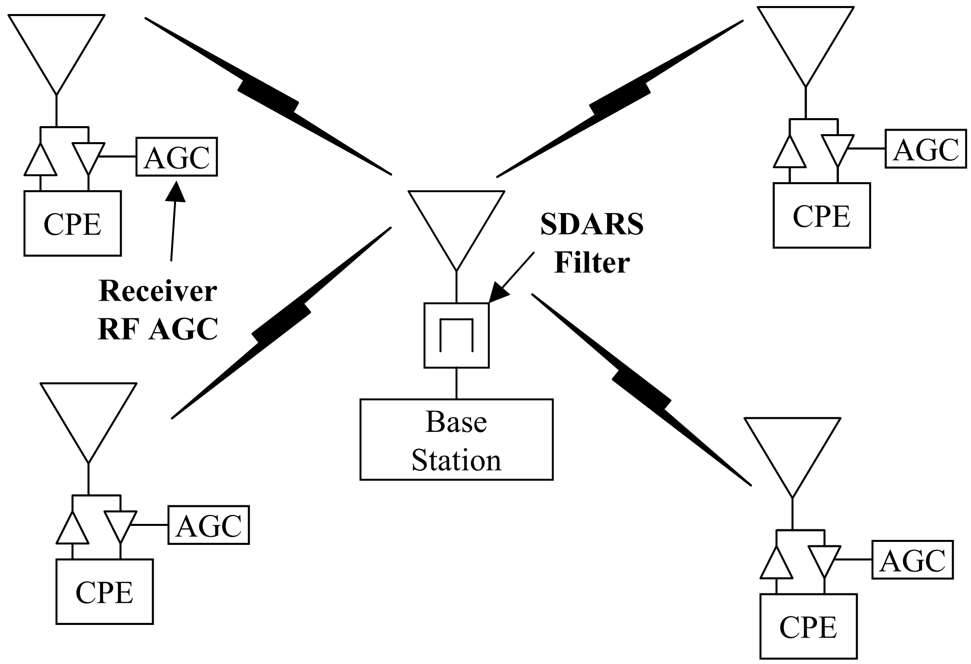

Figure 1. Proposed WCS RF System Diagram

As shown in Figure 1, XM proposes, to the extent necessary, the use of an SDARS filter for WCS base stations and the use of RF AGC for WCS customer equipment. In the WCS system, a cell contains a single base station that serves a large number of subscribers, each with a CPE or RU. The economics of XM's proposal is based on the overall WCS system cost equation, where the CPE or RU cost is multiplied by the number of subscribers, and the base station cost is divided by the number of subscribers. Simply stated, the CPE cost has a 1 to 1 impact on the overall system cost, while the base station cost has a 1 to X impact on the overall system cost, where X is the number of subscribers. Since large numbers of subscribers dilute the costs of the base station equipment, it is common to deploy better quality equipment at the base station as it does not significantly impact the overall system cost or the cost per subscriber.

As discussed in the White Paper, base station filters are available for less than $300 that will provide 35 dB of attenuation and RF AGC that provides 37 dB of attenuation can be added to customer equipment for less than five dollars per unit. Contrary to the contention of the WCS Entities in their September 7 filing, XM has not recommended the WCS Licensees employ an SDARS filter for typical consumer equipment.

In keeping with XM's concept, the discussion that follows in Sections 2 and 3 addresses separately the protection of base stations and the protection of consumer equipment. In order to fully understanding how WCS systems can coexist with SDARS repeaters, it is important not to confuse the approach recommended for one with that recommended for the other.

2. The Use of Properly-Designed Base Station Filters

Several of the WCS licensees have indicated that their present base stations employ filters similar to those used in PCS facilities, which operate in frequencies further removed from the SDARS band. In its August 24 ex parte filing, AWS presented information about its base station duplexor filter response which demonstrates it has been designed with a 25 MHz transition band, similar to the PCS 20 MHz transition band. This not only shows a complete lack of attention to the potential for interference from SDARS repeaters, but it also shows a relatively easy way to improve the base stations' susceptibility to interference. XM recommends redesigning these duplexor filters with a 4 MHz transition band to enable the required rejection of SDARS energy. XM has identified a source for these new filters, FSY Microwave, Inc. in Columbia, MD which is ready to supply these filters with a 4 MHz transition band for less than $300 per unit. Attached hereto are additional responses for bandpass filters available from FSY Microwave, which provide suitable rejection of SDARS energy.

WCS base stations must be equipped with properly designed filters to avoid interference from SDARS or other WCS Service Providers. During the August 30 meeting with the Commission, BeamReach presented data which emphasized their WCS equipment would be severely degraded by the third-order Intermodulation (IM) products introduced by simultaneous high level signals from Sirius and XM repeaters. XM countered that this interference is no different from the interference WCS must address to coexist with nearby WCS Service Providers. In discussions with BeamReach Senior Technical Management subsequent to the August 30 meeting with the Commission, XM explained that third-order intermodulation interference will be present in BeamReach equipment when operating near a single adjacent WCS Service Provider. The BeamReach Senior Technical Management pointed out that for the case of operation in the area of a second WCS Service Provider, the WCS licensees can purchase the cavity filter option for their base station equipment, which would eliminate the WCS and SDARS intermodulation interference. The BeamReach base stations without the cavity filter will provide a viable WCS solution in markets where close proximity deployment to SDARS repeaters and adjacent WCS services is avoided.

In general, WCS base stations properly configured with filters to reject interference from adjacent WCS services will not suffer degradation from SDARS repeaters.

In the WCS Entities September 7 ex parte response to the White Paper, the WCS Entities estimate the cavity filters will raise the cost of the base station between 10% and 25%. The WCS Entities ex parte response infers that this unusually high cost is caused by

BeamReach's unique solution for WCS, where base stations are typically configured with 6 or more antennas, each of which may need a filter. A substantially lower filter cost would be expected with other manufacturer' solutions, which use a simple base station antenna configuration. While the WCS Entities estimates are unsubstantiated and XM believes have been overstated, considering that the base station cost is only a fraction of the total site costs, which include acquisition costs, construction costs and lease costs, and that the total site cost is then divided by the number of subscribers to establish the overall system cost, it is reasonable to conclude that even these worst-case estimates do not substantially affect the financial viability of WCS as a service.

The Commission should also keep in mind that the use of such filters by WCS systems is likely to be required at least as much by the need of WCS systems to protect themselves against intermodulation affects of other WCS transmitters. If, as discussed in the WCS Entities September 7 filing, WCS base station deployment takes place on a 1 to 2 mile grid, cavity filters would likely be required to protect against the WCS-WCS interference, independent of the presence of SDARS repeaters.

3. The use of front-end RF AGC for WCS consumer equipment

XM recommends the WCS licensees employ RF AGC in their RU or CPE equipment to protect against intermodulation distortion and front end overload. There are many possible implementations of front end RF Gain Control to eliminate interference due to high level adjacent-band signals. For illustrative purposes, this section focuses on a simple Manual Gain Control system implementation suitable for deployment in existing WCS CPE equipment. Other implementations might include automatic gain control (AGC) Based on the knowledge acquired from this example the reader will be able understand how an automatic gain control system, which XM has implemented for its system and strongly recommends for future CPE equipment, will be able to improve WCS service quality in the presence of high power SDARS repeaters.

RF AGC is applied to the receiver front end to protect against high level interference and should not be confused with the back end Intermediate Frequency (IF) AGC already used in WCS equipment. Figure 2 depicts the differences.

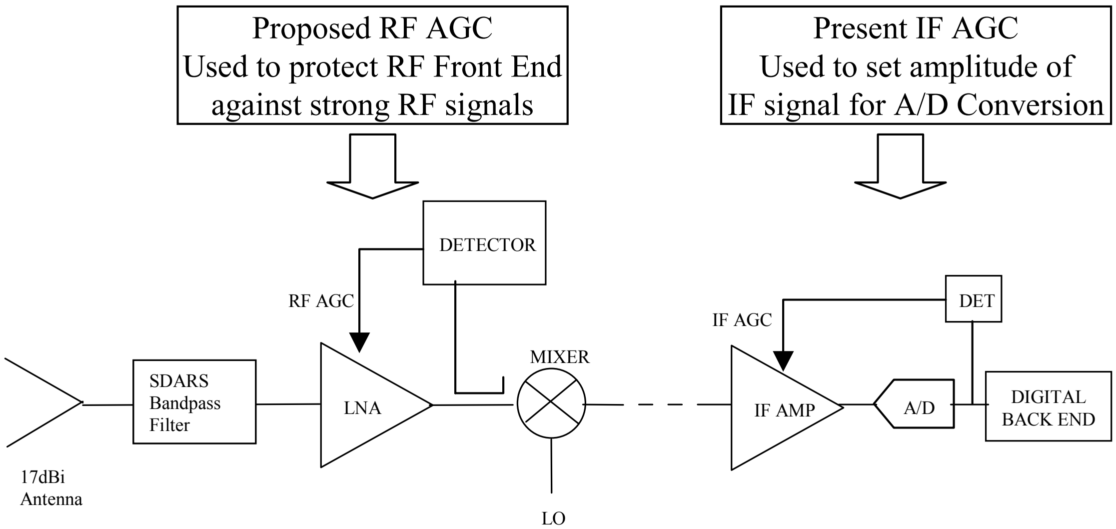

Figure 2. Front End RF AGC and Back End IF AGC in a CPE or RU Device

In Figure 2, the back end IF AGC present in most receiver designs serves the distinct purpose of adjusting the IF gain to keep the IF amplifier output signal absolute level centered at the most desirable operating point of the analog to digital converter. The use of the front end RF AGC serves to adjust the RF gain to keep the RF front end circuitry (LNA and mixer) operating in a linear range in the presence of high level in-band signals, which acts to prevent IM product creation and front end overload. RF and IF AGC operate independently of the other and are configured with independent response bandwidths to avoid oscillation.

In order to understand how RF automatic gain control can be used to protect CPE or RU receivers against potential blanketing interference, it is first necessary to understand how RF gain control in general is used in a receiving system design to protect against interference. Consider the simplified WCS receiver block diagram below:

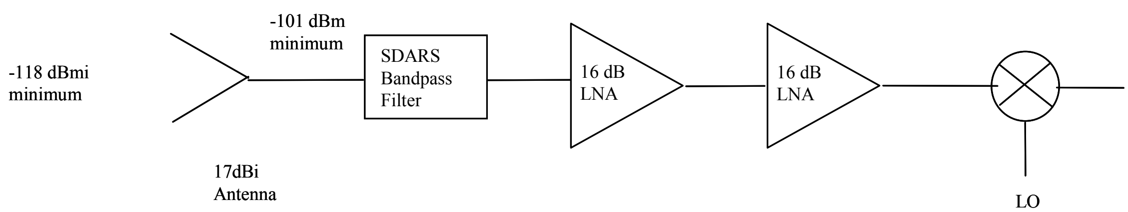

Figure 3. Generic WCS Receiver Block Diagram

The generic WCS receiver of Figure 3 consists of a 17dBi gain antenna connected to an SDARS bandpass filter followed by two LNA stages and a mixer. The receiver performance numbers, referenced at the input to the bandpass filter, as provided by ATTWS, BellSouth and BeamReach for receiver sensitivity threshold, SDARS overload threshold and SDARS intermodulation interference threshold are summarized in Table 1.

Receiver	Sensitivity (dBm)	Overload (dBm)	Intermod (dBm)
RU – Generic	-101	-35	-60

Table 1. Generic WCS Receiver Performance

Note: The intermodulation interference level is from page 15 of the analysis included in the Reply Comments of Verizon Wireless (August 30, 2001).

For purposes of this example, assume the WCS receiver is modified by inserting a fixed resistive attenuator between the SDARS bandpass filter and the first LNA stage as shown in Figure 4.

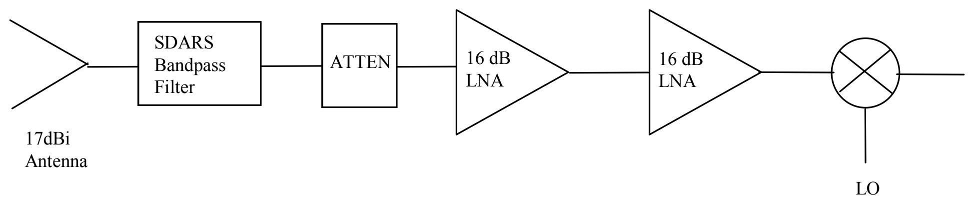

Figure 4. WCS Receiver Block Diagram with Front End Attenuation

In the modified receiver line up in Figure 4, the signal received from the antenna is passed to the SDARS bandpass filter followed by the attenuation block. The attenuation block reduces desired and undesired signals by equal amounts, prior to passing them to the LNA stages. Based on XM's own experience with its consumer receivers, the attenuation block could be easily constructed using surface mount resistors with a total cost less than 5 cents and area less than 0.04 sq. inches. Continuing with the example, assume the attenuation unit is built for use with existing RUs that can be adjusted as appropriate to one of seven options for WCS RU receivers, each differing only by the value of the fixed attenuation. Table 2 summarizes the performance of the modified receiver with these options.

Receiver	Attenuation (dB)	Sensitivity (dBm)	Overload (dBm)	Intermod (dBm)
Option 1	0	-101	-35	-60
Option 2	10	-91	-25	-50
Option 3	20	-81	-15	-40
Option 4	30	-71	-5	-30
Option 5	40	-61	+5	-20
Option 6	50	-51	+15	-10
Option 7	60	-41	+25	0

Table 2. Performance of WCS Receiver Options with Front End Attenuation

Referring to Table 2, RU-Option 1 configured with 0 dB attenuation performs identically to the generic WCS receiver described in Table 1. RU Options 2 through 7 employ varying amounts of attenuation in the RF front end. The important concept here is that while the attenuation reduces the receiver sensitivity, it also increases the level of interfering signal necessary to disrupt service. For example, RU-Option 3 requires a minimum signal amplitude of –81dBm to operate, but the overload threshold is –15 dBm, which is 20 dB higher than the overload threshold of the generic receiver.

When the receiver Options in Table 2 are connected to a 17dBi gain antenna, the resultant RU performance at the face of the antenna in Table 3 results.

Receiver with Antenna	Attenuation (dB)	Sensitivity (dBmi)	Overload (dBmi)	Intermod (dBmi)
RU – Option 1	0	-118	-52	-77
RU – Option 2	10	-108	-42	-67
RU – Option 3	20	-98	-32	-57
RU – Option 4	30	-88	-22	-47
RU – Option 5	40	-78	-12	-37
RU – Option 6	50	-68	-2	-27
RU – Option 7	60	-58	+8	-17

Table 3. Performance of WCS Receiver Options connected to +17 dBi Antenna

It should be noted that the performance described in Table 3 could be achieved in any variety of methods. For example, RU – Option 7 performance could be achieved with 40 dB of attenuation coupled with a –3 dBi antenna gain.

Next, consider how the receiver options in Table 3 could be deployed in a WCS system. For simplification, assume that the RU receivers are deployed in line-of-sight of the WCS base station and that 10 dB of fade margin is required for the link. The regions surrounding a 2 kW EIRP WCS base station containing signal levels above the desired thresholds for the RU receiver options in Table 3 are described in Figure 5.

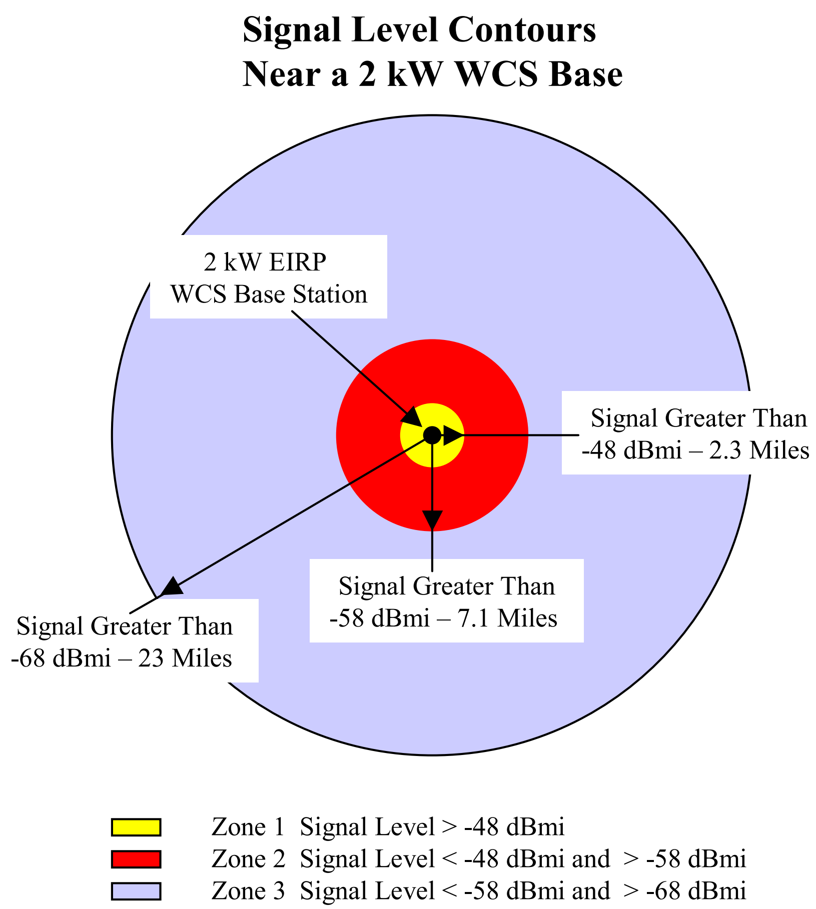

Figure 5. Line-of-Sight Signal Levels Near a 2 kW EIRP WCS Base Station

Zone 1 in Figure 5, highlights the area where the signal level is above –48 dBmi. If the receiver RU-Option 7 from Table 3 is deployed in this 16.6 square mile region it will operate with a minimum of 10 dB fade margin in the line-of-sight environment.

Zone 2 highlights the area where the signal level from the base station is below –48 dBmi and above –58 dBmi. If the receiver RU-Option 6 from Table 3 is deployed in this 142 square mile region it will operate with a minimum of 10 dB fade margin in the line-of-sight environment.

Zone 3 highlights the area where the signal level from the base station is below –58 dBmi and above –68 dBmi. If RU-Option 5 from Table 3 is deployed in this 1503 square mile region it will operate with a minimum of 10 dB fade margin in the line-of-sight environment.

Table 4 summarizes the receiver performance in Zones 1-3.

Zone	Min. Signal in Zone (dBmi)	Receiver with Antenna Deployed	Sensitivity (dBmi)	Overload (dBmi)	Intermod (dBmi)
Zone 1	-48	RU – Option 7	-58	+8	-17

Zone 2	-58	RU – Option 6	-68	-2	-27
Zone 3	-68	RU – Option 5	-78	-12	-37

Table 4. Receiver Deployment with 10 dB Fade Margin in Zones 1-3

With the receiver options deployed in their respective zones as described by Table 4, it is next appropriate to examine the interference susceptibility of the system. From Table 4, it is evident that the receivers are most susceptible to interference from intermodulation, as intermodulation distortion has the potential to occur at a lower signal level than overload occurs.

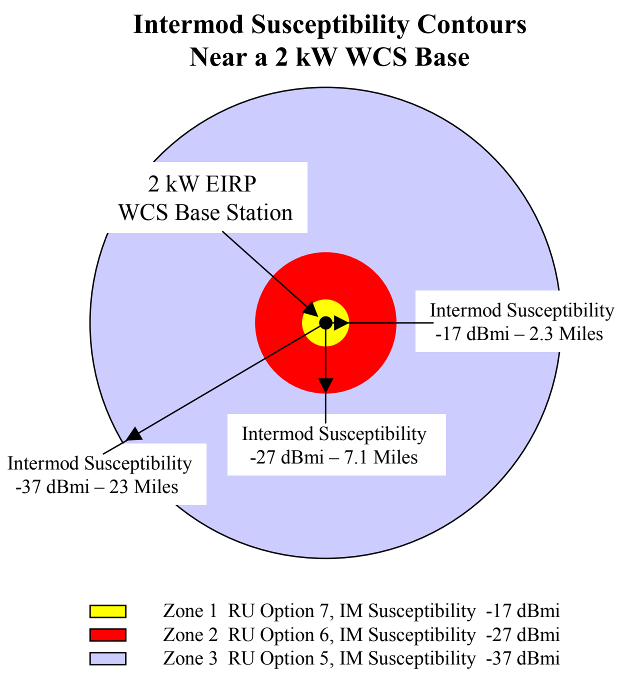

Figure 6. WCS Intermodulation Susceptibility

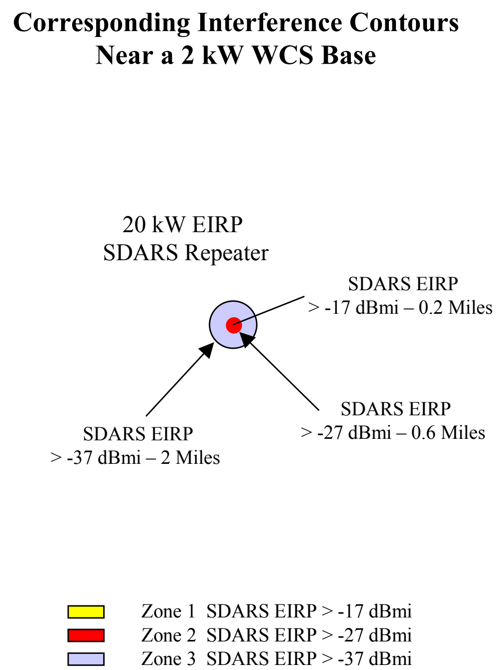

Figure 7. SDARS Repeater EIRP

Figure 6 highlights the intermodulation susceptibility thresholds for Zones 1-3 based on the receiver deployment performance shown in Table 4. As pointed out in the BeamReach analysis, for the intermodulation distortion to be present in the WCS receiver, simultaneous repeater signals must be present from 2 independent SDARS Service Providers.

Figure 7 highlights the corresponding zones which are equal to or exceed the interference signal level thresholds in Figure 6 that under worst-case conditions may be produced by a 20 kW SDARS repeater.

For example in order to exceed the –17 dBmi intermodulation threshold described in Zone 1 of Figure 6, the WCS RU Option 7 would have to be located within 0.2 miles of two SDARS 20 kW EIRP repeaters. This diagram also shows that if the WCS base station were located within 1.7 miles of the SDARS 20 kW repeater, WCS RU receivers in Zones 2 and 3 would never experience intermodulation interference in the worst case line-of-sight environment.

Referring back to Table 3, since the overload threshold for a single SDARS service provider is 25 dB greater than the intermodulation threshold for simultaneous SDARS signals, it is obvious that WCS interference will be nonexistent with only one SDARS Service Provider's high power repeaters present.

The purpose of this example is to explain how the adjustment of the gain in the RF front end may be advantageously employed to improve overall WCS system performance in the presence of strong RF signals. This can be accomplished through the use of RF attenuators, or a well-designed RF AGC circuit. The RF attenuator approach to protect the RF front end is small in size and suitable solution to retrofit into existing CPE or RU equipment. Because the attenuation deployed varies as a function of the distance from the base station, multiple receiver units with differing attenuation must be available for deployment throughout the line-of-sight coverage area. The RF Automatic Gain Control approach to protect the front end is also small in size but implementation would likely require a PCB change to the CPE or RU. The advantage of RF AGC over manual gain control is one receiver unit may be deployed anywhere within the coverage area, as the attenuation in the front end is automatically adjusted based on the signal detected. Both approaches are equally effective, low in cost (attenuators < $0.05, AGC < $5.00), do not affect system coverage, and eliminate the need to deploy filters at the RU.

The AWS September 7 response to the White Paper asserts that the example provided in the White Paper to describe the system operation of AGC is unrealistic, in that collocation opportunities are rare. It is apparent AWS failed to read the example, which was introduced with the following text: "*As discussed further below, it is not necessary that the two facilities be collocated, but the* [AGC] *principle is easier to illustrate using this example*." XM reiterates that collocation of WCS base stations with SDARS repeaters is not necessary to improve the WCS system performance in the presence of strong RF signals.

The WCS Entities' September 7 response to the White Paper claims that RF AGC reduces the radius of the BWA cell by desensitizing the receiver. This shows a misunderstanding of how RF AGC works in the system. A correctly designed RF AGC circuit will not degrade the receiver sensitivity threshold and will not reduce the BWA cell size. As shown by this example, RF AGC takes advantage of excessive link margin to raise the threshold to interference. The excessive link margin that is present in the worst case line-of-sight propagation environment is more than adequate to raise the interference threshold levels, which will allow coexistence with SDARS high power repeaters, using the worst-case line-of-sight propagation model. In the non-line-of-sight environment where some of the additional link margin is required to overcome channel impairments between the CPE and Base Station, the channel impairments will also act on the signal from the SDARS repeater to reduce the interference signal level. In the <u>very rare</u> case where the non-line-of–sight propagation model exists between the CPE and base station and the line-of-sight propagation model exists between the CPE and SDARS repeater, the solution is to simply raise the height of the CPE to a line of sight position with the base station or reposition the CPE to a non-line-of-sight position with the SDARS repeater. In general, the non-line-of-sight propagation environment is not problematic from the SDARS interference standpoint and has not been raised as an issue by the WCS entities.

In the September 7 filings of AWS and the WCS Entities, BeamReach stated a possible WCS deployment would be based on a 1-2 mile grid. With 2 kW EIRP base stations and a line-of-sight propagation model, the signal present at the edge of the 2 mile cell boundary would be –47 dBmi, which is 71 dB above the threshold of the WCS generic receiver sensitivity. In fact, the line-of-sight coverage around a WCS 2 kW EIRP base station using the generic WCS receiver described in Table 1 connected to a 17 dBi antenna would be 7162 miles. With the 71 dB link margin available at the 2 mile cell boundary, more than ample headroom is available for AGC techniques to improve interference rejection. With the 2 mile grid and receiver performance as shown in Table 4, the WCS CPE deployment would not require a single additional base station to provide full CPE coverage in the presence of a worst case line-of-sight high power SDARS repeater.

The September 7 filings of AWS and the WCS Entities reject the possible use of higher WCS base station power as a potential approach in some cases to improve the interference environment. These objections focus on problems with an inability to effectively increase the power level of WCS consumer equipment. In fact, however, increasing only the base station power may provide important improvement for CPE reception. Assume that a WCS base station incorporates a suitable filter such that it does not suffer overload from a high power SDARS repeater. If a CPE with RF AGC is positioned at the sensitivity threshold and a high power SDARS repeater is causing the CPE AGC to engage, that CPE will not be able to receive from the WCS base station. However the WCS base station, immune to the interference, will be able to receive from the CPE. In this case, the link is unbalanced in that the base can receive but the CPE cannot receive. An increase in the base station transmit power would provide the additional link margin necessary for the CPE to receive and provide full service at this location. Other types of link imbalances, which may be corrected with higher base station transmit power, occur in areas where CPE is located closer to a SDARS repeater than to its associated base station. All of this can be done without any increase in power at the CPE, where RF health and safety are primary concerns.

For the first time in its September 7 filing, the WCS Entities claim that a 40 dB power level difference may exist between the received power levels from a BWA transmitter and a high power SDARS repeater at equal distances. Without additional information on the BWA base station characteristics, such as power control strategy and maximum available power, it is not possible to analyze this comment. However, based on the information presented in the previous paragraphs, any increase of power at the BWA base station will provide a dB for dB improvement to the link margin and interference threshold of a BWA CPE receiver equipped with RF AGC. Since the cost of this additional power is applied only to the BWA base station, the overall system cost impact is minimized, as discussed in Section 1.

XM has challenged the WCS licensees to explain why they are uniquely incapable of preventing interference from DARS repeaters, given the success that XM and Sirius have had in doing so. The WCS Entities September 7 filing suggests but never explains that what it calls "broadband wireless access" or BWA is somehow different in this regard. The WCS Entities claim that XM "fails to exhibit a basic understanding of BWA system design, particularly with respect to the modest transmit power that can be used (RF health and safety reasons at the CPE), threshold sensitivity levels, antenna heights, and frequency reuse techniques." In fact, XM has established that it understands the modest transmit power that can be used at the CPE due to RF health and safety reasons and has never recommended increasing the CPE power. The threshold sensitivity levels and antenna heights used in XM's analyses are those provided by the WCS Service Providers. If there are concerns about frequency reuse techniques that are relevant to the discussion, they are yet to be described by the WCS licensees.

The WCS Entities' September 7 filing also claims that XM mistakenly assumed the signal compression and non-linearity in the LNA/mixer determine the receiver's blanketing interference level as opposed to the phase noise of the local oscillator. If XM was mistaken, it is because we relied on the information in BellSouth's March 8 filing (p. 1 of Attachment), which inferred that the 1 dB compression point of the second LNA was the limiting factor for its receiver. In any event, the root cause of the blanketing interference level is inconsequential, as front end RF AGC will raise the blanketing interference threshold regardless of its cause.

The RF AGC techniques deployed by the SDARS community to allow low cost consumer receivers to operate in the presence of high power SDARS repeaters are not new. The Paging community and the PCS community have deployed low cost receivers designed for operation in a crowded spectrum environment for years. Attached hereto is an excerpt from US Patent No. 5,732,341 "Method and Apparatus for Increasing Receiver Immunity to Interference" by Wheatley and assigned to Qualcomm describes an RF environment and solution successfully deployed by CDMA in the presence of AMPS, which largely parallels the WCS environment, and is similar to the solution recommended by XM for the WCS RU or CPE.

A wealth of background material discussing the various RF AGC implementations, which specifically increase receiver immunity to blanketing interference or intermodulation distortion, is readily available in the literature.[1]

[1] A few specific implementations relating to the PCS and Paging systems can be found in the following US patents:
Patent # 05732341 "Method and Apparatus for Increasing Receiver Immunity to Interference" by Wheatley.
Patent # 05930692 "Method and Apparatus for Increasing Receiver Immunity to Interference" by Peterzell et al.

The common thread of the WCS Service Provider's technical objections to the SDARS high power repeaters is based on the performance of existing equipment that is clearly not designed to operate in areas of high spectrum utilization. XM has pointed out the present base station filters have been designed without SDARS repeaters in mind. XM has also pointed out the WCS CPE or RU equipment does not employ available RF front end interference rejection techniques, which are presently in use in PCS systems, Paging systems and SDARS systems. With the first three points of this response, XM has presented extensive evidence that properly designed WCS base stations and CPE or RU equipment will allow the WCS Service Providers to operate in the presence of DARS high power repeaters without compromising service integrity. XM has extensive experience with the techniques described here and is highly confident an economically feasible solution is available to the WCS Service Providers.

4. XM's repeater link budget is appropriate to achieve the needed level of service availability

This section addresses the claims in the September 7 filing of the WCS Entities that XM's use of repeaters at power levels above 2 kW EIRP reflects an excessive link margin. As discussed below, the WCS Entities' link budget assumptions are not correct.

The XM terrestrial deployment of repeaters is designed to efficiently, with as little power as possible, reinforce satellite reception in defined market areas that have a high probability of satellite reception problems due to signal blockage. Maintaining a continuous digital audio service at a level equivalent to traditional FM radio in the land-mobile propagation environment requires the terrestrial repeater network design to meet a 99.9% service availability in these market areas. This is far different than the signal availability that characterizes the two-way mobile services that the WCS Entities use as references.

The WCS Entities also argue that XM can easily turn down its amplifiers to reduce the power of its repeaters. This argument misses the point. The consequence of simply reducing the power of the existing higher power repeaters would be a dramatic reduction in the quality of service and a large increase in the number of repeaters required to provide comparable coverage, an unnecessary process that will take years to complete and add hundreds of millions of dollars to the cost of the system. Worse than being unnecessary, the additional repeaters would also increase the total area of potential WCS exclusion zones. The XM repeater deployment relies on an anchor site concept, which is typical in a SFN RF network. The anchor site is defined as a site that provides a wide

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Patent # 05465408 "AGC Circuit for Operating in Accordance with the Nature of the Interference Signal and Method for Controlling this Circuit" by Sugayama et al.
Patent # 06148189 "AGC Circuit Arrangement for a Tuner" by Aschwanden.

Patent # 05740524 "Feed-Forward RSSI Assisted Radio Frequency Amplifier Power Control" by Pace et al.

area coverage footprint. The transmit data launch timing for all other sites in that coverage area are timed relative to that anchor site. In all cases if the anchor site power were reduced 10 dB, many additional sites would be required to fill in the coverage holes created.

4.1 Actual XM Repeater Link Budget Required Margins

4.1.1 Margin definitions

In order to understand a Terrestrial R.F. network design targeted at a mobility type of service the service availability goals need to be defined. In XM's case the service availability goal, from the combination of satellite and terrestrial signal availability is 99.9%. The margins required during the network modeling phase of the SFN design and development process also need to be quantified. The following are the margin categories and their definition.

4.1.2 Small Scale Fading / fast fading

These effects are caused by the typical multipath channel characteristics and are included in the XM system E_b/N_0 performance specification. Using Standard Channel models to characterize the required C/N for the XM Terrestrial receiver under typical worst-case propagation characteristics, XM has determined the appropriate C/N margin required.

4.1.3 Large Scale Fading/slow fading

In a mobile environment there is an overlaying slow fading of the RF channel caused by local variations in the RF channel propagation characteristics. This means that in a given area the mean field strength is only equal to a 50% service availability. To obtain higher service availability a "Fade Margin" has to be included in the network planning modeling.

During XM's numerous Technology Validation market trials the required Fade margin was empirically derived.

4.1.3 Coverage Prediction Margin

Basic coverage prediction tools compute signal path loss as a function of distance only. This means that the predicted field strength is the same in all directions from a signal source at a given distance. In real world scenarios this is not true due to environmental variations around the site that effect the signal propagation. More sophisticated tools that include data for terrain and clutter are used to improve the accuracy of the network modeling but there is still margin required to include the coverage prediction error.

To make a determination of the margin required for network planning uncertainty several markets were tested utilizing XM's experimental license. During these tests street level signal strength results were compared to the predicted field strength to determine the required network planning uncertainty margin. This margin has been determined for each repeater and that data has been used with the planning tool to minimize the planning uncertainty.

- *"14dB fade margin, providing 99.9% link reliability at the edge of the cell using a straight forward 2-branch diversity combining mechanism. Even higher link availability is realized in the interior of the cell."*

  The 14 dB fade margin number is not accurate. The use of a two-branch diversity model is not appropriate for analysis of the XM repeater network, which uses a multicarrier modulation scheme for optimum performance in a multipath channel and does not require the use of diversity.

- *"8 dB coverage margin provides 100% area coverage (95% via repeaters, 5% via Satellite) within the cell boundaries at the stated link reliability. Rayleigh fading was assumed."*

  As explained previously, the required coverage margin or network planning margin is not uniformly applicable, based on varying morphologies from site to site and market to market.

- *"The combined fade and coverage margins stated above support other coverage and reliability profiles. For example, 98% area coverage at 99.5% link reliability is obtained with a different mix of the 22 dB total margin."*

  XM SDARS system service availability target is 99.9% within the defined market boundaries where terrestrial repeaters are deployed. This requires higher margins than typical mobility services such as PCS. An additional characteristic of the XM system is that the user is utilizing the service at a 100% duty cycle similar to traditional FM radio.

- *"6dB macrodiversity gain due to cellularization at 95% coverage."*

  The 6 dB macro diversity gain does not apply. Theoretically, there is a slight gain in some areas that can be characterized as " SFN combining " gain. This has been characterized in the field tests and under best-case conditions a small gain can be realized. This is not included in our coverage modeling since the realization of this combining gain across a market is very indeterminate.

4.2 WCS Link Budget analysis

The September 7 filing presented the following available path loss calculation based on estimated margins:

System gain with 2 kW repeater	Fade Margin	Coverage Margin	Macro-diversity Gain	Available Path Loss
159 dBm	-14 dB	-8 dB	+6 dB	143 dB

Table 5. WCS Margins Estimated for SDARS

The available path loss estimated by the WCS entities in Table 5 is substantially different from the numbers XM has empirically derived from measured data, which has been recorded throughout extensive drive test campaigns in multiple markets. The 8Km radius calculation based on the estimates in Table 5 is incorrect.

Even with correct margins, XM emphasizes that the accuracy of the coverage prediction is not adequate to design networks to a 99.9% service availability goal in a mobile environment due to inadequacies in existing building clutter and foliage databases and unique characteristics associated with site-related antenna pattern distortion. As discussed in the White Paper, the XM network deployment relies on street level measured data from physical sites in each market.

4.4 Clarification of additional points raised in the XM repeater link budget analysis

- *" No hexagonal cell overlap was included."*

  The characteristics of the actual SFN gain which is realized in an actual network are not predictable and cannot be included in the areas where there is overlapping coverage.

- *"Switchover from a weaker repeater signal to the satellite signal was not assumed. This will have a large positive effect."*

  The deployment of repeaters in fact does consider the availability of satellite signals. Deployment and operation of repeaters is expensive. XM's goal is to minimize the number of repeaters, consistent with providing an appropriate level of service availability.

- *"The worse case Rayleigh fading environment was assumed in computing the link reliability margin. If a Rician distribution was used (appropriate for the high antenna height proposed), 4 dB less margin is needed."*

  The fading margin used is not worse case for XM's service availability requirements as shown previously.

- *"Signal strength augmentation due to deployment on overlooking hills (as in the Atlanta deployment) was not included."*

Normal one-way broadcast wide area networks by their nature attempt to provide the maximum coverage footprint from each site. This is a basic tenet of the XM network system planning process.

- *"Advanced diversity combining techniques were not included."*

- As mentioned previously, the modulation technique used by XM does not significantly benefit from the use of diversity.

5. Replacing high power repeaters with many low power repeaters increases the total area of exclusion zones

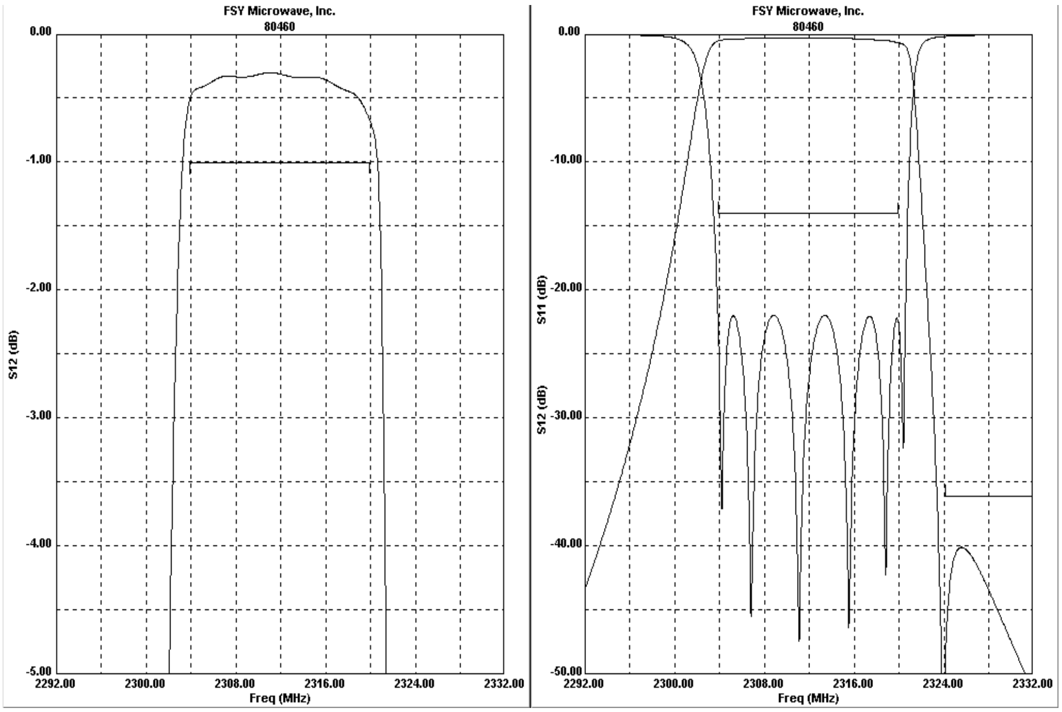
This section responds to AWS' response to the analysis in XM's White Paper demonstrating that replacing high power repeaters with many low power repeaters increases the overall exclusion zone. Specifically, AWS challenges XM's use of 2 kW repeaters with omnidirectional antennas in its description of what XM would deploy if it were precluded from operating higher-power repeaters and it challenges the spacing of the repeaters in the Indianapolis example.

The design examples demonstrate that the deployment of 2 kW repeaters in a market does create a larger overall exclusion zone area when the high power site is replaced. The number of omni repeaters used was determined based on providing equivalent market coverage to that provided by the design with the high power site. The fact that panel antennas would replace the omni antennas in the final SFN implementation would not impact the conclusions drawn with respect to the potential exclusion zone area.

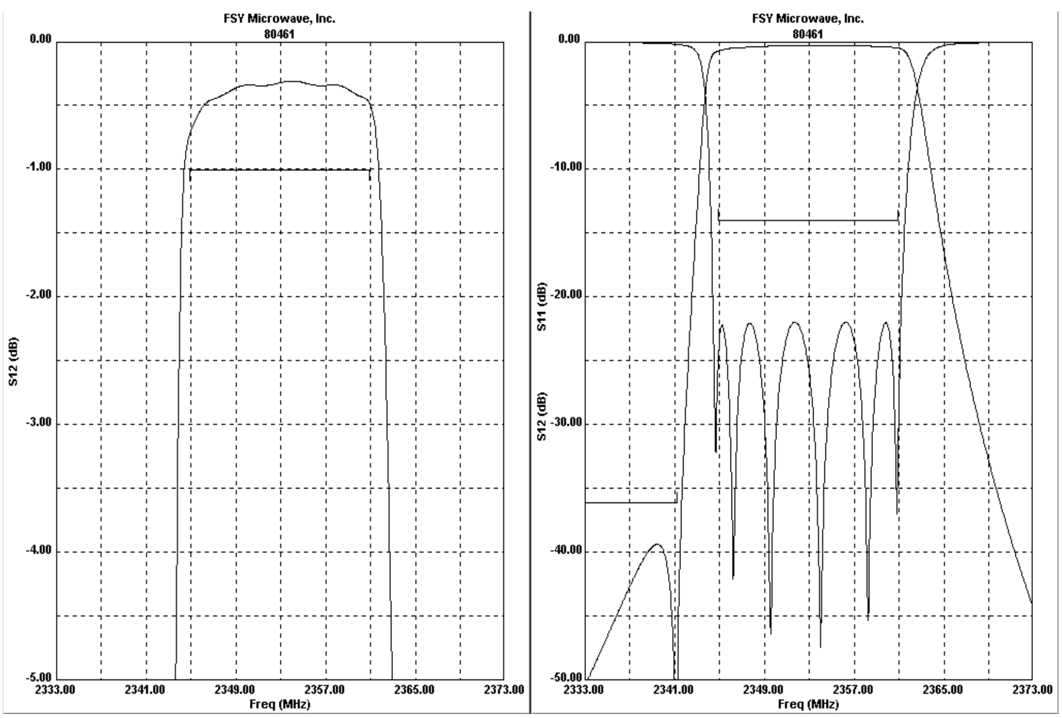
The high-power site design in the Los Angeles example uses the panel antenna patterns, antenna height and down tilt as defined in the current Los Angeles repeater network design. When analyzed using the Free Space + RMD propagation model, the antenna height variation and antenna down tilt impact the real exclusion zones seen at the 25ft. receive antenna height. Sites 3 and 119 are omni sites operating below 2 kW EIRP due to actual cable losses. Sites 028 and 018 have average EIRP, based on 360 degree pattern integration, of less than 2 kW. The exclusion zones around panel sites 028 and 018 are reduced from cable loss and downtilt. Site 101 is the only true high power site in this example. Site 101 has a 5420ft radiation center and using the actual panel antenna pattern the signal level at a receive antenna height close to the site is very low, due to the dramatic ground elevation change. The sites used in the 2 kW EIRP comparison use theoretical sites at constant transmit antenna height with ideal Omni direction antenna patterns operating at 2kW EIRP.

The low power site spacing in the Indianapolis example is based on the actual drive test data collected in the market. The morphology is different in the Indianapolis market than the Los Angeles market and the site spacing to maintain adequate street level signal strength to ensure 99.9 % service availability requires smaller site spacing. The free space + RMD propagation model has no correlation to the street level field strength in a mobile environment.

Attachment A



FSY Microwave, Inc., P/N: 80460



FSY Microwave, Inc., P/N: 80461

Attachment B

************************** Start of Excerpt*******************************
BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to radio communications. More particularly, the present invention relates to improving a communication receiver's immunity to interference.

2. Description of the Related Art

There are presently multiple types of cellular radiotelephone systems operating. These systems include the advanced mobile phone system (AMPS) and the two digital cellular systems: time division multiple access (TDMA) and code division multiple access (CDMA). The digital cellular systems are being implemented to handle capacity problems that AMPS is experiencing.

All the cellular radiotelephone systems operate by having multiple antennas covering a geographic area. The antennas radiate into an area referred to in the art as a cell. The AMPS cells are separate and distinct from the CDMA cells. This makes it likely that the antenna for one system's cell may be located in a cell of another system. Likewise, within a particular system (AMPS, CDMA, and TDMA), there are two service providers within a given area. These providers often choose to place cells in different geographical locations from their competitor, hence there are situations where a radiotelephone on system \`A\` might be far away from the nearest system \`A\` cell while close to a system \`B\` cell. This situation means that the desired receive signal will be weak in the presence of strong multi-tone interference.

This intermixing of system antennas can cause problems for a mobile radiotelephone that is registered in one system, such as the CDMA system, and travels near another system's antenna, such as an AMPS antenna. In this case, the signals from the AMPS antenna can interfere with the CDMA signals being received by the radiotelephone due to the proximity of the radiotelephone with the AMPS cell or the higher power of the AMPS forward link signal.

The multi-tone interference encountered by the radiotelephone from the AMPS signals creates distortion products or spurs. If these spurs fall in the CDMA band used by the radiotelephone, they can degrade receiver and demodulator performance.

It is frequently the case in an AMPS system for the carriers (A and B bands) to \`jam\` the competitor system unintentionally. The goal of the cellular carrier is to provide a high signal to noise ratio for all the users of their system by placing cells close to the ground, or near their users, and radiating the FCC power limit for each AMPS channel. Unfortunately, this technique provides for better signal quality for the carrier's system at the expense of interfering with the competitor's system.

Intermodulation distortion, such as that caused by the above situations, is defined in terms of the peak spurious level generated by two or more tones injected into a receiver. Most frequently, the third-order distortion level is defined for a receiver in terms of a third-order input intercept point or IIP3. IIP3 is defined as the input power (in the form of two tones) required to create third order distortion products equal to the input two tone power. As shown in FIG. 13, IIP3 can only be linearly extrapolated when a non-linear element, such as an amplifier, is below saturation.

As shown in FIG. 14, third-order distortion products occur when two tones are injected in a receiver. Tone #1 is at frequency f1 at power level P1 in dBm. Tone #2 is at frequency f2 at power level P2 in dBm. Typically P2 is set to equal P1. Third-order distortion products will be created at frequencies 2.times.f1 - f2 and 2.times.f2 - f1 at power levels P12 and P21 respectively. If P2 is set to equal P1, then spurious products should be equal, or P12 and P21 should be equal. Signal fc is injected at power level Pc to show that the added distortion is equal to a low level signal in this case. If there is a filter that filters out f1, f2 and f21 after the distortion is created, the power at f12 will still interfere with the signal power at fc. In example FIG. 14, for a CDMA application, the goal is that the intermod P12 should be equal to the signal power of -105 dBm for a total two tone power of -43 dBm, so the IIP3 must be >-9 dBm.

As is well known in the art, IIP3 for a single non-linear element is defined as the following: ##EQU1##

If P.sub.1 =P.sub.2, then P.sub.in =P.sub.1 +3 dB or P.sub.2 +3 dB (dBm) and

IM3=P.sub.1 -P.sub.12 =P.sub.2 -P.sub.21 =P.sub.2 -P.sub.12 =P.sub.1 -P.sub.21 (dB)

For cascaded IIP3, where more non-linear elements are used, the equation is as follows:

IIP3=-10*log10›10.sup.(Gain-element IIP3)/10 +10.sup.(-IIP3 of previous stages)/10 !

where:

Gain=gain to element input.

Therefore, one way to improve the cascaded IIP3 of a receiver is to lower the gain before the first non-linear element. In this case, the LNA and mixer limit IIP3. However, another quantity needs to be defined that sets the sensitivity or lowest receive signal level without interference. This quantity is referred to in the art as the noise figure (NF). If the gain of the receiver is reduced to improve IIP3 (and interference immunity), the NF (and sensitivity to small desired signals) is degraded.

The Element NF is defined as the following: ##EQU2## where:

Si/Ni is the input signal to noise ratio in dB, and

S.sub.o /N.sub.o is the output signal to noise ratio in dB.

For elements in cascade in a receiver, the equation is as follows: ##EQU3## where:

NFe equals the noise figure of the element,

NFi equals the cascaded noise figure up to the element, and

Gain equals the running gain up to the element.

The `best` cascaded NF can be achieved if the gain up to the element is maximized, this equation is in contradiction to the requirement for the `best` cascaded IIP3. For a given element by element and receiver NF and IIP3, there are a limited set of gain values for each element that meet all of the requirements.

Typically, a receiver is designed with NF and IIP3 as predefined constants, as both of these quantities set the receiver's dynamic range of operation with and without interference. The gain, NF, & IIP3 of each device are optimized based on size, cost, thermal, quiescent and active element current consumption. In the case of a dual-mode CDMA/FM portable cellular receiver, the CDMA standard requires a 9 dB NF at minimum signal. In other words, for CDMA mode, the sensitivity requirement is a 0 dB S/N ratio at -104 dBm. For FM mode, the requirement is a 4 dB S/N ratio at -116 dBm. In both cases, the requirements can be translated to a NF as follows: ##EQU4## where

S is the minimum signal power,

S/N is the minimum signal to noise ratio,

N.sub.therm is the thermal noise floor (-174 dBm/Hz@290.degree. K.),

and Signal BW (dB/Hz) is the bandwidth of the signal.

Therefore,

CDMA NF=-104 dBm-0 dB-(-174 dBm/Hz)-61 dB/Hz=9 dB,

FM NF=-116 dBm-4 dB-(-174 dBm/Hz)-45 dB/Hz=9 dB,

where

-61 dBm/Hz is the noise bandwidth for a CDMA channel

-45 dBm/Hz is the noise bandwidth for a FM channel

However, the receiver's NF is only required when the signal is near the minimum level and the IIP3 is only required in the presence of interference or strong CDMA signals.

There are only two ways to provide coverage in the areas where the carrier is creating strong interference. One solution is to employ the same technique; i.e., co-locate their cells along with the competition's. Another solution is to improve the immunity of a receiver to interference. One way to improve the immunity is to increase the receiver current. This is not a practical solution, however, for a portable radio that relies on battery power. Increasing the current would drain the battery more rapidly, thereby decreasing the talk and standby time of the radiotelephone. There is a resulting need to minimize multi-tone interference in a radiotelephone without impacting the current consumption.

SUMMARY OF THE INVENTION

The process of the present invention adjusts attenuation in a circuit, thereby improving a receiver's immunity to interference. The circuit has an attenuator with attenuation and automatic gain control (AGC) with a variable gain. The process varies the attenuation by a predetermined amount. The gain of the circuit is then detected. If the detected gain change is greater than a predetermined threshold, intermodulation products have been detected and the front end attenuation is increased to reduce the intermodulation product power.
*************************End of Excerpt********************************