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April 5, 2006

VIA ECFS

Ms. Marlene H. Dortch, Secretary
Federal Communications Commission
445 Twelfth Street, SW, TW-A325
Washington, DC 20554

Re: Ex Parte Presentation
ET Docket No. 00-258

Dear Ms. Dortch:

On behalf of United States Cellular Corporation, this is to provide additional information concerning proposals made by Sprint Nextel Corporation which might result in delays to the early deployment of advanced services via AWS spectrum as described in USCC's reply comments dated December 12, 2005 in response to the Commission's Fifth Notice of Proposed Rulemaking concerning the relocation of incumbent Broadband Radio Service (BRS) operations in the 2150-2160/62 MHz band.

USCC believes that the early deployment of new AWS systems within line-of-sight of Sprint-Nextel BRS hub uplinks is feasible prior to relocation of these uplinks to replacement spectrum based (1) on USCC's alternative calculations of realistic hub uplink sensitivity objectives for Sprint's incumbent broadband hub operations and (2) on adjacent (and non-contiguous) channel interference and real-world adjacent or out of band rejection considerations with respect to AWS signals.

In his attached Statement, Christopher J. Hall, P.E., Wireless Systems Engineering, Inc., of Satellite Beach, Florida, concludes that based on USCC's calculation of BRS hub uplink sensitivity of Sprint's incumbent broadband hub operations and on adjacent (and non-contiguous) channel interference and real-world adjacent or out of band rejection considerations with respect to AWS signals, new AWS systems can be deployed on the portions of the AWS spectrum which are not co-channel without causing harmful interference to these incumbent operations.

As described in additional detail in the attachment to this letter, Mr. Hall concludes that Sprint analysis misstates the sensitivity of its BRS hub uplinks to interference in two areas: First, the

representation that system cannot tolerate interference which would raise the noise floor by 1 dB above that caused by thermal noise is flawed. Reviewing the Hybrid Series 2000 System Description, Release 5.1, in combination with the California Amplifier (FCC ID J26520005-1) subscriber equipment filings, calculation of reverse link performance yields a full power operating point of -74 dBm at the receive antenna terminals at 30 miles. This, based on manufacturer data, leads to tolerance of interference whose aggregate is -87 dBm or less in 200 kHz RF bandwidth (320 kbps uplink data rate, as mentioned in the Sprint filings), rather than the much lower level claimed by Sprint. While AWS base stations are not yet available, he considers 1900 MHz PCS base stations to be representative of the practical spurious emissions performance that can be expected for AWS band equipment. Using the Lucent CDMA PCS transmitter (FCC ID AS5ONEBTS-02) certification filings, he finds that with 3 CDMA carriers up, transmitting full power (1580W aggregate EIRP), using Lucent-filed out-of-band emissions (OOBE) data, AWS transmitter OOBE should be tolerable at only ¼ mile range from the BRS receive hub. Addition of practical transmit and receive filtering at AWS and BRS hub sites respectively to mitigate OOBE could actually allow co-location on the same tower.

Second, the adjacent (and non-contiguous) channel interference evaluation filed by Sprint on 2/7/2006 is also flawed, as the simulated AWS signal was QAM rather than the essentially constant envelope QPSK used in CDMA systems, and the test signal synthesis and upconversion arrangement shown could have generated very significant intermodulation products which could have fallen cochannel to the test receiver. Thus, he concludes Sprint based its submission on information which did not accurately measure the real-world adjacent or out of band rejection performance of the Hybrid Series 2000 system with respect to AWS signals. Again, use of transmit and receive filtering at the AWS and BRS stations respectively to mitigate possible interference (a common industry practice) was not considered as an alternative to allow peaceful coexistence of the systems – an alternative he concludes to be quite practical.

Pursuant to section 1.1206(b) of the Commission's rules, an electronic copy of this letter is being filed.

In the event there are questions regarding this matter, please contact the undersigned.

Sincerely,

George Y. Wheeler

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Agilent Technologies
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Engineering Analysis of the Interference Impact of AWS Base Station Operations on BRS Uplink Operations

April 4, 2006

1 Executive Summary

After reviewing the Engineering Statement of Kessler and Gehman Associates (KGA) dated 11/21/2005, and the Sprint FCC filing of 2/7/2006, which contained the 2/1/2006 Engineering Statement of KGA, which was in turn based upon the Axcera Test Report dated 1/27/2006, an independent link budget is developed herein for the operation of the BRS uplink used in the Sprint system. This link budget, in concert with Out of Band Emissions (OOBE) data from FCC certification filings for PCS base stations (used as a surrogate for AWS stations) lead to the conclusion that Sprint, in their Ex Parte filing, overrepresents their BRS hub uplink sensitivity to interference in two areas:

First, the representation that system cannot tolerate interference which would raise the noise floor by 1 dB above that caused by thermal noise is flawed. Reviewing the Hybrid Series 2000 System Description, Release 5.1, in combination with the California Amplifier (FCC ID J26520005-1) subscriber equipment filings, calculation of reverse link performance yields a full power operating point of -74 dBm at the BRS hub receive antenna terminals at 30 miles. This, based on manufacturer data, leads to tolerance of interference whose aggregate is -87 dBm or less in 200 kHz RF bandwidth (320 kbps uplink data rate, as mentioned in the Sprint filings), rather than the much lower level claimed by Sprint. While AWS base stations are not yet available, we consider 1900 MHz PCS base stations to be representative of the practical spurious emissions performance that can be expected for AWS band equipment. Using the Lucent CDMA PCS transmitter (FCC ID AS5ONEBTS-02) certification filings, we find that with 3 CDMA carriers up, transmitting full power (1580W aggregate EIRP), using Lucent-filed OOBE data, AWS transmitter OOBE should be tolerable at only 2/3 mile range from the BRS receive hub. Addition of practical transmit and receive filtering at AWS and BRS hub sites respectively to mitigate OOBE could actually allow co-location on the same tower.

Second, the adjacent (and non-contiguous) channel interference evaluation filed by Sprint on 2/7/2006 is also flawed, as the simulated AWS signal used by Axcera was QAM rather than the essentially constant envelope QPSK used in CDMA systems, and the test signal synthesis and upconversion arrangement shown could have generated very significant intermodulation products which could have fallen cochannel to the test receiver. Thus, we believe the Axcera test did not accurately reflect the real-world adjacent or out of band rejection performance of the Hybrid Series 2000 system with respect to AWS signals. Again, use of transmit and receive filtering at the AWS and BRS stations respectively to mitigate possible interference (a common industry practice) was not considered as an alternative to allow peaceful coexistence of the systems – an alternative we believe to be quite practical.

The overall conclusion of the analysis is that AWS base station operation should create levels of interference to BRS hub receivers that in the real world will either pass unnoticed or which could readily be reduced to levels which would pass unnoticed through the use of industry accepted mitigation practices such as transmit and receive filtering.

2 Interference Discussion of AWS Downlink to BRS Uplink

We have reviewed the Engineering Statement of Kessler and Gehman Associates (KGA) dated 11/21/2005, and the Sprint FCC filing of 2/7/2006, which contained the 2/1/2006 Engineering Statement of KGA, based upon the Axcera Test Report dated 1/27/2006. An independent analysis is developed below, for comparison and discussion.

RF emissions generated by the AWS forward link operate on the following frequencies:

AWS Block	Frequency
A	2110-2120 MHz
B	2120-2130 MHz
C	2130-2135 MHz
D	2135-2140 MHz
E	2140-2145 MHz
F	2145-2155 MHz

KGA discusses the resulting energy falling in the MDS1 (2150-2155 MHz) and MDS2 (2155-2160 MHz) BRS Reverse Link Blocks. That report finds the interference to be unacceptably high, and indicates AWS operations will cause interference to BRS receive hubs, cochannel, adjacent channel and on noncontiguous channels.

2.1 Cochannel Interference Case

Clearly, AWS Block F actually overlaps the MDS1 channel. Engineering an AWS system to avoid interference while the AWS and BRS sites have a clear, cochannel line of sight path between them isn't practical. However, depending upon terrain, it *may* be possible to operate an AWS system and BRS system in close physical proximity, provided adequate terrain blockage is available and used carefully. Energy in this band does not diffract terribly well around large scale obstructions blocking the line of sight. Adjacent valleys could perhaps be served by AWS and BRS systems, provided the sites are properly located, and the dividing terrain is suitably high to provide the needed blockage.

Thus, Cochannel reuse will have to be handled on a site and area specific basis.

2.2 Adjacent and Non-Contiguous Channel case - Assumptions

If the AWS operation is on Blocks A-E, KGA's analysis makes the following general assumptions to analyze the interference potential to BRS systems:

1. 36° sectorization at the BRS hub site
2. Multiple AWS sites within a BRS sector, within 35 miles, per AWS block. However, KGA bases its calculations on 5 AWS stations in the BRS field of view.
3. The AWS sites will produce out of band spurious emissions per the FCC emissions template.
4. The AWS and BRS sites have a transmit/receive gain of 17 dBi and 19 dBi, respectively
5. The AWS transmitters have a bandwidth of 5 MHz
6. The BRS receive site has a noise figure of 4 dB,
7. The BRS station has a noise bandwidth of 5 MHz
8. Thus, the BRS receive site has a noise floor of -103.25 dBm, that is: ($10 \log(5 \times 10^6) + 4 - 174$ dBm)
9. Interference which raises the BRS receive noise floor by 1 dB above thermal is unacceptable

These assumptions are relatively straightforward, but they don't reflect the situation with complete accuracy.

Let's address these assumptions, revising them, adding our own to more accurately predict typical interactions:

2.2.1 Assumptions 1 and 2 – BRS Sectorization and AWS deployment lead to an assumption for analysis' sake of 5 AWS transmitters within the BRS receive field of view.

AWS transmitters' deployment may or may not take place in every frequency block, in every market. The AWS sites in a BRS sector field of view will vary in distance, with the closest having the greatest influence. Engineering to utilize man-made and/or terrain obstructions to block line of sight beyond a few miles may be possible in some markets, but not others. Strictly for the sake of similarity of analysis, we'll assume 5 AWS transmitters are seen by a BRS site.

2.2.2 Assumption 3 – OOBE level cochannel to BRS receive hub.

Typical base station radios *do not* simply meet the out of band spurious emissions (OOBE) limit. Well designed, typical equipment such as that produced by Lucent, comfortably beats the limits set. Further, the OOBE FCC template is intended to include single tone or narrowband spurs created in signal synthesis. Such spurs are usually far above the wideband noise floor produced by a transmitter (if they exist in a particular design), and even these must meet the OOBE template.

Thus, the wideband noise produced by an AWS transmitter can be expected to be well below the OOBE limits set by the FCC. In fact, Lucent filings for a typical CDMA base station in the 1900 MHz PCS band should be representative of upbanded hardware operating in the AWS band. The difference in frequency is slight, and transmitter and power amplifier designs should be essentially the same, except for relatively minor tuning changes. As an experienced radio equipment designer, I see no reason to expect that AWS transmitters will in any way be inferior to those designed for the same CDMA 1x technology in the PCS bands.

As a typical example that we consider representative, Lucent has certified a CDMA PCS transmitter designated by FCC ID AS5ONEBTS-02. Looking at Exhibit 15 (Conducted Spurious Data) of that filing (reproduced below as Figure 1), we find that a transmitter (with three simultaneous CDMA carriers up) puts out 60W (+48 dBm) to the antenna connector, that *measured* spurious emissions are generally below –24 dBm, and are *all* below –18 dBm in a 3 MHz measurement noise bandwidth. Only very close to the carriers themselves does one see a level of –18 dBm in 3 MHz. For the sake of argument, we assume herein this to be the level that would fall within BRS receive frequencies, though the actual level may be lower.

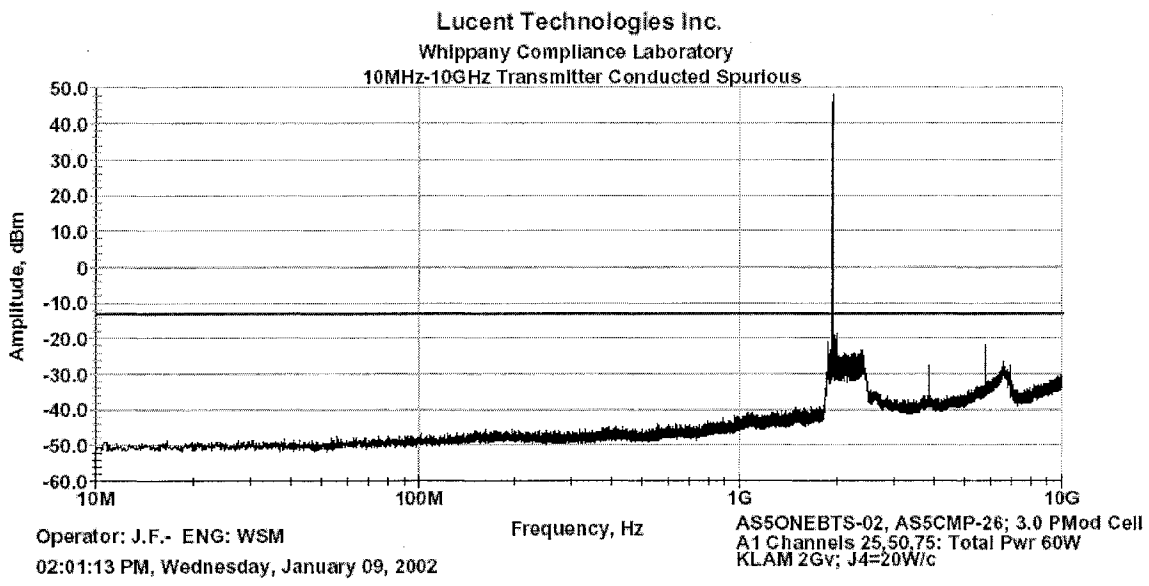

Figure 1 – Three carrier test case data from Lucent transmitter certification

2.2.3 Assumption 4 – Transmit and Receive gains

These are reasonable, so we will assume a BRS receive gain of 19 dBi, and an AWS transmit gain of 17 dBi.

This effectively assumes that the AWS site antenna is effectively zero downtilt, copolarized, and directly faces (boresight to boresight) the BRS site antenna.

2.2.4 Assumption 5 – The AWS transmitters have a bandwidth of 5 MHz

One typical configuration could be to implement no more than 3 CDMA 1x carriers, each approximately 1.25 MHz wide. This is why the Lucent AS5ONEBTS-02 transmitter, 3 carrier case was chosen above. However, each carrier is less than 5 MHz wide, and the aggregate includes some guardband.

2.2.5 Assumption 6 – The BRS receive site has a noise figure of 4 dB.

No supporting information was offered, and this is a fairly low noise figure. However, for the sake of like analysis, we'll use this value herein.

2.2.6 Assumption 7 – The BRS receive site has a noise bandwidth of 5 MHz.

This appears to be incorrect.
Referring to the Hybrid Series 2000 System Description, Release 5.1, the system has several selectable receiver bandwidths to achieve various reverse path data rates:

160 kHz bandwidth for 256 kbps data rate
200 kHz bandwidth for 320 kbps data rate
320 kHz bandwidth for 512 kbps data rate
400 kHz bandwidth for 640 kbps data rate
640 kHz bandwidth for 1024 kbps data rate
800 kHz bandwidth for 1280 kbps data rate
1600 kHz bandwidth for 2560 kbps data rate

Based on our understanding and statements in Axcera's report, Sprint uses the 200 kHz bandwidth. That value is used herein.

2.2.7 Assumption 8 – BRS System Noise Floor

Because the noise bandwidth assumed was incorrect, the noise floor too must be recalculated.

Noise Floor = -173.97 dBm + 4 dB + 10 Log (200000) = -117 dBm
(this figure will change again below when we consider manufacturer data)

2.2.8 Assumption 9 – Interference which raises the noise floor by 1 dB above thermal is unacceptable.

This makes the implicit assumption that the BRS system is operating in a thermal noise limited environment. Arguably, in any populated area, there is a substantial amount of man made noise, not just the thermal noise floor.

In KGA's discussion, the assumption was made that transmitters in adjacent bands produce noise at the FCC OOBE specification, hence AWS stations within line of sight could not be tolerated. Using Lucent measured data (above) as an example for upbanded equipment, we find that fielded transmitters should emit significantly lower out of band levels than the FCC OOBE mask.

2.3 Existing Noise Floor from Non-Contiguous Sources

Using the Lucent PCS transmitter as an example for upbanded equipment raises another issue:

What about PCS stations that already exist? Looking at Figure 1, we see that the Lucent example transmitter *does* produce energy in the 2150 MHz range. In fact, it's on the order of -25 to -30 dBm in 3 MHz bandwidth. Thus, *existing* PCS site influence is very nearly the same as the noise AWS transmitters will produce in the MDS1 and MDS 2 blocks.

These transmitters are fielded in great numbers nationwide, and up to 5 PCS operators could be using them, with three carriers or more, in any given location where Sprint BRS systems now operate....
(If not Lucent 1x, one might reasonably assume other models or other vendors' equipment is comparable.)
While we assumed the worst spurious level of –18 dBm for our calculations herein, the measured data for existing Lucent equipment in the PCS band is within perhaps 6 dB of this value.

If KGA's assumptions are true, a BRS sector covers 384.8 sq mi. If PCS cells have 3 mile radius, each covers about 28.3 sq mi. Thus, a BRS sector could <u>currently</u> see (with 5 PCS licensees) roughly 68 PCS sites emitting these power levels...

Based on this assumption, we can estimate the (minimum) received signal level at a BRS site that would result:

Lucent base station "J4" OOBE output level:	-30 dBm in 3 MHz
Power falling in 200 kHz receive bandwidth of BRS receive site :	-42 dBm in 200 kHz
Cable loss to transmit antenna, including jumpers (typical) :	-3 dB
Transmit antenna gain:	17 dBi
Receive antenna gain:	19 dBi

(Assumptions: antenna boresights directly face each other, antennas are copolarized, line of sight path exists, so free space loss applies – worst case)

To calculate received power at the BRS site antenna terminals:

$$P_{received} = P_{in}\ \lambda^2\ G_t\ G_r\ /\ (16\ \pi^2\ r^2)$$

Where $\lambda = 8.627 \times 10^{-5}$ miles
r = range in miles. Deliberately assuming they're all at 35 miles range (minimizing received power)
and P_{in} = -42 dBm – 3 dB cable loss = -45 dBm

$P_{received}$= -143 dBm per site, or –124 dBm aggregate for 68 sites.

Thus, PCS transmitters alone have likely raised the noise floor by more than 1 dB above thermal.
(PCS is by no means the only other transmitter type operating in nearby bands, making contributions.)

Thus, the BRS system now tolerates *some* interference above thermal noise floor from existing man-made sources.

This raises the question:
Based upon manufacturer data, what is the actual operating point of the system, and what interference tolerance arises from those calculations?

3 The Hybrid Series 2000 System

3.1 Link budget

The system utilized by Sprint uses California Amplifier MDS-MMDS Integrated Planar Transceivers, FCC ID J26520005-1, or similar equipment, as subscriber units. These subscriber units usually use a 17 dBi antenna.

We understand that typically, Sprint uses the 320 kbps uplink data rate, occupying 200 kHz of RF bandwidth.

Reviewing the Hybrid Series 2000 System Description, Release 5.1, in combination with the California Amplifier FCC filings, we can put together a link budget for the reverse path.

Again,

$$P_{received} = P_{transmit}\ \lambda^2\ G_t\ G_r\ /\ (16\ \pi^2\ r^2)$$

Where $\lambda = 8.627 \times 10^{-5}$ miles
r = range in miles = 30, based on Hybrid's statements regarding nominal cell radius

Subscriber unit transmit power ($P_{itransmit}$) is roughly 219 mW.

G_t = 17 dBi = 50.12
G_r = 19 dBi = 79.43

Cell radius is described by Hybrid as 30 miles, so r = 30.

Thus, $P_{received} = (219\ mW)(7.44 \times 10^{-9})(50.12)(79.43) / (16 * \pi^2 * 30^2)$
$P_{received} = 4.56 \times 10^{-8}$ mW = -73.4 dBm

That's at the antenna terminals.

After the antenna, there is apparently a preselect filter with a 12 MHz passband.
To achieve that narrow a passband at a center frequency of roughly 2 GHz will likely require 7-10 stages (The stopband specs will determine the actual number, and that information does not appear in the documentation.) Regardless, such a filter is likely to have 1-2 dB of loss. We'll assume 1.5 dB.

After the preselect filter, there's a preamplifier described as having a 4-5 dB noise figure.
We'll assume 4.5 dB noise figure.

These items are apparently used with a tower mounted downconverter. If so, cable loss can be ignored as a contributor to system noise figure.

Thus, it appears that the system receive noise figure is approximately 6 dB,
(ignoring the downconverter and receiver contributions).

Thus, in a 200 kHz channel, given a 6 dB noise figure, the receiver noise floor is:

Noise Floor = 6dB + 10 Log(200×10^3) Hz – 173.97 dBm/Hz = -115.0 dBm

In the manufacturer data, in order to achieve a bit error rate of 10^{-9}, an RF SNR of 13 dB is specified.

This is more or less in line with what one would expect from QPSK modulation, with minimal forward error correction encoding.

In addition, a 10 dB margin is specified by Hybrid, presumably for some foliage penetration, marginal line of sight conditions, etc.

Thus, one would assume the minimum required receive signal level to be:

$P_{received}$ = (System Noise Floor) + 13 dB +10 dB = -92 dBm

Thus at 30 miles, the system appears to have a (-73.4 dBm) - (-92 dBm) = 18.6 dB margin.

3.2 OOBE Interference Tolerance

Looking at it another way, if we assume:

The subscriber unit is at full transmit power,
A line of sight range at the nominal 30 mile cell radius,
Received signal strength (free space loss) is -73.4 dBm,
200 kHz reverse link bandwidth (320 kbps)

Then the system could ignore interference 13 dB below the -73.4 dBm received signal power level, based on manufacturer data.

So, to be ignored, interference needs to be less than -86.4 dBm

Even if one assumes that an extra 10 dB of margin is needed over and above that specified by Hybrid, to account for the vagaries of propagation or in order to use the maximum 1600 kHz channel width (which is 9 dB wider than 200 kHz), one could engineer a system to coexist peacefully with the Hybrid Series 2000 system, provided it produced a received signal level at the Hybrid receive antenna terminals of **-96.4 dBm or less** in the reception bandwidth.

That's cochannel energy... Adjacent channel energy; that which does not fall in the receiver bandwidth, can be higher. (That topic was discussed in the Sprint 2/7/2006 filing, discussed later in this document.)

3.3 Calculation of AWS-BRS Base Station Coexistance Distance

Based on this conclusion, we can calculate the range at which an AWS site produces sufficient OOBE to interfere with the BRS site:

Lucent base station "J4" OOBE output level:	-18 dBm in 3 MHz
Power falling in 200 kHz receive bandwidth of BRS receive site :	-30 dBm in 200 kHz
Cable loss to transmit antenna, including jumpers (typical) :	-3dB
Transmit antenna gain:	17 dBi
Receive antenna gain:	19 dBi

(Assumptions: antenna boresights directly face each other, antennas are copolarized, line of sight path exists, so free space loss applies – worst case)

To calculate received power at the BRS site antenna terminals:

$$P_{received}=P_{in}\ \lambda^2\ G_t\ G_r\ /\ (16\ \pi^2\ r^2)$$

Where $\lambda = 8.627 \times 10^{-5}$ miles
And P_{in} = -33 dBm = 5×10^{-4} mW
r = range in miles

This assumes free space path loss, which is worst case, but the path is tower to tower, so it's appropriate at short to moderate ranges.

So, $P_{received}$ (mW) = $(9.4 \times 10^{-11}) / r^2$

Or setting $P_{received}$ (dBm) = -96.4 dBm
And setting = -20 Log (r) – 100.3 (dBm)

yields r = 0.64 miles

Thus, The Hybrid Series 2000 system can tolerate one AWS site at a range of 0.64 miles with only standard Lucent transmit filtering.

If 5 AWS sites are in view, the interference will be approximately 10 Log (5) dB higher

so setting $P_{received}$ (dBm) = -96.4 dBm
And setting = -20 Log (r) – 100.3 (dBm) +10 Log (5)

yields r = 1.4 miles
(This of course neglects the fact that 5 sites won't all be this close, and the more distant, the less the influence)

Thus, the Hybrid Series 2000 system can tolerate 5 AWS sites at a range of 1.4 miles with only standard Lucent transmit filtering.

3.4 Mitigation

If a relatively inexpensive transmit filter is added to the AWS transmitter, providing
40 dB of rejection at 2150 MHz or higher,
while passing AWS A-E blocks (2110-2145 MHz) with less than 1 dB loss
(WSE has obtained a quote for such a filter from a reputable vendor for < $700 each.)
the range is reduced by a factor of 100, so:

An AWS site can can be tolerated by a BRS site at a range of 0.0064 miles, or about 34 feet, and 5 sites can be tolerated at a range of 0.014 miles, or about 74 feet.

Thus, one can reasonably conclude that AWS sites will not constitute a major impediment to continued BRS operations by Sprint, at least not due to out-of-band emissions.

4.0 Adjacent and Non-Contiguous Rejection of Hybrid Series 2000 System

The Sprint filing of 2/8/2006 raises another issue; that of adjacent channel rejection in the Hybrid Series 2000 system. The report by KGA included therein, dated 2/1/2006 is based on a laboratory test run by Axcera, in a report dated 1/27/2006.

4.1 Axcera Test Setup and Conditions

The filing and the conclusions of KGA are a direct function of the Axcera test. Let's examine that test:

The test uses a –92 dBm RF signal level for the reverse link, as the "lowest received upstream level for acceptable operation" rather than the much higher level, -73.4 dBm our link budget (based on manufacturer documentation) suggests is possible, making the test condition more susceptible to interference by 18.6 dB.

In the test report, the AWS system is simulated by a series of 64-QAM signals. This choice does not reflect the proposed AWS systems, which are direct sequence CDMA using phase shift keying - that is, the proposed AWS systems are more or less constant envelope modulations, while 64-QAM amplitude varies by up to 16.9 dB, depending on the symbol being sent. 64-QAM also has a 3.7 dB Peak-to-Average power ratio, so a signal that's nominally -100 dB, for instance has excursions from -113.2 to -96.3dB. This makes a significant difference when intermodulation products are being generated.

Next, a 400kHz QPSK signal was used to simulate the 200kHz one actually used by the Hybrid system. It's noted that "The use of the wider bandwidth QPSK signal does not affect the outcome of the test as the S/N comparison of the IF spectrum was performed using a spectrum analyzer resolution bandwidth of 30 kHz."

However, total power of the signal, and the total power of the interference falling in the receiver bandwidth, are normally used in signal to interference calculations. So, the normalization of the measurements is critical if the spectrum analyzer is not bandwidth matched to the signals. It's not clear, in detail, whether and how this normalization was actually done, so some error in calculated S/N value may exist.

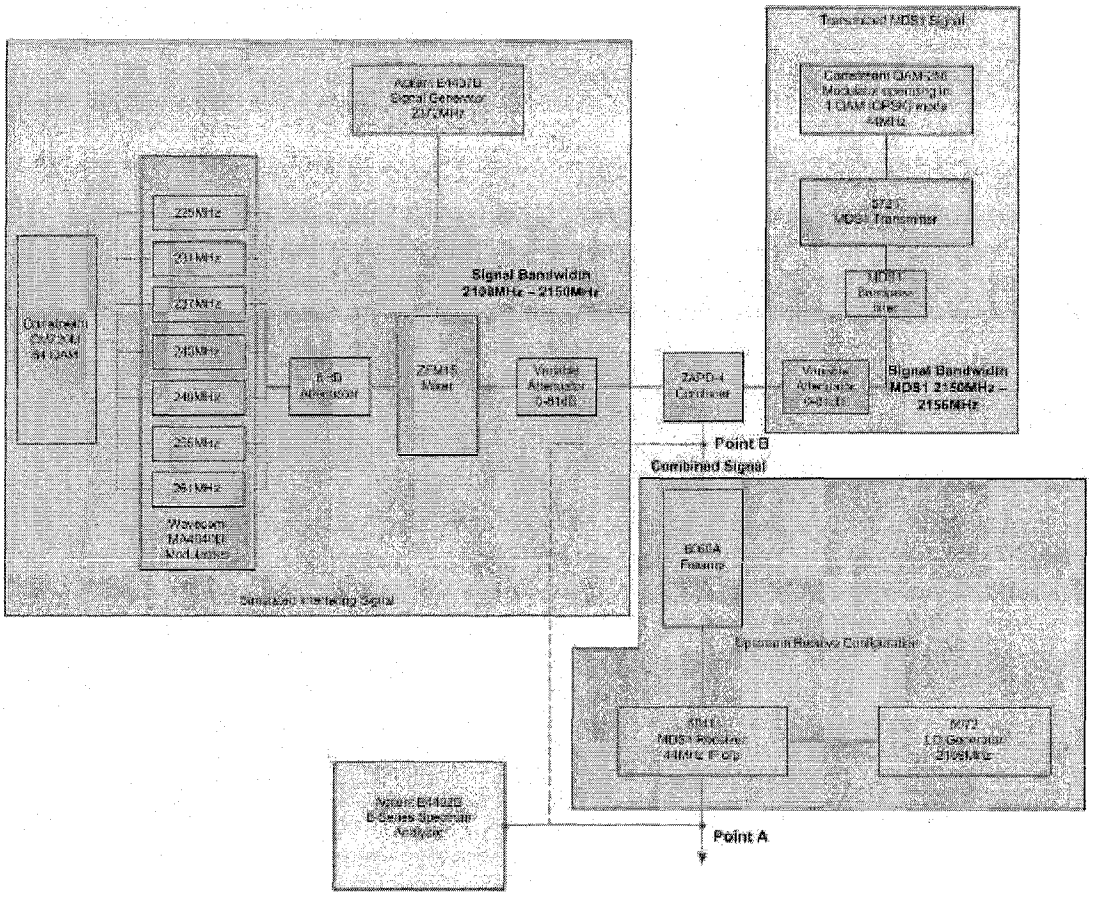

Figure 2 – Axcera Test System (from 2/7/2006 Sprint filing)

Looking at Figure 2 (the Axcera Test System), another issue is evident. It appears that a *single* 64-QAM modulation source was used, and then modulated onto up to 7 IF 'interferer' carriers. If a single signal source is used in this way, *all* the 64-QAM symbols are identical, so when a symbol is at the lowest possible amplitude, *all* 7 signals are. Likewise, when an extreme outer corner symbol of the 64-QAM constellation is sent, leading to a power spike, *all* the signals have a power spike at the same instant. Depending upon the phase relationships of the seven Wavecom modulators, a very substantial spike in peak power could be produced (when all 7 carriers are operating) leading to an entirely different interference scenario than the constant envelope QPSK one from AWS systems as proposed by USCC.

Looking up the Wavecom MA4040D modulators, we found they have a standard 44MHz IF input, which is *exactly the same frequency as the MDS1 receiver IF*. Thus, unless the 6060A preamp is filtered and effectively blind to 44 MHz, a *direct* 44 MHz path may be available leading from the 'interference' modulators to the MDS1 receiver. (The MA4040D specifications we found do not give an IF rejection at this frequency, nor is the loss of

the ZAPD-4 specified for this frequency) In any case, I would be wary of 'sneak paths' in the test setup that could have passed 44 MHz and affected the experimental results.

The MA4040D modulators have a nominal +45 to +61 dBmV (180mV to 1V) output into 75 ohms (-3.6 to +11 dBm). How 7 of these were combined to feed the single 50 ohm ZFM-15 mixer is not shown, but even after a 6 dB attenuator, these signals come to a total power of roughly -18 to -3.5 dBm for one signal, up to -10 to +5 dBm for seven (depending on modulator output power setting).

Sending these signals through a single mixer, apparently at a high (at least -10 dBm total) power level, creates very significant intermodulation, very likely creating evenly spaced mix products right across the band – with some landing cochannel to the receiver. This is especially true as the 2372 MHz upconversion LO (at +10 dBm) is only 28 dB to as little as 5 dB higher power than the QAM signals combined. I also note that there's no filter to remove the 2372 MHz LO, or the sum mix products. Thus, the residual LO, sum, difference, and other intermodulation products are all sent into the LNA, apparently with no filtering.

The ZFM-15 mixer is rated 10-800 MHz on the IF port, so the mixer was likely operated either outside its specified frequency range, or 'backwards' with the input signal into the IF port, and the output taken from the RF port. If operated 'backwards', any DC bias on the signal from the combined MA4040Ds would bias the diodes in the mixer and increase the production of intermodulation products.

So, the 6060A preamplifier appears to have been fed by an unrealistically rich mix of intermodulation products, probably including cochannel ones. Unless the 6060A preamplifier includes the 12 MHz wide preselection filter, which isn't stated, it will likely create further intermodulation products, possibly also creating cochannel ones, further distorting the test results.

Consequently, the Axcera experiment appears to be basically flawed in modeling the AWS signal it applies to the receiver, so the numeric results cannot be used with any confidence. No accurate conclusions can be drawn from the results.

4.2 Conclusions Based on Axcera Test

The Engineering Statement prepared by Kessler and Gehman Associates Inc. uses the numeric results of the Axcera tests as the basis for their model, directly leading to their results. If the Axcera test results are incorrect, then so are any conclusions that arise from it, including those in the KGA report.

A further note is that the Axcera test was conducted at an incident uplink power level far lower than that calculated for a 30 mile line of sight path, with the subscriber unit at maximum power. Thus, the test conditions ignore the system's automatic response (dynamic power control of the subscriber unit) to potential interferers. Since the subscriber units are AC line (rather than battery) powered, there is NO impact caused in system usefulness by requiring subscriber units to increase uplink power to maintain S/(N+I) in the presence of other signals.

4.3 Mitigation

The KGA filing also includes a statement (page 4) that *"...improved filters will not be practical because ten filters would be required for each RSH (one for each sector), each of which would be quite large and all of which would have to be mounted adjacent to the preamplifier located high on the RSH towers."*
This is offered without supporting data and installation details. Creative mounting solutions are usually possible, and higher performance filters and preamps may be an entirely practical, cost-effective alternative to the frequency relocation of the entire system should they be needed. Enhanced transmit and receive filters are the backbone of interference mitigation in many situations, and this approach cannot be rejected out of hand.
As an example, WSE has obtained a quote for a filter that could help significantly. For the BRS1 channel the following price/performance can be achieved: 2150-2155 < 1 dB Insertion Loss, rejection @ 2140 > 55 dB (option 1), rejection @ 2135 > 70 dB (option 2), approx. size: 7" X 5" X 2.5" (weatherproof). (Price $650)

5 Conclusions

In conclusion, we find that further data is needed to support the assertion that the Hybrid Series 2000 has insufficient adjacent channel and non-contiguous rejection to operate in the presence of AWS sites, and that reasonable filtering options can't be implemented to mitigate the possible interference.

Likewise, in Section 3, we found no reason to believe that AWS systems will cause unmanagable interference to BRS receive hubs at significant distances.

At most, it appears that AWS stations within a couple of miles of a BRS receive site may need to employ standard interference-mitigation strategies such additional transmit filters. Higher performance receive filters, retrofitted to the BRS receive sites may also be useful. With such routine measures, even colocation of AWS sites with BRS sites is not out of the question.

Sincerely,

Christopher J. Hall, P.E.
President
FL PE #50011
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