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September 8, 2008

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Written *Ex Parte* Presentation
IB Docket No. 95-91
WT Docket No. 07-293

Dear Ms. Dortch:

Sirius XM Radio Inc. ("Sirius XM")[1] hereby submits these further comments in the above-captioned proceedings in which the Commission is considering the adoption of final rules for satellite radio terrestrial repeaters and the modification of WCS rules in order to significantly expand the use of mobile operations in frequency bands adjacent to satellite radio.

Having participated in these matters for more than 11 years, Sirius XM is very eager to formalize a permanent, routine process for the licensing of its terrestrial repeaters. At the same time, Sirius XM has no interest in delaying the implementation of alternative WCS operations that do not pose significant interference threats to satellite radio reception. Sirius XM's primary intention is to ensure that its nearly 20 million existing subscribers continue to receive high-quality and interference-free programming.

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[1] On July 25, 2008, the Commission granted applications to allow the acquisition of XM Satellite Radio Holdings Inc. ("XM") by Sirius Satellite Radio Inc. ("Sirius") *Applications for Consent to the Transfer of Control of Licenses, XM Satellite Radio Holdings Inc., Transferor to Sirius Satellite Radio Inc., Transferee*, Memorandum Opinion and Order and Report and Order, 23 FCC Rcd. 12348, FCC 08-178 (rel. Aug. 5, 2008). The transaction was consummated on July 28, 2008, and the surviving parent company has been named Sirius XM Radio Inc. For convenience, references to activities previously conducted independently by either Sirius or XM are credited to the new company, Sirius XM.

To these ends, this filing is intended both to respond to certain technical issues raised by WCS interests after the close of the comment period and to present new evidence regarding the likelihood that proposed mobile WCS services will interfere with satellite radio services. In so doing, it is not our interest to rehash issues previously discussed in the record but, rather, to move these proceedings forward to resolution.

As the Commission is well aware, it was Sirius XM's sincere hope that the WCS licensees would join us in supporting independent tests performed by a qualified third party – and overseen by the Commission – that could conclusively resolve many of the key technical issues underlying this proceeding.[2] The WCS interests, however, made it clear that they have no interest in independent joint testing and, instead, chose to reject our proposal out of their stated fear of delaying FCC action.[3] Regrettably and ironically, had the WCS licensees accepted our offer over six months ago to perform independent joint tests, the Commission would have had that body of engineering data long before now.

These additional comments are divided into four parts. First, Sirius XM addresses the probability that satellite radio consumers will suffer interference from WCS mobile operations. Sirius XM has performed simulation analyses based on reasonable assumptions concerning the penetration of both satellite radio and WCS operations as well as typical and likely scenarios for mobile WCS deployment. The results confirm a significant interference threat to satellite radio reception from mobile WCS devices – in stark contrast to the claims made by WCS licensees.

Second, Sirius XM addresses the validity of other technical analyses concerning WCS and satellite radio compatibility that have been recently submitted by WCS interests.

Third, Sirius XM addresses arguments raised by WCS interests in the Part 25 proceeding that emissions from satellite radio's terrestrial repeaters pose a significant interference risk to WCS receivers. WCS interests have not provided any verifiable evidence or test data that documents a legitimate interference threat to their service from satellite radio terrestrial repeaters. In fact, the record in the Part 25 proceeding is sufficiently complete and the disagreements sufficiently narrow that the Commission can and should promptly finalize rules authorizing satellite repeaters and terminate the 11-year-old International Bureau docket once and for all. There simply is no substantive or logical link between these two dockets.

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[2] *See* Letter from Patrick L. Donnelly, Executive Vice President, General Counsel & Secretary, Sirius Satellite Radio Inc. and James S. Blitz, Vice President, Regulatory Counsel, XM Radio Inc., to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91 (filed May 19, 2008).

[3] *See* Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91 (filed May 22, 2008).

Finally, to ensure clarity regarding its positions, Sirius XM provides an updated version of its recommended rule changes. Sirius XM recommends that the existing technical restrictions on mobile devices operating on the WCS C and D blocks remain as is. It is simply not possible for mobile WCS devices to operate without any guard band to the satellite radio allocation and not cause harmful and debilitating interference to any nearby satellite radio receiver. Further, neither the WCS Coalition nor any individual WCS licensee has submitted any data to justify relaxation of the WCS technical rules as they apply to the WCS C and D blocks whereas Sirius XM has carefully quantified the scope of the adjacent band incompatibility. One of the most notable failings in the WCS Coalition's testing – that it based its technical data only on the WCS A and B blocks, and not on the C and D blocks immediately adjacent to satellite radio – suggests the Coalition is well aware that mobile operations in its band would significantly impair satellite radio operations in the adjacent bands.

The Commission previously adopted restrictions on the use of WCS spectrum based on its valid concerns as to the impact that mobile WCS operations would have on adjacent band satellite radio use. The WCS licensees bear the burden of demonstrating that mobile operations sufficiently removed in frequency from the satellite radio allocation can operate without significant potential for causing interference. To date, they have not satisfied this obligation.

Sirius XM also continues to support rules that limit the "on-the-ground" signal strength of both WCS and satellite radio terrestrial base stations rather than imposing EIRP antenna height/downtilt limits to protect adjacent band services. This is a more efficient, practical and compatible approach than arbitrarily established transmitter power limits that may or may not be optimized for satellite radio networks.

One final matter warrants introductory comment. WCS interests have recently endeavored to brand themselves as a rural broadband solution and have argued that modifying the Part 27 rules to accommodate their business plans is somehow tied to expediting their introduction of rural broadband services.[4] However, *absolutely nothing* prohibits the WCS license holders from introducing rural broadband services *now*. In fact, some WCS licensees, notably AT&T, have already begun deploying such services. Any delay in the WCS interests' stated intention to develop rural broadband services is occasioned solely by their desire to modify the WCS rules to permit mobile transmitters that would be incompatible with neighboring operations in the 2.3 GHz band.

WCS interests could provide fixed, wireless broadband service in rural locations at any time – and the Commission should see that they do so with appropriate requirements and timetables for rural buildout.[5] But in evaluating the WCS licensees'

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[4] *See, e.g.*, Letter from William Wallace, Chairman, DigitalBridge Communications Corp., to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91, at 1 (filed July 15, 2008) ("DigitalBridge *Ex Parte*"); *see also* Statement of Commissioner Jonathan S. Adelstein, *in the Matter of Sirius Satellite Radio Inc.*, File Nos. EB-06-SE-250 and EB-06-SE-386, FCC 08-176 (rel. Aug. 5, 2008).

[5] Nextwave, one of the largest holders of WCS spectrum, has recently claimed that the existing out-of-band emissions mask is jeopardizing its ability to comply with the FCC's construction requirements. *See* Letter from Jennifer M. McCarthy, Vice

efforts to add mobility to their available service offerings, the Commission must protect the millions of existing satellite radio consumers – in rural areas and elsewhere – who will experience loss of service as a direct result of mobile WCS operations.[6]

The WCS Coalition tries to suggest that mobile broadband in rural areas will be stifled without relaxation of Part 27 rules governing their service. Yet rural broadband deployment has not been slowed by a lack of available spectrum. Since 2006, the Commission has auctioned licenses for nearly 170 MHz of spectrum that is ideal for mobile broadband services in rural communities.[7] All together, there is more than 600 MHz of spectrum allocated for commercial mobile radio services. In contrast, only 25 MHz is available for satellite radio service, which is all the more reason for the Commission to protect the reliability of satellite radio service as against WCS spectrum owners who can already build fixed broadband systems today.

I. THERE IS A HIGH PROBABILITY THAT MOBILE WCS DEVICES WILL CAUSE INTERFERENCE TO SATELLITE RADIO RECEPTION.

The WCS Coalition's latest argument boils down to a claim that insofar as WCS mobile transceivers will interfere with satellite radio, such interference is acceptable because, they argue, it will not occur frequently. In support of its position, the WCS Coalition presents its own analysis, which shows that Wimax mobile transceivers will interfere with satellite radio downlinks only a small percentage of the time.[8]

President, Regulatory Affairs, NextWave Wireless Inc., to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91, at 2 (filed June 18, 2008); *see also* Letter from Jennifer M. McCarthy, Vice President, Regulatory Affairs, NextWave Wireless Inc., to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91 (filed July 16, 2008) (noting that the parties discussed "the need to resolve the co-existence issue with WCS in order to enable WCS licensees to complete their recently extended construction requirements within the next two years"). This new claim directly contradicts the WCS Coalition's previous declarations stating that rule changes were unnecessary to achieve WCS build-out requirements. *See* Reply Comments of the WCS Coalition, WT Dkt. 06-102, at 12 (filed June 23, 2006).

[6] Satellite radio service in rural areas could be severely hampered by mobile WCS service. For example, the mayor of Gillette, Wyoming, has noted his support for NextWave's proposal to provide broadband services to his rural community of 30,636. *See* Letter from Duane Evenson, Mayor, City of Gillette, Wyoming, to Kevin J. Martin, Chairman, FCC, IB Docket No. 95-91 (filed July 9, 2008). However, the Gillette area has approximately 5,500 existing satellite radio subscribers (approximately 18 percent of the town's population) whose satellite radio reception will be adversely affected by allowing mobile WCS operations in adjacent bands. In fact, satellite radio reception is particularly critical in rural areas because of the limited terrestrial radio service in those areas.

[7] *See* data for FCC auctions 66 and 73 *available at* http://wireless.fcc.gov/auctions/default.htm?job=auctions_home.

[8] *See* Comments of the WCS Coalition, IB Docket No. 95-91, at 6 of Attachment B (filed Feb. 14, 2008).

In part, these claims of the WCS Coalition rest on fundamental mistakes in its technical analysis that unreasonably minimize the distance separation required between a WCS terminal and a satellite radio receiver in order to prevent interference to the satellite radio customer service. These matters are discussed further in Section II below. But even taking these considerations into account, the Coalition grossly understates the number of times that an interference situation would arise under their proposed rule changes.

Despite the need for any technical analysis to be fully transparent, the WCS Coalition filed only a summary of its study, not the software or a description of all assumptions used in the analysis. Indeed, the WCS Coalition acknowledges employing proprietary software. This lack of transparency complicates the ability of Sirius XM, the Commission, and the public, to replicate and verify the Coalition's claimed results. Without complete on-the-record disclosure of its algorithms and inputs, the WCS Coalition's unexplained and untested probability analysis cannot form a rational basis for changes in the Commission's rules.[9]

Beyond the fundamental lack of transparency, other flaws inherent in the WCS Coalition's analysis are obvious. For instance, the Coalition assumed that WCS transceivers and satellite radio receivers will be distributed uniformly throughout a given area.[10] However, satellite radio receivers are not and WCS mobile handsets will not be uniformly distributed. Satellite radio is primarily a service received in vehicles. Similarly, as one WCS proponent has explained on the record,[11] 2.3 GHz mobile Wimax will be used significantly as a means of gaining internet access while traveling and, similar to mobile telephony, will be concentrated in transportation corridors, such as roads and highways.[12] Instead of uniform distribution, a more realistic assumption is that

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[9] *See Am. Radio Relay League, Inc. v. FCC*, 524 F.3d 227, 240-41 (D.C. Cir. 2008) (reversing a technical finding grounded in theoretical modeling because the Commission had dismissed contrary empirical evidence).

[10] *See* WCS Coalition Comments at 12 of Attachment B (describing test parameters which suggest that WCS mobile devices will be distributed in a uniform and evenly spaced manner in a given area).

[11] *See* DigitalBridge *Ex Parte*.

[12] *See id.* The prevalence of WCS devices being used in transportation corridors is illustrated in a recent *Washington Post* article entitled "Surfing the Roads Less Traveled: Ashburn Firm Makes WiMAX a Reality in Small-Town America." *See* Zachary A. Goldfarb, *Surfing the Roads Less Traveled: Ashburn Firm Makes WiMAX a Reality in Small-Town America*, Washington Post, June 30, 2008, at D6. This article makes much of the fact that Wimax technology will allow individuals to "be able to sit in a moving car . . . and take part in a video chat while downloading a movie and writing e-mails." *See id.* In fact, DigitalBridge Communications Corporation's Chairman described a typical use of the service while he was traveling in the passenger seat of a moving car: "We were going over 40 miles per hour. I had a laptop. I was making a Skype call. I was watching a YouTube video and browsing a Web site at the same time." *See id.*

WCS devices and satellite radio receivers will be concentrated along these same traffic corridors and coextensive in time (*e.g.*, at rush hour in metropolitan areas).[13]

By basing its probability analysis on the assumption of uniform distribution, the WCS Coalition's simulation downplays typical use cases and ignores expected and significant concentrations of WCS mobile devices exactly where and when millions of satellite radio receivers are also operating. The reality is that WCS transmitters and satellite radio receivers would be near one another every day, on roads and highways, on single and multi-lane roads, in congested traffic and even at stop lights in non-congested areas.

In contrast, Sirius XM submits its own probability analysis – based on more typical use scenarios – that measurably predicts that situations routinely will arise where mobile WCS devices will mute satellite radio reception to subscribers. The analysis is described below and full description of the methodology and assumptions are included in Appendix A.

The Sirius XM analysis avoids the flaws built into the WCS Coalition's analysis. Sirius XM has modeled activity along a multi-lane highway with high traffic volume and inserted variable assumptions with respect to penetration of both satellite radio and WCS mobile service into the consumer market, speed of vehicles, the duty cycle of transmissions and the probability that the devices will actually be on and active. The results of these analyses show a high probability of material interference to satellite radio reception. For example, Sirius XM's "near term" analysis – which assumes very conservative penetration rates for both satellite radio and WCS service and relatively normal traffic flows – predicts a probability between one and 13 percent that a transmitting WCS mobile unit on a highway will be in sufficient range to cause interference to a customer then listening to a satellite radio. Looking more into the future where both the number of satellite radio receivers and WCS mobile broadband devices both reaches higher levels of penetration into the consumer marketplace, Sirius XM's analysis predicts a probability of between two and 24 percent that a transmitting WCS mobile unit on a highway will be in range of at least one satellite receiver to cause interference. The ranges correspond to different assumed vehicle speeds, WCS transmission blocks and interference mechanisms.

These results are summarized at figures 2 and 3 of Appendix A. Of course, different input parameters will yield different results – both higher and lower. The Sirius XM study represents a conservative approach because it does not show the additional interference that would occur when cars are near one another at slower speeds on other roads, or stopped at intersections.[14] The fundamental point, however, is that a variety of

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[13] Assuming a non-uniform distribution of mobile devices can alter substantially the results of a probability analysis that utilizes repeated random samplings of various input data. *See* Comments of Motorola, Inc., WT Docket No. 07-195 (filed July 25, 2008).

[14] Satellite radio reception is even more jeopardized in those cases, though they are harder to model due to the limited availability of traffic flow data compared to highway traffic statistics.

likely, real-world use cases can easily be selected to demonstrate a high probability of interference to satellite reception from WCS mobile transmitters.

Probability analysis is only one aspect of examining interference potential – one that the Commission has not commonly drawn upon because such studies have inherent limitations. While statistical probability methods can help forecast compatibility between radio systems, they are highly dependent upon the input criteria and the underlying algorithms used to predict propagation and interference. Furthermore, they necessarily require use case assumptions that are static based on current technology, without consideration of how technology may evolve to permit smaller terminals or other developments that expand use, and hence the potential for other significant interference cases. Therefore, simulation results should never be used as a "go/no-go" litmus test in spectrum management; results are far too sensitive to variables such as market penetration and customer applications that are generally beyond the scope of the FCC's areas of expertise.

However, probability studies can be helpful tools that should be used to augment the Commission's traditional analysis for assessing the compatibility of adjacent band services. In this specific case, the totality of the technical data – including Sirius XM's probability studies – confirms the FCC's decision more than 10 years ago to discourage mobile operations in the WCS bands. Predicted levels of interference as described in the attached interference analysis would be highly disruptive to satellite radio subscribers based on Sirius XM's need to provide its customers with high-quality programming with more than 99 percent service availability.

Interference from WCS transmitters would be all the more significant and harmful because it would be unpredictable and unexplainable to satellite radio consumers. This is not a case of customers going through a tunnel where they might not be surprised by loss of signal. Rather, customers would be frustrated to lose service in clear skies conditions. Their service would cut in and out as a WCS transmitter in another vehicle came closer, moved away, and then came closer again. In short, not only would satellite radio service availability fall as a percentage, but the harm to the listener experience would be fundamental.

Mitigating Impact of Satellite Radio Terrestrial Repeaters. The WCS Coalition suggests that interference in practice will be minimized due to the presence of satellite radio repeaters in urban markets. Sirius XM has previously explained that the Commission should not view satellite radio repeaters as a mitigating factor to WCS interference as its repeaters provide coverage to much less than one percent of the U.S. geographic area. Even in major urban areas where the coverage of satellite radio repeaters is much higher, satellite radio is still delivered to customers primarily by satellite based signals.[15] Most important, we have demonstrated that "satellite only" service occurs routinely even in such areas. Repeaters do not provide blanket coverage equivalent to terrestrial radio; listeners move in and out of repeater coverage (and thus in and out of satellite-based service) as they drive in metropolitan areas. Sirius XM locates

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[15] *See, e.g.*, Reply Comments of Sirius Satellite Radio Inc., IB Docket No. 95-91, at 9 of Exhibit A (filed March 17, 2008).

its repeaters only where necessary, given specific terrain characteristics based on drive tests and related analysis. Furthermore, our repeaters were never designed to overcome the harmful effects of WCS mobile interference. The Commission should not adopt policies that would require Sirius XM to install many more terrestrial repeaters in order to overcome interference from mobile WCS transmitters.

***Mitigating Impact of Satellite Path Diversity and Signal Buffers*:** The WCS Coalition argues that path diversity of the satellite and terrestrial signals, as well as the impact of the buffers engineered into satellite radio receivers will help reduce the effects of intermittent interference.[16] Diversity and buffers do indeed provide satellite radio with some protection from blocking and shadowing in the dynamic propagation scenario of satellites and moving vehicles in environments impaired by roadside tree shadowing and obstacle blockage.[17] This helps ensure that satellite radio subscribers receive the continuous, high-quality service they have come to expect, notwithstanding the indiscriminate interference inherent in wireless operations. But satellite radio time diversity and internal buffers are designed to overcome only relatively short-lived loss of a satellite path, as opposed to third party-generated overload or unwanted out-of band emission blocking one or more satellite downlinks more frequently or for longer periods.

When one of the two satellite signals is unavailable due to WCS transmissions, Sirius XM subscribers will lose service more frequently and will ultimately have a less satisfying consumer experience. For this reason, Sirius XM has conducted its analyses based on interference levels that assume the additional system margin due to diversity has been used up. In such interference cases, one of the satellite paths may be already muted completely by the WCS interference and the remaining path is active only with a small margin. Therefore, path diversity is not available.

***Mitigating Impact of WCS Mobile Duty Cycle*:** The WCS Coalition argues that mobile WCS devices will not operate very often. These relatively low terminal duty cycles, the Coalition says, justify reduced protection levels below those determined using well-established static measures. In Section 3 of the attached Appendix A, Sirius XM shows that for the Coalition's currently preferred technology – Wimax – the terminal duty cycles are highly dependent on the network operator's business model and network configuration. Therefore, it is not appropriate to craft rules designed to protect adjacent services based on expectations that subscriber devices would be limited to a single low level duty cycle. Moreover, Appendix A shows that given the channel bandwidths available in the WCS band and the mix of services that form the core of any mobile broadband offering, it is most likely that user terminals will operate at the highest duty cycles permitted (*e.g.*, greater than 40 percent) to provide adequate capacity. In other

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[16] *See* Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91, at 5-6 (filed May 19, 2008) ("WCS Coalition May 19 *Ex Parte*").

[17] The satellite radio propagation environment is thoroughly discussed in a recent *ex parte* presentation in these dockets. *See* Letter from Wolfhard J. Vogel, President, Balcones Industrial Research & Development, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91 (filed Sept. 5, 2008).

words, the WCS Coalition's analysis that is based on a low terminal duty cycle of six percent is flawed and underestimates the potential for interference.

To further emphasize that duty cycle provides no significant support for the relief sought by WCS, the Commission should also consider the difference in framing structures of a one-way service such as satellite radio and a two-way service such as Wimax mobile broadband. In other words, streaming audio services such as Sirius XM's programming service are essentially continuously-on transmissions whereas two-way radio services typically burst on and off. As described in Section 4 of the attached Appendix A, these system and service differences result in service disruption to satellite radio, even at low duty cycles of the two-way radio service. This disruption has greater impact to a user listening to high quality audio programming as opposed to a user having its telephone conversation briefly disrupted.

Of course, these subtle incompatibilities are the reason why the FCC prefers its rules to be technology neutral. The WCS band is no exception, and the FCC should not be persuaded to consider large discounts in adjacent band protection due to complex, technology-specific features that are impossible to properly regulate or quantify in practice. Additionally, there is no assurance that WCS licensees will unilaterally deploy Wimax technology now or in the future.

II. THE WCS COALITION TEST RESULTS ARE UNRELIABLE AND CANNOT BE USED TO JUSTIFY PROPOSED RULE CHANGES.

A. THE WCS COALITION'S ANALYSIS ON THE POTENTIAL FOR OVERLOAD INTERFERENCE IS FLAWED.

In comments previously submitted to the Commission, Sirius XM provided data showing that overload interference from a single WCS transmitter would mute a satellite radio receiver at distances ranging from 18 to 34 meters (*i.e.*, from nearly 60 feet to more than 110 feet), depending upon the WCS block in which the transmitter was operating.[18] Sirius XM included detailed test plans enabling the Commission and other parties to fully understand the circumstances under which the data was gathered.[19] Sirius XM and independent third-party engineers supported the data and the test procedures with sworn statements.[20] In short, the test process was transparent and readily reproducible.

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[18] *See* Comments of Sirius Satellite Radio Inc., IB Docket No. 95-91, at 23 (filed Feb. 14, 2008); Comments of XM Radio Inc., IB Docket No. 95-91, at 9 of Exhibit C (filed Feb. 14, 2008).

[19] *See* Sirius Comments at Exhibit C; XM Comments at Exhibit C.

[20] Reply Comments of XM Radio Inc., IB Docket No. 95-91, at Technical Appendix (filed March 17, 2008) (Certification of Craig P. Wadin, Senior Vice President, RF Systems, XM Radio Inc.); Sirius Reply Comments at Exhibit F (Certification of Terrence R. Smith, Senior Vice President, Technology, Sirius Satellite Radio Inc.).

The WCS Coalition disputes these results and provides alternative test data.[21] But in contrast to the testing plans and measurements provided by Sirius XM, the WCS Coalition has failed to provide the information necessary to allow replication of its tests or full analysis of its testing methodology. The WCS Coalition may have used incorrect parameters or otherwise biased or flawed test procedures in measuring these results – it is impossible to tell – and this lack of transparency robs the Commission and the parties of any ability to question the Coalition's procedures or results. Independent testing, of course, could confirm the Coalition's data, but in the face of opposition from WCS interests, no such testing has been conducted.

***WCS C and D Blocks*:** Even if it were possible to replicate the WCS Coalition's technical submissions, they fall well short of justifying the Coalition's proposed sweeping rule change. For example, WCS consists of four spectrum blocks – A, B, C and D. The A and B blocks are further divided into upper and lower bands. The unpaired C and D blocks are immediately adjacent to satellite radio downlinks and hold the most potential for harmful interference to satellite radio consumers.[22] Remarkably, however, the testing conducted by the WCS Coalition measured the impact of *only* WCS A and B blocks. By ignoring the C and D blocks – the WCS spectrum immediately adjacent to satellite radio downlinks – the WCS Coalition effectively provided at least 5 to 10 MHz of guard band between the WCS operations and the satellite radio allocation and avoided providing test results for the part of the satellite radio spectrum where the interference from WCS mobile service would be most noticeable and most severe.[23] Thus, its analysis supplies only skewed results that say little about the real-world potential for interference from mobile WCS operations.

Rules that enable mobile operations on the WCS C and D blocks pose an obvious and unacceptable risk of interference to satellite radio reception by millions of consumers – a potential that cannot simply be overlooked. Without any separation between the WCS transmit and satellite radio receive frequencies, it is impossible for filters to mitigate the impact of overload interference to satellite receivers.[24] Sirius XM provided

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[21] *See* WCS Test Report, WCS Impact Testing with Navini WiMax CPE (attached to Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91 (filed May 9, 2008)).

[22] The WCS C block is immediately adjacent to the satellite receive portion of the original Sirius Satellite Radio frequency assignment. Likewise, the WCS D block is immediately adjacent to XM Radio's satellite receive band.

[23] WCS Coalition member and WCS licensee Horizon Wi-Com has recommended that the FCC defer action on the C and D block while proceeding to modify the technical parameters for the WCS A and B block. *See* Letter from Thomas Gutierrez, Counsel for Horizon Wi-Com, L.L.C, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91 (filed June 30, 2008).

[24] This point was recently affirmed by WCS licensee and WCS Coalition member Nextwave in the AWS-3 proceeding where it noted that there is a "key spectrum allocation difference" in allocating time division duplex ("TDD") bands that allow mobile transmitters immediately next to frequency division duplex ("FDD") "base transmit" bands as opposed to FDD "mobile transmit" bands. *See* Letter from Jennifer

ample evidence that mobile transceivers in the C or D blocks would mute satellite radio receivers within 34 meters (more than 110 feet).[25]

***Path Loss*:** Path loss is used to estimate the likelihood of interference occurring to a victim receiver located some distance from an interfering device. Overestimating the path loss between the interfering device and the victim receiver will tend to minimize the harmful effects of transmitters. The WCS Coalition minimizes the likelihood of interference by predicting path losses at least 10 dB greater than satellite radio's studies and tries to explain away the discrepancy by alleging that Sirius XM's numbers were based on theoretical formulas not applicable to the 2.3 GHz band.[26] This is false. Sirius XM supplied *measured* data,[27] along with citations to publications – some by the National Telecommunications and Information Administration – reporting essentially the same results.[28]

More recent WCS licensee filings seek to bolster their overstated path loss figures through test set-ups that understate the risk of harmful interference,[29] but the Coalition's purported "vehicle-to-vehicle" measurements are wholly misleading. For example, the WCS Coalition claims that positioning the two vehicles one in front of the other "would likely result in the minimum possible vehicle-to-vehicle separation."[30] While this may be true on its face, it ignores a more typical scenario in which vehicles would be side-by-side – either both stationary (as would be the case at a stop light or in heavy traffic) or both moving (as would be the case with vehicles traveling on adjacent lanes). Thus, the WCS Coalition's "vehicle-to-vehicle" measurement is misleading.

Further, as part of its tests, the WCS Coalition placed a potentially interfering WCS transmitting device within a sedan and then measured the path loss to a satellite

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M. McCarthy, Vice President, Regulatory Affairs, NextWave Wireless Inc., to Marlene H. Dortch, Secretary, FCC, WT Docket No. 07-195 (filed Aug. 25, 2008).

[25] *See* Sirius Comments at 23 and Exhibit C; XM Comments at 30-32 and Exhibit C.

[26] *See* Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91, at 2 (filed May 9, 2008).

[27] *See* Sirius Reply Comments at 23 and Exhibit B; XM Reply Comments at 19-20 and Exhibit B.

[28] *See* ITS, NTIA Report TR-07-449, Propagation Loss Prediction Considerations for Close-In Distances and Low-Antenna Height Applications, Nicolas DeMinco (July 2007), *available at* http://www.its.bldrdoc.gov/pub/ntia-rpt/07-449/ (last visited Aug. 28, 2008).

[29] *See* Path Loss Between WCS Transmitters and SDARS Receivers in Typical Vehicle Usage Scenarios (attached to letter from Mary N. O'Connor, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91 (filed Aug. 1, 2008)).

[30] *Id*. at 8.

radio-equipped van with a roof mounted antenna.[31] However, performing lopsided tests on vehicles of significantly differing heights exaggerates the path losses between the two points and provides no meaningful data on an equally significant scenario of path loss between vehicles of the same height.

Finally, the WCS Coalition's recent tests used cars having tinted (with metallic or other materials) windows and/or metal roof racks. But each of these accessories (which are installed only in a minority of vehicles on the road) introduces further coupling errors and exaggerates path loss – again yielding misleading results. Also, the WCS path loss test result is misleading since it only reported the median path loss information for these complex and highly variable propagation cases (*see* Exhibit A). Simply put, the WCS licensees appear to be evading typical cases – an approach that casts further doubt on the usefulness of the Coalition's filings as a basis for changing the Commission's rules.

B. THE WCS COALITION'S OUT-OF-BAND EMISSION INTERFERENCE ANALYSIS IS MISLEADING.

In 1997, the Commission established out-of-band emission limits for WCS operations specifically to protect satellite radio consumers.[32] In fact, when it adopted the limitations, the FCC found that limits any more generous than the ones promulgated "would be insufficient to protect" adjacent satellite radio operations[33] and that the limits adopted were "*required* in order to adequately protect satellite DARS reception from WCS transmissions."[34]

The need to be conservative in setting out-of-band emissions limits is well understood, stemming from the fact that no amount of future technology development on the part of the victim receiver can improve the mitigation of the in-band interference.[35] In other words, it is impossible for a victim receiver to filter out interference from excessively high out-of-band emissions because the interference occupies the same frequencies as the desired signal. If you filter out the noise, you also will filter out the desired signal.

The centerpiece of the WCS licensees' proposed Part 27 revisions would reduce the WCS mobile out-of-band emissions limits required to protect satellite radio consumers by a staggering 55 dB. Stated another way, the WCS licensees are asking the

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[31] *See id*. at 7-8.

[32] Out-of-band emissions were capped at 110 + 10 log (p) dB at band edge. 47 C.F.R. § 27.53(a)(2) (2007).

[33] *See Amendment of the Commission's Rules to Establish Part 27, the Wireless Communications Service*, Report and Order, GN Docket No. 96-228, 12 FCC Rcd 10785, 10854, ¶ 136 (rel. Feb. 19, 1997) (WCS Report and Order).

[34] *Id.* at ¶ 138 (emphasis added).

[35] *See, e.g.*, Letter from Kathleen O'Brien Ham, Vice President, Federal Regulatory Affairs, T-Mobile USA, Inc., to Marlene H. Dortch, Secretary, FCC, WT Docket No. 07-195, at 6-7 of Attachment (filed Sept. 3, 2008).

FCC to allow an increase in the amount of energy that a WCS subscriber device can place inside the satellite radio band by a factor of 316,000 times from the current limits.[36] The WCS Coalition's proposed relaxation of mobile out-of-band emission limits cannot be justified by any measure. As Sirius XM has repeatedly shown,[37] such a dramatic change would substantially increase the noise floor in the adjacent satellite downlink band – and, thus, would *substantially increase interference to tens of millions of satellite radio consumers.*

The WCS Coalition does not attempt to rationalize how the FCC could have been so wrong in 1997, and the laws of physics have not changed since then. Rather, Sirius XM submits that the Commission was right in concluding over ten years ago that strict out-of-band emission limits on adjacent band terrestrial services were critical to protect a service delivered primarily by satellites transmitting at relatively low power 30,000 miles from Earth.

In Appendix B, Sirius XM provides further analysis of the WCS Coalition's proposed out-of-band emission limits on satellite radio reception. Figure 1 of Appendix B (reproduced below), shows that relaxing the WCS mobile out-of-band specification would eliminate *all* residual satellite margin, including that necessary to overcome WCS overload interference, local foliage, fading and multipath.

If the revised specification were established between 97 + 10 log (p) and 92 + 10 log (p) dB, it would cause frequent muting for satellite radio receivers under foliage or near reflective buildings. Any specification less than 92 + 10 log (p) dB would cause WCS mobile units to *completely mute* nearby satellite radio receivers, even in best-case, clear-sky and static conditions.

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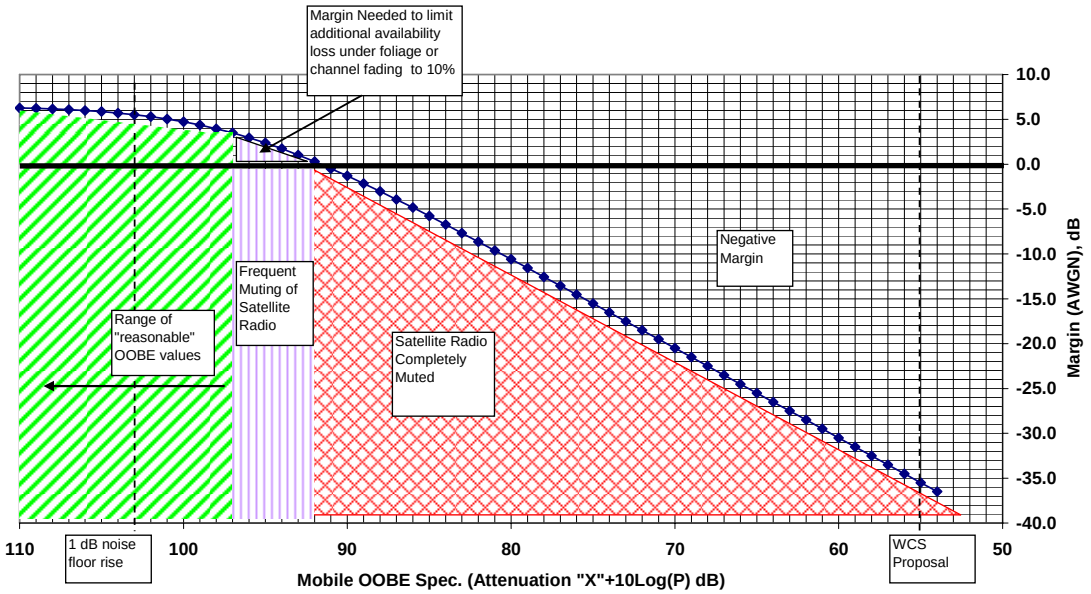
[36] The WCS Coalition proposes to reduce the mobile out-of-band emission attenuation to 55 + 10 log (p) dB at band edge. *See* WCS Coalition Comments at 14.

[37] *See Amendment of Part 27 of the Commission's Rules to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band*, Notice of Proposed Rulemaking and Second Further Notice of Proposed Rulemaking, IB Docket No. 95-91, FCC 07-215, ¶ 24 (rel. Dec. 18, 2007) ("[T]he WCS licensees propose that the suppression of out-of-band emissions would be: (1) 55+10log(p)dB for 2320-2324 MHz and 2341-2345 MHz; (2) 61+10log(p)dB for 2324-2328 MHz and 2337-2341 MHz; and (3) 67+10log(p)dB for 2328-2337 MHz.").



This shows that the WCS licensees proposed out-of-band rules *would completely silence huge numbers of satellite radio receivers in typical operational settings*. Even if the Commission were to substitute "muting" for the time-tested standard of measuring a one percent rise in the noise floor[38] – which it should not – the proposed WCS rule would still flunk a compatibility test by 37 dB with adjacent band spectrum users.

Prohibiting mobile transmitting devices from operating in frequencies immediately adjacent to unaffiliated mobile receivers is not new. Rather, it is a bedrock spectrum management principle to which the Commission has adhered for decades.[39] It is precisely why the Commission decided previously to adopt rules preventing the widespread deployment of mobile WCS operations adjacent to satellite radio frequency bands, and it is precisely why the overwhelming majority of the wireless industry opposes proposals to allow mobile use on frequencies immediately adjacent to AWS-1 and PCS frequency allocations.[40] Previously, Sirius XM submitted analyses demonstrating the consistency of its position in this proceeding with those submitted in the Commission's H-Block and AWS-3 proceedings where similar technical issues are involved.[41] Sirius XM showed that its recommendations for an emissions mask for WCS

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38 ITU Recommendation S.1432-1, recommends, 4.

39 *See, e.g., Service Rules for Advanced Wireless Services in the 2155-2175 MHz Band*, Notice of Proposed Rulemaking, WT Docket No. 07-195, FCC 07-164, at ¶ 51 (rel. Sept. 19, 2007) ("The presence of base *and* mobile transmissions in the same band, adjacent to spectrum designated for base transmissions, creates the possibility for certain types of adjacent channel interference scenarios, which are not present when base and mobile transmissions are situated in spectrum far apart from one another.")

40 *See, e.g.*, Comments of T-Mobile USA, Inc., WT Docket No. 07-195, at 3 (filed Dec. 14, 2007) (AWS-3 Proceeding).

41 Sirius Reply Comments at Exhibit E; XM Reply Comments at Exhibit E.

mobile devices at 103 + 10 log P and a maximum mobile EIRP limit of 10 dBm (A and B Blocks) or 0 dBm (C and D Blocks) is fully consistent with the vast majority of recommendations submitted in those other proceedings, which present similar interference scenarios. Since that analysis was performed, additional comments have been submitted into those other proceedings. At Appendix C, Sirius XM updates its previously filed chart to compare the recommendations of the leading wireless companies on the appropriate technical means to minimize adjacent channel interference. As shown there, the WCS Coalition and its members stand alone with AWS-3 proponent M2Z to suggest that probability analysis obviates the need for rigid technical specifications.

Having adopted the out-of-band rule a decade earlier for valid and necessary reasons,[42] the Commission may not now substantially relax that rule without a thorough explanation for its change in course.[43] Yet, no one has provided any rational explanation to justify allowing WCS transmitters to mute the receivers of millions of satellite radio subscribers.

Mobile broadband will be expansively deployed in other spectrum, including by some of the WCS licensees. Furthermore, WCS licensees may deploy fixed broadband in their spectrum under the current rules. But the record conclusively shows that the FCC should reject the WCS licensees' proposal to relax the Part 27 out-of-band limit for mobile WCS devices.

III. THE RECORD SHOWS NO EVIDENCE OF A SIGNIFICANT INTERFERENCE THREAT FROM SATELLITE RADIO TO WCS.

Without establishing any technical basis for their position, WCS licensees continue to assert that they face a significant interference threat from the operation of satellite radio terrestrial repeaters.[44] Their unsubstantiated argument is essentially that

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[42] *See Amendment of the Commission's Rules to Establish Part 27, the Wireless Communications Service*, Memorandum Opinion and Order, GN Docket No. 96-228, 12 FCC Rcd 3977, 3992, ¶ 27 (rel. April 2, 1997) (WCS MO&O) ("[T]he 2320-2345 MHz frequency band is the only spectrum specifically available for provision of Satellite DARS in the United States. Accordingly, if Satellite DARS in this spectrum is subject to excessive interference, the service will not be successful and the American public will not benefit from the service. In contrast, [terrestrial mobile service] can be provided in other spectrum currently available for use by services including cellular and PCS.").

[43] *See Motor Vehicle Mfg. Ass'n v. State Farm Mut. Auto. Ins. Co.*, 463 U.S. 29, 41-42 (1983) (holding that while an agency is free to change its policy, the agency must provide an explanation for the change that is plain on its face and rational); *Greater Boston Television Corp. v. FCC*, 444 F.2d 841, 852 (D.C. Cir. 1970) ("An agency's view of what is in the public interest may change . . . . But an agency changing its course must supply a reasoned analysis indicating that prior policies and standards are being deliberately changed, not casually ignored, and if an agency glosses over or swerves from prior precedents without discussion it may cross the line from the tolerably terse to the intolerably mute.").

[44] *See, e.g.*, WCS Coalition Comments at (i)-(ii); WCS Coalition Reply Comments at (i)-(iii); WCS Coalition May 19 *Ex Parte* at 7-8; Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-

WCS fixed receivers located in close proximity to satellite radio terrestrial repeaters would be subject to both overload and out-of-band emissions interference.

The Coalition has never provided the results of testing to measure the alleged interference from terrestrial repeaters to WCS devices, suggesting instead that real-world measurements cannot be made because no WCS equipment or service exists.[45] The WCS Coalition cannot claim that interference will be harmful on the one hand while claiming on the other that such interference cannot be proven due to its members' failure to construct the very network necessary to provide real-world measurements.

The WCS Coalition does not assert that satellite radio transmissions have interfered with WCS service and, to the best of Sirius XM's knowledge, no such complaint has ever been lodged. Instead, the WCS Coalition proffers only theoretical data that purports to *predict* interference in a host of controlled scenarios. The WCS Coalition has *never* fully described the technical performance parameters of WCS handsets or base station receivers – data that are critical to determine the impact of the satellite radio terrestrial repeaters. In contrast, Sirius XM has demonstrated that the actual zones of interference to WCS base stations from the relatively small number of terrestrial repeater sites would be much smaller than that suggested by the WCS Coalition. Furthermore, Sirius XM has shown that even limited use of antenna downtilt and appropriate network planning by the WCS licensees would reduce the exclusion zones to inconsequential sizes.[46]

The record demonstrates – with concrete data – that terrestrial repeaters will not interfere with WCS networks.[47] WCS interests' purely theoretical, free-floating allegations cannot override the real-world record evidence – and cannot provide a

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91 (filed July 24, 2008); Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 95-91, at 2 (filed July 22, 2008).

[45] *See* WCS Coalition Comments at 18-19.

[46] *See* Sirius Reply Comments at Appendix B of Exhibit A.

[47] The data presented by Sirius XM showing non-interference is substantial. For example, Sirius submitted data as far back as 2000, analyzing the limited potential for interference from the out-of-band emissions of Sirius' terrestrial repeaters into fixed and mobile service systems operating in the adjacent bands. *See* Supplemental Comments of Sirius Satellite Radio Inc., WT Docket No. 95-91 (filed Jan. 18, 2000). The results of the analyses performed for this report indicate that the out-of-band emissions from Sirius' terrestrial repeaters into WCS systems are far less than WCS adjacent band interference requirements and, therefore, are unlikely to cause any significant interference. *See id.* XM Radio also provided the Commission with data demonstrating the limited potential for interference, specifically data from experiments conducted in the Houston, Texas area showing that a higher power repeater across the street from AWS customer premises equipment and 350 feet from an AWS base station did not cause interference. *See* Comments of XM Radio Inc., IB Docket No. 95-91, at 6 and Exhibit A (filed Dec. 14, 2001).

reasoned legal basis for rulemaking.[48] Lacking usable data to the contrary, the Commission should move on and adopt final rules authorizing satellite radio terrestrial repeaters as proposed by Sirius XM.

IV. SIRIUS XM'S PROPOSED RULES.

This proceeding is focused on complex technical issues to assess the compatibility of two radio services occupying adjacent spectrum allocations. As discussed above, the rules for the two services are not interrelated and the Commission could finalize rules authorizing satellite repeaters before it addresses the proposed Part 27 changes. To assist the Commission with its deliberations, Sirius XM provides, at Appendix C, a set of proposed rule changes to ensure that our positions and recommendations are fully understood.[49]

***Part 25 Proposed Rule Changes*:** The proposed rule changes in the attached Appendix focus on the recommended operational and licensing rules for satellite radio terrestrial repeaters. Sirius XM recommends a blanket licensing approach that would allow the deployment of fixed repeater facilities that conform to certain technical specifications. Sirius XM has the exclusive use of the 2320-2345 MHz band – no other primary or secondary uses are authorized to operate on these frequencies. There is more than ample FCC precedent to provide wide area licensees with exclusive use of their spectrum with blanket licensing authority. Such authority should not require licensees to submit individual applications to license transmitters that comport with minimal technical standards as well as the Commission's implementation of the National Environment Policy Act of 1969.[50]

As recommended by Sirius XM, terrestrial facilities that would fall under the blanket authorization would be restricted to providing an average field strength of less than 100 dBµV/m measured at 1.5 meters (4.9 feet) above ground level at 95 percent of locations within a defined test area and less than 110 dBuV/m at 99 percent of locations. In its proposed rules, Sirius XM provides a methodology for calculating compliance with this proposed requirement based on ITU recommendations for modeling radio wave propagation as used in the recent auction of L-band spectrum licenses in the United Kingdom.[51] While a ground-based emissions level is intended to replace antenna height and power requirements, Sirius XM would not be averse to a concomitant cap on EIRP at 12 kilowatts average power, which would have the added benefit of harmonization with Canadian rules.

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[48] *See Am. Radio Relay League, Inc.*, 524 F.3d at 240-241 (reversing a technical finding grounded in theoretical modeling because the Commission had dismissed contrary empirical evidence).

[49] *See* Exhibit D in the attached Appendix.

[50] 47 C.F.R. § 1.1301 *et seq*.

[51] *See* Award of Available Spectrum: 1452-1492 MHz; Ofcom Office of Communications; (rel. Dec. 7, 2007) *available at* http://www.ofcom.org.uk/consult/condocs/1452_1492/statement/statement.pdf.

Sirius XM also recommends stringent out-of-band emission restrictions for its terrestrial repeaters (90 + 10log P, measured at the transmitter output in a 1 MHz bandwidth) and transmitter equipment certification. Existing terrestrial transmitters would be grandfathered regardless of whether they satisfy either the 12 kW EIRP standard or the ground based emission restrictions proposed for new repeaters.[52] As previously discussed by Sirius XM, the locations of its repeaters are well known and any interference threat, regardless of how negligible, is easily mitigated by routine network design. Advanced coordination requirements also can be used to ensure that the existing repeaters pose no impact to WCS deployment.

***Part 27 Rule Changes*:** Sirius XM believes that relaxing the out-of-band emissions limits for WCS mobile services would create an unacceptable risk of interference to satellite radio reception and, therefore, has not provided any proposed changes to the WCS rules in this regard. In particular, WCS licensees have not provided any data to support modifying the out-of-band emissions limits for mobile devices operating on the WCS C and D blocks. Sirius XM's data and analysis also shows a significant interference threat from WCS mobile devices operating on the WCS A and B blocks and, therefore, urges caution with regard to those frequencies as well. However, Sirius XM is not averse to discussions on the authorization of very low power WCS mobile devices operating under adequate out-of-band emissions on at least some portion of the A and B blocks provided that sufficient frequency separation and protection to satellite radio frequencies is provided.

Sirius XM notes that the WCS Coalition has recommended that the power limits for WCS base stations be increased to a maximum of 2000 watts EIRP average power.[53] The need for this change is not well documented. Rather, the WCS Coalition appears to be seeking this change out of a desire to achieve parity with satellite radio technical standards.[54] While Sirius XM believes that governing transmitting facilities on ground based power levels provides licensees with greater flexibility and compatibility with satellite radio, it is not averse to more traditional power restrictions on WCS fixed transmitters, provided that those restrictions offer sufficient protection to satellite radio service. Examples of such additional restrictions would be controls on allowable downtilt or antenna height.

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[52] The overwhelming majority of existing terrestrial repeaters comport with the proposed EIRP and ground based emission levels.

[53] *See* WCS Coalition Reply Comments at 41.

[54] *See* WCS Coalition Comments at 26 ("It is not expected that WCS licensees will routinely operate at 2,000 Watts average EIRP, because such high power is unnecessary to serve consumers in most environments and could result in self-interference. However, increasing the maximum permissible WCS power level to the same power level authorized for SDARS terrestrial repeaters will provide WCS licensees the ability, where necessary, to increase their own power levels to avoid interference from SDARS.")

V. CONCLUSION.

Sirius XM is anxious to see an end to these regulatory proceedings. Final rules for the deployment of satellite radio terrestrial repeaters have been long delayed, despite the lack of any evidence from WCS licensees that deploying such facilities poses a substantial interference risk to their services. The Commission should proceed immediately to adopt final rules that provide Sirius XM with blanket licensing authority to operate terrestrial repeaters consistent with the technical specifications discussed herein.

On the other hand, the proposals to allow WCS licensees greater flexibility to deploy mobile services pose considerable interference risks to 20 million satellite radio subscribers, if adopted. The consideration of real-world use case scenarios in properly performed simulation studies demonstrates a high probability that WCS mobile transmitters will mute satellite radio reception to many consumers in routine situations. The technical analyses submitted by the WCS Coalition fail to provide adequate evidence of mitigating factors to the predicted levels of interference. Further, the WCS Coalition's analyses are not transparent and, therefore, are not verifiable or reliable.

Given the credible evidence presented herein that mobile WCS service would regularly cause debilitating interference to a large portion of Sirius XM's customers, the FCC should not relax the out-of-band emissions restrictions for mobile WCS devices, especially as they pertain to the WCS C and D spectrum blocks. Furthermore, the FCC should not relax the out-of-band emissions restrictions for WCS mobile devices operating on the A and B Blocks absent further technical evidence that such operations can occur without serious degradation to satellite radio service.

Respectfully submitted,

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Attachments

Exhibit [A]

WCS Interference to Satellite Radio

Highway Use Case Probability Analysis

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1 Executive Summary

There are two basic methodologies that have been used in developing the technical record for the Part 27 rule changes proposed by the WCS Coalition. These two methods can generically be termed "minimum coupling loss" (MCL) and probabilistic (or "Monte-Carlo")[1] based. Each method has different benefits and limitations and, ideally, each method needs to be applied to obtain an optimized outcome in any rules setting process.

In the particular situation addressed in this exhibit, these methods are applied to evaluate the likelihood of WCS mobile terminals and satellite radios operating close enough in proximity to each other, and with sufficient activity levels to generate interference to satellite radio reception. Previous experimental data and analysis[2] have established a range of separation distances at which satellite reception will be impaired if the proposed Part 27 rules changes are implemented and mobile networks are widely deployed in the WCS band.

An intuitive, simple, but highly relevant highway use case is used, together with random prediction of vehicle locations and extraction of example separation statistics. In addition, a simple model of mobile wimax technology is used to demonstrate that the WCS Coalition's proprietary, probability simulations[3] have little utility in rule making for this proceeding.

The conclusions reached are as follows:

- If deployed as envisioned by the WCS Coalition, mobile WCS service has an unacceptably high probability of causing interference to satellite radio under realistic scenarios including regular highway travel. As expected, the probabilities rapidly become worse under congested, slow moving or stationary traffic conditions. It should be noted that even small probabilities of service disruption that have no apparent cause would dramatically increase satellite radio customer dissatisfaction and impact the business model[4].
- The most relevant approach for this rule making is to review the probability of fundamental, characteristics of the potential interference scenarios (such as separation distance) and combine this with well established, minimum coupling loss data. In this note, the separation distance probability for realistic use cases is chosen for the probability analysis and this is combined with adjacent band interference data for satellite receivers to provide a direct, simple and transparent look at interference possibilities.

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[1] ERC Report 101, European Radiocommunications Committee , "A Comparison of the Minimum Coupling Loss Method, Enhanced Minimum Coupling Loss Method, and the Monte-Carlo Simulation", Menton, May 1999, available at http://www.erodocdb.dk/doks/doccategoryECC.aspx?doccatid=4&alldata=1

[2] Comments of Sirius Satellite Radio Inc., WT 07-293, February 14 2008, Exhibit C.

[3] Comments of the WCS Coalition, WT 07-293, February 14 2008, Attachment B.

[4] *See* Comment, Balcones Industrial Research & Development Corporation, IB 95-91, September 5, 2008.

- The WCS Coalition's approach to probability analysis is highly technology specific, uses a single "evenly distributed usage" scenario, and relies on a proprietary, network simulation having little relevancy relevancy to establishing sustainable rules that will be effective across a range of WCS network deployments. The mobile wimax technology that the WCS Coalition is proposing for use in this band is designed to provide network operators with unprecedented flexibility to address the mobile broadband marketplace. Precisely as a result of this capability, numerous parameters, central to assessing adjacent band interference impact (such as transmitter power and duty cycle), are highly dependent on how a network operator decides to optimize the network around its business model or depend on proprietary adaptive algorithms embedded within the network equipment. Aside from the obvious problems with assuming a uniform distribution of users, other examples (described in more detail in this exhibit) of the inappropriate use of complex technology specific features to promote significant discounting of basic static protection requirements are:
    - The benefits of transmitter control (TPC) in adjacent channel interference suppression are highly suspect due to a central feature of mobile wimax allowing the network operator to increase capacity (by dynamically increasing modulation order) as opposed to decreasing transmitter power as well as the fundamental need to overcome the significant imbalance in the link budget between handset and base station. No specific quantitative general estimate can reasonably be obtained for the benefit from TPC. The Coalition distorts their analysis with arbitrary power reductions for higher order modulation schemes.[5].
    - For a given offered traffic profile, uplink duty cycles depend on a myriad of variables; among other things, the ratio of time allocated to the downlink vs. the uplink. This, in turn depends on the type of services the network operator is selling and the allocated quality of service offered for each service. With mobile wimax it is even possible for an operator to dynamically change this ratio over time and from cell to cell to address time variant traffic loading. Even if it were reasonable to apply some form of discount to static margin based on duty cycle, the rules would have to include significant constraints on any advanced network designs using technologies such as mobile wimax to ensure that real duty cycles were constrained to only those values ruled on. Given the sophistication and complexity of such technologies, this would simply be impractical.

[5] Comments of the WCS Coalition, WT 07-239, February 14 2008, Attachment B, Section 7. "Note that the maximum power for 16QAM modulation is assumed to be +21 dBm and +24 dBm for QPSK."

2 Probability Analysis

2.1 Introduction

The technical record regarding the WCS Coalition's proposed rule change for Part 27 contains a significant amount of experimental and theoretical material from both parties addressing the separation distances expected to be found in real world situations where WCS mobile transmitters and satellite radio receivers would interact.

All parties have agreed that adequate protection from interference needs to be demonstrated at distances as close as 3m.

This exhibit focuses on the frequency of occurrence of an interfering signal and the probability of inter- service proximity. The probability of a satellite radio being interfered with by WCS is determined by the following main factors (these are quantified later in this section):

Factor	**Description**
The WCS mobile customer is "active" in initiating or receiving service.	This can be estimated using the proportion of WCS users that are expected to be accessing the mobile service during the commute. Major traffic incidents or natural disasters could be expected to generate much higher values for short periods of time.
Victim satellite radio is "on"	In vehicle mounted situations, the radio is always "on" and can be receiving traffic data to update integrated navigation and weather systems, for example. In terms of the customer experience, most customers listen to the radio during their commute.
At least one signal from a WCS terminal (either from an A, B, C or D block transmission or from the OOBE associated with the transmission) is received strongly enough at the satellite radio to cause service disruption.	This probability can be assessed using a variety of separation distances which can be associated with service disruption. For overload interference, two distances are used, one associated with A,B block interference and one with C,D block interference. For OOBE interference a single distance is used.
WCS mobile terminal is engaged in service "long enough" for the uplink transmissions to disrupt satellite radio reception,	As is shown in Sections 3 and 4 for the applications likely to be used in the commuting use case, once the WCS user terminal is engaged in service, this probability is essentially equal to 1.

In the highway use case situations considered, it will often be the case that multiple WCS terminals are in a position to disrupt any given single satellite radio. This factor is also

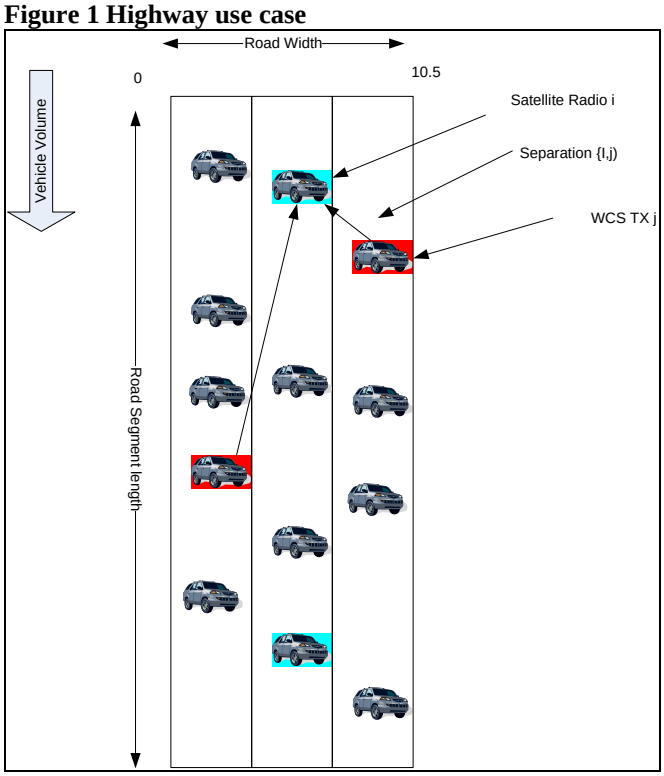
taken into account in the analysis that follows by increasing the effective activity probability.

No allowance is made for transmitter power control in this analysis for two reasons. Firstly, as shown in section 3.2.2, the likely real benefits of transmitter power control are highly variable and impossible to accurately quantify. Secondly, in the circumstances the WCS Coalition portrays potential use (e.g. inside vehicles), transmitter power control will generally act to compensate for additional vehicle penetration losses that the WCS Coalition also includes in it's mitigating factors (through added average excess path losses). In other words, this is a form of "double counting" of any TPC benefits.

2.2 Use case description

The reference use case for this analysis is the vehicular environment as illustrated in Figure 1. The highlighted vehicles represent WCS transmitters and satellite receivers.

Figure 1 Highway use case



The objective of the analysis is to determine what the probability would be of satellite radio reception being disrupted through one or multiple WCS transmitters being close enough for one or more of the recognized interference mechanisms to be present. The distances used[6] are a combination of those derived from measurements and from simple protection requirements using both Sirius XM and the WCS Coalition supplied data.

[6] See Appendix [3] of this Exhibit.

The parameters used in this analysis are given in Table 1.

Table 1 Probability values used in analysis

Parameter	Value	Unit	Notes
Traffic Volume	10,000[7]	Vehicles per Hour	
Average Vehicle Speed	{30,60}	mph	
Satellite Radio Penetration Rate	{13, 30}	%	Represents a range from near to long term.
WCS Penetration Rate	{5, 10.4[8]}	%	Conservative values
WCS Service Being Used (terminal activity level)	0.13[9]	probability	Conservative values. Higher during traffic incidents
satellite radio being listened to during commute	0.85	probability	Based on listening studies.
Interference Distances	{6,19,40,60}[10]	meters	See Appendix [3] of this exhibit.

With these parameters the analysis is be performed as follows:

Using published traffic statistics for a major highway, the total traffic volume is obtained in vehicles per hour between some specific locations on the highway.[11] Service penetration rates are then calculated or predicted on the basis of "real" customers or estimated based on published wimax network design data. The analysis then proceeds as follows:

1. Given the total vehicle volume, calculate the associated volume of satellite radios and WCS transmitters (per hour) by multiplying the total traffic volume by each service's individual penetration rates.
2. Choose a distance over which the traffic volume value is valid ("d" miles), choose an average vehicle speed ("V" mph) and calculate the average number of vehicles of each type that will be present in that distance, assuming a uniform flow of traffic. The fraction to use is d/V times the respective vehicle subset.
3. Randomly locate the satellite radio and WCS vehicles within a rectangle that is d long by the number of lanes wide, restricting the vehicle positions to the centers of each lane.

[7] See Appendix [1] of this exhibit.

[8] "A Comparative Analysis of Mobile WiMAX™ Deployment Alternatives in the Access Network" Wimax Forum White Paper, May 2007 Table 2.

[9] Wimax Forum White paper "A Comparative Analysis of Mobile WiMAX™ Deployment Alternatives in the Access Network" , May 2007, Page 13, Table 3.

[10] See Appendix [3] of this exhibit.

4. Calculate the distance separation matrix from all satellite radio vehicles ("i") to all WCS vehicles, S(i,j).
5. For each chosen distance of interest calculate how many satellite radio vehicles are separated by the interfering distance or less from each of 1,2,3 etc. WCS transmitters.
6. Calculate the probability of at least one of the WCS transmitters located within the interference distance being engaged in WCS service.
7. Multiple the probability of a satellite radio being within the interfering distance of at least one WCS transmitter by the probability obtained in "6" and the probability that a customer is listening to the radio.
8. Steps 3 through 6 constitute the iteration set (i.e. the Matlab program). The probability calculated in "7" is the final result.

The code for performing the analysis in steps 3 through 5 uses the program "Matlab" and is given in Appendix [2]. Table 1 summarizes the parameters used in the analysis.

In the frequent situation where multiple WCS transmitters are within the interference distance of a satellite radio, the probability of at least one of the WCS transmitters being active is calculated using the Binomial distribution. The probability of at least one of the multiple WCS transmitters being active is then used to prorate the probability of satellite radios impacted (see Table 2).

Table 2 Probability (as a fraction) of at least one WCS terminal being active.

Number of WCS transmitters within distance	Probability at least one is active
1	0.13
2	0.24
3	0.34
4	0.43
5	0.50
6	0.57
7	0.62
8	0.67

2.3 Results

Figure 2 and Figure 3 illustrate the results of the analysis for near term and long term service penetration expectations. These probabilities include not just the separation distance (calculated using the Matlab program, represented in terms of the which interference mechanism is being considered, i.e. A,B or C,D or OOBE) but the WCS subscriber activity level, and the probability of a satellite radio customer listening to the radio. It includes within the range of parameters used, the path loss measurements made by the Coalition and straightforward, conventional static protection values[12].

[12] See Appendix [3].

The significance of the results is as follows: the WCS Coalition has claimed that, due to numerous and complex technology specific features of mobile wimax, the probability of interference between these adjacent services is virtually "zero"[13] It is clear, however, that it is anything but zero in this simple to understand but realistic scenario based on largely technology neutral factors.

It should be understood that, absent mobile WCS service with the properties envisaged in the proposed rules change, it is unlikely that any of the satellite radios being listened to on this highway segment would experience muting (i.e. the probability is essentially zero in this real world case). Obstructions due to overpasses, road signage and passing tall vehicles would all be mitigated by additional features such as space and time diversity.

This simple but "real world" analysis illustrates that as the both satellite radio and mobile WCS penetration rate increases, the number of customers traveling on this sort of highway who will experience service disruption will increase from zero to over 12% in the near term and up to almost 25% in the longer term. These numbers will be substantially higher in traffic congestion, traffic accident or tollbooth situations.

This same situation will be repeated across the US on major highways in any markets where mobile WCS service is deployed.

Should mobile WCS service be used for a broader range of vehicle based applications than envisioned here (a likely scenario as one looks at current developments in mobile internet) the conservative penetration and activity rates used here would have to be increased.

The potential impacts on the satellite radio service from these effects are well summarized in recent comments filed in this proceeding by Balcones Industrial Research & Development Corporation.[14]

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[13] Ex parte WCS Coalition, June 13th 2008.

[14] Comments of Balcones Industrial Research & Development Corporation, IB 95-91, September 5 2008.

Figure 2 Probability of satellite radio interference, near term penetration rates

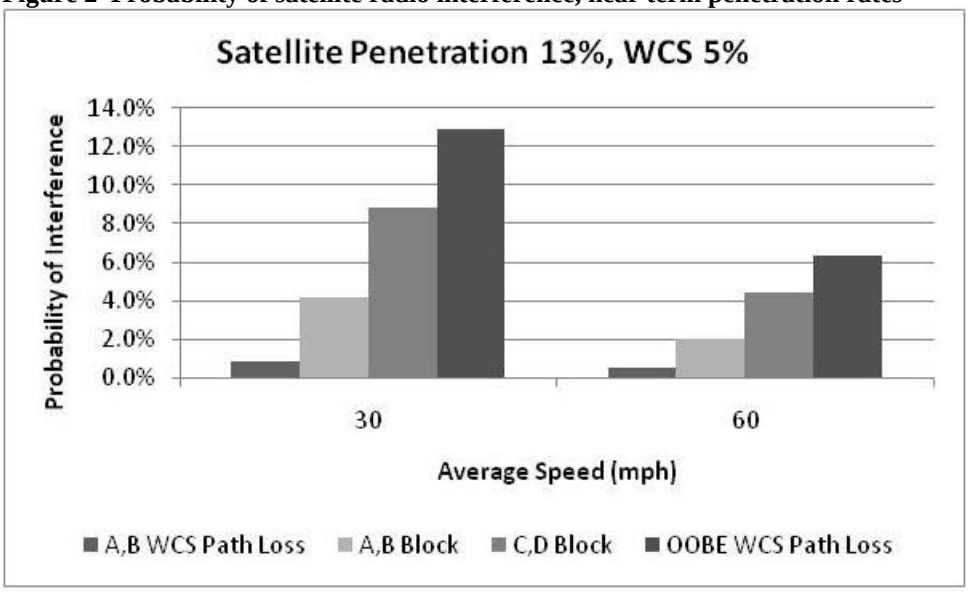
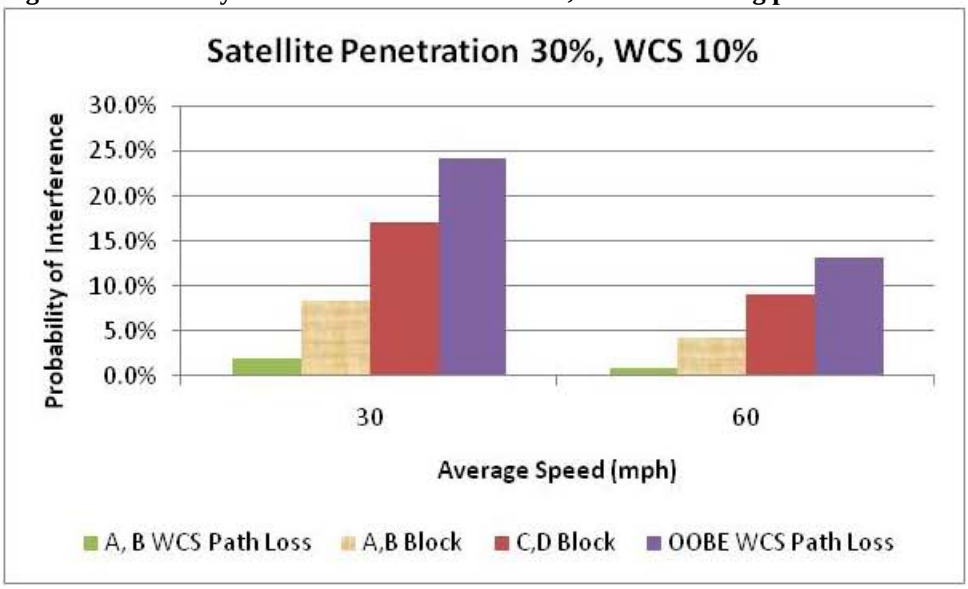


Figure 3 Probability of satellite radio interference, forward looking penetration rates



In summary, what this information illustrates is that prior to abandoning rules that have allowed satellite radio to develop into a service with over 19 million customers, extreme care should be taken to properly weigh conventional, static protection ratio based assessments vs. seemingly precise but inapplicable,, technology specific, probability analyses.

3 Simplified terminal uplink activity model for mobile wimax

3.1 Introduction

The WCS Coalition has attempted to position transmitter power control (TPC) and the “”low duty cycle” of the interfering mobile terminal uplink transmission as mitigating factors allowing significant discounting of the results of simple static tests. Experimental results from both parties have shown a variation in interference effects as a function of the effective “duty cycle” of the terminal, although the term “duty cycle” needs to be more precisely defined. This variation is mainly due to two mechanisms, interaction with the satellite radio’s automatic gain control (AGC) function and varying amounts of disruption of the satellite radio transmission frame.

Although the rules for the WCS band were and are intended to be technology neutral, mobile wimax, IEEE 802.16e-2005 has been extensively used by the parties as a “real world” example of the kind of mobile technology that would be deployed in the band if rules relief were granted. Accordingly, the uplink properties of this technology were chosen as a representative example for this discussion.

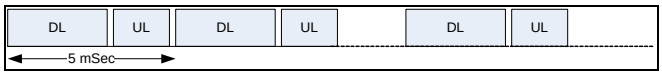


Figure 4 802.16e WiMAX Simplified TDD Channel Structure

The basic wimax Time Division Duplex (TDD)[15] channel structure is shown in Figure 4 for the nominal 5 (mSec) frame format. “DL” denotes downlink and “UL” uplink transmission.

Both the downlink and uplink bursts take place on the same channel and are comprised of “packets” of data and control information distributed in the time and frequency domains. There are also brief gaps between the downlink and uplink transmissions.

Each uplink “burst”, as seen at the base station, consists of transmissions from multiple user terminals which are individually distributed in time and frequency according to a “MAP” provided as part of the downlink data so that they do not, in general, overlap.

Unlike other systems where the “timeslot” for uplink transmission is fixed within the frame (and hence the duty cycle is fixed as the ratio of the uplink timeslot duration to the TDD frame duration), the timeslot duration for an individual wimax terminal uplink transmission is variable. This is because the base station can tell each user terminal to take data it has waiting for uplink transmission and assign it to a variable mixture of RF carriers (i.e. the “frequency” domain) and/or number of transmitted symbols (i.e. the “time domain”) to optimize the capacity or some other metric (e.g. latency for QOS).

[15] TDD operation is most often used as the example mode for deployment in this band.

This is illustrated in Figure 5[16] where it can be seen that the uplink "bursts" ("burst #1, burst #2 etc.) which represent individual WCS terminal uplink transmissions each occupy varying amounts of frequency (sub-channels/groups of RF carriers) and time (OFDM symbol number) within the uplink transmission period. e.g. A user terminal transmitting using "burst#5" will be "on" for a shorter time potentially than another handset using "burst #2. In a related fashion, the bandwidth occupied by each terminal transmission may also be different.

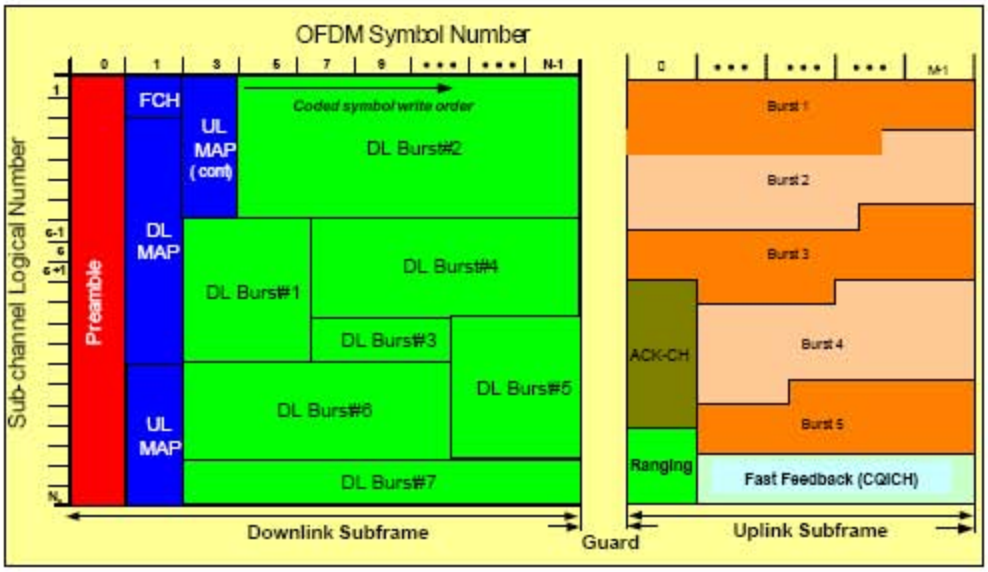


Figure 5 WiMAX detailed frame structure

As the overall capacity of the uplink is limited by the total number of bits that can be transmitted in each uplink burst, user terminals with less data to send may need to use only a low duty cycle to keep up with the user application whereas others may have to utilize a higher value. This will vary with the number of bits per frame available for allocation to the terminal which in turn is a function of the channel bandwidth (e.g. 5 MHz or 10 MHz), the number of active users, the type of application required, where each user is within a cell, and the (typically proprietary) algorithms used by the operator and equipment vendor to assign waiting data to burst resources (i.e. time, frequency and modulation order). It should be noted that this complex optimization capability makes simple association of any particular duty cycle "limit" of limited utility for rulemaking.

3.2 Terminal transmission duty cycle variability

As has been described, the actual "real world" uplink duty cycle of a specific WCS terminal based on mobile wimax is significantly variable, and is influenced by a variety of network configurable parameters set by the WCS operator and in some cases algorithms proprietary to the equipment manufacturer. This makes the use of simple

[16] Mobile WiMAX – Part I: A Technical Overview and Performance Evaluation August, 2006, WiMAX Forum.

single values of "duty" cycle" in either an experimental or rules making context problematic. Examples of network parameters that impact the terminal duty cycle are:

3.2.1 Cell DL/UL ratio

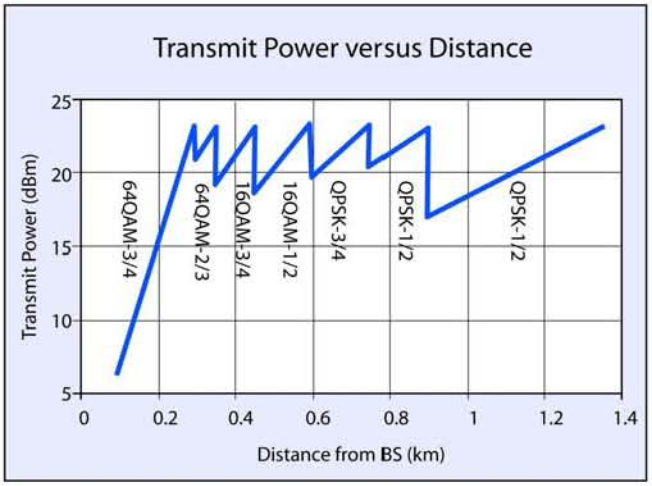
This is the overall ratio of data sent in the downlink direction vs. that sent in the uplink direction. This can even be changed dynamically in some cases. Typical values might be 3:1, 2:1 or 1:1. Depending on this setting (which changes the total amount of capacity available on the uplink vs. the downlink), the amount of data per uplink frame that a terminal can transmit will vary and therefore so will the effective "duty cycle." In addition, depending on the number of handsets with data to send and the real time requirements of such data (i.e. the "QOS" required) the minimum number of available TDD frames per second that the handset has to use to maintain a required data rate will also change, e.g. instead of needing to fill only one uplink transmission per 2 available frames, an increase in the DL:UL ratio (reducing the number of bits per uplink burst that can be accommodated) might require the handset to use a burst every frame, effectively doubling the "intra-frame" duty cycle and the number of bursts per satellite transmission frame.

3.2.2 Coding rates, transmitter power level control (TPC) algorithms

These criteria and algorithms are used for changing modulation levels, coding rates, QOS type and transmitter power levels to maximize capacity or optimize latency (e.g. for VOIP). These all directly impact the distribution of power transmitted, exact duty cycle within a transmitted frame and length of total "on" time that a handset will have with any given customer application and therefore the interference impact on a satellite radio receiver. In particular TPC has been much vaulted as a wimax feature that will always significantly reduce adjacent band interference. That such is not the case is shown in Figure 6 which illustrates how terminal uplink power will really adjust to maximize the available capacity. TPC is a tool that the network operator will always be motivated economically to use to maximize capacity and not minimize adjacent band interference[17]. That is exactly why the higher order modulation schemes (which require higher S/N and therefore transmitter power) are incorporated into the WiMAX standard as opposed to simply reducing the mobile power to the minimum necessary for basic rate communication. The area shown in Figure 6 within which the TPC actually minimizes terminal power (cell radius < 0.3 km) represents less than 6% of the cell area.

[17] "A common misconception is that mobile stations transmit at maximum power only at the edge of a cell, and at lower power when mobiles are closer to the BS. In reality, this is not the case; mobile stations will transmit at high powers over a range of distances." http://www.embedded.com/design/208403248?pgno=3

Figure 6 Transmit Power vs. Distance[18]



Essentially, mobile wimax technology gives the network operator a rich variety of variables to optimize the overall spectrum efficiency within the operator's own band. Unfortunately this makes "representative" interference modeling closely coupled to exactly how the operator intends to operate the network and what specific business models are involved (i.e. what mix of applications the operator wishes to offer etc.).

The complexity and associated variability of likely terminal characteristics can be illustrated by taking two extreme examples of a terminal in a disadvantaged position with respect to a base station (e.g. edge of the cell) vs. and advantaged situation close to the base station.

3.2.3 Outer Cell Area

At the cell edge the mobile terminal needs to construct an uplink burst that will maximize the received signal to noise ratio at the base station. Because the uplink and downlink are significantly imbalanced, the mobile terminal will need to use a robust modulation scheme (such as QPSK) , apply FEC coding gain (e.g. rate one half) and potentially even use repetition. This lowers the maximum effective data rate that the terminal can transmit at and therefore will increase the effective duty cycle as the terminal will have to send more bits per frame to maintain the same transmission rate. An additional "feature" of mobile wimax is that transmission resources can be assigned in both the time and frequency domains. Therefore in order to increase the energy per bit, it is likely that the resources will be assigned more in the time than frequency domains, making the duty cycle trend higher rather than lower[19].

[18] http://www.embedded.com/design/208403248?pgno=3 ,Figure 2.

[19] "Coverage: The downlink and uplink coverage are largely differentiated by maximum transmitted power allowed for base stations (BS) and MS's. Typically, there can be differences of two-orders of magnitude, e.g., 20W versus 200mW. For MS's at the cell edge, it is important to impart as much energy as possible to the information bits in order to maximize the coverage. In order to maximize the time of transmission, it is preferable to use as few subchannels as possible. In power-limiting cases, allocation of radio resources on

So, in general, for that area of the cell where the link margin is imbalanced (which is a large fraction of the area), the mobile wimax system optimization will tend to act in a way to increase both terminal transmitter power and uplink duty cycle.

3.2.4 Cell "core"

Within the cell "core", when the user terminal uplink has a higher link margin, the network operator will have the option of allowing the mobile terminal to choose a higher order modulation rate, reduce the code rate and/or reduce the transmitter power as well as assigning more capacity to the frequency (as opposed to the time) domain. How these various adjustments are made and weighted will be a function of the network operator's settings, the type of traffic offered and the proprietary algorithms of the equipment manufacturer. In general, the network operator will always be driven to maximize capacity and so the better the terminal environment, the higher the modulation order, transmitter power and bandwidth that will be used.

Only when the terminal is very close to the base station will sufficient link margin be available to allow a significant reduction of terminal transmitter power without sacrificing potential revenue generating capacity (see Figure 6). However, in this region the base station signal will be very strong and, as this is a TDD system, any satellite radio in this area will now be subject to strong base station interference on the same channel. The general characteristics to be expected within a wimax cell area are shown in Figure 7. It should be noted that the cell area within which higher order modulation could be used represents over 20% of the cell area.

3.2.5 Summary

As an example of the distortions that these "configurable" features can introduce into the analysis, in the WCS Coalition's probability analysis, operation in this mode was arbitrarily assigned 3 dB lower terminal power, artificially skewing the transmitter power distribution lower.[20]

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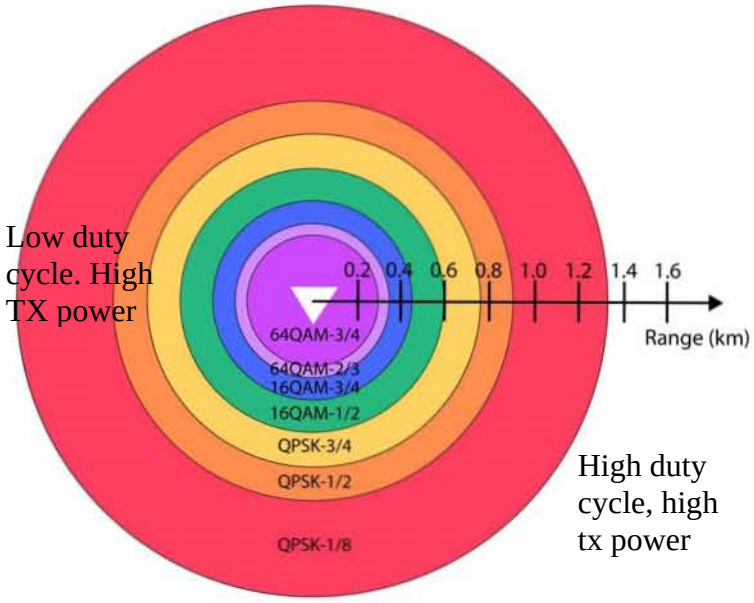
the uplink has a single degree of freedom —time alone can be used to enable the receiver to accumulate more energy per information bit" http://wirelessman.org/maint/contrib/C80216maint-08_215.doc section 2.1.

[20] Comments of the WCS Coalition, February 14 2008, Attachment B, Section 7. "Note that the maximum power for 16QAM modulation is assumed to be +21 dBm and +24 dBm for QPSK."

Figure 7 Modulation vs. cell area[21]



3.3 Relating duty cycles to application types

The following example calculation further illustrates that with the typical applications that mobile WCS systems using wimax will support, such systems will operate at the higher end of the possible range of duty cycle.

Typical applications that will be supported are shown in Table3[22]. Additional insight into the service capabilities that will need to be supported for any mobile wimax based service to be competitive are provided by Autonet's service, which reportedly will soon to be introduced by Chrysler and which claims 200 kbps upload speeds[23].

[21] http://www.embedded.com/design/208403248?pgno=3, Figure 1.

[22] Mobile WiMAX – Part I: A Technical Overview and Performance Evaluation August, 2006, P.48.

[23] http://www.autonetmobile.com/support/faq/ "High speed access ranges from 600Kbps-800Kbps. Upload speeds about 200Kbps."

Table3 Mobile WiMAX Applications

Class	Application	Bandwidth Guideline		Latency Guideline		Jitter Guideline	
1	Multiplayer Interactive Gaming	Low	50 kbps	Low	< 25 msec	N/A	
2	VoIP & Video Conference	Low	32 to 64 kbps	Low	< 160 msec	Low	<50 msec
3	Streaming Media	Low to High	5 kbps to 2 Mbps	N/A		Low	<100 msec
4	Web Browsing & Instant Messaging	Moderate	10 kbps to 2 Mbps	N/A		N/A	
5	Media Content Downloads	High	> 2 Mbps	N/A		N/A	

The minimum TDD frame duty cycle is the same regardless of the DL/UL allocation or bandwidth as it is represented by a terminal transmitting a burst whose duration is the same as a single "slot" (3 symbols long in time). The maximum duty cycle is calculated by assuming that a single terminal uses all the available UL symbols within the frame (not necessarily all the available "slots" or subchannels however). As can be seen the maximum uplink duty cycle depends on how the operator allocates the DL/UL ratio ranging from approximately[24] 25% for 3:1 (28:9 data symbols) to 43% for 1:1 (19:18 data symbols).

Table 4

[redacted]

Using this simplified model, it is possible to relate the number of users and individual data rates that could be supported to the duty cycle range as follows:

The basic unit of resource allocation for wimax is the "slot". A slot is 3 symbols long in the time domain and a number of carriers wide in the frequency domain. The number of available sub channels (a grouping of carriers) depends on the total channel bandwidth

[24] This assumes a 3 symbol overhead on the uplink transmission.

available (e.g. 5MHz or 10 MHz). The number of bits that a single slot can transmit is dependent on the modulation order and code used. For QPSK rate one half, a single slot can transmit 48 bits[25].

Associated with the minimum duty cycle is a trade off between the number of users and the average supported data rate per user as follows (assuming QPSK rate one half)

Assuming that for a 5 MHz channel the number of available uplink sub channels is 17, and for a 10 MHz channel the number is 35[26].

The total available number of bits per frame is calculated as:
Number of bits/slot*Number of subchannels

For 5 MHz =48*17=816 bits/ TDD frame
For 10 MHz=48*35=1680 bits/TDD frame

As a frame is 5 mSec, the associated approximate average data rates at the minimum duty cycle are:

$816/(5*10^{-3})$ = 163,200 bps
$1680/(5*10^{-3})$ = 336,000 bps

Assuming 17 users maximum per cell for 5 MHz and 35 users maximum per cell for 10 MHz, this translates to full capacity uplink data rates per user of less than 9.6 kbit/s at minimum duty cycles.

Given the large "gap" between these rates and those needed to be competitive (e.g. the rates shown in Table3 and the Autonet example of 200 kbps), it is clear that the probability of subscribers ever utilizing such minimum duty cycles is very low. This is especially true for the "C" and "D" blocks (where only a 5 MHz channel is available) and where operators will be challenged to economically provide competitive mobile broadband offerings[27] and where the proximity of the channel to the satellite radio receiving channel will further exacerbate the interference to satellite reception.

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[25] http://www.cse.wustl.edu/~jain/wimax/sch704c.htm

[26] id.

[27] To emulate the Autonet application, described previously, and maintain the minimum duty cycles, the simple model shows that not even a single subscriber could be supported.

4 Impact of WCS terminal duty cycle on the satellite radio system

There are two basic mechanisms by which the uplink bursts can disrupt satellite radio reception:

First, the level and duration of the burst may interact with the satellite radio automatic gain control (AGC) algorithm in a complex way to disrupt signal reception. It is unrealistic to expect that an AGC design optimized for a continuous broadcast transmission (such as satellite radio) would also be optimally designed to accommodate a wide range of adjacent band TDD waveform characteristics.

Second, absent negatively impacting the AGC operation, a WCS user terminal transmission need only be "on" for a certain minimum cumulative amount of time during the duration of a satellite radio transmission frame to cause sufficient bit errors to disrupt reception.

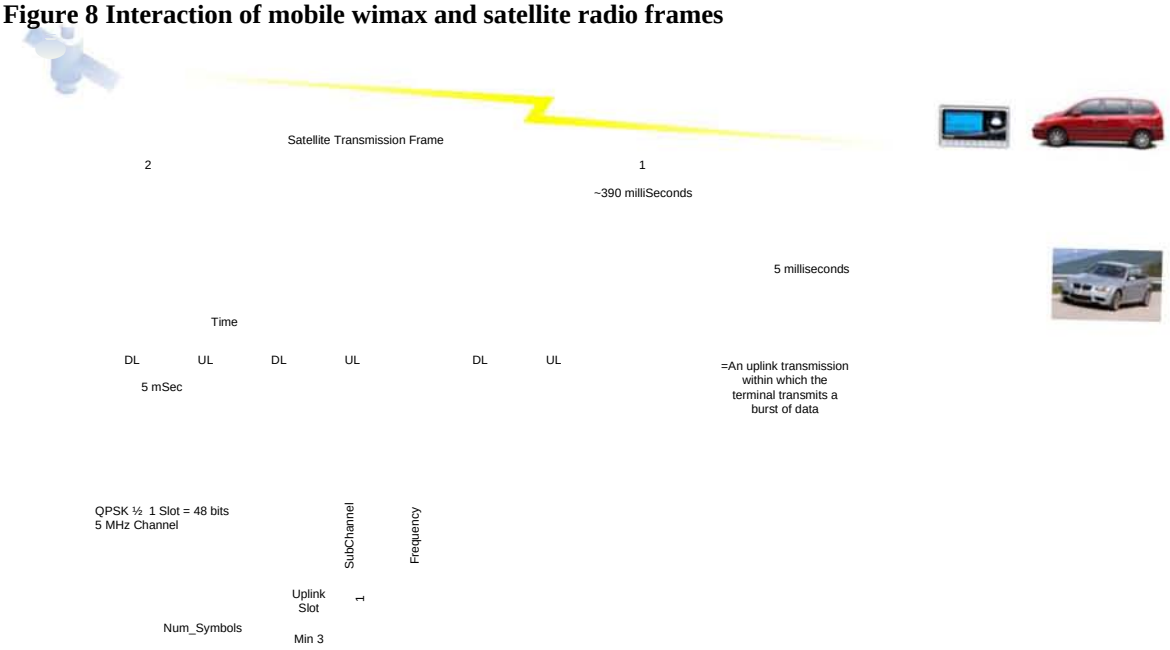
In order to further illustrate the relationship between interference duty cycle and satellite radio disruption, Figure 8 shows the basic transmission frames associated with the most commonly proposed mobile wimax system (5 mSec TDD) and an abstracted view of the XM and Sirius systems. As XM and Sirius have slightly different frame structures, an intermediate value of 390 mSec is used. The first important point to note is that the satellite radio transmission frames are more than 70 times longer than the mobile wimax frames. This is consistent with satellite radio being a broadcast service where transmission latency is not a critical parameter, in contrast to a two way service like WCS where latency is important and lost packets can be detected and re-transmitted quickly to avoid disruptions. This also implies there are significant differences between the two services in the way automatic gain control and other basic functions are designed to operate.

As has been described previously, in order to maintain a certain transmission rate or user service experience, the power and duration of each uplink burst and the number of bursts per second from any given user is dynamically "optimized" depending on a whole host of highly variable conditions. Neglecting the complex behavior induced by the differences in AGC design and assuming that no other impairments are present (a somewhat unlikely condition) satellite radio reception will be noticeably disrupted (i.e. "muted") when a sufficient number of transmission bits are disrupted that the error correcting capabilities of the transmission frame are exhausted. While the Sirius and XM systems are not identical, this disruption can be assumed to occur when approximately 1-5% of the bits in a transmission frame are in error, depending on the channel model.

Even at the minimum duty cycle physically available for wimax (~6%) interference will occur based on the fundamental properties of each system. Additionally, as previously

shown, given the sort of applications and link imbalances that will be present in a WCS mobile environment, this low duty cycle is unlikely to be found frequently in practice.[28]

Figure 8 Interaction of mobile wimax and satellite radio frames



[28] "For instance, transmit duty cycles for WiMAX devices are typically about 40 percent when the MS has data to transmit." http://www.embedded.com/design/208403248?pgno=5.

Appendix [1] Example Road Segment

Figure 9 Example New Jersey Turnpike Road Segment

Figure 9 shows the road segment between two junctions. The segment length is approximately 16 miles. The average daily traffic volume between these two junctions (in either direction) is approximately 80,000 vehicles per day (2006[29]). It can be assumed that the majority of this traffic volume is concentrated within a total period of 8 hours out of the 24 (4 hours in the morning and 4 hours in the evening), giving an average volume per hour of at least 10,000 vehicles.

We can also estimate the average penetration rate of SDARS receivers into these vehicles as follows:

- Number of vehicles in the USA[30]= 143,000,000 (2005)
- SDARS subscribers = 19,000,000
- Average vehicle penetration rate= 19,000,000/143,000,000= 13.2%

We can then estimate the average number of SDARS equipped cars traveling this segment at any instant during the "busy hours" as follows:

- Volume on the NJ turnpike segment per hour = 10,000 (each direction)
- Distance traveled= 16 miles
- Average speed = 60 MPH
- Average time to travel between junctions= 16/60= 0.267 Hour
- Average number of vehicles on segment in one direction at any instant during busy hours and normal traffic flow = 0.267*10000=2670

[29] http://www.state.nj.us/transportation/refdata/roadway/TextFiles/2007/NJTPK_2006.pdf.

[30] http://www.bts.gov/publications/national_transportation_statistics/html/table_01_11.html.

Appendix [2] Code Used for Probability Analysis (Matlab[31])

```
function FCC_Probability1
% This function performs  analysis of vehicle locations
%
clear;
global lane_width
%Interference distances to bucket results into (meters)
%Reference, Overload, A,B Block, C,D block
Int_measures=[19 40];
xlswrite('vehiclestats.xls',Int_measures,'Sheet1','B4');
%Quantities of WCS transmitters to assess within a given distance of a
%Satellite radio
WCS_tx_count_bins=[1 2 3 4 5 6 7 8 9 10 11 12 13 14 15];
xlswrite('vehiclestats.xls',WCS_tx_count_bins',Sheet1','A5');
%Distance Units Conversion Factor
miles_to_meters=1609.344;
% Roadway Characteristics
num_lanes=3;
lane_width=3.5; % meters
% Traffic Volume in Vehicles per Hour
Vehicle_volume=10000;
%Vehicle speed in mph
Vehicle_speed=60;
%Assumed Service Penetration Rates in percent
%WCS Transmitters
WCS_pen_rate=5;
% Satellite radios
Sat_pen_rate=13;
% Length of roadway segment in miles
Roadway_len=16;
%Number of iterations
Iter_cnt=500;
% Calculate number of vehicles of each type
% Number of vehicles on roadway segment
num_vehicles=round(Vehicle_volume*Roadway_len/Vehicle_speed);
% Number of WCS transmitters on roadway segment
num_WCS=round(num_vehicles*WCS_pen_rate/100);
%Number of Satellite receivers on roadway segment
num_Sat=round(num_vehicles*Sat_pen_rate/100);
% Road segment coordinate limit
Y_min=0;
Y_max=Roadway_len*miles_to_meters;
% Write basic parameters to spreadsheet
Headings={'Volume','Speed','WCS_Pen','Sat_Pen','Iter_cnt','n_Satvehicles'};
xlswrite('vehiclestats.xls',Headings,'Sheet1','A1');
Heading_values=[Vehicle_volume Vehicle_speed WCS_pen_rate Sat_pen_rate Iter_cnt num_Sat];
xlswrite('vehiclestats.xls',Heading_values,'Sheet1','A2');
%
n_WCS_bins=length(WCS_tx_count_bins);
```

[31] http://www.mathworks.com/.

```
n_Int_measures=length(Int_measures);
% Predefine array for speed of execution
WCS_count_2=zeros(n_WCS_bins,n_Int_measures,Iter_cnt);

% Main iteration loop start
%
% Indexes
% n= Iteration counter
% i=Sat radio index
% j=WCS transmitter index
%
for n=1:Iter_cnt
%+++++++++++++++++++++++++++++++++++++++++++++
% Random position loop for WCS Transmitters
% Pre-allocation for speed
WCS_Pos=zeros(2,num_WCS);
%
   for j=1:num_WCS
      WCS_Pos(1,j)=Lane(num_lanes);
      WCS_Pos(2,j)=Y_min+(Y_max-Y_min)*rand;
   end
% Random position loop for Satellite receivers
SAT_Pos=zeros(2,num_Sat);
   for i=1:num_Sat
   SAT_Pos(1,i)=Lane(num_lanes);
   SAT_Pos(2,i)=Y_min+(Y_max-Y_min)*rand;
   end
% Create Separation matrix
%Pre-allocation for speed
dist_X=zeros(num_Sat,num_WCS);
dist_Y=zeros(num_Sat,num_WCS);
%
   for i=1:num_Sat
         dist_X(i,:)=WCS_Pos(1,:)-SAT_Pos(1,i);
         dist_Y(i,:)=WCS_Pos(2,:)-SAT_Pos(2,i);
   end
Int_dist=sqrt(dist_X.^2+dist_Y.^2);

% Free up some memory by dumping position matrix

clear SAT_Pos;
clear WCS_Pos;
clear dist_X;
clear dist_Y;
%
%{
Create Statistics based on each satellite radio. For each satellite radio
on the highway, index i determine how many WCS transmitters are within a
distance indexed by q
%}

   for i=1:num_Sat
      for q=1:length(Int_measures)
         bin=[0 Int_measures(q)];
         %
         ni=histc(Int_dist(i,:),bin,2);
```

```
        WCS_count_1(i,q)=ni(1,1);
      end
    end
 %{
Produce count of how many sat radios have, within a given distance, a certain number of
WCS transmitters. WCS_count_2 is a three dimensional (third is the iteration count) matrix whose
elements contain the  number of satellite radios that have the number of wcs transmitters denoted by the
row index value within a distance indexed by the column index value.
%}

WCS_count_2(:,:,n)=histc(WCS_count_1,WCS_tx_count_bins,1);
%
end  % of master iteration loop
%
% Form average and std of all the iterations
for l=1:length(WCS_tx_count_bins)
    for m=1:length(Int_measures)
        Average_count(l,m)=round(mean(WCS_count_2(l,m,:)));
        Std_dev_count(l,m)=std(WCS_count_2(l,m,:));
    end
end
xlswrite('vehiclestats.xls',Average_count,'Sheet1','B5');

% "Lane" Returns a random lane assignment coordinate
function L=Lane(num_lanes)
global lane_width
snap=rand;
switch num_lanes
    case 1
        L=lane_width/2;
    case 2
        if snap <0.5
            L=lane_width/2;
        else
            L=(3/2)*lane_width;
        end
    case 3
        if snap<(1/3)
            L=lane_width/2;
        elseif (snap>(1/3)) && (snap <(2/3))
            L=(3/2)*lane_width;
        else
            L=(5/2)*lane_width;
        end

end
```

Appendix [3] Relevant Separation Distances

This appendix summarizes the rationale for selecting a range of separation distances relevant to the probability analysis. A number of different measures are integrated together to form a broadly applicable set of values for consideration.

Path loss measurements
The WCS Coalition's measured path loss data is summarized in Table 5.

Table 5 WCS Coalition path loss[32]

	Path Loss Near Field Range (5 to 50 ft)	Path Loss Far Field Range (5 to 100 ft)
Measurement	50.3 + 20.9 LogD	52.7 + 17.2 LogD
Theoretical Free Space	40 + 20 LogD	40 + 20 LogD

The WCS Coalition has provided more recent examples of path loss data[33], however the accuracy is misleading since it only reported the median path loss information for these particular complex and highly variable in vehicle use cases. By providing incomplete data, the WCS Coalition diverts attention from the fact that the real issue is interference; where the statistical path loss distribution between the interferer and the victim is the most important parameter to characterize, not just the Coalition's stated simple median path loss measurement data which obscures the problem scenarios. A simple median path loss report for these complex cases would lead to wrongly state that there is no interference problem[34].

Overload measurements
Satellite radio overload level -44 dBm for A,B blocks, -55 dBm for C,D blocks[35]

For a 23 dBm EIRP mobile, overload protection levels required can be calculated as:

Protection level = 23-(-44) = 67 dB for A and B blocks ("A,B protection" horizontal line in Figure 10)
Protection level = 23-(-55) = 78 dB for C and D blocks ("C,D protection horizontal line in Figure 10)

OOBE levels, given WCS Path loss and WCS criteria of muting

[32] Reply Comments of the WCS Coalition, IB 95-91, March 17, 2008, Attachment B, Table 1.3.

[33] Exparte, WCS Coalition, August 1st 2008, WT 07-293.

[34] The correct way to characterize this issue is to show the shape of the signal distribution (and its dynamic temporal-spatial variability), what the WCS calls outliers.

[35] Sirius Comments, WT 07-293, 2/15/2008, Exhibit C.

For OOBE, simple muting case where WCS OOBE uses up all the available link margin and causes an approximately 6dB rise in noise floor (see Exhibit [B]), the satellite radio received level would be =-108 dBm/4MHz.

For WCS OOBE specification of from 55+10logP (=-19 dBm/4MHz) to 67+10logP the OOBE protection level required is between 89 dB to 77 dB (e.g. -19-(-108).)

To simplify the analysis a mid-way value of 83 dB is chosen (The "OOBE protection" horizontal line in Figure 10)

Separation distances
The separation distances appropriate for probability analysis are therefore determined by associating the separation distance with the required protection values as follows:

Figure 10 shows the various path loss models used by both Sirius XM ("Free Space+3") and the WCS Coalition (WCS_1,WCS_2 from Table 5) in the proceedings. Also added to these curves are horizontal lines representing different protection values as described previously. Where these horizontal lines intersect the various path loss curves define a range of separation distances required to mitigate WCS interference.

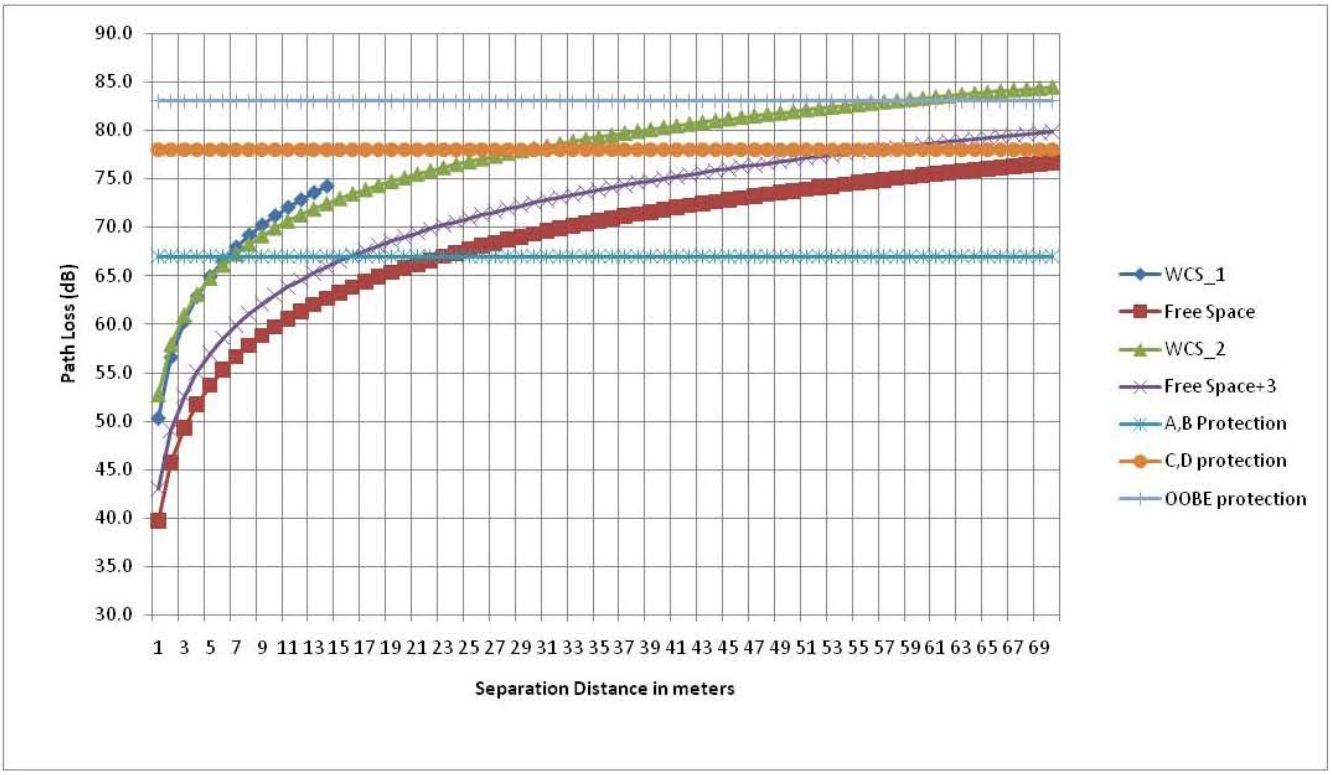


Figure 10 Path loss models used

To reduce the number of permutations, the following distances were chosen for the analysis:

- 6 meters (A,B protection intersects WCS path loss),

- 19 meters (A,B overload using Sirius XM measurements and calculated protection value intersection with free space+3)
- 40 meters (C,D overload using Sirius XM measurements and calculated protection value and intersection with free space+3)
- 60 meters (OOBE, WCS criteria of muting, calculated protection values intersection with WCS path loss model (WCS_1))

Exhibit [B]

WCS Interference to Satellite Radio

A Comparison of Different Metrics for Out of Band Emissions Interference Assessment

1 Introduction

The technical record submitted by the WCS Coalition and the satellite radio operators shows significant differences in the calculated and measured impact of proposed changes to the Part 27.53(a) Out Of Band Emissions (OOBE) rule for mobile devices. This exhibit summarizes the differences in the record and proves that the range of the discrepancy cannot be explained by simple differences in the metrics used.

2 OOBE Interference assessment approaches used in the record

Two approaches are presented in the record:

2.1 1 dB Victim receiver noise floor rise

In this case, the OOBE interference is permitted to account for 1dB of the available excess link margin, i.e. to raise the existing satellite radio receiver noise floor by 1dB.

2.2 Satellite radio is "muted "

In this case, the OOBE interference is permitted to use up the entire available excess link margin (i.e. that margin greater than that required to decode the digital bit stream associated with the satellite service).

3 Parameter ranges used in this comparison

- Satellite signal received level=-100 dBm/ 4MHz (Sirius)[1]
  - This is typical of many major metropolitan markets

- Noise floor
  - -119 dBm/MHz (satellite operator claim/measured)[2]
  - -113 dBm/MHz (WCS claim (thermal with 0.7dB NF LNA))[3]

- Path loss
  - Additional coupling losses (over free space) at 3 meters separation
    - Satellite operator claim = 3 dB (at 3 m path loss = 52.5 dB)[4]
    - WCS claim = 12.2 dB (at 3 m path loss =61.7 dB)[5]

- Satellite signal impairment criteria
  - Satellite operator: 1dB noise floor rise (i.e. loss of 1 dB of margin)
  - WCS: Signal disruption
    - Minimum C/N (Carrier to Noise) required in AWGN to decode QPSK format (Sirius signal format)
      - 1% Bit Error Rate (BER) which requires a C/N of 6.5 dB

[1] Exhibit C Section 2.1.2, Comments of Sirius Satellite Radio Inc. ,IB Docket No. 95-91.
[2] Appendix to Exhibit C, Comments of Sirius Satellite Radio Inc., IB Docket No. 95-91 Feb 14, 2008.
[3] Equation (1), Attachment A, Reply Comments of the WCS Coalition, IB Docket 95-91, March 17th 2008.
[4] Figure [5], Exhibit C, Comments of Sirius Satellite Radio Inc., IB Docket No. 95-91 Feb 14, 2008.
[5] Table 1, Reply Comments of the WCS Coalition, IB Docket 95-91, March 17th 2008.

4 Example calculations

4.1 Received SNR

Equal to:

Eq. 1 Satellite signal received level –Noise floor (4MHz)

Satellite radio operator claim:[6] **=-100-(-113) = 13 dB**

WCS Coalition claim: **=-100-(-107) = 7dB**

4.2 "Excess" link margin

Margin available after decoding the bit stream, applied against all impairments, including interference.

Equal to:

Eq. 2 Satellite signal received level –Noise floor(4MHz)-QPSK decoding C/N[7]

Satellite radio operator claim: **=-100-(-113)-6.5= 6.5 dB**

WCS Coalition claim: **=-100-(-107)-6.5=0.5dB**

It should be noted that if the WCS Coalitions claims as to the normal satellite operating noise floor were correct the satellite radio service would have only 0.5 dB of excess margin which would clearly render the service unusable.

In the case of added interference noise power I_{WCS} (e.g. from WCS OOBE), the Noise floor used in Eq. 2 becomes

Eq. 3 Noise floor=N_{sat} + I_{WCS} where the noise bandwidth used is 4MHz

4.3 "Allowed" mobile OOBE (based on 3m criteria)

Equal to:

Eq. 4 "Allowed" Interference noise power at Satellite radio(I_{WCS}) + assumed separation path loss at 3 m

Where "allowed" = that interference power that causes a 1dB rise in the existing satellite radio noise floor in the case of the satellite radio operators and the interference power that causes satellite radio muting in the case of the WCS coalition's claim.

---

[6] For a 4MHz bandwidth approximating the Sirius Satellite Radio signal bandwidth.

[7] 1% Bit Error Rate (BER) equivalent to loss of service definition for QPSK.

To establish the equivalent mobile OOBE specification, the values are normalized to a 1MHz bandwidth.

Example: Satellite radio operator claim:[8]

-125 dBm/MHz + 52.5 dB =-72.5 dBm/MHz= **102.5+10LOG(P)**

5 Metric Comparison

Figure 1 uses Equations 2, 3, 4 and the EERS model[9] to illustrate the trade space for the possible values of WCS mobile OOBE specification as a function of:

- Different values of excess satellite link margin with allowances for "real world" impairments such as multi-path, Doppler, implementation loss
- An allowance for satellite signal service availability under foliage.
- Different values of noise floor rise deemed "acceptable" at the satellite receiver.

Figure 1 illustrates that, in stark contrast to terrestrial systems, even under ideal circumstances (i.e. AWGN), there is very little excess satellite link margin available. This margin is used to mitigate satellite channel impairments such as interference, foliage attenuation, multipath fading, and Doppler. For a mobile OOBE specification that allows emissions of 97+10log(P) or higher, the satellite radio will be severely impaired and for emissions of greater than 92+10log(P), the radio will be completely muted.

For customers listening while driving under tree cover, an examination of the relationship of the loss of basic service availability of a single satellite under foliage[9] (Figure 2) shows that they will experience severe loss of service at interference levels significantly below that which would cause complete muting .

As can be seen the basic service availability needs to be significantly enhanced through the presence of additional satellite signals, time buffering and other features to provide a reliable service. The loss of a single element of the delivery system therefore has a significant impact on the availability of signal to satellite radio subscribers and the ability of Sirius XM to offer a viable service.

[8] Interference power that causes a 1 dB Noise floor rise from -119dBm/MHz (-113 dBm/4MHz) is -125 dBm/MHz.

[9] Section 3.3.2, Handbook of Propagation Effects for Vehicular and Personal Mobile Satellite Systems, Julius Goldhirsh and Wolfhard J. Vogel.

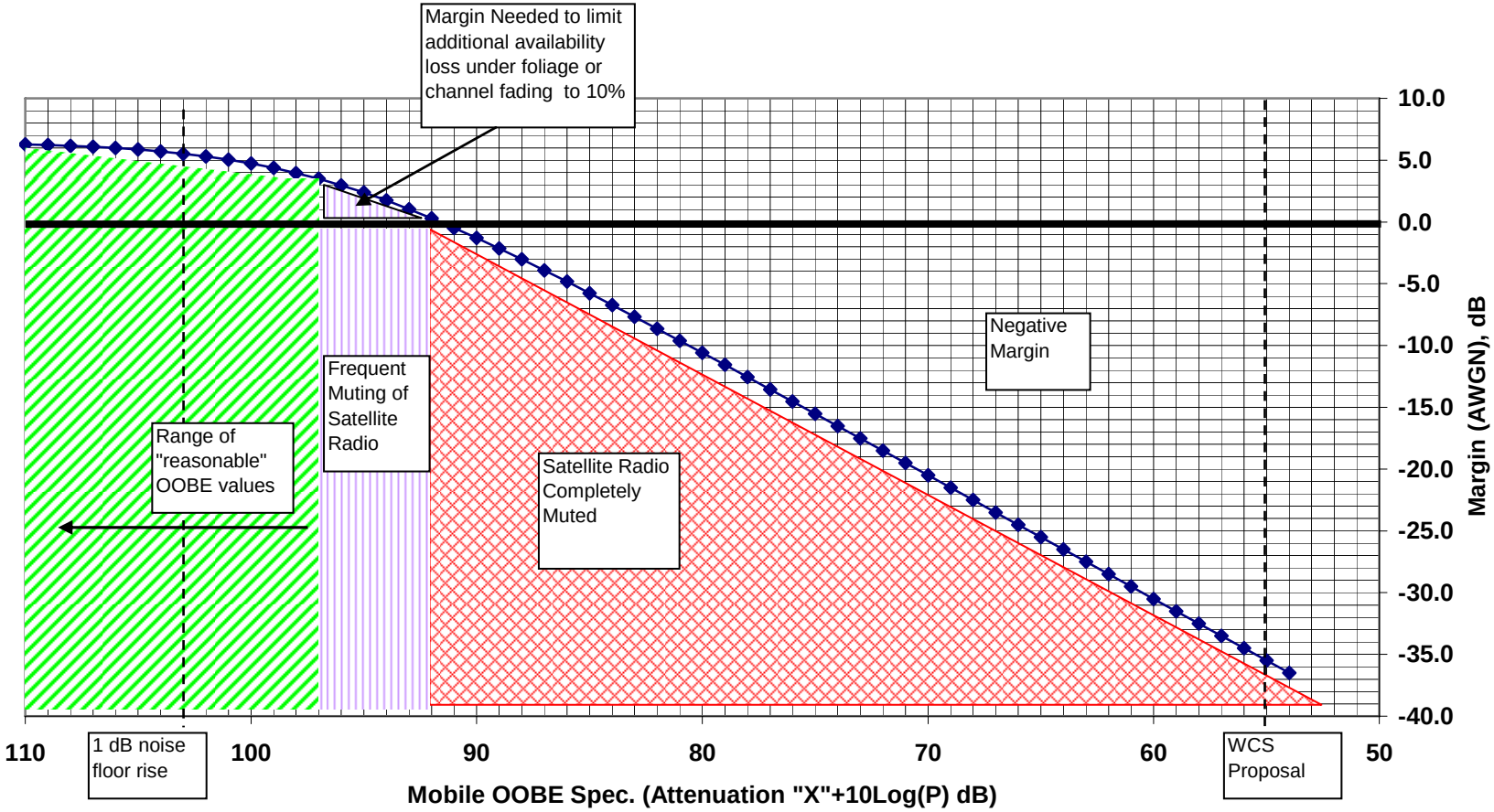


Figure 1 Satellite Excess Link Margin vs. Mobile OOBE Specification

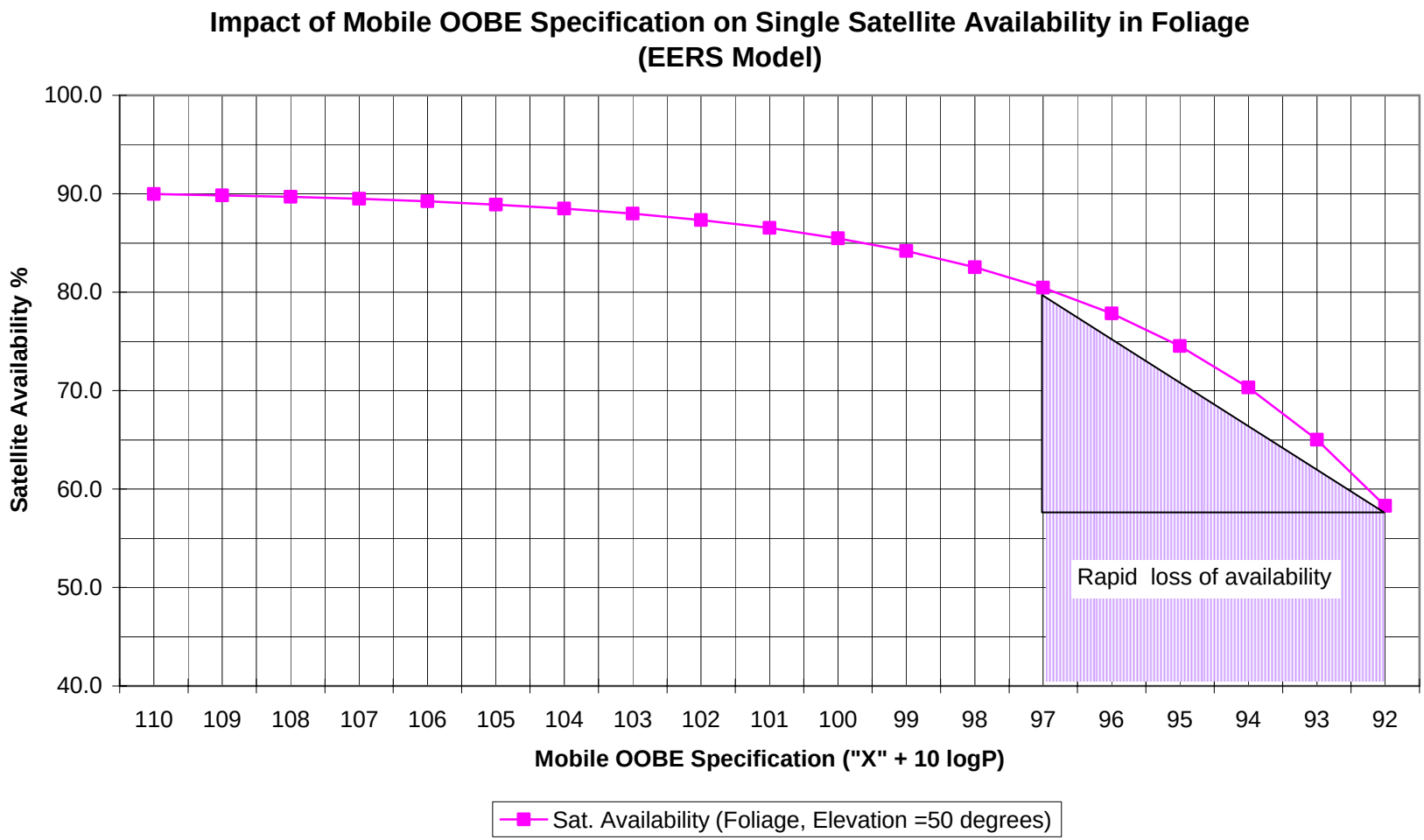


Figure 2 EERS Model of Service Availability

6 Conclusions

It has been illustrated that the difference in allowable mobile OOBE specifications for a 1dB noise floor rise vs. complete satellite radio muting results in a range of potential values of the specification of 103 + 10 log(P) to 93 +10log(P). The WCS proposal of 55+10log(P) is therefore 48 dB less stringent than a value that causes noticeable impairment of the satellite service.

Exhibit [C]

Comparative OOBE and Overload Data from the AWS-3 Proceedings WT 07-195

Summary

The technical issues addressed in the AWS-3 proceedings have previously been shown to be very similar to the issues raised in the WCS Coalition's proposed Part 27 rule change. These issues revolve around adjacent band usage of mobile uplinks and mobile downlinks and what the allowable out of band emissions and overload specifications should be.

Figure 1 and Figure 2 summarize the significant recent proposals in the AWS-3 proceedings, normalized to a 3 meter interference distance and the appropriate bandwidths. While the WCS Coalition has tried to portray the issues of the proposed WCS Part 27 rule change as parochial and unique only to the satellite radio band and has claimed the satellite radios are "overly sensitive", as can be seen, the recommendations of Sirius XM for maximum allowable out-of-band emissions from WCS in the S-band are on the same order as those of commenters in the AWS-3 proceedings having licenses in bands near the proposed AWS allocation (see Figure 1). Indeed, the vast majority of respondents, including WCS Coalition member AT&T, indicated the impracticality of mobile uplink operations immediately adjacent to mobile downlink reception. Moreover, ICO, which operates a MSS space-to-earth link analogous to Sirius XM's downlink, highlights the particular incompatibility between mobile uplinks and satellite downlinks and provides a summary of the issues surrounding mobile satellite reception that dictate a more conservative approach to overload and OOBE rules assessment[1] such as:

- Satellite receiver front-ends are inherently more sensitive than traditional PCS or cellular mobile;
- Filter design is constrained by the imperative of low insertion loss for satellite coverage;
- Mobile-to-mobile interference will be more severe when satellite mobiles are the victim than when PCS mobiles are the victim;
- ICO receiver blocking performance in the immediately adjacent block is -56 dBm (Sirius XM has shown that a satellite radio has -55 dBm blocking in C, D blocks);
- Customers rely primarily on satellite coverage;
- Satellite reception constantly operates near the receiver sensitivity, due to the large distances involved to the satellite;
- A 1dB noise floor rise criterion for OOBE; and
- Satellite receivers will be subject to interference throughout the country.

Additionally, the majority of the respondents view a significant guard band (>10 MHz) as being necessary to permit mobile EIRP's of 200 mW (see Figure 2).

[1] Comments of New Satellite Services G.P., WT 07-195, July 28, 2008.

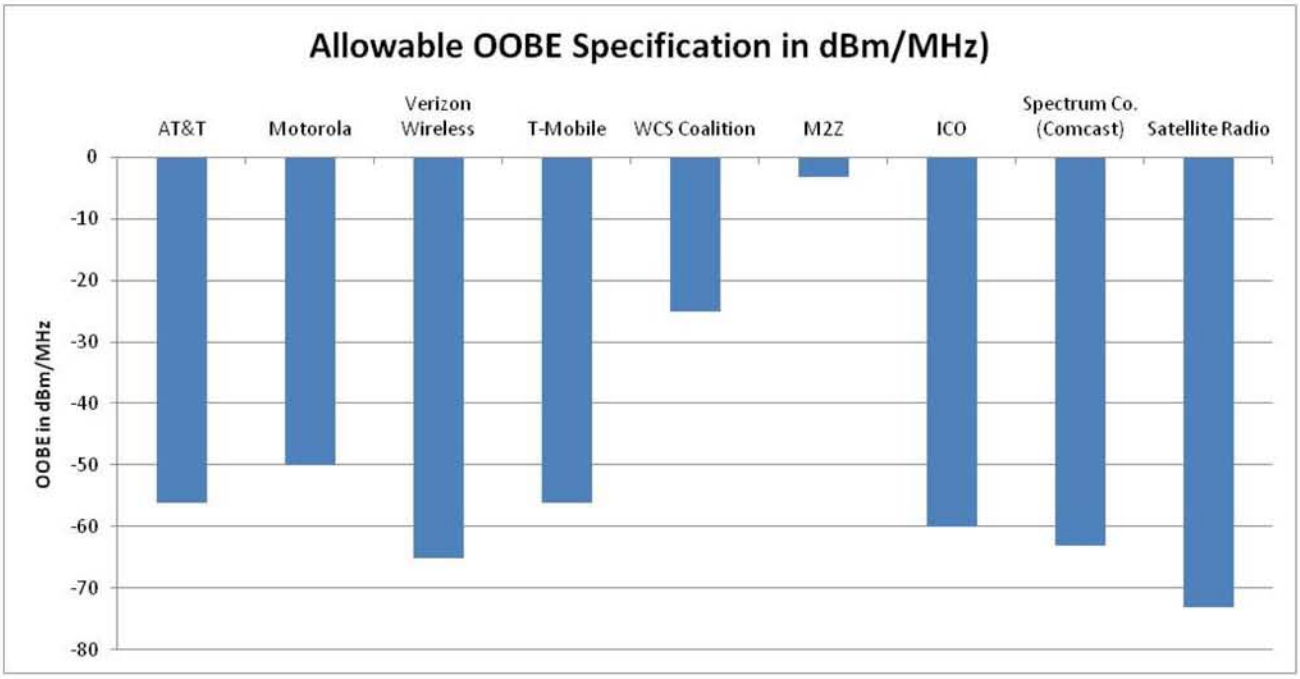


Figure 1 AWS-3 Comparison mobile OOBE

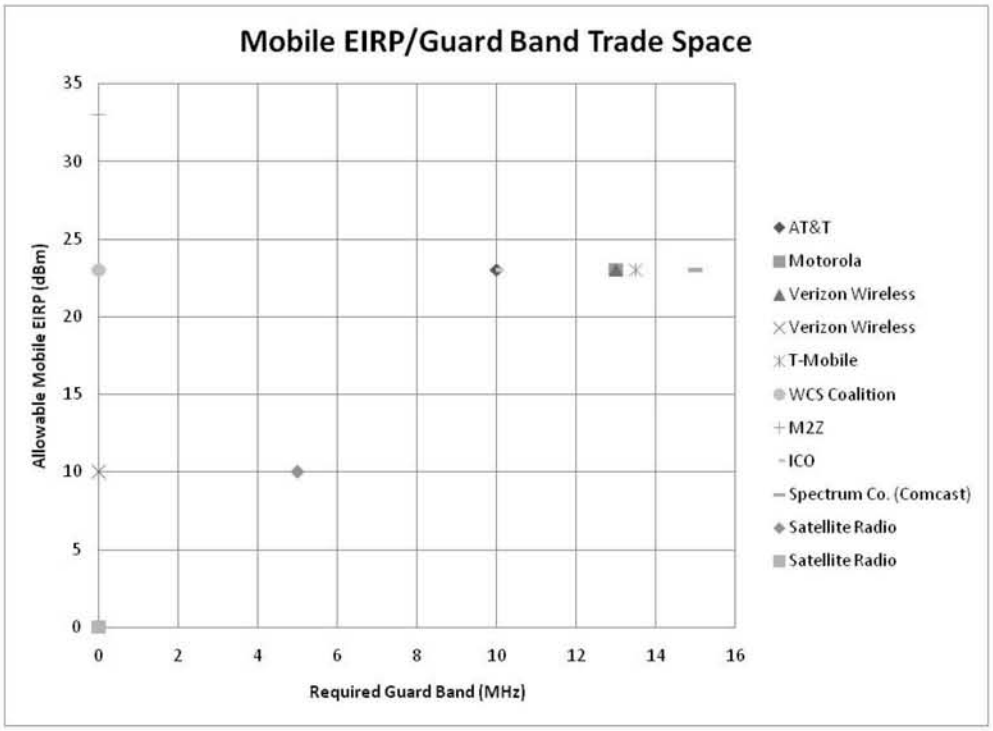


Figure 2 Mobile EIRP/ Guard band trade Space

Exhibit [D]

Sirius XM Rule Proposals

Sirius XM recommends the following modifications to Part 25 of the FCC Rules.

1. Add new paragraph (d) to Section 25.214 to read as follows:

§ 25.214 Technical requirements for space stations in the satellite digital audio radio service.

* * * * *

d) Terrestrial Repeaters. Satellite DARS licensees may construct and operate terrestrial repeaters consistent with the technical provisions of Section 25.218 of this chapter without prior Commission approval. Such blanket license will not expire as long as the licensee maintains a valid space station authorization.

2. Add new Section 25.218 to read as follows:

§ 25.218 Technical standards for terrestrial repeaters in the satellite digital audio radio service.

Satellite DARS licensees may construct and operate terrestrial repeaters consistent with the following requirements.

a) *Frequency Blocks*: Satellite DARS terrestrial repeaters are limited to the 2320.0 MHz – 2332.5 MHz and 2332.5 MHz – 2345.0 MHz bands.

b) *Power levels*. Satellite DARS terrestrial repeaters may operate with a maximum permissible EIRP of 12 kW average power. In addition, Satellite DARS repeater emissions in each block shall not separately exceed an average field strength of 100 dBμV/m measured at 1.5 meters above ground level at more than 95% of locations within a test area as defined in paragraph (e) of this section. The average field strength is due to transmissions by equipment located in the above test area and which is licensed to operate in either Satellite DARS frequency block as specified in paragraph (a) of this section.

c) *Out-Of-Band Limits*. Satellite DARS terrestrial repeater emissions shall be reduced by a factor not less than 90 + 10 log (P) dB in a 1 MHz bandwidth outside the range 2320 to 2345 MHz., where P is the average transmitter output power in watts.

d) *Peak to Average Ratio:* The Complementary Cumulative Distribution Function (CCDF) of the Satellite DARS transmitted signal will be measured at the transmitter output. The transmitter output CCDF will not exceed a peak to average ratio of 13 dB when measured at the 0.1% probability level.

e) *Definition of a Test Area:* In accordance with the requirements of paragraph (b) of this section, the test area is a square area whose location is defined by the coordinates of the bottom left corner of the test area. The appropriate test area is the smallest of the following areas, 1 km^2, 4 km^2, 25 km^2, 100 km^2, 400 km^2, 2500 km^2, 10000 km^2, which includes the least of 10 transmitters or all transmitters in the market if fewer than 10. All test points that occur above a water feature (e.g.

sea, lake or river) will be ignored. Field strength levels at these points will not contribute to establishing compliance.

f) *Equipment Certification*. All satellite terrestrial repeaters will be subject to FCC certification.

g) *Predictive analysis*. No later than 90 days prior to commencement of commercial service on any terrestrial repeater, other than repeater exempt under paragraph (h) of this section, a satellite DARS licensee must conduct a predictive analysis showing field strengths that satisfy the respective emission requirements, by employing the following parameters:

(1) For the purpose of radio-frequency propagation modeling ITU-R Recommendation P.1546-3 (P.1546) shall be used.

(2) Terrain data. 50 m resolution digital terrain map data shall be used.

(3) Clutter data. The 50 m resolution clutter database shall be used. This database identifies a minimum of 10 different clutter categories. For the purposes of incorporation into P.1546 these categories are mapped to the categories noted in P.1546, namely: urban, dense urban, suburban, sea, open. The mapping that will be used is shown in below.

Code	Clutter Database Category	P.1546 category
1	Dense urban	Dense Urban
2	Urban	Urban
3	Industrial	Suburban
4	Suburban	Suburban
5	Village	Suburban
6	Parks/recreation	Open
7	Open	Open
8	Open in urban	Urban
9	Forest	Open
10	Water	Sea

(4) Calculation methodology: To verify compliance, field strength values will be calculated using any suitable radiofrequency software planning tool implementing the radio-frequency propagation model and terrain and clutter data sets described in (g)(1), (g)(2) and (g)(3) of this section. Compliance to the license terms is established if the aggregate field strength values predicted by the radio-frequency software planning tool are no greater than those given in d)(A)(iii) for the specified percentage of locations (pixels) within the test area. Detailed specification of the methodology is given below:

(i) Bin Size. The test area defined in d(2)(vi) will be divided into square bins of size 50m by 50m.

(ii) Summation of signals from transmitters. The aggregate field strength at a pixel will be defined to be the summation of the predicted field strengths for each outdoor

transmitter (expressed in linear units) on an r.m.s. basis (linear addition of power density).

(iii) Excluded pixels. Aggregate field strength will not be calculated for pixels which contain a transmitter. Pixels containing a transmitter will not be considered in determining compliance. Pixels which are of P.1546 clutter type 'Sea' will not be considered in determining compliance.

(iv) The term "adjacent to sea" as described in P.1546, Annex 5, Section 9 is interpreted as "located over the sea". These pixels will therefore not be considered in determining compliance.

(v) Path profile extraction. Both terrain height and clutter height will be assumed to be constant over the area of a pixel. No interpolation of heights will be undertaken P.1546 location variability. Field strengths will be predicted for a 50% location variability

(vi) P.1546 time variability. Field strengths will be predicted for a 50% time variability.

(vii) P.1546 field-strength predictions for distances less than 1 km. For path lengths of less than 1 km, the method described in P.1546, Annex 5, Section 14 will be used.

(viii) Receiving/mobile antenna height. Field strengths will be calculated at the height specified in 2(A)(iii).

(ix) P.1546 correction for receiving/mobile antenna height. For pixels which are classified as P.1546 categories "dense urban", "urban" or "suburban environment", equation *27a* of P.1546 shall be used to determine the correction for receiving/mobile antenna height. For pixels which are classified as P.1546 categories "open" or "sea", equation *27b* shall be used to determine the correction for receiving/mobile height.

(x) Terrain Clearance Angle. Terrain Clearance Angle correction as described in P.1546, Annex 5, Section 11 will be used.

(xi) P.1546 Correction for short urban/suburban paths. (P.1546, Annex 5, Section 10,). No correction for short urban/suburban paths will be applied.

(xii) P.1546 Land paths shorter than 15 km. For paths less than 15 km in length, as described in P.1546, Appendix 5, Section 3.1, equation *6* of P.1546, Annex 5 will be used to determine $h1$ in all cases. In using this equation the actual value of path length d will be used, including cases when d is less than 1 km.

(xiii) Transmit antenna gain. The transmit EIRP assumed will be that in the direction of the reference receiver at the clutter height.

(5) The transmitter be shall assumed to transmit in a continuous transmission mode with an occupied bandwidth equal to the repeater channel;

(h) Exempt repeaters. Subsection (d)(2) of this rule shall not apply to:

(1) Grandfathered repeaters. Repeaters placed into commercial service prior to the effective date of this subsection; or

(2) Substitute repeaters. For the purposes of this subsection, a substitute repeater is a satellite DARS repeater that is intended to replace a Grandfathered repeater, the site for which has become physically unusable or economically impractical, and:

(i) is within 3 km of the Grandfathered repeater it replaces;

(ii) does not increase the size of the area within the 100 dBuV/m contour of the Grandfathered repeater it replaces; and

(iii) does not extend the 100 dBµV/m contour of the Grandfathered repeater it replaces more than 3 km in any direction.

(3) Very low power repeaters. Repeaters with an EIRP of 2 watts or less with the transmitter operating in a continuous transmission mode at full power. The out of band emissions of these repeaters will be attenuated by 75+10log(P) where P is the average transmitter power in watts.

(i) Other limitations.

(1) Authorized services. Satellite DARS repeaters may transmit only information also transmitted by a licensee's DARS space station.

(2) Border coordination. Satellite DARS repeaters must conform to the terms of the U.S.-Mexico Agreement on the Use of the 2310-2360 MHz Band dated July 24th, 2000, and the U.S.-Canadian Agreement on the use of the 2320-2345 MHz band dated August 28, 1998, or any successor.

(j) Notice and record keeping. Satellite DARS licensees must maintain and make available on a secure Internet web site, providing password access to all 2.3 GHz WCS and satellite DARS licensees the following information.

(1) A list of all operating terrestrial repeaters specifying, for each terrestrial site, location (lat/long), height AGL, antenna types, sector azimuths, number of transmitting sectors, EIRP per sector; polarization and down tilt.

(2) All telephone numbers and email addresses of emergency contacts authorized to investigate any complaints of harmful interference.

(3) Not later than 90 days before any transmitter begins commercial operations, the results and methodology of the analysis required by subsection (d)(2)(B) for non-exempt repeaters placed into commercial operation.

(4) Radiation patterns for all transmit antenna types deployed.

(5) Report annually the information required by § 25.144(c)(4).

3. Add new paragraph (c)(4) to Section 25.144 to read as follows:

§ 25.144 Licensing provisions for the 2.3 GHz satellite digital audio radio services.

(c)(4) A listing of operating Satellite DARS terrestrial repeaters including the information specified in § 25.214(i) of this chapter.