**Before the**
**FEDERAL COMMUNICATIONS COMMISSION**
**Washington, D.C. 20554**

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| In the Matter of | ) | |
| | ) | |
| Service Rules for Advanced Wireless Services in the 2155-2175 MHz Band | ) | WT Docket No. 07-195 |
| | ) | |

# COMMENTS OF VERIZON WIRELESS


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## I. SUMMARY

Verizon Wireless respectfully submits these comments in response to the Commission's Notice of Proposed Rulemaking to establish service rules for licensed fixed and mobile services, including Advanced Wireless Services ("AWS"), in the 2155-2175 MHz band ("AWS-3").[1] We appreciate the Commission's continued efforts to identify and make available spectrum that will facilitate the provision of innovative services for the benefit of U.S. consumers and the economy. We agree with the Commission that this spectrum is likely to be used for AWS, and may in fact be used in conjunction with other AWS spectrum. As a result, we urge the Commission to establish rules that will not only promote the efficient and effective use of the AWS-3 spectrum, but will also promote the efficient and effective use of all AWS spectrum, including the 1710-1755 MHz / 2110-2155 MHz band ("AWS-1"), which has already been licensed, and the 2020-2025 MHz / 2175-2185 MHz band ("AWS-2"), which the Commission has indicated will be licensed in the future.

[1] *In the Matter of Service Rules for Advanced Wireless Services in the 2155-2175 MHz Band*, WT Docket No. 07-195, Notice of Proposed Rulemaking ("*Notice*"), FCC 07-164 (rel. Sep. 19, 2007).

The establishment of flexible, market-based service rules is important to the continued development of advanced wireless services, and to the continued growth and vitality of the wireless industry. However, as discussed infra, certain uses of the AWS-3 spectrum could result in significant harmful interference to AWS licensees in adjacent bands. In 2006, Verizon Wireless purchased thirteen AWS-1 licenses at auction that cover approximately half of the United States and it has already begun to make additional investments to prepare for the future use of this important spectrum. Certain uses of the AWS-3 spectrum which are contemplated in the *Notice*, however, would interfere with the use of the AWS-1 spectrum by Verizon Wireless and numerous other licensees, and as a result, would undermine the benefits to the public from the provision of service on the auctioned AWS spectrum.

Verizon Wireless urges the Commission to establish rules that protect existing licensees from harmful interference. Specifically, we recommend that the Commission prohibit mobile transmissions in the AWS-3 band, as such uses would impede the provision of effective mobile communications services by existing AWS licensees. The AWS-3 band should be limited to base station transmissions (if used to provide a mobile service) or for fixed services. In the alternative, the Commission should establish technical rules, such as strict power and out-of-band emission limits, which would ensure that use of the AWS-3 band will not cause harmful interference.

Verizon Wireless does not propose such strict limitations lightly. However, such rules are necessary to prevent the occurrence of harmful mobile-to-mobile interference that would substantially affect the reliability and availability of mobile services provided

on other AWS systems. Indeed, limiting the AWS-3 band to base station transmissions or fixed services would be consistent with current limitations imposed on the adjacent AWS-1 and AWS-2 bands.[2] As the Commission has noted, the upper segments of the AWS-1 and AWS-2 bands (2110-2155 MHz and 2175-2180 MHz) are designated and proposed to be designated, respectively, for base transmissions.[3] Verizon Wireless believes that the efficient and effective use of the entire 2110-2180 MHz AWS band requires that all segments of the band be subject to the same interference standard.

## II. THE COMMISSION MUST PROTECT EXISTING LICENSEES FROM HARMFUL INTERFERENCE.

Verizon Wireless has previously noted the importance of limiting the potential for harmful interference.[4] This objective is at the very core of the Commission's spectrum management responsibilities, as codified in Section 303 of the Communications Act, which requires the Commission to establish rules to "prevent interference between stations."[5] As the Commission considers rules that would govern the use of the AWS-3 band, it must be mindful of its mandate to protect licensees in adjacent bands and should not promote uses of the spectrum that would result in harmful interference to others.

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[2] *See* 47 C.F.R. § 27.50(b).

[3] *Notice* at 15.

[4] *See* Letter from Richard J. Lynch, Executive Vice President and CTO, Verizon Wireless, to the Honorable Michael K. Powell, Chairman, Federal Communications Commission, IB Docket No. 01-185 and ET Docket No. 95-18, filed Jan. 22, 2003; *see also* Comments of Verizon Wireless, in response to AWS 3rd NPRM, ET Docket No. 00-258 ("*Verizon Wireless AWS Comments*") (filed Apr. 14, 2003); *see also* Joint Comments of Sprint Corporation and Verizon Wireless, WT Docket No. 04-356 (filed Dec. 8, 2004) ("*Sprint/Verizon H Block Comments*");

[5] *See* 47 U.S.C. § 303 (f).

As a general matter, significant public benefits can be derived from the use of spectrum if it is permitted to be used flexibly – i.e., with whatever technologies and for whatever services the market dictates. Indeed, Congress has recognized these benefits and authorized the Commission to allocate spectrum in a manner that provides flexibility of use, subject to certain conditions:[6]

1. Such use must be in the public interest;
2. Such use must not deter investment in communications services and systems, or technology development; and
3. Such use must not result in harmful interference among users.

This is the policy framework that the Commission must use in deciding what rules it should establish to govern the use of the AWS-3 band. It must take into account the potential for the use of this spectrum to cause harmful interference, and must take action that would either prohibit such uses or establish technical rules that adequately protect existing licensees. Failure to do so would not only directly violate the third tenet of the Congressional mandate described above, but would result in diminished service availability and reliability to wireless consumers. Wireless carriers would be forced to divert limited resources to interference mitigation efforts. Depending on the severity of the interference caused by operations in the AWS-3 band, effective mitigation may not be possible or may come at a substantial cost. As a result, investments in the communications services and systems affected by this interference would be deterred (2nd tenet), and the public interest would clearly not be served (1st tenet).

[6] *See* 47 U.S.C. § 303 (y) (2).

## III. MOBILE DEVICES PRESENT INTERFERENCE CHALLENGES WHEN OPERATED IN CLOSE PROXIMITY TO ONE ANOTHER.

The *Notice* acknowledges the significant interference challenges associated with operating both base and mobile transmitters in the same band.[7] While such operations create the potential for both base-to-base and mobile-to-mobile interference, it is the mobile-to-mobile interference problem that is the most difficult to resolve.

The Commission has been advised of the mobile-to-mobile interference problem in various past proceedings, including most recently in the "*H Block Proceeding*."[8] In each of those proceedings, Verizon Wireless and others cautioned the Commission about the risks of harmful mobile-to-mobile interference and urged it to establish rules that would protect existing services.[9] The risk of harmful interference from operations in the AWS-3 band is especially high because, unlike the H Block, there is no guard band separating the band from adjacent licensees that are likely to suffer interference.

As the *Notice* acknowledges, there is a significant risk of interference whenever two or more mobile devices are in close physical proximity and operate in the same frequency bands or in bands that are spectrally close to one another.[10] The record in previous proceedings shows that the wireless industry generally employs a one meter

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[7] *Notice* at ¶¶ 11-23.

[8] *In the Matter of Service Rules for Advanced Wireless Services in the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz Bands (WT Docket No. 04-356)*, Notice of Proposed Rulemaking, 19 FCC Rcd 19263 (2004) ("*H Block Proceeding*").

[9] *Verizon Wireless AWS Comments*; *Sprint/Verizon H Block Comments*; *see also* Comments of CTIA – The Wireless Association, WT Docket No. 04-356 (filed Dec. 8, 2004) ("*CTIA H Block Comments*"); *see also* Comments of Motorola, Inc., WT Docket No. 04-356 (filed Dec. 8, 2004) ("*Motorola H Block Comments*"); *see also* Ex parte presentation of CTIA, IB Docket No. 01-185 (filed Jan. 14, 2003).

[10] *Notice* at 15.

separation distance as the standard for mobile operations.[11] The reason for such a standard is obvious. As the use of wireless devices continues to proliferate, there are many circumstances in which mobile users will be in close proximity to one another. This includes a variety of high user density locations that are both inside buildings (e.g., offices/conference rooms, convention centers, train stations, airport terminals, and sports arenas) and inside vehicles (e.g., aboard trains, buses, or in a van pool while commuting to/from work). In the case of vehicular locations, there are many circumstances in which the separation distances between users would be substantially less than one meter.[12] As the use of wireless devices for non-voice applications such as data and video continues to increase, the potential for harmful mobile-to-mobile interference will also increase.

Interference between mobile devices can manifest itself in various ways, including: (1) receiver overload; (2) out-of-band emissions; and (3) intermodulation distortion. Receiver overload interference occurs when an interfering signal in an adjacent band is strong enough to desensitize the mobile receiver. The potential for overload can be reduced by employing a filter in the receiver to attenuate the interfering signal. However, filtering may not be sufficient if the interfering signal is too strong, or is too close in frequency to the pass band of the receiver.

Interference can also result from excessive out-of-band emissions ("OOBE") from the interfering mobile transmitter, which raises the noise floor in the receive band and

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[11] *See* Ex Parte Letter of Paul Garnett, CTIA, to Marlene H. Dortch, Secretary, Federal Communications Commission, ET Docket No. 00-258 (filed Jul. 30, 2004); *CTIA H Block Comments* at 13; *Motorola H Block Comments* at 5; *"Review of H-Block Test Results with PCS Handsets,"* V-COMM Presentation, filed with Ex Parte Letter of Donald Brittingham, Verizon Wireless, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 04-356 ("*V-COMM H-Block Presentation*") (filed Sep. 21, 2005).

[12] *V-COMM H-Block Presentation* at 16-19.

desensitizes the receiver. In this case, the interfering signal falls into the pass band of the mobile receiver, and thus, cannot be attenuated with a receive filter. OOBE can only be mitigated by employing a transmit filter in the interfering mobile device.

Intermodulation ("IM") distortion is caused when strong interfering signals mix with the mobile's own transmitting signal to create new signals ("IM products") that fall within the pass band of the mobile receiver. The risk of IM interference can be reduced through filtering, but is more challenging because of the variety of IM products that can be produced from various sources.

As noted above, the risks of harmful interference from each of these three interference mechanisms can be reduced through some combination of transmit and receive filtering. However, there are practical limitations to the amount of effective filtering that can be achieved. Included with this filing as Attachment B is a presentation from Avago Technologies, a leading manufacturer of RF filters, that describes the use of filters in mitigating harmful interference.[13] As Avago notes, for "filtering to be an effective cure for interference, there must be adequate frequency spacing (guard band) between the frequency of transmission and the frequency of reception to allow a filter to achieve the desired amount of rejection."[14]

Moreover, Avago states that there are three design factors that will have a substantial effect on the ability of any filter to achieve its desired result; i.e., slope, temperature, and consistency.[15] The "slope" of the filter determines how quickly the

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[13] *"Some Comments on RF Filtering."* Technical presentation of Avago Technologies provided to Verizon Wireless ("*Avago Presentation*"), Dec. 5, 2007, included as Attachment B.

[14] *Id* at 13.

[15] *Id* at 8-11.

transition is made from pass band (where the desired signal is passed) to reject band (where interfering signals are attenuated). The steepness of the slope is determined by several factors, including the operating frequency and bandwidth. Lower frequencies and narrower bandwidths allow for a steeper slope, while higher frequencies and wider bandwidths require a more gradual slope. Filters must also be designed to account for the fact that the pass band shifts with changes in "temperature." Filters are designed for an operating range of -30$^{o}$C to +85$^{o}$C.[16] And, due to variations in the manufacturing process, the pass band of the filter will vary in "consistency" from one filter to the next.

Importantly, filter designs must also take into account a variety of other practical and economic considerations, such as the markets for which the filter is being manufactured and the specific frequency plans in those markets. A filter designed to accommodate multiple markets and frequency plans will be more cost effective than one designed for a single market, and may also facilitate roaming from one market to another.

## IV. THE USE OF THE AWS-3 BAND FOR MOBILE TRANSMISSIONS WOULD CAUSE HARMFUL INTERFERENCE TO SERVICES IN ADJACENT BANDS.

As a preliminary matter, we note that the filter information provided by Avago, in and of itself, demonstrates that using the AWS-3 band for mobile transmissions would cause harmful interference to other AWS licensees. Avago's analysis demonstrates that a filter designed to operate in the 2 GHz AWS band would require 12.5-13 MHz of guard band between the AWS-3 band and the adjacent AWS-1 and AWS-2 bands to provide

[16] Note that filters are designed to operate at very high temperatures not just because of ambient temperature, but because the transmitter generates a substantial amount of heat during operation.

sufficient rejection of any interfering signals.[17] Since there is only 20 MHz of spectrum available in the AWS-3 band, providing such guard bands is not possible if both the AWS-1 and AWS-2 bands are to be protected. Consequently, the operation of mobile transmitters in the AWS-3 band will undoubtedly result in harmful interference to adjacent AWS licensees.

It should be noted that these conclusions are not based on the use of inexpensive filters with relatively poor performance characteristics. Avago's analysis is based on the use of film bulk acoustic resonator ("FBAR") technology, which produces band-pass filters that have a high Q factor to achieve a steeper slope. These filters are able to perform substantially better than older filter technologies, but are also more expensive.

It should also be noted that Avago and other filter manufacturers are already designing and manufacturing filters for the AWS mobile receive band that cover a broader range than the AWS-1 band (2110-2155 MHz) used in the U.S. For the practical and economic reasons already mentioned, filters are being manufactured to cover the entire 2110-2175 MHz band so they will accommodate the various frequency plans that are used in U.S., European, Asian, and South American markets.[18]

To better understand the risk of harmful interference from AWS-3 operations, Verizon Wireless commissioned V-COMM, a leading provider of integrated network engineering and support services, to analyze the potential for mobile operations in the AWS-3 band to interfere with operations in the adjacent AWS spectrum. V-COMM's

[17] This includes 2 MHz to account for filter slope, 7.5 MHz to account for temperature motion, and 3 MHz to account for filter consistency. *Avago Presentation* at 14.

[18] *Id* at 12.

findings are included as Attachment A.[19] In conducting its analysis, V-COMM considered: (1) the practical filter design issues raised by Avago; (2) the previous test data submitted by the wireless industry in response to the *H Block Proceeding*; and (3) new data from tests recently conducted by Motorola, which were provided to Verizon Wireless.[20]

V-COMM notes that the interference potential between the AWS-3 and AWS-1 bands is comparable to the interference potential between the H Block (1915-1920 MHz) and the nearby PCS spectrum above 1930 MHz.[21] Consequently, if 10 MHz of guard band were provided between the AWS-1 band and any AWS-3 spectrum used for mobile transmissions (as is the case for the proposed H Block), then we could expect AWS-1 mobile receivers to experience similar levels of interference to those that were described in detail in the *H Block Proceeding*.[22] Specifically, we could expect receiver overload to occur at approximately -28 dBm, -25 dBm, and -17 dBm for mobile transmissions in the 2165-2167 MHz, 2167-2168 MHz, and 2168-2170 MHz bands, respectively.[23]

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[19] "*AWS-3 Band Interference Analysis*." Presentation of V-COMM Telecommunications Engineering to Verizon Wireless ("*V-COMM AWS Presentation*"), Dec. 7, 2007, included as Attachment A.

[20] The Motorola test data is included in the filing made by Motorola. *See* Comments of Motorola, Inc., WT Docket No. 07-195 ("*Motorola AWS Test Data*"), filed Dec. 14, 2007.

[21] V-COMM concludes that mobile transmissions in the AWS-3 band will cause receiver overload and OOBE interference, but not Intermodulation (IM) interference, into the adjacent AWS bands. IM interference is not anticipated to be a problem because any IM products would fall outside of the AWS-1 band. *V-COMM AWS Presentation* at 16.

[22] Previous interference analyses concluded that there would be substantial harmful mobile-to-mobile interference from use of the H Block, despite the presence of a 10 MHz guard band. *CTIA H Block Comments; Motorola H Block Comments*. V-COMM's recent analysis, included with this filing, demonstrates that similar interference would occur as a result of mobile transmissions in the AWS-3 band if a comparable 10 MHz guard band were provided. *V-COMM AWS Presentation* at 16-18.

[23] *V-COMM AWS Presentation* at 14.

Assuming a one meter separation standard, the AWS-3 mobile power that would produce these interference levels would be +14 dBm, +17 dBm, and +25 dBm, respectively.[24] Since the typical power level for a wireless mobile device today is +23 dBm (200 mW), significant reductions in normal mobile operating power would be required in significant portions of the 2165-2175 MHz AWS-3 band to avoid harmful interference.

Importantly, the analysis described above only considers the interference impacts on the AWS-1 band if a 10 MHz guard band is provided, i.e., mobile transmission occurs only in the 2165-2175 MHz segment of the AWS-3 band and not in the 2155-2165 MHz band. It does not consider the interference impacts of such operations on the proposed AWS-2 band, nor does it consider the impacts on the AWS-1 band if there is no guard band, or if the guard band is less than 10 MHz. This analysis also does not take into account the fact that actual AWS filters being manufactured today are not being designed to accommodate the split band arrangement described above. Rather, for the practical and economic reasons already noted, they are being designed to cover the entire 2110-2175 MHz band. And, as a result, these filters would not provide adequate rejection of interference originating from any part of the AWS-3 band.[25] V-COMM concludes that these filters can be expected to have 10-20 dB less rejection than the H Block test case.[26]

Motorola recently conducted additional tests to assess the potential interference from AWS-3 mobile operations if there is no guard band separating the AWS-3 band

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[24] *Ibid*.

[25] *Id* at 22.

[26] *Ibid*.

from other AWS spectrum.[27] V-COMM reviewed this test data, and incorporated it into its overall analysis. Motorola tested the potential for interference into the AWS-1 band from an interfering CDMA mobile device transmitting in the 2156.25 MHz, 2157.5 MHz, and 2162.5 MHz bands, i.e., with 1.25 MHz, 2.5 MHz, and 7.5 MHz guard bands, respectively. Motorola observed no substantial difference between these three test cases, with each resulting in a dropped call when subjected to an interfering signal of approximately -34 dBm. At normal mobile power levels, this would require a separation distance of approximately ten meters – ten times the industry standard.

Importantly, Motorola's recent testing used dropped calls as its reference point for determining when interference occurs. This is an extreme measure of interference to a mobile call. As V-COMM describes in its analysis, call quality is degraded long before the call is dropped, which indicates that much lower interference levels than those identified by Motorola would be harmful to effective mobile operations.[28] Previous H Block testing performed by Motorola and CTIA observed increases in frame error rates as a more accurate determinant of harmful interference to a mobile device.[29] Based on analysis of the H Block lab test data, V-COMM concludes that impairments to call quality occur about 8 dB before a call is dropped, which corresponds to an interference level of -42 dBm.[30] This result confirms V-COMM's previous conclusion that the amount of rejection that can reasonably be expected to be achieved with a practical AWS

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[27] *See generally Motorola AWS Test Data*.

[28] *V-COMM AWS Presentation* at 16.

[29] CTIA's tests were conducted by two independent testing labs, Rutgers University's WINLAB and PCTEST. *See generally CTIA H Block Comments*.

[30] *V-COMM AWS Presentation* at 20-21.

filter is substantially less than what is achieved today with PCS filters, as observed through the H block testing.[31]

In order to satisfy the one meter separation standard, V-COMM concludes that AWS-3 mobiles transmitting in the 2155-2165 MHz band would have to be limited to a power level of 0 dBm (1 mW) to avoid harmful interference to AWS-1 mobile receivers.[32] Similarly, if AWS-2 mobile receivers are afforded the same level of protection, AWS-3 mobiles transmitting in the 2165-2175 MHz band would have to be limited to 1 mW as well.

## V. THE COMMISSION SHOULD ESTABLISH RULES THAT PROMOTE EFFICIENT AND EFFECTIVE USE OF AWS-3 SPECTRUM, WHILE AVOIDING HARMFUL INTERFERENCE TO OTHER BANDS

The Commission asks what service or technical rules should be established to avoid harmful interference, and seeks comment on three specific AWS-3 band arrangements. These include an "Uplink/Downlink" approach that would allow both base and mobile transmissions throughout the AWS-3 band, a "Structured Uplink/Downlink" approach that would permit mobile transmissions in only the 2160-2170 MHz portion of the band, and a "Downlink Only" approach that would prohibit mobile transmissions throughout the band.[33] For the reasons described supra, Verizon Wireless believes that the "Downlink Only" approach is the only viable option for the AWS-3 band because it is the only practical option that would allow for the provision of mobile services without causing significant harmful interference to adjacent AWS

[31] *Id* at 22.

[32] This assumes 39 dB of path loss at one meter and 3 dB of additional losses. *Id* at 17.

[33] *Notice* at 11-23.

licensees. We note, however, that fixed services could also be provided in the band without the same risk of interference as that which applies to mobile transmissions.

The analysis provided by V-COMM, the filter information provided by Avago, the previous H Block testing conducted by CTIA and Motorola, and the recent AWS testing conducted by Motorola all point to the same conclusion. Mobile transmissions cannot be allowed in <u>any</u> portion of the AWS-3 band if the AWS-1 and AWS-2 bands are to be protected from harmful mobile-to-mobile interference. The reason is simple. The RF filters employed in mobile devices that employ frequency division duplex ("FDD") technology require a minimum guard band to separate transmit and receive frequencies.[34] Avago has shown that the minimum guard band for the AWS band, under idealized conditions, would be 12.5-13 MHz.[35] A guard band of less than that amount would not provide adequate rejection (30-50 dB) of the interfering signals, and would result in harmful interference. Even a guard band as large as 10 MHz would not provide enough rejection, and thus would not significantly reduce the risk of interference. The previous H Block testing conducted by CTIA and Motorola and the recent Motorola testing all support this conclusion.

While it would be possible to avoid AWS-3 interference if mobile power levels are limited to 1 mW (as V-COMM's analysis demonstrates), it is not practical to economically deploy a wide area mobile network with such a limitation. Consequently,

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[34] Filters employed in TDD devices do not present similar problems because those devices transmit and receive at different times. However, as the Commission acknowledges, multiple AWS-3 licensees employing TDD systems would have to synchronize their operations to avoid interference, which could limit the flexibility of AWS licensees. *Notice* at footnote 27.

[35] As already noted, actual AWS filters can be expected to cover a broader range of spectrum for practical and economic reasons.

Verizon Wireless believes that the proper course for the Commission to take – the one that would promote the most efficient and effective use of the AWS-3 band – would be to adopt the proposed "Downlink Only" approach. By prohibiting mobile transmissions in the entire band, the Commission will ensure adequate protection to AWS-1 and AWS-2 operations, while providing an opportunity for both AWS-1 and AWS-2 licensees (and possibly others) to acquire additional downlink spectrum capacity that could be paired on an asymmetrical basis with other spectrum. Verizon Wireless and others in the wireless industry have previously noted the potential value of such asymmetrical spectrum pairing arrangements.[36] The Commission itself acknowledged such benefits and identified numerous licensees that might be interested in seeking such arrangements.[37] By adopting the "Downlink Only" approach, the Commission can maximize the efficiency and effectiveness of all AWS spectrum, because the entire AWS-3 spectrum would be put to effective use and use of the AWS-1 and AWS-2 spectrum would not be diminished. Indeed, limiting the AWS-3 band to base station transmissions or fixed services would be consistent with current limitations imposed on the adjacent AWS-1 and AWS-2 bands. The efficient and effective use of the entire 2110-2180 MHz AWS band requires that all portions of the band be subject to the same interference standards.

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[36] *Verizon Wireless AWS Comments* at 7-8; *see also* Comments of the Cellular Telecommunications & Internet Association, ET Docket No. 00-258 (filed Apr. 14, 2003) at 6.

[37] *Notice* at footnotes 20 and 22.

## VI. CONCLUSION

Verizon Wireless urges the Commission to establish rules for the AWS-3 spectrum that will promote the most efficient and effective use of all AWS spectrum, including the adjacent AWS-1 and AWS-2 bands. We believe that the Commission can best accomplish this result by adopting the proposed "Downlink Only" approach, which would prohibit mobile transmissions in the AWS-3 band. In the alternative, the Commission should adopt rules that limit mobile transmissions in the AWS-3 band to a power level of 1 mW, as any transmission exceeding that level would result in harmful interference to other AWS operations.

Respectfully submitted,

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# <u>Attachment A</u>

## "AWS-3 Band Interference Analysis"

Technical Presentation of V-COMM Telecom. Engr.
December 12, 2007

# <u>Attachment B</u>

## "Some Comments on RF Filtering"

Technical Presentation of Avago Technologies
December 5, 2007