occurred even when the WCS mobile device was operating at full power without ATPC employed, with the EIRP fixed at 24 dBm (*i.e.*, 250 mW) over 5 megahertz. Moreover, although the WCS Coalition's tests showed that in a vehicular-mobile environment, muting could occur when the devices are within 3 meters of one another, the WCS device is transmitting with ATPC activated, only one SDARS satellite is visible, only one satellite channel is available, and no terrestrial repeater is present at that same moment, the tests showed muting is not inevitable in every instance when a WCS mobile or portable device is in close proximity to an SDARS receiver.

59. *Comments*. In its comments on the Commission staff's proposed interference rules in the *WCS/SDARS Technical Rules Public Notice*, Sirius XM contends that the power limit for WCS mobile and portable devices should be reduced to 150 mW average EIRP in the WCS C and D blocks, recognizing that NextWave and Horizon previously informed the Commission that 150 mW, along with a power density of 50 mW/MHz, should provide additional interference protection to Sirius XM but would still enable WCS C and D block licenses to offer a viable two-way broadband service.[157] Sirius XM further contends that the Commission should adopt a variable duty cycle limit ranging from 12.5 to 35 percent for WCS mobile and portable devices, depending on the spectrum block, as in the Commission staff's recommended proposals shared with the licensees on March 2, 2010,[158] and that the rules should specify a duty cycle measurement frame of 5 milliseconds (ms). Sirius XM further argues that the power level and duty cycle limitations would be controlled by the network and would require no special design modifications for WCS mobile devices that would defeat standardization or otherwise delay deployment.[159] In addition, Sirius XM states that a reduction in the frame repetition rate from transmissions every 5-ms frame to transmissions every other frame (*i.e.*, activity over 10 ms) would significantly decrease the potential for interference into an SDARS receiver from a WCS WiMAX signal because there would not be any activity in consecutive transmit frames for any mobile device.[160] Sirius XM also repeats its suggestion that the Commission set a ground-level emission limit of -44 dBm per 100 meters on major and secondary roads.[161] Sirius XM further argues that WCS rules should establish a maximum occupied bandwidth of 5 megahertz because WCS transmissions that occupy 10 or 12.5-megahertz-wide channels would have a greater potential to interfere with SDARS receivers.[162] In a subsequent filing, a consultant for Sirius XM, Dr. Theodore S. Rappaport, P.E., recommends that WCS

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generation software was performing a high-data-rate upload from the mobile device to the base station, and the WiMAX mobile device, with ATPC turned on, was being held at lap height. No muting was observed for two additional tests of a WCS signal composed of 2.5-megahertz portions of WCS Blocks D and A, when the 5-megahertz-wide WCS signal was centered in the lower WCS B block (*i.e.*, 2310-2315 MHz), or that was composed of 2.5-megahertz portions each of WCS Blocks B and C (*i.e.*, 2312.5-2317.5 MHz).

[157] *See* Comments of Sirius XM, filed Apr. 23, 2010, at 31.

[158] On March 2, 2010, staff from the Commission's Office of Engineering and Technology, the International Bureau, and the Wireless Telecommunications Bureau met with representatives from Sirius XM and the WCS Coalition to discuss its recommended proposals for 2.3 GHz WCS mobile and portable devices' power and OOBE limits that included a 2.5-megahertz WCS guard band, relaxed OOBE limits for WCS mobile and portable devices, and a stepped maximum duty cycle requirement that would place greater restrictions on WCS mobile and portable devices in the WCS blocks closest to the SDARS band than on those devices operating in WCS blocks further removed from the SDARS band. Specifically, the Commission staff's proposal included setting the maximum duty cycle for WCS mobile and portable devices at 12.5 percent in the 2.5-megahertz portions of the WCS C and D blocks furthest from the SDARS band, at 25 percent in the inner WCS A and B blocks, and at 35 percent in the outer WCS A and B blocks.

[159] *Id.* at 30-31.

[160] *Id.* at 30-31 and Appendix A, 7-8.

[161] *See* Comments of Sirius XM Radio Inc., filed April 23, 2010, at 32.

[162] *Id.* at 35.

mobile and portable devices' EIRP be limited to 100 mW per 2.5 megahertz and that a 2.5-megahertz guard band be established between the WCS and SDARS band edges. Dr. Rappaport believes this power limit would provide sufficient protection to SDARS receivers while allowing WCS licensees to build out a viable terrestrial mobile network.[163]

60. In its *Ex Parte* Letter of March 15, 2010, the WCS Coalition states that if the Commission were to adopt a graduated duty cycle ranging from 12.5-35 percent, and A and B block licensees simultaneously employed the outer 2.5 megahertz of the C or D block along with the A or B blocks to provide for mobile handoffs, the duty cycle of all the channels would be reduced to the lowest duty cycle of 12.5 percent. However, the WCS Coalition contends that the 12.5 percent duty cycle is not supported by any fourth generation (4G) wireless communications standard. The WCS Coalition also argues that the 5 ms frame for measuring the duty cycle was for a specific WiMAX protocol and that other 4G standards utilize other frame rates. To maintain technology neutrality, the WCS states that any duty cycle specification should be tied directly to the frame duration of the technology in use.[164] In its comments on the Commission staff's proposed interference rules, the WCS Coalition states that although the proposed power limits will not preclude the deployment of viable mobile broadband services, the proposed technical rules are not the optimum from the perspective of one hoping to utilize the WCS spectrum.[165] However, Wolfhard J. Vogel, Ph.D., a satellite radio engineer, believes that to prevent interference to SDARS receivers, WCS mobile devices should be limited to a duty cycle of 12.5 percent.[166] On the other hand, Horizon Wi-Com, LLC (Horizon), a WCS licensee, disputes Sirius XM's assertion that using every other 5-ms frame for mobile device transmissions would be consistent with current technology. Horizon submits that, in reality, a TDD frame consists of the complete cycle of base station transmissions, transmit guard time, mobile station transmissions, and receive guard time, not simply the portion of time in which a given device transmits. Horizon argues that requiring WCS mobile devices to remain silent during every other transmit sub-frame would reduce the duty cycle for a WiMAX system to 19 percent and cut the throughput capacity of the system in half, depriving subscribers of adequate two-way speeds. As a result, Horizon contends, WCS would be precluded from providing broadband services and from becoming a viable competitor in the marketplace.[167]

61. The Telecommunications Industry Association (TIA) believes that the Commission staff's proposals will adequately protect SDARS and AMT operations, but recommends that the Commission abandon any WCS limitations based on duty cycle. If the Commission does impose duty cycle limits, however, TIA contends that the Commission must ensure that these limits allow WCS operations in a manner that enables service and device provision, and it should reconcile the discrepancy between the proposed FDD and TDD duty cycle limits.[168] Ericsson Inc. (Ericsson) believes that, in order to avoid conflicts with the standards of Time Division-LTE[169] (TD-LTE) and other technologies, the

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[163] *See* "Technical Analysis of the Impact of Adjacent Service Interference to the Sirius XM Satellite Digital Audio Radio Services (SDARS)" by Theodore S. Rappaport, P.E., TELISITE Corp., submitted with Supplemental Comments of Sirius XM, filed April 29, 2010, at 73.

[164] *See* WCS Coalition Mar. 15, 2010, *Ex Parte* Letter at 2.

[165] *See* Comments of the WCS Coalition, filed April 23, 2010, at 4-5.

[166] *See* Wolfhard J. Vogel, Ph.D., President, Balcones Industrial R&D Corp., comments, filed April 21, 2010, at 3.

[167] *See* Horizon Wi-Com May 12, 2010, *Ex Parte* Letter at 2-3.

[168] *See* Comments of the Telecommunications Industry Association, filed April 23, 2010, at 2-4.

[169] LTE (Long Term Evolution) is a new high performance wireless broadband technology developed by the Third Generation Partnership Project (3GPP), an industry trade group. LTE, which supports both FDD and TDD modes of operation, is based on Orthogonal Frequency Division Multiple Access (OFDMA) and uses Internet Protocol (IP) packets rather than a proprietary packet structure. LTE provides a framework for increasing data rates and overall

(continued...)

Commission should not specify any duty cycle limit. Ericsson contends that a network that can match the uplink and downlink needs of users will use spectrum more efficiently, while placing the fewest constraints on user data rates. If the Commission nevertheless adopts a maximum uplink duty cycle, Ericsson argues that it should select a limit that imposes the fewest constraints on standards-based technologies. Considering TD-LTE networks, Ericsson believes the minimum ideal duty cycle level would be set above 63.333 percent to permit the use of all the current TD-LTE uplink-downlink configurations. At the least, Ericsson argues, the minimum duty cycle should be raised above 43.333 percent, which corresponds to the 3:2 downlink-uplink ratio of TD-LTE configuration 1, which is considered to be typical in many TDD networks and most appropriate for networks with nearly symmetrical traffic.[170] Alcatel-Lucent shares Ericsson's concerns about the need to accommodate the 43.3-percent duty cycle for TD-LTE, and notes that the proposed limitations on FDD duty cycles could preclude FD-LTE in the WCS band. Alcatel-Lucent contends that the Commission should refrain from imposing duty cycle limitations to allow the greatest flexibility for WCS operators to maximize network efficiency and capacity.[171] In addition, Alcatel-Lucent submits that the Commission should reject Sirius XM's proposal to preclude mobile transmissions during every other frame, which would cut the uplink speeds in half, and is not supported by any standard technology in existence.[172] Alcatel also states that so there is no impact on existing WCS point-to-point operations, the Commission should not bar WCS fixed stations from transmitting in the 2305-2320 MHz band.[173] In its May 12, 2010, *Ex Parte* presentation, the WCS Coalition states that the Commission should not adopt any duty-cycle limitations, but if deemed necessary, the duty cycle should be at least 43.333 percent to accommodate the use of TD-LTE technology.[174]

62. *Discussion*. As an initial matter, our objective here is not to eliminate all interference, but rather eliminate the potential for harmful interference – which we define as interference that repeatedly disrupts or seriously degrades service. Upon careful review and consideration of all of the information in the record, including the various analyses and test results, we conclude that an average power level of 250-mW EIRP over 5 megahertz (50 mW/MHz) accompanied by ATPC and a duty cycle limit of 38 percent is appropriate for mobile and portable devices operating in the WCS A and B blocks and the 2.5-megahertz portions of the WCS C and D blocks furthest removed from the SDARS band (*i.e.*, 2305-2317.5 and 2347.5-2360 MHz). Assessing the likelihood of interference from WCS to SDARS is an extremely complex exercise because there are many variables involved and there is considerable variability in each of the underlying assumptions. There were a number of differences between the measurements and technical analyses submitted by Sirius XM and the WCS Coalition in their comments. These include the power levels, duty factor or duty cycle of the WCS signal, WCS signal strength as a result of propagation losses, WCS antenna heights and positions (outside and inside the test vehicle), various combinations of WCS frequency blocks and SDARS receivers, and the use of actual WCS equipment or WiMax signal generators and other test equipment.

63. Based on our thorough review of the record in this proceeding, the individual measurements and technical analyses provided by the commenters, and the results of Sirius XM's and the

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system capacity, reducing latency, and improving spectral efficiency and cell-edge performance. *See* Agilent Technologies LTE Overview, *available at* http://www.home.agilent.com/agilent/editorial.jspx?cc= US&lc=eng&ckey=1803101&nid=34867.0.00&id=1803101.

[170] *See* Comments of Ericsson, filed April 22, 2010, at 4-5.

[171] *See* Alcatel-Lucent *Ex Parte* presentation, filed May 13, 2010, at 4.

[172] *Id.*

[173] *Id.* at 5.

[174] *See* WCS Coalition *Ex Parte* presentation, filed May 12, 2010, at 2.

WCS Coalition's testing in Ashburn, we conclude that the public interest will be served by significantly lowering the current 20-W EIRP limit for mobile device operations in the WCS band.[175] Specifically, we are adopting a power limit of 250-mW average EIRP over 5 megahertz (*i.e.*, 50 mW/MHz) for mobile and portable devices operating in WCS Blocks A, B and the 2315-2317.5 and 2347.5-2350 MHz portions of WCS Blocks C and D, respectively. These power levels, coupled with the other actions that we take today, will protect satellite radio receivers from experiencing harmful interference while advancing our goal of enabling mobile broadband service to the public in the WCS spectrum, while limiting potential harmful interference to satellite radio reception. We also believe that our decision strikes the appropriate balance between the WCS Coalition's request that we adopt a 250-mW average EIRP limit for mobile and portable stations in WCS Blocks A and B[176] and a 150-mW average EIRP limit for mobile and portable devices in the first 3 megahertz of WCS Blocks C and D, respectively (*i.e.*, 50 mW/MHz),[177] and the SDARS licensees' preference for a 150 mW (50 mW/MHz) power limit on WCS mobile and portable devices operating in the 2.5-megahertz portions WCS Blocks C and D furthest removed from the SDARS band.[178] Overall, we find that the risk of harmful interference from WCS mobile and portable devices operating in accordance with these power limits that would seriously degrade, obstruct, or repeatedly interrupt SDARS service is low. To further reduce the risk of harmful interference, we restrict WCS mobile and portable devices from operating in the 2.5-megahertz portions of WCS Blocks C and D closest to the SDARS band, limit WCS mobile and portable devices' duty cycle, and adopt a requirement that WCS licensees expeditiously resolve any harmful interference caused to SDARS operations, should it occur.

64. Although we rely heavily on the technical information provided by the commenters, we have the benefit of Commission staff's observations of Sirius XM's and the WCS Coalition's Ashburn test results[179] to raise our confidence that our decisions on final rules for mobile WCS operations will reduce the risk of harmful interference to SDARS to a negligible level. During the WCS Coalition's tests of overload interference, muting of the SDARS signal only occurred during one test case. Specifically, muting occurred when the WCS device was operating with an average EIRP of 250 mW for a 5-megahertz-wide signal spanning 2.5 megahertz each of the WCS D and A blocks (*i.e.*, the edge of the WCS signal was separated by 2.5 megahertz from the edge of the SDARS band), a duty cycle of 35 percent, and when located within 1 vehicle's distance from the vehicle containing the SDARS receiver using a rooftop mounted antenna (*i.e.*, separated by at least 3 meters). Under this scenario, the WCS mobile device was uploading a large file. Muting was not observed when the WCS mobile was transmitting in the upper WCS A block. Thus, we believe that there will not be significant potential for harmful interference to SDARS receivers from WCS mobile transmitters operating at the power limits we adopt.

65. During the WCS Coalition's test, FCC staff observed that operation of a WCS mobile device at 250-mW average EIRP over 5 megahertz and a duty cycle of 35 percent in combination with a frequency separation of 2.5 megahertz from the SDARS band sufficiently mitigated the impact of overload interference to the SDARS receiver. Generally, the WCS Coalition's tests revealed what one may anticipate seeing, where additional signal attenuation was present due to the WCS device being used inside a vehicle and either held in a user's hand or on a lap, and where effects such as the difference in height between the WCS transmitter antenna and SDARS receiver antenna, the vehicle attenuation, the

[175] 47 C.F.R. § 27.50(a)(2).

[176] *See, e.g.*, WCS Coalition Oct. 7, 2009, *Ex Parte* at 3.

[177] *See* WCS Coalition Mar. 15, 2010, *Ex Parte* Letter at 2.

[178] *See* Comments of Sirius XM, filed Apr. 23, 2010, at 31.

[179] *See* paras. 55-58, *supra*.

effect of head and body losses, multipath, and clutter from other nearby objects would all come into play and have a mitigating effect on potential overload interference.

66. Also, although the Ashburn testing was not representative of a fully-deployed WCS WiMAX network, we believe the WCS device's interactions with the SDARS receivers demonstrate that the potential for harmful interference is negligible even during the worst-case situations where a WCS mobile transmitter is operating at full power without ATPC, is transmitting during the allocated transmit sub-frame of each and every frame, and is in close proximity to an OEM or aftermarket SDARS receiver. In a fully-deployed WCS network where multiple WCS mobile or portable devices are operating in close proximity to one another, these devices share the available transmit sub-carriers in a particular channel's frame, and the base station will assign each device a specific portion of the available transmit sub-carriers.[180] In this manner, the potential for interference from multiple proximate WCS mobile and or portable devices using their assigned portions of transmit sub-carriers will not be any greater than the potential for interference from one device using all the allocated transmit sub-carriers of each and every frame in a channel, as was demonstrated during the testing in Ashburn. In addition, not all of the WCS devices using sub-channels of the same channel will be in close proximity to an SDARS receiver, which would further lessen the potential for harmful interference to SDARS receivers. Furthermore, in a fully-deployed WCS network where more base stations are deployed to provide improved coverage and service to WCS users, WCS mobile and portable devices will experience fewer "edge-of-coverage" situations where they must operate at maximum transmitter power; instead, they will be handed off to a different base station before needing to operate at full power, thereby further reducing the potential for harmful interference to SDARS receivers.

67. In support of the 250-mW power limit, as set forth above, our examination of the record in this proceeding reflects that the potential for harmful interference to SDARS receivers from WCS mobile transmitters operating at full power in close proximity is low. Despite Sirius XM arguments to the contrary,[181] we do not believe that the test scenario employed by Sirius XM during its testing in Ashburn, in which it used a signal generator to produce a 5-megahertz-wide WiMAX carrier in the WCS D block, immediately adjacent to the SDARS band edge, that was characterized by bursty signals,[182] accurately reflects how a practical WCS two-way broadband system would operate in the 2.3 GHz band. To the contrary, as noted by the WCS licensee Horizon Wi-Com, a typical 5-ms TDD frame consists of base station transmissions, guard time, mobile station transmissions, and guard time, not simply bursty transmissions from a single mobile device that occupies every subcarrier of each 5-ms frame in a 5-megahertz-wide channel.[183] Moreover, with regard to the video that Sirius XM submitted with its May 6, 2010, *ex parte*, without knowing the test setup and technical parameters, the purported demonstration has not probative value. Also, because the radio frequency filter necessary to meet the WCS Coalition's proposed OOBE limits would be too large for a mobile or portable WCS device if operated in the manner assumed by Sirius XM, we do not expect a WCS device to operate in the WCS C or D blocks in that manner once a WCS system is deployed. However, we note that when Sirius XM

[180] *See* "Understanding OFDMA, the interface for 4G wireless," Arnon Friedmann, Texas Instruments, Network Systems Design Line, April 23, 2007, at 2-3; Agilent Technologies' N1911A/N1912A P-Series Power Meters for WiMAX™ Signal Measurements Demo Guide, at 4-5.

[181] Sirius XM argues that there is no record evidence that justifies the technical limits identified in the Commission staff's April 2, 2010 *WCS/SDARS Technical Rules Public Notice*. It asserts that WCS interests have yet to provide extensive and verifiable test data to demonstrate that mobile WCS operations will not cause harmful interference, whereas Sirius XM has demonstrated that the proposed rules will cause harmful interference. *See* Comments of Sirius XM, filed April 23, 2010, at 46-47.

[182] A bursty signal is a method of transmission that combines a very high data signaling rate with very short transmission times. *See* Newton's Telecom Dictionary, 21st Edition, CMP Books, 2005, at 137.

[183] *See* Horizon Wi-Com May 12, 2010, *Ex Parte* Letter at 2-3.

moved its test WCS signal 2 megahertz away from the SDARS band edge, only slight muting of the SDARS signal occurred, which is consistent with the WCS Coalition's test results that resulted in only one instance of muting when the edge of the WCS signal was separated from the SDARS band edge by 2.5 megahertz. Thus, in order to further limit the potential for harmful interference to SDARS receivers, we are prohibiting WCS mobile and portable devices from operating in the 2.5-megahertz portions of WCS Blocks C and D closest to the SDARS band.

68. In establishing the allowable power level for WCS mobile and portable devices, along with the need to limit the potential for harmful interference to SDARS receivers, we also consider the impact of the mobile and portable devices' power limit on the viability of deployment of mobile service in the WCS band. We observe that mobile handheld devices operating in other services typically employ a transmitter power level of up to about 250 mW. We also observe that the trend among commercial radio services is towards the convergence of fixed and mobile services where the same network can serve the needs of consumers and businesses for both types of services and synergies are created between fixed and mobile applications. Accordingly, we believe that an average EIRP of 250 mW over 5 megahertz is an appropriate permissible power level for WCS mobile and portable devices in the WCS A and B blocks and the 2.5-megahertz portion of the WCS C and D blocks furthest removed from the SDARS band, which, with the duty cycle limits we are adopting, we believe will be sufficient to protect SDARS receivers from harmful interference while supporting the provision of WCS mobile services. For the portions of the WCS C and D blocks immediately adjacent to the SDARS band (*i.e.*, 2317.5-2320 and 2345-2347.5 MHz), however, WCS mobile and portable devices are not permitted to operate. Also, WCS mobile and portable devices using FDD technology are restricted to transmitting in the 2305-2317.5 MHz band.

69. We reject the 125-mW power limit suggested by Sirius XM for WCS mobile and portable devices because it is not necessary to protect SDARS receivers from harmful interference and because such limits could unnecessarily impede the provision of WCS mobile broadband services by forcing WCS licensees to install many more base stations than would be needed with a higher power limit for mobile and portable devices. We also reject the staggered power limits suggested by the WCS Coalition for the WCS C and D blocks. Instead, we adopt a uniform power limit for the 2.5-megahertz portions of the WCS C and D blocks that are furthest removed from the SDARS band, and prohibit mobile and portable devices from operating in the 2.5-megahertz portions of WCS Blocks C and D closest to the SDARS band. The 250-mW power limit and the 50 mW/MHz power spectral density limits we adopt will create a uniform operating environment for WCS licensees to provide mobile broadband services and, combined with the prohibition on mobile and portable devices operating in the 2.5-megahertz portions of the WCS C and D blocks closest to the SDARS band, will further limit the potential for harmful interference to SDARS receivers.

70. In order to protect SDARS operations from harmful interference, it is also necessary that we adopt a specific duty cycle that WCS devices must employ for TDD networks.[184] Features such as Discontinuous Transmission (DTX) and Discontinuous Reception (DRX), which are used to improve battery life and minimize intra-system interference, can substantially contribute to the reduction of a communications system's in-band and out-of-band power, and thereby significantly reduce its potential to

[184] In this case, we define duty cycle (also known as duty factor) as the percentage of a transmission frame that a WCS user device uses to transmit uplink information to the base station (*i.e.*, the "on time" of a WCS user device's transmitter in a given transmission frame). The activity factor is the portion of WiMAX transmission frames that the base station has allocated for uplink traffic. *See* Sirius XM *Ex Parte* presentation, dated February 24, 2010, at 4. *See also* "activity factor" and "duty cycle" definitions at Federal Standard 1037C Telecommunications: Glossary of Telecommunication Terms at http://www.its.bldrdoc.gov/fs-1037/fs-1037c.htm. The WCS transmitter the WCS Coalition used in its testing in Ashburn, VA, employed a duty cycle of 35 percent. *See* WCS Coalition *Ex Parte* filing, dated January 29, 2010, at 4.

cause harmful interference. During DTX and DRX, the number of sub-frames being exchanged on the physical layer could be reduced or the user's equipment could simply stay in the monitoring mode. Because the duty cycle is relevant to particular air interface technologies such as WiMAX and LTE, and cannot always be assured when licensees have the flexibility to select the technology of their choice, we decide to adopt a rule limiting the maximum transmitter duty cycle of mobile and portable WCS devices using TDD technology to 38 percent in the upper and lower WCS A and B blocks and the outer 2.5-megahertz portions of WCS blocks C and D (*i.e.*, 2315-2317.5 and 2347.5-2350 MHz).[185]

71. The WCS Coalition also submits that it is common for commercial WiMAX systems to allocate approximately 38 percent of each frame to uplink (*i.e.*, user device) transmissions in order to maximize throughput based on known user traffic patterns and customer experience expectations.[186] It explains that, only a limited number of duty cycles are supported by the vendor community and that there is no support for the recommended 12.5-percent duty cycle. Thus, the entire C and D blocks will not be available for mobile use if the staff's proposal is adopted. And, the WCS Coalition continues, because there is no support for the 35-percent duty cycle, operators would be required to limit mobile operations to the 24.96-percent duty cycle that is the closest available, which does not violate the 35-percent limit.[187] Ericsson, too, explains that there are a variety of TD-LTE uplink-downlink configurations that allow a network operator to allocate the network's capacity between uplink and downlink traffic to meet the needs of the network. Although an examination of the uplink/downlink duty cycles of seven configurations shows that three of the seven uplink/downlink configurations for TD-LTE set forth in the global standard exceed the proposed uplink duty cycle limit of 38 percent (which are relatively symmetrical configurations), the remaining configurations are highly asymmetrical in favor of downlink traffic, with uplink duty cycles ranging from approximately 11.7 to 31.7 percent. Notably, the 38-percent duty cycle exceeds the majority of the profiles in commercially available WiMAX systems[188] A network that can match the uplink-downlink needs of users will use spectrum more efficiently, Ericsson contends, and if a large proportion of a network's traffic is uplinked such as video, a limitation of the uplink duty cycle will cause uplink data sessions to be more congested and slower.[189]

72. We find that application of a 38-percent duty cycle to WCS mobile and portable operations will not appreciably increase the potential for harmful interference to SDARS receivers even though the 38-percent duty cycle limit is slightly higher than the 35-percent duty cycle demonstrated in Ashburn, VA. Although a maximum duty cycle limit has been shown to be an important factor in limiting a WCS mobile or portable device's potential to interfere with SDARS receivers, we believe the most critical factors in controlling the potential for harmful interference in this case are the relative power of a WCS signal and the spectral proximity of the WCS signal to the SDARS band. Thus, in our judgment, a 38-percent duty cycle limit coupled with the 250-mW EIRP over 5-megahertz mobile/portable device power limit, the 2.5-megahertz WCS guard bands, and the requirement to employ

[185] In support of this duty cycle limit, we note that in order for a 2.6 GHz WiMAX CPE device to obtain a 1 megabit per second (Mbit/sec) uplink data rate with a 5-megahertz-wide Orthogonal Frequency Division Multiple Access 512 Fast Fourier Transform 64 Quadrature Amplitude Modulation (OFDMA 512 FFT 64 QAM) output signal (*i.e.*, 512 subcarriers), the typical duty cycle setting for the device is 37.4 percent. *See* Motorola, Inc.'s United States Patent Application 20090295485, Dynamically Biasing Class AB Power Amplifiers Over a Range of Output Power Levels, *available at* http://www.freepatentsonline.com/y2009/0295485.html, at 6.

[186] *See* WCS Coalition *Ex Parte* filing dated March 31, 2010, at 2. The WCS Coalition test transmitter used in the Ashburn, VA testing employed a duty cycle of 35 percent, and only caused the SDARS signal to mute in one isolated instance. *See* WCS Coalition *Ex Parte* filing, dated Jan 29, 2010, at 4.

[187] *See* WCS Coalition March 31, 2010 *Ex Parte*, at 3, and Attachment at 2.

[188] *See* Comments of Ericsson Inc. filed April 22, 2010, at 3.

[189] *Id.*, at 4.

ATPC that we are adopting, will be sufficient to limit the potential for harmful interference to SDARS receivers. We also believe that application of a 38-percent duty cycle to WCS mobile and portable operations will allow for the majority of TDD WiMax and Long Term Evolution (LTE) profiles to be implemented. Notwithstanding that this limit is applicable to, and was determined when testing WiMAX equipment, we believe it is appropriate to apply it to other TDD technology, such as LTE. Granting that some high data rate uplink applications such as video uploads would run more efficiently in a more symmetrical configuration (*i.e.*, with a higher uplink duty cycle), we find that application of a maximum duty cycle setting of 38 percent strikes an appropriate balance between our goals of protecting SDARS receivers from harmful interference and enabling the provision of WCS mobile broadband services using different technologies.

73. We decline to adopt a frame repetition limitation as proposed by Sirius XM, whereby a WCS mobile device would be limited to transmitting on every other 5-ms TDD transmit frame.[190] Rather, we require WCS licensees to apply the duty cycle requirement in a manner that is referenced directly to the frame duration for the technology in use in order to strike an appropriate balance between our goals of protecting SDARS receivers from harmful interference and enabling the provision of WCS mobile broadband services using different technologies.

74. We also permit WCS mobile and portable transmitting devices using FDD technology in the 2305-2317.5 MHz band (and consequently FDD base station transmitters in the upper WCS blocks). We restrict mobile transmitters to the lower WCS block to accommodate XM's earlier proposal to limit the upper WCS bands to base stations only, which, as they contend, would reduce the likelihood of interference to legacy XM receivers.[191] Restricting mobile transmitters to the lower WCS blocks would also improve adjacent-band sharing with AMT and would accommodate the Aerospace and Flight Test Radio Coordinating Council's (AFTRCC's)[192] proposal to limit the use of the upper WCS bands to base stations only.[193] For WCS mobile and portable devices operating in the 2305-2317.5 MHz band using FDD technology, we set the same transmitter power level of 250-mW average EIRP with ATPC. In order to further limit the potential for interference to SDARS receivers from WCS operations, WCS mobile and portable devices using FDD technology are restricted to transmitting in the lower WCS A and B blocks and the 2.5-megahertz portion of the WCS C block furthest removed from the SDARS band (*i.e.*, 2305-2317.5 MHz). Recognizing that neither the WCS nor SDARS licensees provided analysis or testing of FDD equipment, we rely heavily on the fact that mobile and portable device using FDD technology will have a dedicated band for uplink transmissions rather than sharing a band with base stations' downlink transmissions to establish this restriction. We also limit the duty cycle of WCS mobile and portable devices using FDD technology to a duty cycle of 25 percent for the lower WCS A and B blocks (*i.e.*, 2305-2315 MHz) and maintain the 12.5-percent duty cycle for the 2.5 megahertz portion of the WCS C block furthest from the SDARS band (*i.e.*, 2315-2317.5 MHz). To treat the paired A and B block licenses equitably, we adopt a duty cycle limit that is double the limit currently specified in our Rules for WCS portable devices operating in the 2305-2315 MHz band.[194] We note that Sirius XM did not object to the graduated duty cycle levels proposed by the Commission staff which included a 12.5-percent duty

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[190] Cite to Sirius XM Ex parte

[191] *See* XM Reply Comments, filed March 17, 2008, at 33-36; Sirius XM Aug. 11, 2009 *Ex Parte* presentation at 27. *See also* Sirius XM Jan. 22, 2010, *Ex Parte* presentation at 12.

[192] AFTRCC, founded in 1954, is a not-for-profit organization of Radio Frequency Management Representatives from major aerospace companies and is the Non-Federal Government coordinator for the shared Federal/Non-Federal spectrum allocated for flight testing. *See* <http://www.aftrcc.org/> (last visited October 26, 2009).

[193] *See* AFTRCC March 22, 2010 *Ex Parte* presentation at 15.

[194] 47 C.F.R. § 27.53(a)(9)(i).

cycle limit on mobile and portable transmitters operating in the 2.5-megahertz portion of the WCS C block furthest from the SDARS band.[195] By restricting the duty cycle of such devices, their potential for interference to adjacent-band SDARS receivers will be limited even though these devices will be operating with a 100-percent activity factor.

75. We will continue to require that WCS devices be ATPC-capable. The use of ATPC (automatic transmit power control) by the WCS licensees will also help to mitigate the potential for SDARS receiver overload interference.[196] We note that ATPC has been, and will continue to be, an integral feature of various commercial mobile service technologies. ATPC use is motivated by the need to control interference within a licensee's own system and by extension neighboring bands. We expect that WCS licensees, no matter what technology they deploy, will implement ATPC to control self interference. We therefore have no reason to believe that WCS networks will be configured to use maximum power to achieve maximum data throughput at all times. This would run counter to the principles of intra-system interference control. Moreover, operating all portable devices at full power all the time would tend to sharply increase intra-cell and inter-cell interference, which would lead to capacity reduction and would reduce battery life, although we recognize that there can be trade-offs on whether it is best to transmit high data rates for short periods or lower data rates for longer periods. Consequently, use of ATPC will make it unlikely that a WCS mobile or portable station's transmitter power will be at its maximum level of 250 mW at all times, which will further mitigate the potential for harmful interference to SDARS receivers. Thus, we require that WCS mobile and portable devices include the capability for ATPC, as proposed by the WCS Coalition and as currently required by Part 27 of our Rules for WCS portable devices.[197]

76. We also will prohibit the use of vehicle roof-mounted antennas for WCS transmissions and reception. The WCS Coalition's Ashburn tests were performed with the WCS device in the vehicle. Because of this, the WCS signal was attenuated by the glass windows and metal and composite structure of the vehicle. If a WCS device was installed inside a vehicle but the device's antenna was mounted on the outside of the vehicle, however, this attenuation would not exist, and we would expect more SDARS receiver muting to occur. Although we have not seen any evidence that such outside antenna installations would be the predominant use of mobile WCS networks, in order to forestall the potential for interference from such situations, we are adopting a rule to prohibit the use of vehicle roof-mounted antennas for WCS transmissions and reception.

77. We believe that the 250-mW average EIRP limit over 5 megahertz we are establishing for mobile and portable devices in the WCS Blocks A and B and the 2.5-megahertz portions of WCS Blocks C and D furthest removed from the SDARS band, coupled with a duty cycle limit of 38 percent and the prohibition of WCS mobile and portable devices operating in the 2.5-megahertz portions of the WCS C and D blocks closest to the SDARS band, are sufficient to protect existing SDARS receivers from harmful interference and at the same time provide as much flexibility as possible to WCS licensees to provide mobile services. Nonetheless, we expect the two services to work together cooperatively and take whatever additional steps are necessary to mitigate potential harmful interference and expeditiously remedy harmful interference, should it occur.

[195] *See* Comments of Sirius XM Radio Inc. filed April 23, 2010, at 30. In support of setting the duty cycle at 12.5 and 25 percent, respectively, we recognize that mobile and portable FDD devices' transmitters typically employ a 100-percent activity factor (*i.e.*, FDD-based networks employ a dedicated band for uplink transmissions and there is no sharing of a band for uplink transmissions and downlink transmissions, as in a TDD network).

[196] *See* n.5, *supra*.

[197] 47 C.F.R. § 27.53(a)(9)(iv).

78. We believe that the rules we adopt are sufficient to mitigate the risk of harmful interference to SDARS to a negligible level. WCS licensees, however, are obligated to expeditiously remedy harmful interference caused to SDARS. Harmful interference is that which seriously degrades, obstructs or repeatedly interrupts SDARS reception (i.e. muting). We establish, below, a notification process whereby WCS licensees and SDARS licensees are required to share sufficient information prior to operation to provide an opportunity for licensees to analyze the placement of infrastructure, assess the potential for harmful interference, and allow for modifications to mitigate interference risk prior to operation. The notification process will also assist the licensees in identifying the cause of actual harmful interference and lead to a timely resolution of such interference.

79. *Prior notification of WCS information.* We require prior notification to minimize the potential for harmful interference between WCS and SDARS. Specifically, we require WCS and SDARS licensees to share information regarding the location and technical parameters of their base stations and terrestrial repeaters, respectively. WCS licensees must notify the SDARS licensee of the location of any new or modified base stations that will operate in the 2305-2320 MHz and 2345-2360 MHz bands prior to operation. Furthermore, WCS licensees must cooperate in good faith in the selection and use of new station sites and new frequencies to minimize the potential for harmful interference and make the most effective use of the authorized facilities. Notwithstanding the relatively short notification times we establish below, we expect WCS licensees to provide Sirius XM as much lead time as practicable, under non-disclosure agreements if appropriate, to provide ample time to conduct analyses and opportunity for prudent base station site selection prior to WCS licensees entering into real estate and tower leasing or purchasing agreements.

80. *Pre-Commercial Service Operation.* We anticipate that any interference problems will become evident during the initial deployments and market trials of WCS mobile service. During the time when market trials begin but full commercial service has not yet been initiated, the licensees will have an opportunity to conduct further tests using actual WCS equipment in particular markets. We expect any interference issues that arise during market trials to be resolved before the transition from market trials to commercial service happens. We also expect that WCS licensees will have sufficient operational flexibility in their network design to implement one or more technical solutions to remedy harmful interference before it occurs in a fully loaded network offering commercial service. The notification process will foster early collaboration at the network planning and deployment stages so licensees can gain experience with the WCS network operations and gain confidence that harmful interference will not occur. That experience could be valuable in streamlining the process further in other similarly situated markets.

81. *Post Operation.* Licensees of stations suffering or causing harmful interference must cooperate in good faith to expeditiously resolve such problems by mutually satisfactory arrangements. If the licensees are unable to do so, either licensee may file an interference complaint with the Commission. The Wireless Telecommunications Bureau, in consultation with the Office of Engineering and Technology and the International Bureau, will consider the actions taken by the parties to mitigate the risk of and remedy any alleged interference. In determining the appropriate action, the Bureau is to take into account the nature and extent of the interference and act promptly to remedy the interference. The Bureau may impose restrictions including specifying the transmitter power, antenna height, or other technical or operational measures to remedy the interference, and take into account previous measures by the licensees to mitigate the risk of interference. WCS operators will have at their disposal various techniques (*e.g.*, power reduction, duty cycle, etc.) that would not require specific end-user device modifications. WCS licensee must use these network control capabilities to expeditiously remedy interference once notified.

82. In this connection, we recognize there are legacy SDARS receivers deployed in large numbers, and that some of those receivers are more susceptible to interference than others. We note Sirius XM's assertion that the SDARS receivers were designed based on the existing FCC rules, which effectively precluded mobile WCS operations. We observe that the rules we adopt today will now

provide for the deployment of wide area mobile networks and lead to the possibility of mobile devices being in close proximity to SDARS receivers, albeit at much less power than 20 W. At the same time, we are cognizant of the need to consider the potential impacts of our decision on existing SDARS receivers and the resultant impacts on consumers, irrespective of Sirius XM's assumptions as to the nature of the operations in the adjacent WCS spectrum. On a going forward basis, however, Sirius XM will be able to take into account the mobile WCS operating environment when designing new receivers, and we anticipate that future deployments of SDARS receivers will be built consistently robust to interference from mobile WCS operations.[198] We believe that the introduction of a new class of interoperable SDARS receivers presents an opportunity to also ensure that future SDARS receivers continue to exhibit state-of-the-art filtering sufficiently adequate to accommodate the RF environment established by the rules we adopt today for future adjacent-band WCS mobile stations' operations. Although we conclude based on our analysis of the extensive technical record and the results of the testing in Ashburn, VA that the WCS mobile and portable devices' limits we adopt herein will adequately protect legacy SDARS receivers from harmful interference, we expect Sirius XM to adjust to the changed RF environment in the 2.3 GHz band so that over time, the potential for interference to SDARS receivers will diminish even further as these receivers' susceptibility to interference decreases.

D. WCS Mobile and Portable Device Out-of-Band Emissions Limits

83. Our principal objectives in this proceeding are to mitigate the potential for harmful interference that may be caused to adjacent-band services while at the same time enabling the provision of promising new mobile broadband services to the public in the WCS spectrum to the maximum extent practicable. For the reasons stated below, we adopt a revised OOBE attenuation factor to protect satellite radio users, NASA Deep Space Network receivers, and AMT receivers. Specifically, we relax the 110 + 10 log (P) dB OOBE attenuation factor that currently applies to WCS mobile devices operating in the WCS A and B blocks and the 2.5-megahertz portion of the WCS C and D blocks furthest removed from the SDARS band (2305-2317.5 MHz and 2347.5-2360 MHz)[199] to the following factors: not less than 55 + 10 log (P) dB in the 2320-2324/2341-2345 MHz bands, not less than 61 + 10 log (P) dB in the 2324-2328/2337-2341 MHz bands, and not less than 67 + 10 log (P) dB in the 2328-2337 MHz band to protect SDARS. Additionally, to protect the National Aeronautics and Space Administration (NASA) Deep Space Network below the WCS band, mobile and portable stations' OOBE must be attenuated by a factor of not less than 43 + 10 log (P) dB in the 2300-2305 MHz band, not less than 55 + 10 log (P) dB in the 2296-2300 MHz band, not less than 61 + 10 log (P) dB in the 2292-2296 MHz band, not less than 67 + 10 log (P) dB in the 2288-2292 MHz band, and not less than 70 + 10 log (P) dB below 2288 MHz. To protect AMT operations above the WCS band, mobile and portable stations' OOBE must also be attenuated by a factor of not less than 43 + 10 log (P) dB in the 2360-2365 MHz band, and not less than 70 + 10 log (P) dB above 2365 MHz. We revise the 110 + 10 log (P) dB OOBE attenuation in Section 27.53(a)(2) accordingly, and remove Section 27.53(a)(9), which provides that portable devices in the 2305-2315 MHz band may operate subject to an OOBE attenuation of 93 + 10 log (P) dB into the SDARS band, provided that they meet certain technical requirements.

84. In the *2007 Notice*, we sought comment on the costs and benefits of revising the OOBE limits that currently apply to SDARS and WCS.[200] We specifically asked interested parties to comment

[198] *See* Fostering Innovation and Investment in the Wireless Communications Market, GN Docket No. 09-157; A National Broadband Plan For Our Future, GN Docket No. 09-51, *Notice of Inquiry*, 24 FCC Rcd 11322, 11333 ¶ 36 (2009), where the Commission noted how receivers' lack of rejection of adjacent-band signals could impede or prevent effective operation of new services in the adjacent band or necessitate the imposition of limits on the types of operations permitted in the adjacent band.

[199] *See* 47 C.F.R § 27.50(a)(1).

[200] *2007 Notice*, 22 FCC Rcd at 22142 ¶ 24.

on the impacts (including interference, economic, and business) that any revision of the OOBE limits would have on SDARS operations.[201] We also requested parties to address how the WCS industry would be affected if we were to retain the current OOBE limits.[202]

85. WCS licensees and other parties argue in the first instance that unless the OOBE limits for mobile and portable devices in the 2305-2320 and 2345-2360 MHz WCS bands are relaxed they will be unable to develop affordable equipment capable of providing mobile broadband services to consumers.[203] The WCS Coalition states that it seeks relief only for subscriber equipment operating at lower power levels, including mobile stations transmitting at less than 2 W average EIRP.[204] The WCS Coalition further claims that the current 110 + 10 log (P) dB mask exceeds what is required to protect an SDARS receiver by a margin of 50 dB.[205] Accordingly, the WCS Coalition proposes that we adopt the following OOBE attenuation factors for WCS mobile and portable devices: 55 + 10 log (P) dB in the 2320-2324/2341-2345 MHz bands, 61 + 10 log (P) dB in the 2324-2328/2337-2341 MHz bands, and 67 + 10 log (P) dB in the 2328-2337 MHz band.[206] The WCS Coalition bases its proposed OOBE attenuation factors of 55/61/67 + 10 log (P) dB on their feasibility and the potential economic viability they offer over the existing 110 + 10 log (P) dB mask currently required for WCS mobile devices in Section 27.53(a).[207] The emission mask proposed by the WCS Coalition would also require that all devices use ATPC.[208] The WCS Coalition, however, concedes that its proposal does not entirely foreclose the possibility of potential interference from WCS to SDARS subscribers.[209]

86. On the other hand, Sirius and XM initially proposed that we relax the OOBE attenuation factors for WCS mobile and portable devices from 110 + 10 log (P) dB to 103 + 10 log (P) dB for all WCS spectrum blocks.[210] Sirius asserts that the WCS Coalition's proposal to reduce the OOBE

[201] *Id.*, at 22142-3 ¶ 25.

[202] *Id.*

[203] *See* WCS Coalition Comments at 4-5; Motorola Comments at 8-9. *See also* Bednekoff Comments at 1-2; WCS Coalition Reply Comments at 7-9.

[204] WCS Coalition Comments at 10.

[205] *Id.* at 14. The WCS Coalition contends that an OOBE attenuation of 55 + 10 log (P) dB will sufficiently protect SDARS receivers in such a way that the receiver's noise floor does not rise by more than 1 dB for 94 percent of the time. *See* WCS Coalition Comments at 11, 13, and Attachment B at 25. The WCS Coalition notes that the 1-dB figure it uses is a typical industry value for noise floor protection. In addition, the WCS Coalition estimates the noise floor of SDARS receivers to be -106.8 dBm/4MHz, or -112.8 dBm/MHz. *See also* WCS Coalition Reply Comments, Attachment A. WCS calculates its noise floor using a thermal noise power of -108 dBm/4 MHz (based on an antenna temperature of 290° K), or -114 dBm/MHz, and a receiver noise figure of 1.2 dB. We note that these parameters, when used in a common formula for calculating the noise floor for a terrestrial receiver, produce the noise floor calculated by the WCS Coalition.

[206] *See* WCS Coalition Comments at 10. Henceforth, we refer to this OOBE mask as the 55/61/67 + 10 log (P) dB mask.

[207] *See* 47 C.F.R. §§ 27.53(a). WCS Coalition Comments at 4-7.

[208] *Id.* at 14. See n.5, *supra*, for a description of ATPC.

[209] WCS Coalition Comments at 3 and 11. NextWave Wireless indicates that, alternatively, a "flat mask" of 60 + 10 log (P) dB, which is roughly equivalent to the WCS Coalition's stepped mask proposal, would serve to provide adequate protection to SDARS. *See also* NextWave Wireless Nov. 16, 2008, *Ex Parte* at 2.

[210] *See* Sirius Comments at 34; XM Comments at 32, Exhibit A at 18 (proposing an OOBE attenuation factor of 102.7 + 10 log (P) dB). Sirius XM later adds that, based on its tests, satellite radio devices could experience frequent muting under foliage or near reflective buildings if the OOBE attenuation factors were established between 97 + 10 log (P) dB and 92 + 10 log (P) dB, and complete muting if the OOBE attenuation factor was below

(continued...)

attenuation factor for WCS mobile devices to 55 + 10 log (P) dB would result in unacceptable mobile-to-mobile interference, even if separated by a large distance from an SDARS receiver.[211] XM claims that, under the limits proposed by the WCS Coalition, a hypothetical mobile WiMAX device operating in the WCS band could cause interference to satellite radio reception within a radius of 115 meters around the WCS device.[212]

87. Based on the same SDARS radio parameters in its previous filings[213] and its contention that a maximum receive interference power of -107 dBm/4MHz would produce muting of the SDARS satellite receiver, Sirius XM later adjusted its proposed WCS OOBE attenuation factor to 86.5 + 10 log (P) dB.[214] In its *ex parte* filing, Sirius XM added its calculated path loss of 56.7 dB to the -107 dBm/4 MHz maximum interference power to obtain a maximum WCS mobile device OOBE level of -50.3 dBm/4MHz (-56.3 dBm/MHz).[215] Sirius XM explains that this level is equivalent to an emission attenuation factor of 86.3 + 10 log (P) dB, which Sirius XM rounded to 86.5 + 10 log (P) dB).[216]

88. *Measurements and Technical Analyses.* The parties' arguments relative to the WCS OOBE limits are interwoven with their arguments relative to WCS signal attenuation and the SDARS receiver parameters. In particular, path loss is central to their arguments about potential interference and the interference criteria to use to determine the potential for harmful interference due to WCS OOBE has been debated heavily. The WCS Coalition and Sirius XM conducted several individual measurements, tested various SDARS receivers, and provided numerous technical analyses in their comments in an effort to support their proposals. We describe these below.

(Continued from previous page)
92 + 10 log (P) dB. *See also* Sirius XM Sept. 8, 2008, *Ex Parte* at 13-15 and subsequent corrections to this filing made on September 10, 2008, ("Sirius XM Sept. 10, 2008, *Ex Parte*") and Sept. 18, 2008, ("Sirius XM Sept. 18, 2008, *Ex Parte*").

211 Sirius Comments at 20-21.

212 XM Comments at 32.

213 Sirius XM Nov. 13, 2008, *Ex Parte*, Appendix at 6. These assumptions include a received interfering power of -119 dBm/4MHz, or -125 dBm/MHz, causing a 1-dB rise in the noise floor of -113 dBm/4MHz, or -119 dBm/MHz; a received interfering power of -107 dBm/4 MHz, causing muting of the SDARS satellite radio, given an average serving signal level of -100 dBm/4 MHz; a carrier-to-interference-plus-noise (C/(I+N)) ratio of 6 dB required for decoding the receive signal; a combined interference plus noise (I+N) level causing muting of the serving signal, -100 dBm/4 MHz – 6 dB, or -106 dBm/4 MHz, which, when considered with the -113 dBm/4MHz noise floor, necessitates the maximum -107 dBm/MHz receive interference power cited above to avert muting of the SDARS receiver. *See also* Sirius XM Sept. 8, 2008, *Ex Parte*, Exhibit B.

214 Sirius XM applies a methodology consistent with that used by the Commission's Office of Engineering and Technology in its technical report on Advanced Wireless Services (AWS) interference, while maintaining the same assumptions that underlie its previous recommendations. *See* Sirius XM Nov. 13, 2008, *Ex Parte* at 1, 4, Appendix at 8 and 10. *See also* Advanced Wireless Service Interference Tests Results and Analysis, Federal Communications Commission, Office of Engineering and Technology, WT Docket No. 07 195 (filed Oct. 10, 2008). When subtracting out 7.5 dB of losses due to head and body, antenna mismatch, and multipath/shadowing, in addition to free space loss (FSL) at 3 m (49.2 dB), Sirius XM contends to show that its receiver will experience muting if the WCS OOBE attenuation level in the SDARS bands is below 94 + 10 log (P) dB. *See* Sirius XM Nov. 13, 2008, *Ex Parte*, Appendix at 13.

215 Sirius XM Nov. 13, 2008, *Ex Parte* at 10.

216 Sirius XM Nov. 13, 2008, *Ex Parte* at 4.

89. In an effort to bolster its arguments for its proposed stepped OOBE mask, the WCS Coalition measured the noise floor associated with practical installations of SDARS antennas[217] and determined that to avoid raising the SDARS receiver's noise floor by more than 1 dB (the interference criteria initially proposed by the SDARS licensees), the maximum WCS OOBE received at the SDARS receiver must not exceed a level approximately 6 dB below the noise floor.[218] The WCS Coalition also measured the path loss from a WCS transmitter to an SDARS receiver.[219] To simulate a WCS device, the WCS Coalition used a 30-kHz continuous tone and a WiMAX signal generator together with a "chip" antenna mounted to a cart with an elevated on a plastic pole at the same height as the SDARS test receive antenna.[220] The SDARS test receive antenna was mounted on a vehicle roof, and a spectrum analyzer was used to measure the received signal.[221] In its filing, the WCS Coalition displayed the results of its tests and, using curve fit analysis, concluded that they yielded an aggregate Wireless Coalition Path Loss Model (WPM) of 50.9 + 21.8 log (D_{meters}) dB for distances from 5 to 50 feet (1.5 to 15 meters).[222] The WCS Coalition employed this aggregate WPM in subsequent showings and presentations.[223] Using its WPM, the WCS Coalition calculated the path loss at a separation of 3 meters to be 61.3 dB.[224] In an effort to show that its minimum proposed OOBE mask attenuation of 55 + 10 log (P) dB at the WCS transmitter will protect SDARS receivers to 6 dB below their noise floor 94 percent of the time, the WCS Coalition used a probabilistic simulation which incorporated its WPM-based path loss, ATPC (which the simulation assumes exeeeds 3 dB for 99 percent of the time), and increased OOBE attenuation resulting from ATPC, owing to operation of the transmitter in its non-linear region.[225]

90. Taking a different approach, the WCS Coalition also measured the distance-to-mute of the SDARS receiver due to OOBE produced by the complete proposed WCS OOBE mask attenuation of 55/61/67 + 10 log (P) dB, together with duty cycles of 6 percent for such applications as VoIP calling,

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[217] The WCS Coalition measured the noise floor of SDARS antennas at -106.2 dBm/4 MHz (-112.2 dBm/MHz) in a rural area and -96.4 dBm/4 MHz (-102.4 dBm/MHz) in an urban area. *See* WCS Coalition Reply Comments, Attachment A.

[218] WCS Coalition Comments at 13, Attachment B at 11. The WCS Coalition notes that the 1-dB figure is a typical value used by industry for noise floor protection.

[219] WCS Coalition Reply Comments, Attachment B at 4 and 25. The WCS Coalition completed measurements of its WPM of (50.9 + 21.8 log (D_{meters}) dB) between antenna connectors, *i.e.*, from the input of the transmit antenna to the output of the SDARS receive antenna, on unobstructed paths of varying distances. *See also* WCS Coalition Reply Comments, Attachment B at 15, 20, and 24.

[220] WCS Coalition Reply Comments, Attachment B at 14, 15, 20, and 24.

[221] WCS Coalition Reply Comments, Attachment B at 14, 15, 20, and 24. A photograph of the test set-up suggests that the tests were conducted with the WCS transmitter located to the side of the vehicle. Similar earlier tests were conducted earlier with the WCS transmitter located to the front of the vehicle, at a 45-degree angle from the front, and to the side of the vehicle, with similar results: an attenuation factor of 52 + 22 log (P) dB. *See* WCS Coalition Comments, Attachment B at 12.

[222] WCS Coalition Reply Comments, Attachment B at 4, 22, and 25. We observe that the WPM path loss can also be approximated as Free Space Loss (FSL) + 12 dB.

[223] *See, e.g.*, WCS Coalition Aug. 1, 2008, *Ex Parte* at 2.

[224] WCS Coalition Aug. 1, 2008, *Ex Parte* at 13.

[225] WCS Coalition Comments, Attachment B at 16-25. The WCS Coalition notes that ATPC is considered a crucial algorithm in many cellular technologies, such as WiMAX, as it minimizes intra-system interference and maximizes battery life. The WCS Coalition also notes that it assumes a conservative 2-dB reduction in WCS OOBE for every 1-dB reduction in the fundamental WCS signal, and only for the first 5 dB of reduction in the fundamental, thereafter assuming a 1-dB reduction in OOBE for every 1-dB reduction in the fundamental. WCS Coalition Comments at Attachment B, 11 and 23. *See also* WCS Coalition Reply Comments at Attachment C, 5.

and 43 percent for such applications as data uploads.[226] The WCS Coalition measured the muting distance to be less than 3 meters for the 6-percent duty cycle case, but approximately 6.4 to7.3 meters for the 43-percent case.[227] The WCS Coalition contends its analysis demonstrates that the extra attenuation needed to ameliorate the 43-percent duty cycle case and reduce the separation distance to 3 meters can be provided by accounting for vehicular-mobile obstructions such as tinted glass, body loss, and other vehicles; for the low probability that a WCS user will actually be transmitting in proximity to the SDARS receiver; for ATPC and increased OOBE attenuation as described above; and for the highly unlikely expectation of WCS operation at 43-percent duty cycle.[228]

91. Sirius conducted tests on SDARS receivers and made path loss measurements as well. In developing its original proposal for an OOBE attenuation factor of 103 + 10 log (P) dB to protect an SDARS receiver (located in a vehicle at a minimum distance of 3 meters)[229] from a WCS mobile transmitter,[230] Sirius modeled the path loss from a WCS transmitter to an SDARS receiver as (Free Space Loss (FSL) + 3 dB) (SDARS Propagation Model).[231] Sirius determined its SDARS Propagation Model (SPM) of (FSL + 3 dB) by taking measurements between antenna connectors, *i.e.*, from the input of the transmit antenna to the output of the SDARS receive antenna, on an unobstructed path at varying distances.[232] In its model, Sirius attributes the additional 3 dB to various coupling losses.[233] To simulate a WCS device during its testing, Sirius used a WiMAX signal generator together with a dipole antenna mounted on a cart and elevated on a pole 6 feet (approx. 2 meters) above ground, with a gain of 0 dBi toward the horizon.[234] The SDARS test receiving antenna was mounted on the rear portion of a sedan roof with the receiver inside the vehicle, which Sirius explains is a typical OEM factory installation.[235] In

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226 WCS Coalition Reply Comments at 13, Attachments B and C. The WCS Coalition used a white noise generator at stepped power levels to simulate the WCS OOBE.

227 WCS Coalition Reply Comments at 13; Attachment B at 19- 20; Attachment C at 3.

228 WCS Coalition Reply Comments, Attachment C at 4-7.

229 Sirius Comments, Exhibit A at A14. Sirius states that it believes this distance represents the absolute maximum interference radius around WCS user terminals that SDARS service can tolerate without significant service disruption. Sirius also relates this distance to the average lane widths of 3.3 meters to 4 meters for major roads, from the Bureau of Transportation Statistics. Sirius Reply Comments, Exhibit B at 5; U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, Journal of Transportation and Statistics, Volume 7, Number 23, Development of Prediction Models for Motorcycle Crashes at Signalized Intersections on Urban Roads in Malaysia, Table 1 - Description, Factor Levels, Coding System, and Basic Statistics of the Explanatory Variables, Department of Transportation Statistics, available at <http://www.bts.gov/publications/journal_of_transportation_and_statistics/volume_07_number_23/html/paper_03/table_03_01.html>. We note that the mean lane width of 3.6 meters in the above reference agrees with the predominant 12-feet (3.7 meters) lane width of "federal aid" highways in the United States. *See* U. S. Department of Transportation, Federal Highway Administration, table at <http://www.fhwa.dot.gov/ohim/hs98/tables/hm33.pdf>.

230 Sirius explained that to avoid raising the receiver's noise floor by more than 1 dB, the maximum WCS OOBE emissions received at the SDARS receiver must not exceed a level 5.9 dB below the noise floor, or -124.9 dBm/MHz. Sirius XM also measured the noise floor of its receiver to be -119 dBm/MHz.

231 Sirius Comments, Exhibit A at A14; Exhibit C at C5-C9.

232 *Id.*

233 Sirius Comments, Exhibit A at A14.

234 Sirius Comments, Exhibit C at C5; Sirius Reply Comments, Exhibit C at 4.

235 Sirius Comments, Exhibit C at C5-C6. A photograph of the test set-up suggests that the tests were conducted with the WCS transmitter located to the side of the sedan.

its filing, Sirius displayed the results of its tests and concluded that they are in agreement with its SPM of (FSL + 3 dB).[236]

92. At a distance of 3 meters and using its SPM, Sirius calculated a path loss of 52.2 dB. To obtain the maximum permissible power of OOBE emissions at the WCS transmitter, Sirius added the 52.2-dB SPM path loss to the -124.9 dBm/MHz maximum power of OOBE interference at the receiver, resulting in a maximum OOBE power of -72.7 dBm/MHz at the transmitter. Sirius explained that this level is equivalent to an emission mask attenuation of 102.7 + 10 log (P) dB, which it rounded to 103 + 10 log (P) dB, where P is the average transmitter output power in Watts.[237]

93. *Ashburn, VA Tests.* In the testing in Ashburn, Virginia noted above, Sirius XM used a signal generator and other test equipment to create what it argues is a signal that is representative of the OOBE levels that would result from a WiMAX transmission in the WCS bands. The WCS Coalition separately tested an actual WCS device operating with a WCS base station to produce the OOBE levels that would be present in the SDARS bands.[238] Both tests used OEM and aftermarket SDARS receivers in order to determine the distance at which muting of the SDARS receiver would occur due to OOBE interference.[239] In the paragraphs below, we discuss the WCS Coalition's and Sirius XM's interpretation of their respective test results.

94. The WCS Coalition asserts that its Ashburn tests show that the WCS Coalition's proposed OOBE limits and reduced mobile power levels, coupled with other vehicular-mobile parameters that will attenuate the WCS signal, will be sufficient to protect SDARS operations from harmful interference when the WCS and SDARS users are separated by only 3 meters.[240] In support of its position, the WCS Coalition points out that the SDARS signal experienced only slight muting even when the WCS mobile device was operating with a fixed EIRP of 250 mW (*i.e.*, without ATPC) and an OOBE attenuation factor of 43 + 10 log (P) dB, which was less restrictive than its proposal of 55 + 10 log (P) dB in the 2320-2324 MHz and 2341-2345 MHz portions of the SDARS band. However, the WCS Coalition, in addition to its earlier power/spectral mask proposal of 250 mW/55/61/67 + 10 log (P) dB for all WCS mobile and portable devices, proposes to apply the power/spectral mask of 55 + 10 log (P) dB in the first 4 megahertz of the SDARS band (*i.e.*, 2320-2324/2341-2345 MHz), 61 + 10 log (P) dB) in the next 4 megahertz of the SDARS band (*i.e.*, 2324-2328/2337-2341 MHz), and 67 + 10 log(P) dB in the center 9 megahertz of the SDARS band (*i.e.*, 2328-2337 MHz) to the following WCS devices: (a) battery-operated (*i.e.*, mobile and portable) user stations transmitting at no greater than 250 mW average EIRP on the A and B blocks; (b) battery operated user stations transmitting at no greater than 50 mW/MHz average EIRP between the 2315-2318 and 2347-2350 MHz portions of the C and D blocks, respectively; and (c) battery operated user stations transmitting at no greater than 30 mW/MHz average EIRP between the 2318-2320 and 2345-2347 MHz portions of the C and D blocks, respectively. Under the WCS Coalition's proposal, the less restrictive spectral mask, which mirrors its previously proposed spectral mask of 55/61/67 + 10 log (P) dB, would be available only if the WCS device uses the power levels noted

[236] Sirius Comments, Exhibit C at C9; Sirius Reply Comments, Exhibit C at 4.

[237] Sirius Comments at 34 and Exhibit A at A16. *See also* Sirius XM Sept. 8, 2008, *Ex Parte* at 14, 15.

[238] *See* WCS Coalition *Ex Parte* filed February 22, 2010.

[239] *See* Appendix E of this *Report and Order* for a description of the test setups in Ashburn, VA.

[240] *See* WCS Coalition Aug. 4, 2009, *Ex Parte* at Exhibit B.

above and employs ATPC.[241] With regard to the WCS Coalition's most recent proposal, Sirius XM believes that these power and OOBE levels would result in massive interference to SDARS operations.[242]

95. On the other hand, Sirius XM argues that because the Ashburn, VA test area receives the strongest possible signals from Sirius XM's satellites (as much as 6 dB greater in the mid-Atlantic area in which the testing was performed than in other areas of the country) and did not have many obstructions (foliage, buildings, or overpasses) that would attenuate the received satellite signal, the WCS Coalition's testing did not accurately reflect the potential for WCS transmissions to interfere with Sirius XM's transmissions in areas where the satellite signal strength is not as strong. Sirius XM states that even though its testing was done in a geographic area that receives some of the strongest satellite radio signals in the country and has little foliage or other obstructions to diminish reception of the satellite signal, the WCS mobile device still interfered with Sirius XM's signal.[243] Sirius XM believes that its testing in Ashburn shows that the WCS Coalition's power/spectral mask proposal of 250 mW/55/61/67 + 10 log (P) dB will cause harmful interference to SDARS operations, even at a separation distance greater than 25 meters between the WCS transmitter and SDARS receiver and in the presence of a terrestrial repeater.[244] To prevent such interference, Sirius XM contends that WCS mobile and portable devices should be restricted to the lower WCS A and B blocks (2305-2315 MHz) with a maximum EIRP of 250 mW (*i.e.*, no mobile devices would be allowed to transmit in the WCS C and D blocks at 2315-2320 and 23450-2350 MHz, respectively, or the upper WCS A and B blocks at 2350-2360 MHz), with 150 mW not being exceeded more than 10 percent of the time, a duty cycle of 6 percent, and with OOBE attenuated by a factor of not less than 70 + 10 log (P) dB in the 2320-2345 MHz band.[245] Fixed WCS service would still be permitted in the WCS C and D blocks and the upper WCS A and B blocks.

96. Commission staff observed that the SDARS receivers did not mute when only WCS OOBE energy was transmitted by the Sirius XM signal generator in the SDARS band while the vehicles hosting the devices were in very close proximity to one another (*i.e.*, in adjacent parking spaces). However, staff observed that the SDARS receivers did mute when a WiMAX signal was generated within certain portions of the WCS bands in the absence of any OOBE energy from the signal generator. The Ashburn tests appeared to show that the interference to SDARS receivers was dominated by overload interference since the presence of OOBE did not seem to have any material effect on SDARS reception at practical distances between the vehicle installations. Commission staff also observed that the WCS interference primarily occurred from WCS mobile operations in the adjacent WCS C and D blocks, however there was considerably less interference when the WCS mobile device's transmitting frequency was separated from the SDARS band edge by 2.5 megahertz or greater, or if the duty cycle of the WCS device was lowered.

97. *Comments.* In its comments on the Commission staff's proposed interference rules, the WCS Coalition states that although WCS licensees would prefer less restrictive OOBE limits on WCS user devices, the WCS OOBE limits proposed in the Commission staff's *WCS/SDARS Technical Rules Public Notice* will not preclude the deployment of viable mobile broadband services in the 2.3 GHz WCS

[241] WCS Coalition Aug. 19, 2009, *Ex Parte* presentation at 14-20

[242] *See* Sirius XM Sept. 3, 2009, *Ex Parte* presentation at 27, 29.

[243] *See* Sirius XM *Ex Parte* filing dated August 3, 2009, at 3-4.

[244] *See* Sirius XM Aug. 3, 2009, *Ex Parte* at 4.

[245] *See* Sirius XM Jan. 22, 2010, *Ex Parte* presentation at 12. Previously, Sirius XM believed that WCS mobile and portable devices should be restricted to operating in the WCS A and B blocks with an EIRP of 125 mW and OOBE attenuated by a factor of not less than 90 + 10 log (P) dB, with fixed operations still permitted in WCS Blocks C and D. *See* Sirius XM Aug. 11, 2009 *Ex Parte* presentation at 27.

band.[246] The WCS Coalition is concerned, however, that further restrictions on WCS OOBE levels in excess of those proposed in the *WCS/SDARS Technical Rules Public Notice* could substantially delay the availability of equipment in the United States, or, at worst, prevent vendors from offering user devices that meet the prerequisites – reasonably low costs, small form factors, and extended battery life – for success in the U.S. market.[247] To improve the measurement accuracy of OFDMA signals, however, the WCS Coalition proposes that in the one-megahertz bands immediately outside and adjacent to the WCS frequency blocks, measurements for compliance with the WCS OOBE limits should be based on a resolution bandwidth of one percent of the emission bandwidth, as provided under the existing procedures for other bands, so long as the measured power is integrated over a one-megahertz bandwidth. The WCS Coalition contends such an approach is needed in the first megahertz on either side of a frequency band being used for wideband technologies that incorporate OFDMA technology, including WiMAX and TD-LTE (Time Division-Long Term Evolution), due to the wideband nature and spectral roll-off characteristic of the OFDMA signal.[248]

98. In its comments on the *WCS/SDARS Technical Rules Public Notice*, Sirius XM argues that the proposed reduction in the attenuation of WCS OOBE to as little as 55 + 10 log (P) dB would not be sufficient to protect SDARS receivers. Further, Sirius XM contends that the proposed limits were tested and shown to cause harmful interference. Also, although Sirius XM acknowledges that the effects of overload interference are dominant, it contends that introduction of OOBE will exacerbate the impact of this interference.[249] Sirius XM also argues that the WCS demonstration was conducted in an area of the country receiving the strongest possible signals for the Sirius XM satellites.[250] (In its comments on the Ashburn testing, Sirius XM noted that other areas of the country receive signals that are as much as 6 dB weaker than the signal that is received in Ashburn.[251]) Sirius XM also filed supplemental comments containing a technical analysis of the impact of WCS out of band emissions from WCS devices on SDARS receivers by Dr. Theodore S. Rappaport, P.E. (Dr. Rappaport's Study).[252] Dr. Rappaport compares existing interference protection rules that apply to services adjacent to broadcast services. He also describes the Sirius and XM satellite systems with general consistency with the characteristics provided by Sirius and XM in their earlier comments. Dr. Rappaport oversaw creation of a software simulator to model the WCS OOBE impact on SDARS receivers. The details of the simulator, the assumptions used and the results of the simulation are provided in the analysis. He concludes, based on his simulation results in five cities, that to provide sufficient protection to SDARS receivers, WCS mobile and portable devices must be limited to an OOBE attenuation of 75 + 10 log (P) dB.[253]

[246] *See* Comments of the WCS Coalition, filed April 23, 2010, at 4-5.

[247] *Id.* at 5.

[248] *Id.*, Appendix A at xi. *See also* WCS Coalition *Ex Parte* Presentation, filed April 30, 2010, at 2-3. TD-LTE uses TDD unpaired spectrum channels, which alternately use the same channel for uplink and downlink, splitting resources as necessary on the basis of real-time demand , whereas FDD-LTE uses the FDD paired spectrum with two separate channels, one for the uplink and one for the downlink.

[249] *See* Comments of Sirius XM Radio Inc., filed April 23, 2010, at 12-13.

[250] *Id.* at 26.

[251] *See* Sirius XM *Ex Parte* filing dated August 3, 2009, at 3-4.

[252] *See* "Technical Analysis of the Impact of Adjacent Service Interference to the Sirius XM Satellite Digital Audio Radio Services (SDARS)" by Theodore S. Rappaport, P.E., TELISITE Corp., submitted with Supplemental Comments of Sirius XM, filed April 29, 2010, at 73.

[253] *See* "Technical Analysis of the Impact of Adjacent Service Interference to the Sirius XM Satellite Digital Audio Radio Services (SDARS)" by Theodore S. Rappaport, P.E., TELISITE Corp., submitted with Supplemental Comments of Sirius XM, filed April 29, 2010, at 73.

99. *Discussion*. We have reviewed all of the various analyses and test results concerning the risk of interference due to OOBE from a WCS device. Each side has taken a position which led, at least initially, to a nearly 50-dB difference in their assessments of potential OOBE interference.[254] Sirius XM had maintained that the interference criteria should be no more than a 1-dB degradation of the SDARS receiver's noise floor. We recognize that its position is based on the need to preserve the maximum margin possible in its link budget to deal with propagation phenomena such as shadowing from trees, buildings, and other objects. The WCS Coalition's position that interference should be based on muting could, on the surface, appear to completely eliminate any margin to provide for reliable satellite reception. We appreciate that such margins serve to provide reliable reception in difficult propagation environments. Yet, consumers will not lose reception simply because of degradation in the link margin unless other factors already are causing weak satellite signals. Moreover, given the complexity of these particular satellite systems which are designed to use multiple satellite feeds and terrestrial signals, the degradation of the margin to one satellite delivery path may have no material effect on the listener experience at various locations. We note, too, that losses in addition to free space loss will exist in a vehicle-to-vehicle scenario, as evidenced in the results from the Ashburn testing discussed earlier. These additional path losses will help to offset the degradation of the satellite link margin and, consequently, mitigate the risk of muting the SDARS receiver.

100. Accordingly, we conclude that it is appropriate to relax the current OOBE restriction.[255] We require that WCS mobile and portable devices operating in the WCS A and B blocks and the 2.5-megahertz portion of the WCS C and D blocks furthest removed from the SDARS band attenuate their out-of-band emissions, as measured over a 1-megahertz bandwidth, by a factor of not less than 43 + 10 log (P) dB on all frequencies between 2305-2317.5 MHz and between 2347.5-2360 MHz that are outside the licensed band of operation, not less than 55 + 10 log (P) dB in the 2320-2324/2341-2345 MHz bands, not less than 61 + 10 log (P) dB in the 2324-2328/2337-2341 MHz bands, and not less than 67 + 10 log (P) dB) in the 2328-2337 MHz band. OOBE must also be attenuated by a factor of not less than 43 + 10 log (P) dB in the 2300-2305 and 2360-2365 MHz bands, not less than 55 + 10 log (P) dB in the 2296-2300 MHz band, not less than 61 + 10 log (P) dB in the 2292-2296 MHz band, not less than 67 + 10 log (P) dB in the 2288-2292 MHz band, and not less than 70 + 10 log (P) dB below 2288 MHz and above 2365 MHz. Several factors weigh in our decision. According to the measurements and technical analyses provided by the commenters, the signal propagation loss will be greater than free space loss between two vehicles. The exact signal attenuation will vary depending on many circumstances including the distance between the vehicles, the use scenario (*e.g.*, whether the transmitting WCS device is held at head or lap height), and the orientation of the WCS antenna with respect to the SDARS receive antenna (*e.g.*, whether it is below, above or in the same plane as the SDARS antenna). Commission staff observed from the Ashburn tests that when using an actual WCS device in a manner that a subscriber would use the system (*e.g.*, placing a VOIP call or uploading/downloading files), there were no observations of muting due solely to OOBE. This indicates that signal attenuation plays a significant role in mitigating the potential for WCS OOBE interference. The Ashburn tests also underscore the fact that

[254] Based on Sirius XM's filing prior to the Ashburn tests showing that its receiver would be muted if the WCS OOBE attenuation level in the SDARS band were to reach 94 +10 log (P) dB, there was a difference of 39 dB in attenuation between the positions of the parties. *See* Sirius XM Sept. 8, 2008, *Ex Parte* presentation at Exhibit B, at 7.

[255] Sirius XM argues that the lowering of the OOBE limit is arbitrary and capricious because it is a dramatic and unsupported departure from the prior Commission conclusion that a highly restrictive OOBE limit is "required" to protect SDARS spectrum, and that no technical explanation could justify this "complete about-face." *See* Comments of Sirius XM, filed April 23, 2010, at 44-45. However, it is well within our authority to change our rules and standards in a rulemaking, so long as we provide a reasoned explanation for doing so. As detailed herein, we believe that the OOBE limits we are adopting are appropriately tailored to accomplish our dual policy goals of enabling the provision of mobile broadband services in the WCS spectrum, while protecting SDARS operations from harmful interference.

the satellite link margin was not entirely eliminated during the numerous test points since receiver muting did not occur.

101. We note, however, that neither the Sirius satellites nor the XM satellites provide coverage of the conterminous United States at a uniform power level. Under the Agreement Between the Government of the United States of America and the Government of the United Mexican States Concerning the Use of the 2310-2360 MHz Band, the power flux density level of the Sirius satellites at the U.S.-Mexico border is limited to -126.5 dBW/m2/4 kHz, and the power flux density level of the XM satellites at the U.S.-Mexico border is limited to -122.0 dBW/m2/4 kHz. These limits constrain the power levels the SDARS satellites can transmit into the southwest part of the United States, while allowing higher power levels further north. Sirius and XM have designed their geostationary satellites to provide higher power levels into the heavily-populated areas of the East and West Coasts of the United States than along the southern border. The physics constraints of satellite antenna design are such that the power level of the Sirius and XM downlink signals must taper off gradually, rather than abruptly as the downlink antenna patterns approach the southern border.

102. Although the power of Sirius XM's satellite signals in the southern portion of the United States is lower than in the northern portion, we believe that the WCS mobile and portable devices' power and OOBE limits we are adopting, coupled with the limits on these devices' duty cycle, the requirement that they employ ATPC, and the 2.5-megahertz WCS guard bands on both sides of the SDARS band, will be sufficient to limit the potential for harmful interference to SDARS receivers in those areas of the United States that receive relatively lower-power satellite signals. In our judgment, because the testing showed that potential for harmful interference from WCS mobile and portable devices is negligible, it is reasonable to conclude that there will not be an appreciable increase in the potential for WCS mobile and portable devices to interfere with SDARS receivers, even though Sirius XM's signal level is less in some portions of the United States.

103. In supplemental comments on the Commission staff's *WCS/SDARS Technical Rules Public Notice*, Sirius XM submitted an assessment on the probability of WCS interference to SDARS service performed by Dr. Theodore S. Rappaport, P.E., of the Telisite Corporation.[256] We commend Sirius XM for supporting development of a Monte-Carlo model for analysis of Mobile Satellite reception. As an initial matter, however, although Dr. Rappaport characterizes Sirius XM's service as a broadcast service, we believe that their service is more akin to a subscription-based mobile satellite service (MSS) offering.[257]

104. In Dr. Rappaport's software simulator, he uses SDARS receiver parameters generally consistent with what Sirius XM have provided in the record. With regard to path loss between the WCS and SDARS terminals, he uses path losses with exponents of either 2.0 (free space, as suggested by Sirius XM) or 2.18 (as suggested by the WCS Coalition) and an additional loss factor, described by a Gaussian random variable having a mean of either 10 or 16 dB and a standard deviation of 0, 2, or 4 dB to simulate different use cases;[258] he indicates that both the Sirius XM and WCS propagation loss data are well-matched by one of the resulting parameter combinations. The simulator permits the distance between a WCS transmitter and an SDARS receiver to be as small as 3 meters (about 10 feet) to simulate congested conditions across multiple traffic lanes. We believe that such conditions are most likely to exist in urban areas. However, the model does not consider terrestrial repeaters, and apparently does not

[256] *See* Supplemental Comments of Sirius XM Radio, Inc. filed April 29, 2010.

[257] Under the Commission's Rules, a broadcasting-satellite service is a radiocommunication service in which signals transmitted or retransmitted by space stations are intended for direct reception by the general public. 47 C.F.R § 2.1(c).

[258] *See* Supplemental Comments of Sirius XM Radio, Inc. filed April 29, 2010, Dr. Rappaport's Study at 20.

consider the 4-second buffer contained in SDARS receivers, which allows, for example, for uninterrupted reception as a vehicle passes under an overpass resulting in momentary loss of the satellite signals. The model also appears to assume that WCS transmitters operate in the frequency blocks nearest the SDARS receiver[259] (*i.e.*, it is never assumed that a WCS transmitter in Block D (in the upper WCS band) could be operating near a Sirius receiver (in the lower SDARS band) or that a WCS transmitter in Block C (in the lower WCS band) could be operating near an XM receiver (in the upper SDARS band)). We believe that this assumption overstates the likelihood of interference, since all SDARS receivers are always assumed to be experiencing WCS transmissions that have the highest OOBE level. Finally, the model assumes constant gain of the SDARS receive antenna with elevation angle. We note that Sirius XM appears to have no gain specification within 20 degrees of the horizon for SDARS receive antennas, and that some SDARS vehicular receive antennas have gains that are 7-10 dB below the nominal, specified value at elevation angles within 15 degrees of the horizon.[260]

105. Other parameters can be adjusted by the user of the software, but for the simulations submitted by Sirius XM, it is assumed that 34 percent of all vehicles on the road have on-board SDARS receivers, which are in use 85 percent of the time, and that WCS transmitters are installed in 5 percent of all vehicles and are transmitting 13 percent of the time. We note that the current number of Sirius XM subscribers is less than 19 million,[261] while there are over 240 million vehicles (of which 134 million are cars).[262]

106. We believe that the assumed 3-meter separation between SDARS and WCS units conflicts with the assumption of no terrestrial repeater service, since such repeaters are installed primarily in urban areas where congested traffic across multi-lane roads is most likely to occur. Further, we note that SDARS terrestrial repeaters transmit further into the SDARS frequency band that are also subject to lower OOBE from WCS devices. We also believe that vehicle-mounted SDARS receive antennas will generally provide significant isolation from WCS operations in nearby vehicles since the elevation angle associated with reception of the WCS signal will generally be low (or nearly horizontal). Finally, while reductions in link margin are useful indicators of reliability, we note that both parties have agreed that a muted SDARS receiver defines interference and the simulations do not provide insight on whether or when actual muting will occur.[263]

107. In our judgment, the modified WCS mobile and portable devices' operating power and OOBE limits we adopt will prevent interference to SDARS operations except in the rarest of instances when a number of WCS and SDARS operating conditions coincide (*e.g.*, WCS mobile device in close proximity to SDARS receiver, high degree of mutual coupling between WCS and SDARS antennas, lack of obstructions between WCS transmitter and SDARS receiver, WCS mobile device transmitting channel is immediately adjacent to SDARS receiving channel, etc.).

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[259] *See* Supplemental Comments of Sirius XM Radio, Inc. filed April 29, 2010, Dr. Rappaport's Study at 41.

[260] Licul, S., et al., "Reviewing SDARS Antenna Requirements," Microwaves and RF, September 2003, available from http://www.mwrf.com/Articles/Print.cfm?ArticleID=5892

[261] Sirius XM's SEC Form 10-Q, filed May 7, 2010, lists 18,944,199 total subscribers; 9,157,165 subscribers on the SIRIUS system and 9,787,034 subscribers on the XM system, as of March 31, 2010. *See* Sirius XM's SEC Form 10-Q, *available at* http://www.faqs.org/sec-filings/100507/SIRIUS-XM-RADIO-INC_10-Q/.

[262] http://www.census.gov/Press-Release/www/releases/archives/facts_for_features_special_editions/012439.html (retrieved May 13, 2010)

[263] *See, e.g.*, Comments of Sirius XM , filed April 23, 2010, at 33; WCS Coalition *Ex Parte* presentation, filed May 13, 2010, at 2-4.

108. The arguments from Sirius XM for a more severe OOBE limit would, in effect, maintain the *de facto* preclusion of mobile devices from operating in the WCS spectrum. Our current rules permit mobile operations on their face but apply such a severe OOBE limit that no mobile operation is feasible. As a result, there have been no mobile operations in the WCS spectrum and continuing to apply a severe OOBE limit would surely perpetuate the *status quo*. We find this situation unacceptable because it effectively makes valuable spectrum unusable for the provision of mobile broadband services, despite results from the Ashburn tests that indicate that highly restrictive OOBE limits, such as the current OOBE restriction or the limits proposed by Sirius XM, are not necessary to protect satellite radio operations.

109. In the past, the Commission has generally established OOBE limits based on factors such as the impact on the viability of service and a general assessment of the risk of harmful interference.[264] This approach has generally been successful. For example, the service rules adopted for the 1710-1755 MHz/2110-2155 MHz AWS-1 bands have fostered the nationwide provision of mobile broadband services using that spectrum.[265] The stepped emissions limit proposed by the WCS Coalition is 12 dB more stringent for the outer satellite channels than our typical OOBE limit of 43 + 10 log (P) dB and is 24 dB more stringent for the inner satellite channels. We note that Sirius XM is opposed to the stepped OOBE limit approach recommended by the WCS Coalition because it claims this inappropriately provides more protection to one satellite feed than another.[266] We do not agree that this is a valid objection. Because the WCS Coalition's proposed OOBE attenuation factors will provide adequate interference protection for the outer satellite channels of the SDARS band, due to the roll-off (*i.e.*, further attenuation) of a signal that is passed through a typical radio frequency filter, additional protection will be available to the terrestrial repeater channels towards the middle of the SDARS band, and still further protection will be available to the inner satellite channels in the middle portion of the SDARS band.

110. There is also precedent in the rules for a stepped OOBE limit. In establishing OOBE limits for the BRS and EBS operating in the 2496-2500 MHz band, including OOBE limits to protect the Mobile Satellite Serviee (MSS) operating below 2495 MHz, the Commission speeified an emissions limit of not less than 43 + 10 log (P) dB at the channel edge and not less than 55 + 10 log (P) dB at 5.5 megahertz from the channel edge.[267] Therefore, the limit proposed by the WCS Coalition is also more stringent than the limit we have applied to adjaeent band BRS and EBS operations in order to protect Mobile Satellite Service (MSS) operations from harmful interference.

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[264] *See, e.g.*, Service Rules for the 698-746, 747-762 and 777-792 MHz Bands, WT Docket No. 06-150, Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, CC Docket No. 94-102, Section 68.4(a) of the Commission's Rules Governing Hearing Aid-Compatible Telephones, WT Docket No. 01-309, Biennial Regulatory Review – Amendment of Parts 1, 22, 24, 27, and 90 to Streamline and Harmonize Various Rules Affecting Wireless Radio Services, WT Docket 03-264, Former Nextel Communications, Inc. Upper 700 MHz Guard Band Licenses and Revisions to Part 27 of the Commission's Rules, WT Docket No. 06-169, Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band, PS Docket No. 06-229, Development of Operational, Technical and Spectrum Requirements for Meeting Federal, State and Local Public Safety Communications Requirements Through the Year 2010, WT Docket No. 96-86, Declaratory Ruling on Reporting Requirement under Commission's Part 1 Anti-Collusion Rule, WT Docket No. 07-166, *Second Report and Order*, 22 FCC Rcd 15289, 15418 ¶ 361 (2007) (*Second Report and Order*) *recon. pending*; Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands, WT Docket No. 02-353, *Report and Order*, 18 FCC Rcd 25162 (2003) (*AWS-1 Service Rules Order*); *Order on Reconsideration*, 20 FCC Rcd 14058 (2005).

[265] *See* Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993, Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services, WT Docket No. 08-27, *Thirteenth Report*, 24 FCC Rcd 6185, 6256 ¶ 140 (rel. Jan. 16, 2009).

[266] *See* Sirius XM *Ex Parte* Presentation at 3 (filed November 13, 2008).

[267] *See* 47 C.F.R. Section 27.53(l)(4).

111. On balance, we conclude that the OOBE limits proposed by the WCS Coalition are reasonable are sufficient to protect SDARS receivers from harmful interference without precluding the operation of mobile and portable devices in the WCS spectrum. Thus, for WCS mobile and portable devices operating in the WCS A and B blocks and the 2.5-megahertz portions of the WCS C and D blocks furthest removed from the SDARS band, we are adopting OOBE attenuation factors of not less than 43 + 10 log (P) dB on all frequencies in the 2305-2317.5/2347.5-2360 MHz bands that are outside the licensed band of operation, not less than 55 + 10 log (P) dB in the 2320-2324/2341-2345 MHz bands, not less than 61 + 10 log (P) dB in the 2324-2328/2337-2341 MHz bands, and not less than 67 + 10 log (P) dB in the 2328-2337 MHz band. As indicated above, these stepped limits should provide sufficient protection to the outer SDARS channels used at the satellites, slightly greater protection to the SDARS channels used by the terrestrial repeaters, and still greater protection to the inner SDARS channels used by the satellites. We anticipate that interference will occur very rarely under these limits. For interference to occur, the WCS device would have to be transmitting at full power at the exact moment that it is within a few meters of the SDARS receiver and there is no satellite diversity or terrestrial repeater is present. As discussed in more detail below, in order to protect aeronautical mobile telemetry (AMT) service operations in the adjacent 2360-2395 MHz band from harmful interference, OOBE for WCS mobile and portable devices must also be attenuated by a factor of not less than 43 + 10 log (P) dB in the 2360-2365 MHz band and not less than 70 + 10 log (P) dB above 2365 MHz. To protect deep space network (DSN) operations in the second adjacent 2290-2300 MHz band from harmful interference, WCS mobile and portable devices' OOBE must be attenuated by a factor of not less than 43 + 10 log (P) dB in the 2300-2305 MHz band, not less than 55 + 10 log (P) dB in the 2296-2300 MHz band, not less than 61 + 10 log (P) dB in the 2292-2296 MHz band, not less than 67 + 10 log (P) dB in the 2288-2292 MHz band, and not less than 70 + 10 log (P) dB below 2288 MHz. We believe that applying these stepped OOBE masks for the upper and lower adjacent spectrum will allow for full use of the WCS A and B blocks and 2.5 megahertz of both the WCS C and D blocks with equipment that is currently available, while also allowing for the interference potential with AMT and DSN to be addressed with reasonable coordination requirements.

112. Although the typical measurement bandwidth used in measuring compliance with specific OOBE attenuation factors is 1 megahertz, because we are requiring that WCS devices' OOBE be attenuated by a specific amount at the band-edge frequency, in the one-megahertz bands immediately outside and adjacent to the WCS frequency blocks (*i.e.*, 2304-2305 and 2360-2361 MHz), measurements for compliance with the WCS OOBE limits may be based on a resolution bandwidth of 1 percent of the emission bandwidth, so long as the measured power is integrated over a 1-megahertz bandwidth. As noted by the WCS Coalition, this should improve the OOBE measurement accuracy for OFDMA signals in the one-megahertz bands immediately outside and adjacent to the WCS frequency blocks.[268]

113. We will, however, also employ the same approach to OOBE interference protection of SDARS operations that we apply to protect SDARS operations from overload interference. Specifically, WCS licensees must cooperate in good faith in the selection and use of new station sites and new frequencies to reduce interference and make the most effective use of the authorized facilities. Licensees of stations suffering or causing harmful interference must cooperate in good faith and resolve such problems by mutually satisfactory arrangements. If the licensees are unable to do so, the Wireless Telecommunications Bureau, in consultation with the Office of Engineering and Technology and the International Bureau, may impose greater OOBE attenuation than described above.[269]

[268] *See* WCS Coalition *Ex Parte* Presentation, filed April 30, 2010, at 2-3.

[269] 47 C.F.R. § 27.53(n).

E. WCS Base and Fixed Station and Customer Premises Equipment Power and Out-of-Band Emissions Limits

114. In the *2007 Notice*, we sought comment on the WCS Coalition's proposal that we adopt a 2-kW EIRP average power limit for WCS fixed and base stations.[270] We specifically asked interested parties to address what impact, if any, adoption of an average, rather than peak, power limit for WCS base stations would have on the ability of WCS licensees to deploy new services, and whether it would increase the risk of interference with adjacent channel licensees outside of the 2305-2360 MHz range.[271] We also requested comment on whether the Commission should adopt a 6-dB PAPR (peak-to-average power ratio) proposed by the WCS Coalition, or whether a different PAPR, such as 13 dB, which the Commission adopted for wireless services in the 700 MHz band[272] and more recently for services in certain PCS/AWS bands,[273] would be more appropriate.

115. In the *2007 Notice*, the Commission also invited comment on three proposals for power limits for SDARS terrestrial repeaters and WCS transmitting stations. One proposal, from Sirius, is to limit ground-level emission levels. The second, proposed by WCS licensees, is to limit average EIRP and the ratio between average and peak EIRP. The third proposal is a hybrid of the ground-level emission limit and the average EIRP limit. We discuss each of these proposals in more detail below.

116. In its *2006 Petition for Rulemaking*, Sirius asserted that the Commission could limit interference between SDARS repeaters and WCS stations by establishing a "ground-level emission limit" of -44 dBm for both SDARS terrestrial repeaters and WCS stations.[274] To verify compliance, Sirius proposes that the received power from either an SDARS repeater or a WCS base station would be measured at a height of 2 meters above ground level, at a distance from the base of the antenna that is equal or greater than the effective height above ground level of the SDARS or WCS station's antenna.[275] Additionally, under Sirius' proposal, the average power received at a distance of 1 meter from a transmitting WCS subscriber station's antenna would also be limited to -44 dBm.[276] In its comments on

[270] *2007 Notice*, 22 FCC Rcd at 22141 ¶ 22.

[271] *Id.*

[272] *See* Service Rules for the 698-746, 747-762 and 777-792 MHz Bands, *Report and Order and Further Notice of Proposed Rulemaking*, 22 FCC Rcd 8064, 8103-04 ¶¶ 105-06 (2007) ("*700 MHz Report and Order*").

[273] *See* Biennial Regulatory Review—Amendment of Parts 1, 22, 24, 27 and 90 to Streamline and Harmonize Various Rules Affecting Wireless Radio Services, WT Docket No. 03-264, *Third Report and Order*, 23 FCC Rcd 5319, 5336-37 ¶¶ 29-42 (2008) ("*Streamlining Third Report and Order*").

[274] *2006 Petition for Rulemaking* at 4-5, *cited in 2007 Notice*, 22 FCC Rcd at 22129 ¶ 15. XM and Sirius have referred to the proposed "ground-level emission limit" as a power flux density (PFD) limit. Letter from Carl R. Frank, Counsel for XM/Sirius, to Secretary, FCC (dated Aug. 14, 2006) at 1; Letter from Patrick L. Donnelly, Executive Vice President, General Counsel, and Secretary, Sirius, and James S. Blitz, Vice President and Regulatory Counsel, XM Radio Inc., to Marlene H. Dortch, Secretary, FCC (dated Sept. 19, 2007) at 7-8 and Annex 2. In the *2007 Notice*, however, the Commission explained that the ground-level emission limit is actually a received power limit (similar to the limits on incidental radiator emissions in Section 15.209 of the Commission's Rules, 47 C.F.R. § 15.209). The Commission explained further that a rule incorporating Sirius' basic idea could be expressed as an equivalent power flux density (PFD) or electric field strength limit. Assuming a 0 decibel over isotropic (dBi) measurement antenna (as Sirius does), the -44 dBm received power limit is equivalent to a PFD limit of -45.3 dBW/m² or a field strength limit of 100.5 dBμV/m. *2007 Notice*, 22 FCC Rcd at 22129 n.42.

[275] *See 2006 Sirius Petition for Rulemaking*, Appendices A, proposed Section 25.214(d)(2)(A)(i), and B, proposed Section 27.50(a)(1)(A), *cited in 2007 Notice*, 22 FCC Rcd at 22129 ¶ 15.

[276] *See 2006 Sirius Petition for Rulemaking*, Appendix B, proposed Section 27.50(a)(1)(C), *cited in 2007 Notice*, 22 FCC Rcd at 22129 ¶ 15. SDARS subscriber units are receivers only and do not transmit. Therefore, Sirius did not propose a similar provision for SDARS.