Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Amendment of Part 27 of the Commission's Rules	)	
to Govern the Operation of Wireless	)	WT Docket No. 07-293
Communications Services in the 2.3 GHz Band	)	
	)	
Establishment of Rules and Policies for the	)	IB Docket No. 95-91
Digital Audio Radio Satellite Service in the	)	GEN Docket No. 90-357
2310-2360 MHz Frequency Band	)	RM-8610

REPORT AND ORDER AND SECOND REPORT AND ORDER

Adopted: May 20, 2010 **Released: May 20, 2010**

By the Commission:

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I. INTRODUCTION

1. By our actions today, we make available an additional 25 megahertz of spectrum for mobile broadband service in much of the United States, while protecting adjacent satellite radio, aeronautical mobile telemetry, and deep space network operations. Although the current technical rules for Wireless Communications Service (WCS) in the 2.3 GHz band effectively limit terrestrial operations to fixed services, we find today that these technical rules can be changed without risking harmful interference to neighboring operations, and that these changes will enable licensees to provide mobile broadband services in 25 megahertz of the WCS band. To ensure that the promise of mobile broadband is realized, we adopt new build-out requirements for WCS licensees. In addition, to make possible high-quality satellite radio services to the American public, we adopt rules governing the use of terrestrial repeaters by Satellite Digital Audio Radio Service (SDARS) licensees.

2. The current Part 27 rules preclude WCS licensees from providing mobile broadband services, and the current Part 25 rules do not provide technical rules or a licensing regime for SDARS terrestrial repeaters, which are currently authorized via special temporary authority on a non-interference basis. In the Report and Order in WT Docket No. 07-293, we adopt final rules for the WCS that will modify the technical parameters governing the operation of WCS mobile and portable devices and thereby provide WCS licensees with the ability to offer mobile broadband services, while limiting the potential for harmful interference to incumbent services operating in adjacent bands. In the Second Report and Order in IB Docket No. 95-91, we adopt technical rules governing the operation of SDARS terrestrial repeaters that will not impede their deployment or function, but will limit the potential for harmful interference to adjacent bands' WCS spectrum users, and adopt a blanket-licensing regime for SDARS repeaters to promote their flexible deployment.

3. Specifically, the Report and Order we adopt in WT Docket No. 07-293 establishes a regulatory framework for the co-existence of SDARS and WCS licensees in the 2305-2360 MHz (2.3 GHz) frequency band.

- The Report and Order modifies the rules governing WCS operations to allow the operation of mobile and portable[1] stations at power levels of up to 250-milliwatts (mW) average equivalent isotropically radiated power (EIRP) per 5 megahertz in WCS Blocks A and B and in the portions of WCS Blocks C and D that are separated by 2.5 megahertz from the edges of the SDARS band at 2320-2345 MHz (*i.e.*, 2305-2317.5 and 2347.5-2360 MHz). WCS mobile and portable devices are not permitted to operate in the 2.5-megahertz portions of the WCS C and D blocks closest to the SDARS band (*i.e.*, 2317.5-2320 and 2345-2347.5 MHz). WCS mobile and portable devices using time division duplex (TDD)[2] technology are limited to a duty cycle[3] of 38 percent. WCS mobile and portable devices using frequency division duplex (FDD)[4] technology are limited to a duty cycle of 25 percent in the lower WCS A and B blocks and 12.5 percent in the 2.5-megahertz portion of the WCS C block furthest from the SDARS band edge, and are restricted to transmitting in the 2305-2317.5 MHz band. WCS mobile and portable devices must also employ automatic transmit power control (ATPC) when operating so the devices use the minimum power necessary for successful communications.[5]

[1] Under the Commission's rules for radio frequency (RF) exposure evaluation, a mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. 47 C.F.R. § 2.1091. A portable device is defined as a transmitting device where the radiating structure(s) of the device is/are within 20 centimeters of the body of the user. 47 C.F.R. § 2.1093.

[2] TDD is a radio communications technology where a single radio frequency band is divided into timeslots and used for uplink (*i.e.*, user device) and downlink (*i.e.*, base station) transmissions.

[3] Duty cycle (also known as duty factor) is 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).

[4] FDD is a radio communications technology where two separate radio frequency bands are used for uplink and downlink transmissions.

[5] ATPC is a feature of a digital microwave radio link that adjusts the transmitter output power based on the varying signal level at the receiver. ATPC allows the transmitter to operate at less than maximum power for most of the time, thereby minimizing the potential for intra and inter-service interference; when fading conditions occur, transmit power is increased as needed until the maximum is reached. An ATPC equipped system has several potential advantages over a fixed transmit power system, including less transmitter power consumption, longer amplifier component life, and reduced interference potential to other microwave radio systems. *See* National Spectrum Managers Association Recommendation WG 18.91.032 Automatic Transmit Power Control (ATPC) at 1, (continued...)

- Additionally, under the new rules we adopt today, WCS mobile and portable devices' out-of-band emissions (OOBE), as measured over a 1-megahertz resolution bandwidth,[6] must be attenuated below the transmitter power P by a factor not less than 43 + 10 log (P) decibels (dB) on all frequencies between 2305-2317.5 MHz and on all frequencies 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, not less than 67 + 10 log (P) dB in the 2328-2337 MHz band, where P is the transmitter output power in Watts. 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.

- WCS base and fixed stations in WCS Blocks A and B (*i.e.*, 2305-2315 and 2350-2360 MHz) will be permitted to operate with up to 2 kilowatts (kW) average EIRP per 5 megahertz with a 13 dB peak-to-average power ratio (PAPR). Base and fixed stations in WCS Blocks C and D (*i.e.*, 2315-2320 and 2345-2350 MHz) are limited to the 2 kW per 5 megahertz peak EIRP limit currently specified in our Rules. WCS base stations supporting FDD mobile and portable operations are restricted to transmitting in the 2345-2360 MHz band. WCS base and fixed stations' OOBE must be attenuated below the transmitter power P by a factor of not less than 43 + 10 log (P) dB on all frequencies between 2305-2320 MHz and on all frequencies between 2345-2360 MHz that are outside the licensed band of operation, not less than 75 + 10 log (P) dB on all frequencies in the 2320-2345 MHz band, not less than 43 + 10 log (P) dB in the 2300-2305 and 2360-2362.5 MHz bands, not less than 55 + 10 log (P) dB in the 2362.5-2365 MHz band, not less than 70 + 10 log (P) dB in the 2287.5-2300 MHz and 2365-2367.5 MHz bands, not less than 72 + 10 log (P) dB in the 2285-2287.5 and 2367.5-2370 MHz bands, and not less than 75 + 10 log (P) dB below 2285 MHz and above 2370 MHz.

The Report and Order also establishes enhanced performance requirements to ensure that WCS licensees use the spectrum intensively in the public interest.

- For mobile and point-to-multipoint services, licensees must serve 40 percent of a license area's population within 42 months, and 75 percent within 72 months. For fixed point-to-point services, licensees must construct and operate 15 point-to-point links per million persons in a license area within 42 months, and 30 links within 72 months. Licensees will not be required to satisfy submarket construction requirements.

- In those license areas where licensees must coordinate with aeronautical mobile telemetry (AMT) receive sites to serve a significant percentage of a market's total population, we establish alternative requirements for mobile and point-to-multipoint services. Specifically, affected licensees must serve 25 (rather than 40) percent of the population within 42 months, and 50 (rather than 75) percent within 72 months.

(Continued from previous page)
available at http://www.nsma.org/recommendation/WG18-91-032.pdf (last visited Oct. 21, 2009). In our Part 27 Rules, we currently require a WCS portable device operating in the 2305-2315 MHz band to employ ATPC. 47 C.F.R. § 27.53(a)(9)(iv).

[6] Consistent with our existing Rules for the 2.5 GHz band in Section 27.53(m)(6), however, in the 1-megahertz bands immediately outside and adjacent to the WCS frequency blocks (*i.e.*, at 2304-2305 and 2360-2361 MHz), a resolution bandwidth of at least 1 percent of the emission bandwidth of the fundamental emission of the transmitter may be employed, provided the measured power is integrated over a 1-megahertz bandwidth.

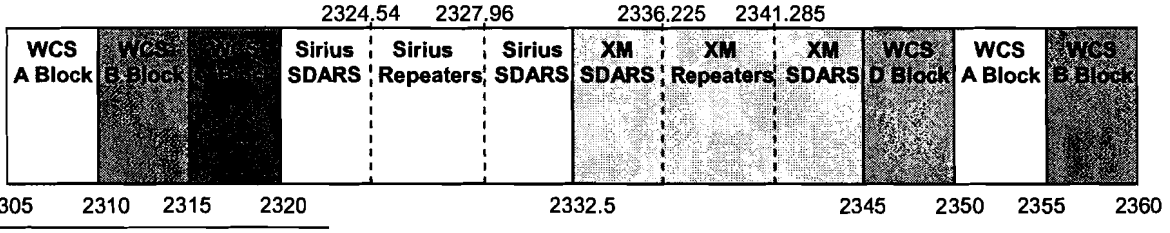
4. The Second Report and Order in IB Docket No. 95-91 provides permanent rules for the operation of SDARS terrestrial repeaters, including establishing a blanket licensing regime for repeaters operating up to 12-kW average EIRP. As part of this Second Report and Order, we also deny the petitions for reconsideration of the *1997 SDARS Order*[7] filed by the Consumer Electronics Manufacturing Association (CEMA)[8] and the Cellular Phone Taskforce.[9]

II. BACKGROUND

5. A principal challenge in establishing a permanent regulatory framework for the 2305-2360 MHz frequency band has been the difficulty of resolving potential interference among the proposed operations of SDARS and WCS licensees in a manner that will permit the two services to co-exist. These interference concerns arise from the fact that these two very different services – one chiefly satellite-based and the other terrestrial-based – are allocated to adjacent frequency bands, with no guard bands separating the services.

6. Specifically, the SDARS and WCS services occupy 55 megahertz of spectrum from 2305-2360 MHz, in a portion of the radio frequency (RF) spectrum frequently referred to as the "S-band." SDARS occupies the center portion of this band, 2320-2345 MHz, and this spectrum is divided evenly between two separate, but co-owned, SDARS networks, Sirius and XM.[10] The WCS service occupies frequencies on either side of the SDARS allocation and consists of six blocks of 5 megahertz each in the 2305-2320 and 2345-2360 MHz bands.[11] The figure below shows the spectrum allocations in the 2305-2360 MHz bands.

2305-2360 MHz Band Plan (not to scale)



[7] Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band, *Report and Order, Memorandum Opinion and Order and Further Notice of Proposed Rulemaking*, 12 FCC Rcd 5754 (1997) (*"SDARS Order and FNPRM"*).

[8] Petition for Reconsideration of the Consumer Electronics Manufacturing Association, IB Docket No. 95-91 (Mar. 27, 1997) (*"CEMA Reconsideration Petition"*).

[9] Petition for Partial Reconsideration of the Cellular Phone Taskforce, IB Docket No. 95-91 (Apr. 9, 1997) (*"Cellular Phone Taskforce Reconsideration Petition"*).

[10] The 2320-2332.5 MHz band was originally assigned to Sirius Satellite Radio Inc. (Sirius) (formerly, Satellite CD Radio, Inc.), and the 2332.5-2345 MHz band was originally assigned to XM Radio Inc. (XM) (formerly, American Mobile Radio Corporation). As discussed below, Sirius and XM have since merged to form a single company – Sirius XM Radio, Inc. (Sirius XM) – but the merged entity continues to operate the Sirius and XM systems as separate networks and there is still a separate license for each system. *See* Applications for Consent to the Transfer of Control of Licenses XM Satellite Radio Holdings Inc., Transferor, to Sirius Satellite Radio Inc., Transferee, *Memorandum Opinion and Order and Report and Order*, MB Docket No. 07-57, 23 FCC Rcd 12348 (2008) (*"SDARS Merger Order"*). Sirius and XM were separate entities at the time they filed pleadings in this proceeding prior to the merger, but filed as the combined entity, Sirius XM, subsequent to the merger. We shall refer to them as separate entities or the combined entity, hereafter, as appropriate.

[11] The WCS spectrum is separated into paired blocks (A and B) that have been allocated on a regional basis, and unpaired blocks (C and D) that have been allocated over very wide service areas. For more on the WCS spectrum blocks, see *infra*, Section III.A.

A. SDARS Overview

7. The Commission's rules define SDARS – commonly known as "satellite radio" – as "[a] radiocommunication service in which audio programming is digitally transmitted by one or more space stations directly to fixed, mobile, and/or portable stations, and which may involve complementary repeating terrestrial transmitters, telemetry, tracking and control facilities."[12] Thus, SDARS is primarily a satellite-delivered service in which programming is sent directly from satellites to subscriber receivers either at a fixed location or in motion. Because a direct line of sight is generally required in order to receive an acceptable satellite signal, ground-based terrestrial repeaters are used in many areas to re-transmit the same signals provided by satellites directly to subscribers in order to maintain adequate signal power.[13] These areas include "urban canyons" between tall buildings, heavily foliaged areas, tunnels, and other places where obstructions could limit satellite visibility or cause multipath interference from reflected signals.[14]

8. Licenses to provide SDARS within the United States were awarded by auction in early April, 1997.[15] The two winners of the auction – XM and Sirius – were each assigned 12.5 megahertz of spectrum for their exclusive use on a primary basis.[16] XM and Sirius launched their satellites and began commercial operations in 2001 and 2002, respectively.[17] As of March 31, 2010, Sirius XM reported it had 18,944,199 subscribers in the conterminous United States.[18]

9. On August 5, 2008, the Commission approved the merger of XM and Sirius, which have subsequently combined to form a merged entity called "Sirius XM."[19] In the merger proceeding, the Commission found that significant engineering differences in the XM and Sirius infrastructures make

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[12] 47 C.F.R. § 25.201.

[13] *See* Amendment of Part 27 of the Commission's Rules to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band and Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band, *Notice of Proposed Rulemaking and Second Further Notice of Proposed Rulemaking*, WT Docket No. 07-293 and IB Docket No. 95-91, 22 FCC Rcd 22123, 22123 n.2 (2007) (we refer to the item containing the two notices as the "*2007 Notice*").

[14] *Id.*

[15] *See* Public Notice, *"FCC Announces Auction Winners for Digital Audio Radio Service,"* 12 FCC Rcd 18727 (Apr. 2, 1997). Sirius and XM Radio paid a total of $173.2 million for the 2 SDARS licenses.

[16] *See American Mobile Radio Corporation Application for Authority to Construct, Launch, and Operate Two Satellites in the Satellite Digital Audio Radio Service*, Order and Authorization, 13 FCC Rcd 8829 (Int'l Bur. 1997) ("*1997 XM Authorization Order*"), modified by 16 FCC Rcd 18484, application for review denied, 16 FCC Rcd 21431 (2001), *aff'd sub nom. Primosphere Ltd. Partnership v. FCC* (Case Nos. 01-1526 and 1527), 2003 WL 472239 (C.A.D.C. Feb. 21, 2003); *Satellite CD Radio, Inc. Application for Authority to Construct, Launch, and Operate Two Satellites in the Satellite Digital Audio Radio Service*, Order and Authorization, 13 FCC Rcd 7971 (Int'l Bur. 1997) ("*1997 Sirius Authorization Order*"), application for review denied, 16 FCC Rcd 21458 (2001), *aff'd sub nom. Primosphere Ltd. Partnership v. FCC* (Case Nos. 01-1526 and 1527), 2003 WL 472239 (C.A.D.C. Feb. 21, 2003).

[17] XM Radio commenced nationwide commercial service in September 2001. Sirius began commercial service in February 2002.

[18] 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/. The conterminous United States consists of the contiguous 48 States and the District of Columbia. 47 C.F.R. § 2.1.

[19] *SDARS Merger Order*, 23 FCC Rcd at 12351-52 ¶ 1. *See also Sirius XM July 29, 2008, Press Release.*

integration of the two systems difficult in the short term.[20] In addition, the Commission noted that XM and Sirius had each invested significantly in their existing infrastructure, with the expectation of operating this infrastructure for years to come.[21] Thus, despite the merger of the two companies, the XM and Sirius satellite and repeater infrastructures will operate as separate, legacy systems, at least in the near term.[22]

10. Sirius XM offers hundreds of channels of music, entertainment, news, and sports programming on the Sirius and XM satellite radio networks, as well as weather and data information services for maritime, aeronautical, and other purposes.[23] SDARS radio receivers are used in cars, trucks, boats, aircraft, and homes – and are available for portable use.[24] All of Sirius XM's arguments about interference have focused on protecting SDARS receivers located in close proximity to mobile WCS transmitters, particularly in automobiles.[25] Thus, we analyze this worst-case interference scenario and make our determinations accordingly. Nevertheless, the 2.5-megahertz WCS guard bands and the limits on WCS customer premises equipment and mobile and portable devices' power, OOBE, and duty cycle that we are adopting, along with the signal attenuation that is attendant with the propagation of a WCS signal through the walls of a structure, will be sufficient to prevent harmful interference to in-home SDARS receivers.

B. WCS Overview

11. The Commission's rules define WCS as a radiocommunication service licensed pursuant to Part 27 of the Commission's rules in specified frequency bands, including the 2305-2320 and 2345-2360 MHz bands.[26] The Commission established the WCS in February 1997.[27] Licensees in this service are permitted to provide fixed, mobile, portable, and radiolocation services.[28] The Commission found that allowing a broad range of services would permit the development and deployment of new telecommunications services and products to consumers.[29] Specific potential services advocated by WCS proponents in 1997 included high-speed wireless Internet access, return links for interactive cable and broadcasting services, mobile data, fixed terrestrial use, and the provision of wireless local loop services.[30] The Commission auctioned 128 WCS licenses in April 1997.[31] In July 1997, the Commission issued licenses to the WCS auction winners.[32]

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[20] *SDARS Merger Order*, 23 FCC Rcd at 12360-61 ¶ 24.

[21] *SDARS Merger Order*, 23 FCC Rcd at 12361 ¶ 24.

[22] *SDARS Merger Order*, 23 FCC Rcd at 12360-61 ¶ 23.

[23] *See SDARS Merger Order*, 23 FCC Rcd at 12351-52 ¶ 2. In addition, Sirius offers streaming video services in select vehicles. *Id.*

[24] *SDARS Merger Order*, 23 FCC Rcd at 12351-52 ¶ 2.

[25] *See* Sirius XM *Ex Parte* dated Fed. 9, 2009; Sirius XM *Ex Parte* dated Aug. 11, 2009.

[26] 47 C.F.R. §§ 27.4, 27.5.

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

[28] *See id.* at 10797 ¶ 25. The Commission also permitted WCS licensees to provide SDARS in the 2310-2320 and 2345-2360 MHz bands that were previously allocated to SDARS. *See id.*

[29] *See id.* at 10798 ¶ 26.

[30] *See id.* at ¶ 27.

[31] *See* "WCS Auction Closes, Winning Bidders in the Auction of 128 Wireless communications Service Licenses," *Public Notice*, DA 97-886, 12 FCC Rcd 21653 (rel. Apr. 28, 1997).. Seventeen winning bidders won 126 WCS

(continued...)

12. *WCS Blocks A and B.* In 1997, the Commission awarded WCS licenses for 2 paired 5-megahertz-wide channel blocks (WCS Blocks A and B) in 52 Major Economic Areas (MEAs) authorizing service on 10 megahertz of spectrum.[33] WCS Block A is comprised of spectrum at 2305-2310 MHz paired with 2350-2355 MHz. The lower band edge of Block A (2305 MHz) is adjacent to a 5-megahertz-wide Amateur Radio Service band at 2300-2305 MHz,[34] and second adjacent to Federal Deep Space Network (DSN) Receivers at 2290-2300 MHz. WCS Block B is immediately above Block A, and is comprised of spectrum at 2310-2315 MHz paired with 2355-2360 MHz. The upper band edge of Block B (2360 MHz) is adjacent to an Aeronautical Mobile Telemetry (AMT) Service band at 2360-2395 MHz.

13. *WCS Blocks C and D.* The Commission also awarded WCS licenses for 2 unpaired 5-megahertz-wide channel blocks (WCS Blocks C and D) in 12 Regional Economic Area Groupings (REAGs) separately authorizing service on 5 megahertz of spectrum.[35] WCS Block C is located at 2315-2320 MHz and is adjacent to the lower band edge of the SDARS spectrum at 2320-2345 MHz. WCS Block D is located at 2345-2350 MHz and is adjacent to the upper band edge of the SDARS spectrum.

14. Although the Commission permitted WCS licensees to provide both fixed and mobile services, it adopted different power and OOBE limits for these two classes of service.[36] For WCS fixed operations in the 2305-2320 and 2345-2360 MHz bands, the Commission adopted a power limit of 2 kW peak EIRP.[37] The Commission also required WCS fixed stations' OOBE to be attenuated below the transmitter power (P) within the SDARS frequencies of 2320-2345 MHz by a factor not less than 80 + 10 log (P) dB).[38] For WCS mobile stations, the Commission adopted a peak power limit of 20-W EIRP[39] and required an OOBE attenuation factor of not less than 110 + 10 log (P) dB within the SDARS frequencies.[40] The Commission adopted these power and OOBE limits, in part, to protect neighboring SDARS operations from harmful interference.[41]

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licenses with total net bids of more than $13.6 million. Two licenses did not receive bids after a standing high bid was withdrawn.

[32] *See* Public Notice, *"FCC Announces the Grant of Wireless Communications Service ("WCS") Licenses, Balance of Winning Bids are Due by August 4, 1997,"* 13 FCC Rcd 4782 (rel. Jul. 21, 1997).

[33] *See* Public Notice, April 28, 1997, 12 FCC Rcd 21653. An MEA map is available at http://wireless.fcc.gov/auctions/data/maps/mea.pdf.

[34] 47 C.F.R. § 97.303(j)(2)(i).

[35] A REAG map is available at http://wireless.fcc.gov/auctions/data/maps/REAG.pdf.

[36] An out-of-band emission is an "[e]mission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excludes spurious emissions." 47 C.F.R. § 2.1.

[37] 47 C.F.R. § 27.50(a)(1).

[38] 47 C.F.R. § 27.53(a)(1).

[39] 47 C.F.R. § 27.50(a)(2).

[40] 47 C.F.R. § 27.53(a)(2). The rules for WCS portable devices operating in the 2305-2315 MHz band were slightly relaxed, however. Specifically, in the 2305-2315 MHz band, WCS portable devices' peak transmitter output power was limited to 200 milliwatts (mW) (25 mW average power), and their OOBE in the 2320-2345 MHz band must have been attenuated by a factor of not less than 93 + 10 log (P) dB. 47 C.F.R. § 27.53(a)(9) and (a)(9)(iii).

[41] Amendment of the Commission's Rules to Establish Part 27, the Wireless Communications Service, Memorandum Opinion and Order, GN Docket No. 96-228, 12 FCC Rcd 3977, 3991 ¶ 25 (1997) (*"WCS Reconsideration Order"*).

15. Originally, the Commission's rules required WCS licensees to make a showing of substantial service in their license areas by the end of their initial 10-year license term, which commenced on July 21, 1997.[42] However, in December 2006, the Wireless Telecommunications Bureau (WTB) granted a 3-year extension of the construction deadline for certain WCS licensees.[43] WCS licensees argued, among other things, that the uncertainty regarding the rules governing the operation of adjacent-band SDARS terrestrial repeaters had hindered WCS equipment development, network design, and facility deployment, and that an extension would allow them to deploy newly developed WiMAX[44] technology in the 2.3 GHz band in the next few years.[45] WTB found that the possibility of WiMAX deployment warranted a 3-year extension of the initial 10-year construction requirement.[46] Thus, the current deadline for meeting the construction requirements set forth in Section 27.14 of the Commission's rules was extended until July 2010 for WCS licensees.

C. Procedural History

1. 1997 Further Notice

16. Although the Commission adopted service rules for most aspects of SDARS operations in 1997,[47] it did not adopt rules governing terrestrial repeater operations at that time. Instead, the Commission concurrently issued a Further Notice of Proposed Rulemaking (*1997 Further Notice*) seeking comment on the proposed use and authorization of SDARS terrestrial repeaters.[48] The *1997 Further Notice* acknowledged the SDARS applicants' intention to use repeaters in conjunction with their satellite systems and proposed authorizing deployment of SDARS repeaters on an "as-needed" basis in order to meet service requirements.[49] The *1997 Further Notice* also invited comment to address any potential impact that the operation of SDARS repeaters would have on the services of neighboring countries and on any potential effects RF emissions from SDARS repeaters may have on the public.[50] In addition, the *1997 Further Notice* sought comment on how the Commission's Rules could ensure that any use of SDARS repeaters remains complementary to the satellite service, as well as on the tentative conclusion to prohibit the use of SDARS repeaters to transmit locally originated programming.[51]

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[42] 47 C.F.R. § 27.14(a).

[43] Consolidated Request of the WCS Coalition for Limited Waiver of Construction Deadline for 132 WCS Licenses, *Order*, 21 FCC Rcd 14134 (2006) (*"WCS Extension Order"*).

[44] WiMAX (Worldwide Interoperability for Microwave Access) is a wireless broadband access technology based on the Institute of Electrical and Electronics Engineers (IEEE) 802.16 standard which supports delivery of non-line-of-sight connectivity between a subscriber station and base station with a typical cell radius of 3 to 10 kilometers. WiMAX can support fixed and nomadic, as well as portable and mobile wireless broadband applications. The latest version of the standard on which WiMAX is based, IEEE 802.16(e), has specifications for the 2 to 11 GHz range, uses scalable orthogonal frequency division multiple access (OFDMA), and supports both FDD and TDD profiles. *See generally* http://www.wimaxforum.org/resources/frequently-asked-questions.

[45] *WCS Extension Order*, 21 FCC Rcd at 14137 ¶ 5.

[46] *WCS Extension Order*, 21 FCC Rcd at 14140-41 ¶ 12.

[47] Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band, *Report and Order, Memorandum Opinion and Order and Further Notice of Proposed Rulemaking*, 12 FCC Rcd 5754 (1997) (*"SDARS Order and FNPRM"* or *"1997 Further Notice"*).

[48] *See SDARS Order and FNPRM*, 12 FCC Rcd at 5810-12 ¶¶ 138-142.

[49] *See id.* at 5812 ¶ 142.

[50] *See id.*

[51] *See id.*

17. In response to the *1997 Further Notice* and later supplemental filings by Sirius and XM,[52] the WCS licensees expressed concern about the possibility of harmful blanketing interference to WCS base stations and customer premises equipment (CPE) from SDARS repeaters operating at more than 2 kW EIRP.[53] In addition to WCS licensees, Broadband Radio Service (BRS) and Educational Broadband Service (EBS) (formerly Multipoint Distribution Service (MDS) and Instructional Television Fixed Service (ITFS), respectively) licensees operating in the 2150-2162 and 2496-2690 MHz frequency bands raised similar concerns.[54] Specifically, WCS, BRS, and EBS licensees raised concerns over two types of potential interference from SDARS repeater operations: "blanketing interference" and "third order intermodulation distortion (IMD)."[55] More recently, the WCS licensees have raised concerns regarding overload and adjacent band OOBE interference to WCS base stations from SDARS terrestrial repeaters.[56]

18. SDARS licensees generally acknowledged the possibility of blanketing interference and IMD, but opposed placing a 2 kW EIRP limit on their repeater operations. SDARS licensees argued that such a limit would impose substantial costs on SDARS licensees and that WCS and other terrestrial wireless licensees could mitigate any potential interference from SDARS repeater operations, respectively, by converting wireless operations from analog to digital, and by using WCS down-converters that are sufficient to protect against interference from the proposed SDARS repeaters.[57]

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[52] *See* Letter from Robert D. Briskman, Chief Technical Officer, CD Radio Inc., to Rosalee Chiara, Deputy Chief, Satellite Policy Branch, International Bureau, FCC, dated Nov. 14, 1997; Letter from William Garner, Chief Scientist, American Mobile Radio Corporation, to Rosalee Chiara, Deputy Chief, Satellite Policy Branch, International Bureau, FCC, dated Nov. 14, 1997; Supplemental Comments of Sirius Satellite Radio (filed Jan. 18, 2000) (Sirius Supplemental Comments); Supplemental Comments of XM Radio Inc. (filed Dec. 17, 1999) (XM Radio Supplemental Comments).

[53] *See* WCS Coalition Comments (dated Dec. 14, 2001) at 3-4. Blanketing interference occurs when a receiver is near a relatively high-powered adjacent-band transmitter and the high power overloads the components of the receiver and prevents reception of the desired signal by the receiver. *See* Sirius Satellite Radio, Inc., Application for Special Temporary Authority to Operate Satellite Digital Audio Radio Service Complementary Terrestrial Repeaters, *Order and Authorization*, 16 FCC Rcd 16773, 16774 n.5 (Int'l Bur. 2001) ("*Sirius 2001 STA Order*"); XM Radio, Inc., Application for Special Temporary Authority to Operate Satellite Digital Audio Radio Service Complementary Terrestrial Repeaters, *Order and Authorization*, 16 FCC Rcd 16781, 16782 n.5 (Int'l Bur. 2001) ("*XM Radio 2001 STA Order*").

[54] *See* Wireless Communications Association International, Inc. (WCA) Comments (filed Feb. 22, 2000) at 2; BellSouth Corporation and BellSouth Wireless Cable, Inc. Comments (filed Feb. 22, 2000) at 6-7. *See also* Metricom, Inc. Reply Comments (filed March 8, 2000) at 2-3; MCI WorldCom, Inc. Reply Comments (filed March 8, 2000) at 2-3, and WCS Coalition Comments at 2-3 (filed Dec. 14, 2001) at 3-4.

[55] The SDARS licensees operate their terrestrial repeaters in the middle of their authorized frequency bands (*i.e.*, 2324.54-2327.96 MHz for Sirius and 2336.225-2341.285 for XM). WCS licensees fear that the SDARS repeater frequencies will cause IMD interference when they mix with WCS transmission frequencies to form higher frequencies that will land directly in the WCS band and render WCS receivers inoperable. *See* WCS Coalition Comments (filed Dec. 14, 2001) at 3-4.

[56] *See, e.g.*, WCS Coalition Reply Comments, WT Docket No. 07-293, filed March 17, 2008, at 18-26, and WCS Coalition Comments, WT Docket No. 07-293, filed February 14, 2008, at 21-22. Overload interference, like blanketing interference, occurs when a receiver is near a relatively high-powered adjacent band transmitter and the high power from the transmitter overloads the components of the receiver and prevents reception of the desired signal. *See* n.53, *supra*. Out-of-band emissions (OOBE) from an adjacent-channel licensee's transmitter are received in-band to the desired signal's receiver and if over a prescribed limit, can interfere with and prevent the reception of the desired transmitter's signal.

[57] *See* Reply Comments of Sirius Satellite Radio (filed Mar. 8, 2000) at 2-3; Consolidated Reply of XM Radio Inc. (filed Mar. 8, 2000) at 8.

We note that since the inception of this proceeding, BRS and EBS licensees operating in the 2150-2162 and 2496-2690 MHz bands have converted from analog to digital technology. With this transition, coupled with the large frequency separation between the SDARS operations and the BRS/EBS operations, there have not been any complaints of interference to BRS or EBS operations from SDARS terrestrial repeaters' transmissions even though a substantial number of SDARS repeaters have been operating with an EIRP greater than 2 kW.

19. Commission staff met with SDARS and WCS licensees several times in 2001 to supplement the record on these issues.[58] In November 2001, the International Bureau sought comment on various additional proposals to resolve interference (*"2001 Public Notice"*),[59] but the supplemental record developed in response to that Public Notice did not provide a basis for resolving these issues.[60] Because of the inability to reach a consensus on final rules, SDARS licensees have been operating terrestrial repeaters pursuant to grants of special temporary authority (STA), which were granted on a non-interference basis and subject to other conditions.[61]

2. 2007 Notice

20. In May 2002, at the request of SDARS and WCS licensees, the Commission decided to refrain from adopting SDARS repeater rules and to allow SDARS and WCS licensees to attempt to resolve the interference concerns privately.[62] Although initially promising, the negotiations were ultimately unsuccessful.[63] After nearly 4 years of private negotiations, Sirius filed a White Paper in which it examined the technical difficulties involved in SDARS and WCS co-existence in the S-band.[64] In October 2006, Sirius filed a petition for rulemaking which included new proposals for resolving interference issues between SDARS and WCS licensees.[65] Sirius' proposals were based chiefly on its previously-filed White Paper. XM supported Sirius' proposals and urged the Commission to seek

[58] For example, the International, Wireless Telecommunications, and Media Bureaus of the Commission – together with the Commission's Office of Engineering and Technology – held industry meetings on January 11, 2001, March 1, 2001, and August 30, 2001, with the SDARS licensees' and WCS licensees' representatives in an attempt to craft solutions to the SDARS-WCS interference issues. *See* Letter from Paul J. Sinderbrand, Counsel for WCIA, to Secretary, FCC, dated Jan. 11, 2001; Letter from Carl R. Frank, Counsel for Sirius, to Secretary, FCC, dated Mar. 2, 2001; Letter from Donald C. Brittingham, Director of Spectrum Policy, Verizon, to Secretary, FCC, dated Aug. 31, 2001.

[59] Request for Further Comment on Selected Issues Regarding the Authorization of Satellite Digital Audio Radio Service Terrestrial Repeater Networks, *Public Notice*, Report No. SPB-176, 16 FCC Rcd 19435 (Int'l Bur., 2001) (*2001 Public Notice).*

[60] *2007 Notice*, 22 FCC Rcd at 22127 ¶ 10.

[61] *See generally Sirius 2001 STA Order* and *XM 2001 STA Order*. Since 2001, both Sirius and XM have submitted additional STA requests seeking to modify their repeater networks or to add new repeaters. A full list of SDARS STA requests are available through the International Bureau Filing System (IBFS), which is available online at http://licensing.fcc.gov/myibfs.

[62] *2007 Notice*, 22 FCC Rcd at 22127 ¶ 10.

[63] *2007 Notice*, 22 FCC Rcd at 22127 ¶ 10.

[64] *2007 Notice*, 22 FCC Rcd at 22128 ¶ 12, *citing* White Paper: Interference to the SDARS Service from WCS Transmitters, attached to Letter from Carl R. Frank, Counsel to Sirius Satellite Radio Inc., to Marlene H. Dortch, Secretary, FCC, WT Docket No. 05-256 and IB Docket No. 95-91 (Mar. 29, 2006) ("Sirius 2006 White Paper").

[65] *2007 Notice*, 22 FCC Rcd at 22128 ¶ 12, *citing* Sirius Satellite Radio Inc., Petition for Rulemaking and Comments (filed Oct. 17, 2006) (*"2006 Sirius Petition for Rulemaking*").

comment on them expeditiously.[66] In response to Sirius' petition, WCS licensees offered their own counter-proposals for the resolution of SDARS and WCS interference issues.[67]

21. The Commission determined that Sirius' proposal and WCS licensees' counterproposal could provide a basis for resolving the ongoing issues of potential interference between SDARS terrestrial repeaters and WCS stations.[68] The Commission also decided to take the opportunity to update and refresh the record on other issues raised in the *1997 Further Notice* and the *2001 Public Notice*.[69] Accordingly, in December 2007, the Commission issued a Second Further Notice of Proposed Rulemaking in IB Docket No. 95-91, inviting comment on issues related to the operation of SDARS terrestrial repeaters. In order to have the greatest flexibility in resolving interference issues between SDARS and WCS licensees and develop a record that would enable the provision of innovative broadband services in the 2.3 GHz WCS band, the Commission also issued a Notice of Proposed Rulemaking in a new docket (WT Docket No. 07-293), which sought comment on proposals to make changes to the Commission's rules in Part 27 governing WCS operations.[70] In response to the Commission's notice, eight comments were filed on February 14, 2008, and five reply comments were filed on March 17, 2008.[71] Since the closing of the comment periods, numerous *ex parte* presentations have been made in these proceedings.[72]

22. In a related matter, the current performance requirements (also known as "buildout" or "construction" requirements) for all spectrum blocks in the 2.3 GHz WCS band is a substantial showing at the end of the license term.[73] On March 29, 2010, the Commission sought comment on whether, if we alter the technical rules for this band, we should also revise the substantial service performance requirements (*WCS Performance Public Notice*).[74] Specifically, the Commission sought comment on particular reliable signal and license area coverage benchmarks for WCS mobile and point-to-multipoint services and possible alternatives, on particular link construction and operation benchmarks for WCS

[66] *See 2007 Notice*, 22 FCC Rcd at 22128 ¶ 12.

[67] *2007 Notice*, 22 FCC Rcd at 22128 ¶ 12, *citing* Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC, dated July 9, 2007 (*"WCS July 2007 Letter"*).

[68] *2007 Notice*, 22 FCC Rcd at 22124 ¶ 2 and 22128-29 ¶ 14.

[69] *2007 Notice*, 22 FCC Rcd at 22128-29 ¶ 14.

[70] *2007 Notice*, 22 FCC Rcd at 22124 ¶ 3.

[71] A list of these commenters and reply commenters is shown in Appendix A to this Order. Pleadings filed in response to the *1997 Further Notice* and the *2001 Public Notice* are listed in Appendix B to this Order. In addition, a number of parties in the SDARS Merger proceeding, MB Docket No. 07-57, filed arguments related to that proceeding in these proceedings. In some cases, repeater issues were relevant to the proposed merger of Sirius and XM. The Commission addressed those issues in the context of the merger, and we referenced those conclusions in this proceeding. Other repeater issues that were raised in the context of the merger, however, were not relevant to the merger. To the extent that those arguments were not also raised in these proceedings, they were filed in a procedurally deficient manner, and therefore will not be considered further.

[72] A list of significant *ex parte* presentations relied on in this Order is included in Appendix A.

[73] Section 27.14(a) of the Commission's rules provides that 2.3 GHz WCS licensees "must, as a performance requirement, make a showing of 'substantial service' in their license area within the prescribed license term set forth in § 27.13." 47 C.F.R. § 27.14(a). The rule defines substantial service "as service which is sound, favorable and substantially above a level of mediocre service which just might minimally warrant renewal." *Id.* Section 27.14(a) provides that failure by any WCS licensee to meet its performance "requirement will result in forfeiture of the license and the licensee will be ineligible to regain it." *Id.*

[74] *See* Federal Communications Commission Requests Comment on Revision of Performance Requirements for 2.3 GHz Wireless Communications Service, WT Docket No. 07-293, Public Notice, FCC 10-46, 75 Fed. Reg. 17349 (rel. Mar. 29, 2010).

point-to-point services and possible alternatives, and on related construction notification filing requirements.[75] In response to the Commission's *WCS Performance Public Notice*, six comments were filed by April 21, 2010; seven reply comments were filed by May 3, 2010.[76]

23. On April 2, 2010, Commission staff issued a public notice seeking comment on draft interference rules for the WCS and SDARS (*WCS/SDARS Technical Rules Public Notice*).[77] Specifically, Commission staff sought comment on provisions intended to minimize the risk of harmful interference from WCS mobile and portable devices to SDARS, AMT, and DSN receivers. In addition, Commission staff sought comment on draft technical rules for SDARS terrestrial repeaters intended to minimize the potential for harmful interference to WCS receivers. Commission staff also sought comment on licensing provisions for SDARS terrestrial repeaters, as well as rules regarding the use of terrestrial repeaters to originate local programming.[78] In response to the Commission staff's *WCS/SDARS Technical Rules Public Notice*, 14 comments were filed by April 23, 2010.[79]

24. In the mid-1990's when the Commission allocated spectrum and adopted service rules for WCS and SDARS, only general information was available on what new wireless applications might be deployed in the WCS spectrum and minimal information was provided on how the SDARS licensees intended to deploy terrestrial repeaters or gap-fillers. The wireless sector, however, has seen dramatic growth in the past decade. Wireless subscribers grew from approximately 24 million subscribers in 1994 to more than 263 million by the end of 2007.[80] The National Broadband Plan recognized that the convergence of Internet computing and mobile communications is rapidly fueling the demand for mobile broadband services.[81] The 2.3 GHz WCS spectrum will help to increase the supply of flexible use spectrum that can be used to address the explosive nationwide growth in consumer demand for mobile broadband services.

25. The SDARS licensees have seen dramatic increases in subscribers since they initiated service only a few short years ago. As of the end of 2009, there were over 18 million consumers subscribing to SDARS throughout the conterminous United States, with the large majority of them using the service while in their automobiles.[82] To help improve the quality of the consumers' audio experience, the SDARS licensees have deployed significant numbers of repeaters mainly in large market areas[83] where satellite coverage could be blocked or attenuated.

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[75] *Id.* at 2-3.

[76] A list of these commenters is shown in Appendix A to this Order.

[77] *See* Commission Staff Requests That Interested Parties Supplement the Record On Draft Interference Rules for Wireless Communications Service and Satellite Digital Audio Radio Service, WT Docket No. 07-293, IB Docket No. 95-91, GEN Docket No. 90-357, RM No. 8610, Public Notice, DA 10-592 (rel. Apr. 2, 2010).

[78] *Id.*

[79] A list of these commenters is shown in Appendix A to this Order.

[80] *See* Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993, WT Docket No. 08-27; Annual Report and Analysis of Competitive Market Conditions With Respect to Commercial Mobile Services, *Thirteenth Report*, 24 FCC Rcd 6185, 6280-81 ¶ 197 (WTB 2009).

[81] *See* Connecting America: The National Broadband Plan at 75.

[82] *See* Annual Report Pursuant to Section 13 of 15(d) of the Securities Exchange Act of 1934 for Fiscal Year Ended December 31, 2009, Sirius XM Radio Inc. (filed February 25, 2010), at 2, *available at* http://files.shareholder.com/downloads/SIRI/902162459x0xS950123-10-17181/908937/filing.pdf.

[83] Today, the top 15 markets covered by repeaters include Atlanta, Boston, Chicago, Dallas, Detroit, Las Vegas, Los Angeles, Miami, Minneapolis, New York, Philadelphia, Pittsburgh, San Francisco, Seattle, and Washington, DC.

26. Because both services target the same types of consumers (*i.e.*, those who are mobile, particularly in vehicles for long periods of time), the anticipated growth of these services presents the potential for mutual interference under certain scenarios. For example, a mobile WCS transmitter may cause interference to a mobile SDARS receiver when the SDARS receiver is in close proximity to the WCS transmitter. Alternatively, when the SDARS terrestrial repeaters and WCS base stations are serving the same geographic areas (*i.e.*, in dense urban areas and along major corridors leading to and from those areas), the relatively higher power repeaters have a potential to interfere with WCS mobile station and base station receivers. Our objective in this proceeding is to foster the co-existence of these services despite the technical difficulties that arise from them being in close proximity to each other, both geographically and in the radio frequency spectrum.

27. Over the past several years, we have provided numerous opportunities for the parties to come to an agreement that would facilitate Commission adoption of rules for both services and provide for their deployment and growth without many of the uncertainties that still exist today. Our efforts to persuade the parties to come to agreement have been unsuccessful, however, and the time to bring closure to this long-standing rulemaking has arrived. Our approach to move forward is described in detail in the following sections.

III. REPORT AND ORDER IN WT DOCKET NO. 07-293

A. Introduction

28. Our objective in this Report and Order is to craft WCS service rules that will allow the WCS to co-exist with adjacent band SDARS without reaching the threshold of SDARS experiencing harmful interference.[84] The service rules we adopt today will not result in an environment where interference will never occur under any circumstances. However, based on the technical record of this proceeding, the results of several tests conducted by Sirius XM and the WCS Coalition,[85] and FCC staff observations of tests Sirius XM and the WCS Coalition each conducted in Ashburn, VA, we are confident that the instances where WCS would seriously degrade or obstruct or repeatedly interrupt SDARS reception will be rare. Furthermore, consistent with the Commission's long-standing policies of maintaining technical and service neutrality in its rules and allowing flexible spectrum use by licensees, we adopt rules that remain technology neutral instead of adopting rules that mandate the use of a particular technology or service. Our requirements for the WCS power limits and OOBE attenuation are based on a balancing of the need to provide for multiple types of mobile broadband platforms and the need to protect SDARS mobile receivers from harmful interference.

29. As explained below, we find that the public interest will be served by revising certain WCS power and OOBE rules to enable the deployment of mobile broadband services in the WCS bands. Balancing the competing interests of SDARS and WCS providers, considering commenters' technical proposals, and basing our decisions on the extensive technical record, as well as on the results of the testing Sirius XM and the WCS Coalition each performed in Ashburn, Virginia,[86] we are adopting rules, as explained below, that are crafted to limit the potential for harmful interference to satellite radio users in

[84] Harmful interference is defined as: "Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with [the ITU] Radio Regulations. 47 C.F.R. § 2.1.

[85] The WCS Coalition was founded by the Wireless Communications Association International, Inc. ("WCA") and includes Horizon Wi-Com LLC ("Horizon"), AT&T Inc., Comcast Corporation, NTELOS Inc. and NextWave Broadband Inc., who collectively hold virtually all the 2305-2320/2345-2360 MHz WCS spectrum within the United States. *See* WCS Coalition Comments (dated Feb. 14, 2008) at 1, n.1.

[86] See paras. 55-58 and 93-96, *infra*.

the SDARS band and foster the provision of mobile services by WCS providers. Specifically, we decrease the power limit for mobile device operations in WCS spectrum Blocks A and B, and the 2.5-megahertz portions of WCS Blocks C and D that are furthest removed from the SDARS band (*i.e.*, 2305-2317.5 and 2347.5-2360 MHz) from the current 20-W EIRP limit to a 250-mW average EIRP per 5 megahertz limit. Mobile and portable devices using TDD are limited to an uplink duty cycle of 38 percent. Mobile and portable devices using FDD technology are limited to an uplink duty cycle of 25 percent and are restricted to transmitting in the 2305-2317.5 MHz band.[87] WCS mobile and portable devices are not permitted to operate in the 2.5-megahertz portions of WCS Blocks C and D closest to the SDARS band (*i.e.*, 2317.5-2320 and 2345-2347.5 MHz). WCS mobile and portable devices must also use ATPC when operating, so the device operates with the minimum power necessary for successful communications.[88]

30. For mobile and portable WCS 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 also relax the OOBE attenuation factors of 110 + 10 log (P) dB and 93 + 10 log (P) dB, respectively, that currently apply to these devices' emissions into the 2320-2345 MHz SDARS band. Specifically, as measured over a 1-megahertz resolution bandwidth, these WCS mobile and portable devices' OOBE must be attenuated below the transmitter power P 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, where P is the transmitter output power in Watts.[89] In addition, the OOBE from WCS mobile and portable devices must 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.

31. Furthermore, we relax the OOBE attenuation required for WCS customer premises equipment (CPE) stations. Specifically, for fixed CPE transmitting with more than 2-W average EIRP, the power of any emissions must be attenuated by a factor of not less than 43 + 10 log (P) dB on all frequencies between 2305-2320 MHz and on all frequencies between 2345-2360 MHz that are outside the licensed band of operation, not less than 75 + 10 log (P) dB on all frequencies in the 2320-2345 MHz band, not less than 43 + 10 log (P) dB in the 2300-2305 and 2360-2362.5 MHz bands, not less than 55 + 10 log (P) dB in the 2362.5-2365 MHz band, not less than 70 + 10 log (P) dB in the 2287.5-2300 MHz and 2365-2367.5 MHz bands, not less than 72 + 10 log (P) dB in the 2285-2287.5 and 2367.5-2370 MHz bands, and not less than 75 + 10 log (P) dB below 2285 MHz and above 2370 MHz.

32. For fixed CPE transmitting with 2 watts average EIRP or less, the power of any emissions must be attenuated by a factor of not less than 43 + 10 log (P) dB on all frequencies between 2305-2320 MHz and between 2345-2360 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. In addition, OOBE must 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

[87] Average power is determined only when a device is transmitting and does not include periods of time when the device is turned off.

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

[89] Under current Section 27.53(a)(9), portable devices in the 2305-2315 MHz band may operate subject to an OOBE attenuation factor of 93 + 10 log (P) dB into the SDARS band, provided that they meet certain technical requirements. 47 C.F.R. § 27.53(a)(9).

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.

33. For WCS base stations supporting WCS mobile, portable, and CPE devices, we adopt an OOBE attenuation factor below the transmitter power P of not less than 43 + 10 log (P) dB on all frequencies between 2305-2320 MHz and on all frequencies between 2345-2360 MHz that are outside the licensed band of operation, not less than 75 + 10 log (P) dB on all frequencies in the 2320-2345 MHz band, not less than 43 + 10 log (P) dB in the 2300-2305 and 2360-2362.5 MHz bands, not less than 55 + 10 log (P) dB in the 2362.5-2365 MHz band, not less than 70 + 10 log (P) dB in the 2287.5-2300 MHz and 2365-2367.5 MHz bands, not less than 72 + 10 log (P) dB in the 2285-2287.5 and 2367.5-2370 MHz bands, and not less than 75 + 10 log (P) dB below 2285 MHz and above 2370 MHz. All of these emission limits will be measured over a 1-megahertz resolution bandwidth.

34. Moreover, we relax the current 2-kW power limit for base and fixed station operations in WCS Blocks A and B[90] by measuring the power on an average, rather than peak, basis and adopt a peak-to-average power ratio (PAPR) of 13 dB to better enable the use of technologies such as Code Division Multiple Access (CDMA), Wideband CDMA (WCDMA), and Orthogonal Frequency Division Multiplexing (OFDM).[91] We also recognize that the OFDM-based technologies currently contemplated for various fourth generation (4G) air interface technologies that could be deployed in this band are being improved in order to reduce peak power and thus, by extension, the PAPR on the uplink, which is a source of SDARS licensees' concerns regarding interference from WCS operations. Further, to minimize the potential impact on satellite radio users, we are retaining the more stringent 2 kW peak EIRP limit for base and fixed station operations in WCS Blocks C and D, which are immediately adjacent to satellite radio downlinks in the SDARS band.

35. As discussed in more detail below, we are also requiring that WCS entities coordinate the deployment of their base stations with the National Aeronautics and Space Administration's (NASA's) Deep Space Network Facility at Goldstone, CA, which operates below 2300 MHz, and with AMT operations at various locations, which operate on frequencies above 2360 MHz.

36. In this Report and Order, we also seek to promote broadband competition and facilitate the development and provision of innovative broadband services, including mobile broadband services, to the American public in the 2305-2320 and 2345-2360 MHz bands allocated to WCS.[92] The actions we

[90] 47 C.F.R § 27.50(a)(1).

[91] CDMA is a wideband spread-spectrum technology that, *inter alia*, employs a special coding scheme, with each signal assigned a digital code. OFDM is a digital multi-carrier modulation scheme in which each signal is split into multiple smaller sub-signals that are then transmitted simultaneously at different frequencies to the receiver. But OFDM-based technologies can exhibit infrequent undesired power spikes. The larger the power spike, the greater the magnitude of the PAPR. There are, however, a number of solutions, both theoretical and practical, that can be used to substantially mitigate the effects of the PAPR. Examples of PAPR reduction include the use of simultaneously transmitted independently modulated streams in the uplink, based on Discrete Fourier Transform Spread-OFDM (DFTS-OFDM), as well as interleaved sub-carriers schemes that are currently being implemented in long term evolution (LTE) networks. Although such schemes are not part of the IEEE's 802.16e standard, the IEEE 802.16m study group is working on a similar scheme for its uplink/reverse link.

[92] WCS licensees may provide any service for which their frequency bands are allocated, including fixed, mobile, radiolocation, and audio broadcasting-satellite services. *See* 47 C.F.R. §§ 2.106, 27.2(a). WCS proposals are based in large part on the desired use of the WiMAX, which is a protocol based on the harmonized IEEE 802.16/ETSI High Performance Metropolitan Area Network (HiperMAN) standard. WiMAX is sometimes referred to as the Wireless Metropolitan Area Network (WirelessMAN) standard and is used to provide fixed and mobile broadband services over distances ranging up to 10 miles (16 km), with average cell ranges for most WiMAX networks in the 4-5 mile range (6.4-8 km), depending, *inter alia*, on the frequency. *See* "What is the Range of WiMAX?" at http://www.wimax.com/education/faq/faq/31. In fixed WiMAX networks, both the base stations and subscriber (continued...)

take in this order are designed to further our strategic broadband goal that "[a]ll Americans should have affordable access to robust and reliable broadband products and services."[93] In achieving this critical broadband goal, we must also safeguard the public's interest in continuing to receive and enjoy diverse satellite radio services, which are provided in the interstitial 2320-2345 MHz SDARS band. The relaxed technical rules that we adopt today and other related actions are intended to limit the potential for harmful interference to satellite radio users, while enabling WCS licensees to deliver mobile broadband services to the public, including to individuals residing in rural and underserved areas of the United States.

B. Systems Descriptions

37. *Descriptions of Satellite Radio Network Designs.* Sirius XM operates two satellite radio networks, the Sirius Satellite Radio, Inc., network and the XM Radio, Inc., network. We will refer to these as the Sirius network and the XM network, respectively. The Sirius network provides service directly to subscribers via a fleet of three satellites in highly-elliptical orbits (HEOs) and a satellite in geostationary satellite orbit (GSO) at the 96° West Longitude (W.L.) orbital location.[94] Sirius has also been granted authority to launch and operate a satellite to eventually replace two of its three in-orbit non-geostationary orbit (NGSO) satellites,[95] but has filed an application to convert this NGSO replacement satellite into a GSO satellite.[96] The Sirius network serves subscribers throughout the conterminous United States and includes a network of terrestrial repeaters in urban areas to re-transmit the SDARS signal to subscribers in areas where the satellite signal is blocked or degraded. That is, the terrestrial repeaters are deployed in order to maintain adequate signal power in areas where there are tall buildings, tunnels, heavy foliage, or other obstructions.[97] The XM network provides its service directly to

(Continued from previous page)

stations are stationary during use. In mobile WiMAX networks, subscriber stations (mobile and portable devices) may move during operation. Additional information regarding WiMAX technologies and their deployment is available on the WIMAX Forum's website. *See* http://www.wimaxforum.org/home/. *See* WCS Coalition Comments at 4-7, 27-28, 30-32, 34; WCS Coalition Reply Comments at 2-8. Although the WCS Coalition has indicated that WCS licensees would prefer to implement systems based on TDD technology, we are not prohibiting the implementation of WCS systems based on FDD technology. *See* WCS Coalition *Ex Parte* dated January 29, 2010, at 2.

[93] *See* FCC Strategic Plan for FY 2009-2014 at 6, available at http://www.fcc.gov/omd/strategicplan/#goals. The broadband goal also provides that our "[r]egulatory policies must promote technological neutrality, competition, investment, and innovation to ensure that broadband service providers have sufficient incentive to develop and offer such products and services." *Id.*

[94] The Commission originally licensed Sirius to launch and operate 2 satellites in geostationary orbit at the 80° and 110° West Longitude orbital locations. *1997 Sirius Authorization Order*, 13 FCC Rcd at 7971, 7994. Sirius later requested, and was granted, authority to change its satellite configuration from two geostationary satellites to three satellites in a highly elliptical non-geostationary orbit (NGSO). *Sirius Satellite Radio Inc., Minor Modification of License to Construct, Launch and Operate a Non-Geostationary Satellite Digital Audio Radio Service System*, Order and Authorization, 16 FCC Rcd 5419 (Int'l Bur. 2001). Sirius brought its first geostationary SDARS satellite, Sirius FM-5, into operation on August 25, 2009. *Sirius Satellite Radio Inc., Application for Authority to Launch and Operate SIRIUS FM-5, a Geostationary Satellite, to Provide Satellite Digital Audio Radio Services*, IBFS File No. SAT-LOA-20060901-00096 (granted April 16, 2007).

[95] *See* Satellite CD Radio, Inc., Application for Modification of Authority, IBFS File No. SAT-MOD-20080521-00110 (granted Sept. 17, 2008).

[96] *See* Satellite CD Radio, Inc., Application for Authority to Launch and Operate the FM-6 Satellite, IBFS File No. SAT-LOA-20100409-00072 (filed April 9, 2010).

[97] *See, e.g., Sirius Satellite Radio, Inc., Application for Special Temporary Authority to Operate Satellite Digital Audio Radio Service Complementary Terrestrial Repeaters*, Order and Authorization, 16 FCC Rcd 16773 (Int'l Bur. 2001) ("*Sirius STA Order*"). *See also Sirius Satellite Radio Inc.*, Order, FCC 08-176 (adopted July 25, 2008) ("*Sirius Consent Decree Order*"). Sirius states that it plans to deploy a significant number of additional terrestrial repeaters in the future. *See* Sirius Form 10-K at 18.

subscribers via satellites located at the nominal geostationary orbit locations of 85° W.L. and 115° W.L.[98] From these orbital locations, the XM network is able to provide service to the conterminous United States, as well as parts of Alaska.[99] The XM system also includes a network of terrestrial repeaters, greater in number than those of the Sirius system, which are used to re-transmit XM's signal in areas where the satellite signal may be degraded or obstructed by tall buildings, heavy foliage, and/or tunnels.[100] Sirius XM operates all terrestrial repeaters pursuant to grants of special temporary authority (STA), which authorize the operations of terrestrial repeaters while this rulemaking proceeding is pending.[101] Prior to September 11, 2009, neither Sirius nor XM operated repeaters outside the conterminous United States.[102] On September 11, 2009, however, Sirius XM was granted STA to operate 20 SDARS terrestrial repeaters in the Commonwealth of Puerto Rico for a period of 180 days.[103]

38. The Sirius and XM networks each use their full 12.5 megahertz of spectrum to deliver content to their respective SDARS receivers. To overcome signal obstructions and impairments, both networks transmit multiplexed digital data streams from their satellites to the users' receivers using time, frequency, and spatial signal diversity techniques. A terrestrial repeater channel may also be present if the user receiver is in an area where repeaters are deployed. Each licensee's network transmits time-diverse satellite channels on multiple frequencies allocated within the SDARS licensee's spectrum from two spatially-separated satellites in view of the users' locations.[104] Signal diversity is necessary to reduce outages due to a wide range of impairment factors that include electromagnetic interference and signal obstruction by buildings, hills, and trees.[105] The data streams transmitted by the satellites are combined in the receivers to provide diversity gain. The satellite signals are designed such that reception may be possible even when the signals from one of a licensee's satellites are blocked. Thus, the two

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[98] *1997 XM Authorization Order*, 13 FCC Rcd at 8850 ¶¶ 51-52; *2005 XM Authorization Order*, 20 FCC Rcd at 1620 ¶ 1.

[99] *See SDARS Merger Order*, 23 FCC Rcd at 12355 ¶ 12..

[100] *Id. See also XM Radio Inc., Application for Special Temporary Authority to Operate Satellite Digital Audio Radio Service Complementary Terrestrial Repeaters*, Order and Authorization, 16 FCC Rcd 16781 (Int'l Bur. 2001) ("*XM Radio STA Order*"); *XM Radio, Inc.*, Order, FCC 08-177 (adopted July 25, 2008) ("*XM Consent Decree Order*").

[101] Sirius Satellite Radio, Inc., Application for Special Temporary Authority to Operate Satellite Digital Audio Radio Service Complementary Terrestrial Repeaters, *Order and Authorization*, 16 FCC Rcd 16773 (Int'l Bur. 2001) (*Sirius 2001 STA Order*); XM Radio, Inc., Application for Special Temporary Authority to Operate Satellite Digital Audio Radio Service Complementary Terrestrial Repeaters, *Order and Authorization*, 16 FCC Rcd 16781 (Int'l Bur. 2001) (*XM Radio 2001 STA Order*). Since 2001, both Sirius and XM have submitted additional STA requests seeking to modify their repeater networks or to add new repeaters. A full list of SDARS STA requests are available through the International Bureau Filing System (IBFS), which is available online at http://licensing.fcc.gov/myibfs.

[102] Sirius sought authority to operate terrestrial repeaters in Alaska and Hawaii in 2006; that request remains pending. *See* Sirius Satellite Radio Inc., *Request for Special Temporary Authority to Operate Four Satellite DARS Terrestrial Repeaters in Alaska and Hawaii*, IBFS File No. SAT-STA-20061107-00131, filed Nov. 11, 2006. In addition, both Sirius and XM operate terrestrial repeaters in Canada through affiliated Canadian subsidiaries, but these repeater operations are conducted pursuant to authorizations from the Canadian government, not through Commission authorizations.

[103] *See* Application of Sirius XM Radio Inc. For Special Temporary Authority to Operate Twenty SDARS Terrestrial Repeaters in the Commonwealth of Puerto Rico, IBFS File No. SAT-STA-20081027-00210, *Order and Authorization*, DA 09-2039, 24 FCC Rcd 11827 (rel. Sept. 11, 2009).

[104] Letter from Terrence R. Smith, Sr. Vice President, Technology, and James S. Blitz, Vice President, Regulatory Counsel, Sirius XM Radio Inc., to Marlene H. Dortch, Secretary, FCC (dated Nov. 13, 2008) (Sirius XM Nov. 13, 2008, *Ex Parte*) at 2.

[105] *Id.*

satellite feeds transmitted by the Sirius and XM platforms are not interchangeable, but instead are used in complementary fashion to overcome outages due to various signal impairments to ensure that the required service is provided to consumers.[106] The Sirius XM networks rely heavily on the systems' diversity aspect to deliver high quality, continuous, broadcasts to low-cost mobile receivers from distant satellites in order to avoid the need to build a large repeater network similar to the scope of terrestrial cellular communications systems.[107]

39. *Description of Anticipated WCS Deployments.* WCS licensees have expressed a desire to deploy mobile units using WiMAX technology. Since there have not been any WCS mobile systems deployed in the United States, it is still unknown what types of mobile WCS devices and products will be widely adopted by consumers. However, in the tests they have conducted, the WCS licensees have placed an emphasis on using mobile handheld devices, such as cell phones, and data products, such as for laptop computers, to provide service. Additionally, a WiMAX network can be deployed as a cellular technology in FDD mode or TDD mode.[108] The WCS Coalition has indicated their preference for TDD, and asserts that a WiMAX mobile station's transmit power level in TDD mode is a function of multiple algorithms and parameters that are primarily designed to ensure that a mobile transmits at the lowest possible power level necessary in order to minimize intra-system interference and maximize battery life.[109] Under real-world deployment conditions, the mobile device transmit power varies dynamically over time and location. Moreover, the WCS Coalition contends that in a TDD configuration, the mobile station would transmit only during the uplink portion of a frame and only when it has packets to transmit. The length of these packets (bursts) is a function of the duty cycle (*i.e.*, how much of a transmission frame a mobile device has been allocated) and application model (traffic pattern), which is commonly biased towards the downlink. According to the WCS Coalition, the result of these factors is that the mobile station in a typical WiMAX deployment is almost always operating at power levels well below its allowable maximum.[110]

40. These SDARS and WCS system descriptions identify several points such as satellite diversity, ATPC, and duty cycle, among other things, that have been heavily debated by the parties in this proceeding. The interference modeling results considered in this proceeding are affected by the assumptions used to define the mobile device operation (and depending upon those assumptions, whether a corresponding reduction in interference levels should be assumed). In addition to the analyses and previous individual test results submitted by the parties, we also have the results of the testing Sirius XM and the WCS Coalition each conducted in Ashburn, Virginia with FCC staff and interested parties present. Below, we evaluate the potential interference that may be caused by a WCS mobile transmitter

[106] *Id.*

[107] *See* Sirius XM Nov. 13, 2008, *Ex Parte*. Sirius XM reiterates that the multiple satellite feeds are not for redundancy and that the loss of one feed would degrade the service received by satellite radio subscribers. It points out further its earlier objection to the proposal by the WCS Coalition to permit an out-of-band emissions (OOBE) mask for WCS mobile devices that would allow higher levels of OOBE interference at the WCS/satellite radio band edge and then require higher levels of attenuation deeper inside the satellite radio allocation.

[108] FDD simultaneously provides separate radio transmission channels for the mobile device and the base station, so that they both may constantly transmit while simultaneously receiving signals. With TDD, a single radio channel is used a portion of the time to transmit from the base station to the mobile device, and the remaining time is used to transmit from the mobile device to the base station.

[109] *See* WCS Coalition Comments, Attachment B, at 6.

[110] *See* WCS Coalition Comments, Attachment B, at 6. Sirius XM disputes this contention. *See* Sirius XM *Ex Parte*, dated Sept. 8, 2008, Exhibit A at 14 ("Sirius XM Sept. 8, 2008, *Ex Parte*"), citing a trade magazine article: Poulin, Darcy, "How to meet the design challenges of WiMAX power amplifiers," Embedded.com, (June 10, 2008) *available at* http://www.embedded.com/design/208403248.

located in a vehicle to an SDARS receiver located in another nearby vehicle and base our decisions, in large part, on the results of the Ashburn testing.

C. WCS Mobile and Portable Device Power Limits

41. *Background.* As noted above, the current rules permit WCS mobile transmitters to operate with up to 20 W of power. However, the WCS licensees claim that no WCS mobile transmitters have been deployed because the out-of-band emissions limit of -110 dBW for WCS mobile devices in the SDARS band cannot viably be met in a mobile transmitter.[111] Thus, two fundamental issues must be considered relative to WCS mobile transmitter power as we consider revisions to the rules that would facilitate deployment of mobile WCS operations. First, there exists a potential for overload interference to the SDARS receiver that could be caused by a WCS mobile device operating in close proximity, both physically and in terms of frequency separation. Overload occurs when a receiver is unable to reject excessive energy outside its intended frequency band of operation. The second issue, which is equally important, is the effect of the power limit on the viability of the WCS mobile service. As the power level of the mobile device is reduced, the number of required base stations increases, which can make the system impractical and uneconomical to deploy.

42. Sirius XM argues that, in order to protect satellite radio consumers from WCS interference, the Commission should retain the current technical restrictions on WCS mobile and portable devices for WCS Blocks C and D.[112] Sirius XM claims that no WCS mobile or portable devices can operate on WCS Blocks C and D without causing harmful interference to satellite radio devices and argues that only WCS fixed operations should be allowed in WCS Blocks C and D.[113] For WCS mobile and portable devices operating in WCS Blocks A and B, however, in September 2009, Sirius XM proposed a power limit of 125 mW.[114]

43. The WCS Coalition proposes that WCS mobile and portable devices operating in WCS Blocks A and B be permitted to use an average EIRP of 250 mW.[115] For WCS Blocks C and D, the WCS Coalition proposes mobile and portable device EIRP limits of 50 mW/MHz (*i.e.*, 150 mW per 3 megahertz) between the 2315-2318 and 2347-2350 MHz portions of the C and D blocks, and

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[111] *See* WCS Coalition Comments at 5.

[112] *See* Sirius XM Sept. 3, 2009, *Ex Parte* presentation at 27. *See also* Sirius XM Sept. 8, 2008, *Ex Parte* at 3. Sirius XM initially proposed limiting mobile and portable devices operating in WCS blocks C and D to 1 mW EIRP. *See* Sirius Comments at 34; XM Comments at 31.

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

[114] *Id.* Sirius XM initially proposed a limit of 10 mW EIRP for WCS mobile and portable devices operating in WCS Blocks A and B.

[115] *See* WCS Coalition *Ex Parte* presentation (dated Oct. 7, 2009) at 3. Previously, the WCS Coalition proposed that all WCS mobile and portable devices that comply with its proposed out-of-band emissions limit should be allowed to transmit with an average EIRP of 250 mW. *See* Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC (dated July 22, 2008), at 4 ("WCS Coalition July 22, 2008, *Ex Parte*"). The WCS Coalition also proposed that WCS mobile and portable devices should be required to employ automatic transmitter power control (ATPC), which would generally reduce the EIRP to levels below the proposed 250-mW average EIRP. *See* WCS Coalition July 22, 2008, *Ex Parte* at 4. NextWave suggested that WCS Blocks C and D mobile and portable devices be limited to 150 mW in the 2315-2318 and 2347-2350 MHz sub-bands and to 60 mW in the 2318-2320 and 2345-2347 MHz sub-bands. *See* Letter from Jennifer M. McCarthy, Vice President, Regulatory Affairs, NextWave Wireless Inc., to Marlene H. Dortch, Secretary, FCC (dated Nov. 16, 2008) ("NextWave Nov. 16, 2008, *Ex Parte*") at 2, and Letter from Jennifer M. McCarthy, Vice President, Regulatory Affairs, NextWave Wireless Inc., to Marlene H. Dortch, Secretary, FCC (dated Nov. 26, 2008) ("NextWave Nov. 26, 2008, *Ex Parte*") at 3.

30 mW/ MHz between the 2318-2320 and 2345-2347 MHz portions of the C and D blocks (*i.e.*, 60 mW per 2 megahertz). The WCS Coalition believes that there will be little or no muting of the SDARS signal from WCS mobile and portable devices operating with these EIRP limits.[116]

44. *Measurements and Technical Analyses.* Sirius, XM, and the WCS Coalition each conducted individual measurements and technical analyses to support their proposed WCS power levels in their initial comments. Sirius and XM originally conducted tests with an SDARS receiver using an antenna mounted on the roof of a vehicle and a WiMAX signal generator connected to an antenna mounted at a height of 2 meters and attached to a cart so that the separation distance could be varied. Sirius claims the tests it conducted indicated that overload interference that would block reception of (*i.e.*, mute) the SDARS satellite signals would occur at a distance of up to 34 meters from a 250 mW WCS signal in the C block and at a distance of up to about 20 meters from a 250 mW WCS signal in the A and B blocks.[117] XM claims the tests it conducted indicated that overload interference that would mute the SDARS satellite signals would occur at a distance of up to 16 meters from a 112 mW WCS signal in the D block and a distance of up to about 13 meters from a 112 mW WCS signal in the A and B blocks.[118] Sirius' tests also showed that interference to the SDARS terrestrial signals would occur at a distance of up to approximately 23 meters from a 250 mW WCS signal in the C block and at a distance of up to approximately 15 and 18 meters from a 250 mW WCS signal in the A and B blocks, respectively.[119]

45. The WCS Coalition originally conducted tests of overload interference only for the WCS A and B blocks. For this testing, an SDARS antenna was mounted on the roof of a vehicle 48 inches from the rear bumper of the vehicle. Out-of-vehicle tests used a WCS WiMAX consumer premises equipment (CPE) device positioned in the same horizontal plane as the roof-mounted SDARS antennas at varying distances. In-vehicle tests used WCS WiMAX CPE positioned inside the same vehicle containing the SDARS equipment positioned either in the front passenger seat or the rear passenger seat. During this testing, the WCS Coalition found that muting occurred at distances of 3 meters or less. The WCS Coalition submits that these tests showed that in typical satellite-only coverage, the WCS CPE devices induced muting at distances of 2 to 13 feet outside the vehicle. The Sirius receiver experienced muting at 4 feet with the WCS WiMAX CPE at 250-mW average EIRP, and at 2 feet with the CPE at 100-mW average EIRP. The XM receiver experienced muting at 10 to 13 feet with the WCS WiMAX CPE at 250-mW average EIRP, and at 7 to 10 feet with the CPE at 100-mW average EIRP. With the WiMAX CPE antenna inside the vehicle, only one instance of muting of the XM receiver occurred with the WiMAX antenna inside the same vehicle as the XM antenna and directly below it.[120]

46. There were a number of differences between the SDARS and WCS tests, such as the power levels, bandwidths, duty cycle of the WCS signal, and various combinations WCS frequency blocks. Much of the disagreement relative to potential overload interference also stems from different findings about the path loss as a signal propagates between a WCS mobile device and an SDARS mobile receiver. The WCS Coalition and Sirius XM both measured and modeled the propagation path loss from a WCS mobile device to an SDARS mobile receiver input – with the SDARS antenna situated atop a car

[116] *See* WCS Coalition Oct. 7, 2009, *Ex Parte* presentation at 3 and 15.

[117] *See* Sirius Comments, Exhibit C at C8.

[118] XM Comments, Exhibit C, at 8 and 9. We note that these distances are equivalent to distances of 24 meters from a 250-mW WCS signal in the D block and 20 meters from a 250-mW WCS signal in the A and B blocks, given the square root relationship between distance and power. (*I.e.*, under Free Space Loss conditions, the ratio of two distances is equal to the square root of the ratio of the two powers involved.).

[119] *See* Sirius Reply Comments at 13.

[120] *See* WCS Coalition *Ex Parte* dated May 9, 2008, WCS Test Report at 3-10.

with a clear line of sight to the WCS transmit antenna – and obtained different results.[121] The WCS Coalition determined the path loss in decibels (dB) to be (50.9 + 21.8 log (D_{meters}) dB), which is approximately equal to Free Space Loss (FSL) + 12 dB at 3 meters, whereas Sirius XM determined the loss to be (42.8 + 20 log (D_{meters}) dB), or FSL + 3 dB, which is 9-dB lower than the WCS Coalition's determination. Sirius XM and the WCS Coalition each reference various technical papers in support of their respective positions on the appropriate path loss.[122]

47. The WCS Coalition also made measurements to evaluate the additional attenuation for the case when a WCS mobile device is held against the user's head or lap while a user is sitting inside of a vehicle. From these measurements, the WCS Coalition found that there was a combined additional attenuation ranging from 4.8 dB to over 14.1 dB.[123] In this testing, to determine the additional losses expected when a WCS transmitter is operated in a vehicle and an SDARS receiver is in a different vehicle or the same vehicle, the WCS Coalition placed the WCS test device inside a vehicle in a manner which also incorporated head and body losses associated with use of the WCS device.[124] The WCS Coalition explains that the basic test set-up was the same as with previous testing, *i.e.,* from the input of the transmit antenna to the output of the SDARS receive antenna, on paths of varying distances, though now obstructed by head and body and vehicle losses.[125] The position of the WCS test transmitter was varied between front and rear seats, left and right seats, ear and lap heights, with the WCS transmitting vehicle behind and in front of the SDARS receive vehicle, and with the WCS transmitter and SDARS receiver in the same vehicle.[126] The position of the SDARS test receiving antenna mounting is similarly varied between the front and rear of the roof of the vehicle, on the centerline of the roof, representative of OEM installations. The WCS Coalition explains that a total of 20 scenarios were measured, each with multiple frequency sweeps, with path distances varying from 4.4 to 7.2 meters to represent vehicles stopped at a traffic signal or in traffic.[127] The WCS Coalition calculates and displays the median measured path loss results for the various separation distances, then subtracts the WCS Coalition Propagation Model (WPM) path losses calculated for those distances, to arrive at the additional path losses by which these measured path losses exceed the unobstructed WPM model path losses: 4.8 to 14.1 dB.[128] The WCS Coalition attributes these additional losses primarily to shielding of the WCS transmit antenna by the vehicle in

[121] *See* WCS Coalition Reply Comments, Attachment B; Sirius Comments, Exhibit C.

[122] Sirius XM frequently refers to a paper presented by a member of the staff of the National Telecommunications and Information Administration at an Institute of Electrical and Electronics Engineers Vehicular Technology Society Conference entitled "Propagation for Mobile-to-Mobile Communications." *See, e.g.,* Sirius Reply Comments at 23. The WCS Coalition responds in its May 9, 2008, *Ex Parte* filing that Sirius XM's conclusion is flawed because it is based on a computational error and further, the findings of this study are based on free-standing antennas and follow free space loss. The WCS Coalition goes on to cite other papers that it contends support higher path losses for situations similar to the one at issue here where the SDARS receiving antenna is located on a ground plane (the roof of a vehicle). *See* WCS Coalition May 9, 2008, *Ex Parte* at 7-9

[123] *See* Letter from Mary N. O'Connor, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, FCC (dated Aug. 1, 2008)(WCS Coalition Aug. 1, 2008, *Ex Parte*).

[124] *Id.*, Attachment at 4 and 7.

[125] *Id.*, Attachment at 4.

[126] *Id.*, Attachment at 3 and 6-8.

[127] *Id.*, Attachment at 8-11.

[128] *Id.*, Attachment at 14. The WCS Coalition measured the path loss between a WCS transmitting antenna and an SDARS receiving antenna on a vehicle at various separation distances and found the path loss to be 50.9 + 21.8 log (D_{meters}) dB (WCS Coalition Propagation Model, or WPM) for distances from 5 feet to 50 feet (1.5 to 15 meters). *See* ¶¶ 90-91, *infra.*

which it is located from the external, roof mounted SDARS receive antenna, to head and body losses, and to other propagation factors.[129]

48. The WCS Coalition and the SDARS licensees also offer different assessments as to the capabilities of SDARS receivers to reject overload interference. Sirius XM claims that a received interfering power level of -44 dBm from WCS operations in Blocks A and B and interfering power of -55 dBm from WCS operations in Blocks C and D will cause muting of the SDARS receiver.[130] According to the WCS Coalition, however, some SDARS receivers have a very steep front end filter roll-off (*i.e.*, attenuation of adjacent-bands' signals) and are therefore better able to reject overload interference.[131]

49. Furthermore, the WCS Coalition and the SDARS licensees provide different assessments of the likelihood of receiver overload interference. The WCS Coalition argues that interference is highly unlikely and would require the coincidence of a variety of conditions to occur: both devices are operating in close geographic proximity and are stationary relative to one another; the WCS device is transmitting and operating at or near the maximum permitted power; no obstructions exist between the transmitter and receiver; there is good coupling between the antennas; and the WCS and SDARS devices are operating in adjacent frequency bands.[132] The WCS Coalition underscores that mobile handsets would operate at or close to their maximum power only rarely and will operate at 3-4 dB[133] less power 99 percent of the time.[134] Sirius XM denies each of these points claiming that devices will often be in close proximity, the devices will be side by side and stationary in heavy traffic, and there will be a high degree of antenna coupling as reflected in its testing.[135] Sirius XM also disputes the WCS Coalition's claim that WCS devices will operate at 3-4 dB below maximum power 99 percent of the time and asserts that the WCS device will often operate at its maximum power to achieve the highest available data rate.[136] Sirius XM claims that based on its analysis, up to 13 percent of SDARS users will experience interference in early deployment of WCS and up to 24 percent in later stages of deployment.[137] NextWave, a WCS licensee, disputes the basis for this analysis and counters that the predictions of interference are grossly inflated due to inappropriate assumptions, such as no consideration of ATPC or the required separation distances for vehicles located in the same traffic lane.[138] Sirius XM responds that the WCS Coalition's analysis is

[129] *Id.*, Attachment at 13 and 14.

[130] *See* Sirius Comments, Exhibit C.

[131] *See* WCS Coalition Comments at 11, n.24, and Attachment A. *See also* WCS Coalition May 19, 2008, *Ex Parte* at 7.

[132] *See* WCS Coalition Comments, Attachment B at 19; *see also, e.g.*, WCS Coalition *Ex Parte* filing dated May 5, 2008.

[133] A 3-dB reduction equates to reducing the transmitted power by one-half.

[134] *See* WCS Coalition Comments, Attachment B at 19.

[135] *See* Letter from Patrick L. Donnelly, Executive Vice President, General Counsel & Secretary, Sirius Satellite Radio Inc., and James S. Blitz, Vice President and Regulatory Counsel, XM Radio Inc., to Marlene H. Dortch, Secretary, FCC (dated May 9, 2008) (Joint Sirius/XM May 9, 2008, *Ex Parte*), Attachment at 35.

[136] *See* Letter from James S. Blitz, Vice President, Regulatory Counsel, Sirius XM Radio, Inc., to Marlene H. Dortch, Secretary, FCC (dated Sept. 8, 2008) (Sirius XM Sept. 8, 2008, *Ex Parte*) at 4, 13, and 14.

[137] *See* Letter from Robert L. Pettit, Counsel to Sirius XM Radio, Inc., to Marlene H. Dortch, Secretary, FCC (dated Oct. 2, 2008) (Sirius XM Oct. 2, 2008, *Ex Parte*).

[138] *See* Letter from Jennifer M. McCarthy, Vice President, Regulatory Affairs, NextWave Wireless Inc., to Marlene H. Dortch, Secretary, FCC (dated Nov. 16, 2008) (NextWave Nov. 16, 2008, *Ex Parte*), Technical Analysis at 4.

predicated on assumptions about the specific technologies that will be used and business plans that will be implemented, which cannot be assured.[139]

50. *Princeton, NJ Tests*. In January of 2009, Sirius XM tested a WCS device's potential to cause interference to SDARS operations in Princeton, New Jersey. Sirius XM reported that it chose this location for the testing because it receives strong satellite signals with minimal terrestrial repeater coverage on the test route. As part of the test, Sirius XM outfitted one vehicle with test equipment that generated a mobile WiMAX waveform in various WCS sub-bands and an in-vehicle antenna, and a second vehicle with Sirius and XM satellite radio receivers and typical roof-mounted antennas. Sirius XM tested the generated WiMAX test signals in the WCS D block at 150 mW transmit power and an OOBE attenuation of 55 + 10 log (P) dB at the SDARS band edge, in the WCS C block at 150 mW transmit power and an OOBE attenuation of 60 + 10 log (P) dB at the SDARS band edge, and in the lower WCS B block (*i.e.*, 2310-2315 MHz) at 250 mW transmit power and an OOBE attenuation of 60 + 10 log (P) dB at the SDARS band edge.[140]

51. During the testing, Sirius XM monitored an XM upper-ensemble channel[141] and a Sirius channel for muting while testing three different WCS use cases – handheld, laptop, and dashboard installation – to simulate the WCS Coalition's proposal for the WCS band emission levels. Specifically, Sirius XM tested WCS handheld use in the WCS D, C, and B (lower) blocks, and laptop and dashboard use in the WCS C block. Sirius XM reported that it observed severe interference from the WCS signal for long durations over large distances and in typical traffic patterns. Sirius XM also reported that interference occurred in typical mobile conditions where the satellite receivers had a clear view of the sky without any obstructions. In addition, Sirius XM reported that the WCS mobile devices caused interference in areas near Princeton where repeater coverage was present. In its report, however, Sirius XM did not specify whether the WCS interference was attributable to overload or OOBE interference.[142]

52. The WCS Coalition filed *ex parte* comments on Sirius XM's testing in New Jersey after a meeting with Sirius XM representatives and Commission staff regarding the testing.[143] In its filing, the WCS Coalition alleged flaws in the testing that it contends had led Sirius XM to claim that its SDARS receivers are vulnerable to interference from WCS mobile operations. Specifically, the WCS Coalition argues in its March 9, 2009, *ex parte* filing that the testing Sirius XM conducted did not reflect "real world" operating conditions for the WCS transmitters. As an initial matter, the WCS Coalition states that Sirius XM did not employ the stepped OOBE limits that the WCS Coalition has proposed for all mobile devices, which Sirius XM confirmed was true during the meeting. Also, the WCS Coalition noted that Sirius XM stated that the mobile device it used during the testing did not employ ATPC, which the WCS Coalition has proposed be required for all WCS mobile devices.[144] We note also Sirius XM recently

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[139] *See* Letter from Terrence R. Smith, Chief Engineering Officer, and James S. Blitz, Vice President, Regulatory Counsel, Sirius XM Radio Inc., to Marlene H. Dortch, Secretary, FCC (dated Nov. 20, 2008) (Sirius XM Smith/Blitz Nov. 20, 2008, *Ex Parte*) at 4 (summarizing a meeting with Commission staff on Nov. 16, 2008).

[140] *See* Sirius XM *Ex Parte* dated February 10, 2009. Sirius XM used a "flat mask" of 60 + 10log (P) dB, rather than the WCS Coalition's proposed stepped mask, because, it contends, two WCS Coalition members – Nextwave Wireless and Horizon Wi-Com – believe that such a mask is roughly equivalent to the WCS Coaltion's stepped mask and is therefore an acceptable alternative to the stepped mask. *See* Sirius XM *Ex Parte* dated April 8, 2009, at 3.

[141] In the XM network, each of the two XM satellite and terrestrial repeater sub-bands are divided into separately transmitted lower ensemble signals and upper ensemble signals.

[142] *See* Sirius XM *Ex Parte* dated February 9, 2009.

[143] *See* WCS Coalition *Ex Parte* filing dated March 9, 2009, at 2.

[144] *Id.*

submitted an *ex parte* video that is contends demonstrates harmful interference will occur to SDARS receivers under the WCS rules proposed in the *WCS/SDARS Technical Rules Public Notice*.[145] The WCS Coalition believes that the demonstration is not representative of how an actual mobile WiMAX system will perform, but instead, was designed and implemented to maximize potential interference.[146]

53. In addition, the WCS Coalition stated that Sirius XM also stated that it did not conduct any testing over the A block or upper B block channels, which it concedes are less likely to interfere with SDARS operations. The WCS Coalition further noted that Sirius XM stated that the test transmitter used in New Jersey was operated with a 25-percent duty cycle, which the WCS Coalition contends is not representative of how a WCS mobile would likely operate.[147] Instead, as the WCS Coalition subsequently noted, a duty cycle of at least 35 percent would be needed to facilitate the provision of a viable broadband service.[148] During the meeting, Sirius XM also conceded that it did not conduct the tests in a manner that would permit the Commission to determine how much, if any, of the purported interference actually was caused by OOBE. As a result, the WCS Coalition contends, the testing did not illustrate the need for the onerous OOBE restrictions that have been proposed by Sirius XM. The WCS Coalition also contends that Sirius XM implemented its test setup in such a manner that leakage from the power amplifier could have been a material contributor to the interference.[149]

54. In light of these differences, Sirius XM urged the Commission to require additional testing be performed by a third party or under Commission supervision that would examine various combinations of conditions, including different SDARS receivers, an actual WCS mobile device, multiple vehicles, stationary vehicles, and vehicles in motion.[150] The WCS Coalition agreed to conduct further tests with Sirius XM and FCC staff present during the testing. Consequently, on July 28 and 29, 2009, in Ashburn, VA, Sirius XM and the WCS Coalition, with FCC staff present, each conducted testing of a WCS signal's potential to interfere with the reception of Sirius XM's SDARS transmissions.[151] The WCS Coalition performed its testing on July 28 and Sirius XM performed its testing on July 29.[152]

55. *Ashburn, VA Tests.* During the tests it performed in Ashburn, the WCS Coalition demonstrated actual WiMAX equipment under several use scenarios. Sirius XM states that the WCS Coalition's Ashburn testing demonstrates that a certain configuration of mobile WCS devices that are operated under specific usage patterns will cause only limited interference to the reception of Sirius XM's signal. Sirius XM also states that although the operating parameters were not fully transparent, the WCS mobile device's signal transmitted at a variety of operating powers and WCS frequencies generally did

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[145] *See* Sirius XM *Ex Parte* filing dated May 6, 2010 at 2.

[146] *See* WCS Coalition *Ex Parte* Presentation dated May 12, 2010, at 1-2.

[147] *See* WCS Coalition *Ex Parte* filing dated March 9, 2009, at 2. The WCS Coalition subsequently stated that it is common for commercial WiMAX systems to allocate approximately 38 percent of each frame to uplink (*i.e.*, user device) transmissions. *See* WCS Coalition *Ex Parte* filing dated March 31, 2010, at 2.

[148] *See* WCS Coalition *Ex Parte* filing dated January 29, 2010, at 4.

[149] *See* WCS Coalition *Ex Parte* filing dated March 9, 2009.

[150] *See* Sirius XM *Ex Parte* filings of May 9, 2008, May 19, 2008, May 20, 2008, June 4, 2008, June 13, 2008, June 16, 2008, and July 2, 2008.

[151] We refer to these tests henceforth as the "Ashburn tests," "Ashburn testing," or "testing in Ashburn."

[152] *See* Sirius XM *Ex Parte* filing dated August 3, 2009, and WCS Coalition *Ex Parte* filing dated August 4, 2009. *See also* WCS Coalition *Ex Parte* filing dated August 4, 2009. FCC staff from the Commission's Office of Engineering and Technology, the International Bureau, and the Wireless Telecommunications Bureau observed the Ashburn, VA testing sessions. For a detailed description of the testing, see Appendix E.

not mute Sirius XM's audio channel signal in the other test vehicle.[153] Sirius XM believes its own Ashburn testing demonstrates how different mobile WCS configurations and use cases (such as those proposed by the WCS Coalition) would cause muting of Sirius XM's signal, even at transmitter/receiver separation distances greater than 25 meters and in the presence of a Sirius XM terrestrial repeater. During its testing, Sirius XM used test equipment to simulate WiMAX operations. Although Sirius XM believes its testing showed that some mobile use of the WCS spectrum could be allowed, it believes that such use must be strictly controlled and limited to certain technologies and test cases that can be demonstrated not to prevent reception of the SDARS signal.[154]

56. The WCS Coalition states that its testing in Ashburn demonstrated that WCS interference to SDARS will occur only in the rarest of real-world circumstances if the WCS Coalition's proposed rules for WCS are adopted, especially given that there was only one instance of muting of the SDARS receiver during the WCS Coalition's drive testing. The WCS Coalition also contends that Sirius XM's testing in Ashburn was not realistic and did not reflect how any practical two-way broadband system would operate on the WCS frequencies. Specifically, the WCS Coalition believes that the SDARS muting that resulted from Sirius XM's use of a 5-megahertz WiMAX carrier in the WCS D block that was immediately adjacent to the SDARS band edge is a worst-case scenario that would not occur with an operating WCS system. The WCS Coalition states that it is unrealistic to expect an operational WCS two-way broadband system to operate a full 5-megahertz carrier in the WCS C and D blocks because the resultant filter that would be necessary to meet the proposed OOBE limits would be too large to include in a mobile device. In summary, the WCS Coalition believes that the testing demonstrated that out-of-band emissions interference from a WCS mobile device into an SDARS receiver will only occur under worst-case artificial conditions.[155]

57. FCC staff observed Sirius XM's test using test equipment to generate a WiMAX signal and the WCS Coalition test using an actual WCS device communicating with a WCS base station. Both individual tests were conducted while the simulated and actual WCS end-user device was operating in close geographic proximity to an original equipment manufacturer (OEM) and aftermarket SDARS receiver. FCC staff observed that test scenario employed by Sirius XM's signal generator produced a five-megahertz-wide WiMAX carrier in the WCS D block, immediately adjacent to the SDARS band edge, which produced several instances of SDARS muting. Staff observed too that when Sirius XM moved its test WCS signal two megahertz away from the SDARS band edge, only slight muting of the SDARS signal occurred.

58. During the WCS Coalition's testing, drive tests were performed for a total of six WCS mobile device configurations; each configuration was tested at least once, and a few of the configurations were tested two or more times. No muting was observed when the edge of the WCS signal was separated from the SDARS band by 5 megahertz. Although the staff observed in one instance that the SDARS signal was muted when the WCS mobile device was being operated with a 250 mW EIRP over 5 megahertz, ATPC employed, and a 2.5-megahertz guard band between the WCS signal and the SDARS band, during the remainder of the WCS Coalition's testing with these same operating conditions, no muting of the Sirius or XM signal was observed even though there were hundreds of instances during the drive tests when conditions were such that interference could have occurred.[156] Significantly, no muting

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

[154] *Id.*

[155] *See* WCS Coalition *Ex Parte* filing dated August 4, 2009, at 1-2.

[156] During the drive tests conducted in the two sedans rented by the WCS Coalition, FCC staff saw only a short interval of satellite radio receiver muting during one test scenario, at a single location on the route, with the XM original equipment manufacturer (OEM) satellite radio receiver. In this occurence, the WiMAX link was operating with a 5-megahertz-wide signal comprised of 2.5-megahertz portions each of WCS Blocks D and A, the traffic

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