Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Investigation of the Spectrum Requirements for Advanced Medical Technologies	)	ET Docket No. 06-135
	)	
Amendment of Parts 2 and 95 of the Commission's Rules to Establish the Medical Device Radio Communications Service at 401-402 and 405-406 MHz	)	RM-11271
	)	
DexCom, Inc. Request for Waiver of the Frequency Monitoring Requirements of the Medical Implant Communications Service Rules	)	ET Docket No. 05-213
	)	
Biotronik, Inc. Request for Waiver of the Frequency Monitoring Requirements for the Medical Implant Communications Service Rules	)	ET Docket No. 03-92

To: The Commission

REPLY COMMENTS OF GE HEALTHCARE

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INTRODUCTION AND SUMMARY

GE Healthcare ("GEHC") hereby submits its reply to the comments submitted by other parties in response to the Commission's Notice of Proposed Rulemaking ("*NPRM*") and Notice of Inquiry ("*NOI*") in this proceeding. 1/ As discussed herein, the record before the Commission supports the allocation of additional spectrum for next generation wireless medical devices, such as the body sensor networks ("BSNs") described in GEHC's comments. In these

1/ *Investigation of the Spectrum Requirements for Advanced Medical Technologies*, Notice of Proposed Rulemaking, Notice of Inquiry and Order, FCC 06-103, 21 FCC Rcd 8164 (rel. July 18, 2006) ("*NPRM/NOI*").

reply comments, GEHC proposes specific 400 MHz and 2300 MHz bands where such an allocation could be made, and explains how the low power, short range and frequency agile BSN devices could coexist with high power, long range incumbent services without causing harmful interference.

I. COMMENTERS SUPPORT NEW SPECTRUM AND RULES CONSISTENT WITH GEHC'S PROPOSALS RELATING TO BODY SENSOR NETWORKS

The record reflects broad support for the allocation of additional spectrum for wireless medical devices. A number of commenters joined with GEHC in establishing the need for additional spectrum. As Medtronic stated, "now is the time to identify possible additional spectrum bands to support future advanced wireless medical uses, as the communications needs of medical devices will expand greatly in the coming years." 2/ Partners Healthcare System ("Partners") reported that their WMTS systems are at maximum capacity and that unlicensed devices are also facing capacity constraints as they proliferate within the hospital setting. 3/ Partners also raised quality of service concerns given that both WMTS and unlicensed devices have experienced harmful interference and require "active management" with regard to the number and types of devices operating. 4/ The Alfred Mann Foundation ("AMF"), like GEHC, called for additional spectrum specifically to support new devices that cannot be accommodated in the 401-406 MHz MedRadio band. AMF explained that WMTS and Part 90 spectrum above 450 MHz is too congested and populated with commercial, high-power systems that could preclude the operation of lower-power wireless medical devices, while the emissions limits for unlicensed

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2/ Medtronic, Inc. Comments at 17.

3/ Partners Healthcare System, Inc. ("Partners") Comments at 2-3.

4/ *Id.*

operations are too restrictive to permit the kind of wideband microstimulator devices AMF is developing. 5/

In its comments, GEHC described the significant potential benefits of body sensor networks ("BSNs") – very short range networks consisting of multiple body-worn sensors/nodes and a nearby hub station. Such networks would replace the tangle of sensor cables that today act to tether most patients to their bedside monitoring units and frequently result in disconnected sensors. A number of other commenters also noted industry efforts underway to develop body-worn wireless sensors. 6/ To be viable, the body-worn sensors must be very low cost devices. As AMIS notes, the low cost of body-worn sensors will reduce health care costs while improving care to patients. 7/

Similar to next generation medical devices being developed by the Cleveland FES Center ("Cleveland"), 8/ BSNs would be a high bandwidth / low latency application. The high bandwidth (channel bandwidth would be approximately one megahertz) enables the relatively low duty cycle needed to achieve necessary battery life. With such channel size, however, spectrum reuse becomes an issue. In order to ensure sufficient capacity in high patient density environments such as hospitals, GEHC has determined that a minimum of five to ten megahertz of available spectrum (*i.e.*, after any sharing) will be needed. Thus, GEHC disagrees with any suggestions

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5/ Alfred Mann Foundation ("AMF") Comments at 10-11.

6/ *See, e.g.*, Medtronic Comments at 6 (referencing "Body Area Networks"); AMI Semiconductor, Inc. ("AMIS") Comments at 2 ("many developers are investigating the incorporation of body-worn sensors to monitor patients' vital signs, eliminating a wired connection and providing additional patient mobility"); Intel Corporation ("Intel") Comments at 4 (noting advantages of wireless sensors).

7/ AMIS Comments at 4. Ideally, devices would be sufficiently low cost to be regarded as disposable devices, thereby eliminating the need for sterilization between uses, as AMIS notes. *Id.*

8/ Cleveland FES Center ("Cleveland") Comments at 1-2.

that body-worn sensor devices will necessarily be able to operate within either the 402-405 MHz "core" MedRadio band, or the "wing" bands at 401-402 and 405-406 MHz. 9/

Due to the importance of preserving capacity in any band allocated for new wireless medical devices, GEHC joins with Partners and Intel in recommending that permitted devices be limited to those involved in the monitoring, diagnosing or treatment of a patient. 10/ GEHC also agrees with several commenters that the rules should nevertheless be flexible enough to enable use of the devices by patients, and outside of health care facilities, such as in patients' homes. 11/

In its comments, GEHC noted the benefits of providing for some type of spectrum protocol that could promote device coexistence and a predictable quality of service. Other commenters made similar recommendations. For example, Partners urged the Commission to "require device manufacturers to develop industry standards, similar to the IEEE 11073 Medical Device Communications efforts, to ensure coexistence between device communications protocol." 12/ Medtronic and Intel also expressed support for a spectrum protocol or industry standard. 13/

9/ *See* AMIS Comments at 3; Medtronic Comments at 6, 13.

10/ *See* Partners Comments at 5, 7 (noting that eligible devices should be those regulated by the FDA); Intel Comments at 5.

11/ *See* NDI Medical Comments at 2 (urging the Commission not to limit use to clinical settings); Cleveland Comments at 2 ("allow use in any environment"); Partners Comments at 4 (noting need for home-based monitoring); Intel Comments at 4-5 (arguing that operation at home and by patients should be permitted).

12/ Partners Comments at 7.

13/ *See* Medtronic Comments at 13 (stating that a protocol is "required to support a necessary level of communications reliability for short range medical applications"); Intel Comments at 6.

Finally, GEHC disagrees with the blanket statement of AMIS that "the use of wireless devices in life-critical applications should be strongly discouraged." 14/ Wireless technology may offer significant benefits for many life-critical applications. With the proper regulatory framework, sufficient controls and protections can be put in place to significantly mitigate the risks of interference or malfunction.15/ Therefore, GEHC believes that these determinations should be left to medical device manufactures to be made on a case-by-case basis through FDA-required risk management processes such as EN ISO 14971.

II. LOW POWER BSN DEVICES COULD SHARE SPECTRUM WITH INCUMBENTS IN THE 400 MHZ AND 2300 MHZ BANDS

In its comments, GEHC explained why the existing MICS/proposed MedRadio, WMTS, and unlicensed Part 15 bands are not suitable for BSN operations. 16/ In these reply comments, GEHC proposes a number of frequency bands that would be suitable for BSN operations on a secondary status basis, without affecting the operations of incumbent users. In the attached Appendix A, GEHC submits an Engineering Analysis which explains why BSN devices should be able to successfully coexist with high-power, long-range ("HPLR") systems found in the proposed frequency bands. GEHC proposes that BSN devices be licensed-by-rule to eligible health care providers, like current WMTS and MICS devices, but that operations be permitted both inside and outside of medical facilities.

Power Levels. At the outset, it should be emphasized that GEHC's proposed BSN systems are low power, short range devices. Although GEHC is not prepared at this time to

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14/ AMIS Comments at 4.

15/ *See* Medtronic Comments at 18 (noting the role of wireless devices to support life-critical functions and recognizing the ability to develop a regulatory framework capable of providing adequate protection for such operations).

16/ GEHC Comments at 7-11.

propose specific power limits to govern medical devices in the proposed allocation, GEHC expects that BSN devices will operate with maximum emissions in the range of -30 dBm for operations at 400 MHz, and -10 dBm EIRP for operations at 2300 MHz.

Spectrum Requirements. In order to avoid capacity constraints within high patient-density facilities such as hospitals, 5-10 megahertz of spectrum will need to be available for BSN communications at any given location, *after* taking into account spectrum that may be in use by incumbent spectrum users at any point in time and thereby not available for BSN communications. Thus, due to the need to share with other spectrum users, the Commission should allocate a sufficiently large quantity of spectrum such that the frequency agile and low power BSN devices will be able to avoid frequencies in use by other licensees and still be able to access 5-10 megahertz of clear spectrum within the allocated band(s). 17/ If the allocation is made in separate blocks within a particular frequency band, then the frequency blocks should be separated by no more than 150 megahertz, in order to reduce the cost of component parts and overall manufacturing costs. The allocation being requested here need not be limited to BSN devices; other medical devices could be included as well, such as the microstimulators proposed in the AMF comments. 18/ Finally, as noted above, the commercial acceptance of BSN devices will depend on whether manufacturers can keep sensor costs low (*e.g.*, low enough to be disposable in some cases), which in turn will depend on manufacturers' ability to obtain low cost, off-the-shelf

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17/ *See* "Engineering Analysis" attached as Appendix A, at 2.

18/ Presumably, the Commission would want to include this allocation under the rubric of the MedRadio service. The Commission could rely on the same licensee eligibility provisions that will apply to the MedRadio service, but GEHC urges the Commission not to limit operations to medical facilities, as many of the benefits of BSNs could be realized in home environments as well. Technical rules for the new band will need to be different from the MedRadio rules in order to limit the allocation to devices that cannot operate in the 401-406 MHz MedRadio allocation, due, for example, to high bandwidth or throughput requirements. Any Further Notice issued by the Commission regarding the new allocation should seek comment on the technical rules for the band.

radio components (or at least components that can be modified at a relatively modest cost). The component cost factor therefore limits the number of potential bands to those in which radio chips are already available.

Proposed Bands. Based on all of the above considerations, the specific frequency bands GEHC proposes are as follows:

- 410-450 MHz. In its comments, AMF proposed that three 6-megahertz bands below 450 MHz be allocated for new medical devices: 413-419 MHz, 426-432 MHz, and 438-444 MHz.19/ As AMF explained, these bands do not appear to be heavily congested, with most use limited to select government and amateur operations, with which low power medical devices would be able to share on a secondary, non-interference basis. 20/ As AMF also noted, the bands in the 420-450 MHz range are currently allocated for fixed, non-aeronautical mobile, radiolocation and amateur use throughout substantial portions of the ITU's three geographic regions, 21/ which could facilitate international harmonization of the bands as a home for advanced medical devices. AMF's rationale for suitability and coexistence applies equally to the entire 410-450 MHz band. Therefore, to provide greater flexibility and avoid capacity constraints and/or harmful interference among medical devices, GEHC proposes that advanced medical devices be permitted to operate anywhere within this 40-megahertz range, which is divided into two bands in the Table of Allocations:

> *410-420 MHz*. This band is used largely for narrow-band Federal Land Mobile Radio ("LMR") operations that support agency infrastructure functions at and in the vicinity of

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19/ AMF also proposed the allocation of a fourth band, 451-457 MHz, although it cautioned it was still exploring the feasibility of this band, which is fairly congested with high-power commercial transmitters, but could potentially provide a back up channel in case the first three are occupied. AMF Comments at 12-13. GEHC does not include the 451-457 MHz band as part of its proposal.

20/ AMF Comments at 13.

21/ *See* 47 C.F.R. § 2.106 (Table of Frequency Allocations) and n. 5.269, 5.270.

their stations. 22/ As the attached Engineering Analysis indicates, BSNs can operate without causing interference to such high-power, long-range ("HPLR") operations. 23/ Moreover, NASA also uses the band for space-to-space communications, which should not be affected by low power terrestrial devices. A limited number of channels are used by various Federal agencies for the fixed transmission of hydrological telemetry, but as noted by AMF, such use should not be problematic. 24/

420-450 MHz. This band is used on the Federal side primarily for radar systems, and on the non-Federal side for various amateur uses on a secondary basis. 25/ As the attached Engineering Analysis indicates, BSNs can operate without causing interference to HPLR operations such as these. 26/

According to the NTIA, "The amateur radio service has successfully co-existed with Federal fixed, mobile and radiolocation services (*i.e.*, radar) for nearly fifty years… This success is primarily due to the fact that much of the Federal spectrum usage is located away from populated areas, minimizing potential interference as well as the amateur's ability to utilize the guard bands placed between different types of Federal services." 27/ For the same reasons, it is likely that Federal services and frequency-agile BSNs could share the same spectrum.

22/ *See* NTIA, *Federal Long Range Spectrum Plan* (Sept. 2000), at 75-77.

23/ *See* "Engineering Analysis" attached as Appendix A, at 1-2. If necessary, it may also be possible to limit BSN operations to health care facilities on these frequencies to enable coordination with Federal users.

24/ AMF Comments at 13-14. As AMF notes, these channels can also be allocated for non-Federal fixed stations for the transmission of hydrological data, but a review of the FCC licensing database suggests little interest for such operations. Moreover, eight out of ten of these channels could be protected simply by avoiding use of the 412.6625 – 412.775 MHz sub-band for BSN operations.

25/ In addition, private mobile radio services ("PMRS") are permitted to operate on certain frequencies between 422-430 MHz within 50 miles of Buffalo, New York; Detroit, Michigan; and Cleveland, Ohio. 47 C.F.R. § 2.106, n. US230. If necessary, BSN operations could be limited to health care facilities in these markets and coordinated with the PMRS licenses.

26/ *See* "Engineering Analysis" attached as Appendix A, at 1-2.

27/ NTIA, *Spectrum Reallocation Final Report*, NTIA Special Publication 95-32 (1995) ("*NTIA Final Report*") at Appendix B, p. 2.

- 2360-2395 MHz. This band is used primarily for Federal and non-Federal aeronautical telemetry and telecommand applications. 28/ In addition, the 2390-2395 MHz band is used for fast-scan amateur TV under a primary Amateur allocation. 29/ In a 2004 order, the Commission described the characteristics of the aeronautical mobile operations and determined that such operations could share the 2390-2395 MHz band with the amateur usage. 30/ Specifically, the Commission explained that:

> Aeronautical mobile use of the band will likely be predominantly at remote facilities… We observe that the potential for interference from amateur operations, even directional point-to-point operations, to flight testing operations, would be small, due to the high altitudes of aeronautical mobile flight testing transmitters, and the correspondingly high elevation and off-axis attenuation of high gain flight testing receive antennas on the ground. Although … we cannot rule out the possibility of interference to flight testing from amateur operations, we believe the likelihood of such an occurrence is limited by the remoteness of flight testing facilities… 31/

For similar reasons, the Commission reasoned that aeronautical mobile operations would not cause interference to amateur receivers due to large separation distances. The Commission observed "that aeronautical mobile operations will not be widespread and will often occur in the vicinity of test ranges. Thus, it is expected that there normally would be large separation distances between aeronautical mobile transmitters" and victim receivers.32/ For all these same reasons, BSN devices should be able to share with aeronautical operations, especially given that BSN operations

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28/ In 2004, the Commission added a Federal allocation for Radiolocation (primary) and Fixed (secondary) in this band, but GEHC has been unable to locate information on the operations that may have been initiated pursuant to those allocations.

29/ This band is allocated to the amateur service in many countries, which would aid international harmonization.

30/ *Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services*, Seventh Report and Order, FCC 04-246, Docket Nos. 00-258 and 02-8 (rel. Oct. 21, 2004).

31/ *Id*. at ¶ 47.

32/ *Id*. at ¶ 48.

are much lower power and shorter range than amateur applications. Moreover, as explained in the Engineering Analysis, BSNs should not cause interference to HPLR amateur operations.

- 2395-2400 MHz. This band is considered undesirable for commercial services due to the need to share with amateur radio, the adjacent band ISM operations, the need to protect sensitive passive NASA and radio astronomy operations at 2380 MHz, and the lack of a paired band. 33/ Motorola has previously commented that the band may only be of practical use for low-powered localized systems. 34/ This band contains a primary Amateur Radio allocation and is designated for fast-scan TV, high-rate data, packet, and control and auxiliary link transmissions, according to the Amateur Radio Relay League ("ARRL") band plan. 35/ It is not used for weak signal operations. Under the band plan, the 2396-2399 MHz sub-band is allocated for point-to-point data links paired with 2300-2303 MHz. Expert representatives in the amateur community have previously commented that these point-to-point relay systems have good potential for sharing with commercial and even unlicensed services. For example, the Southern California Repeater and Remote Base Association ("SCRRBA") has stated to the Commission that "We can visualize how amateur fixed point-to-point services might effectively use the same spectrum as low power spread spectrum or medium bandwidth digital commercial devices intended for localized areas,"36/ and that amateur point-to-point relay systems are generally located on commercial communications sites which provide physical isolation that would facilitate potential sharing with

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33/ *NTIA Final Report* at Section 2.

34/ *Id*. (citing comments from Motorola).

35/ ARRL, *FCC Rule Book*, 13th ed. (2004) at 4-26. Like some of the other candidate bands, this band is allocated to the amateur service in many countries, which would aid international harmonization.

36/ SCRRBA Comments, filed in ET Docket No. 94-32 (June 14, 1994) at 11 (attached to comments filed Dec. 17, 1994).

Part-15 users. 37/ BSNs would have similar (or likely less) transmit power and ubiquity as the unlicensed Part-15 devices contemplated in the context of those comments. In addition, ARRL has stated that wideband systems with low duty cycles and spread spectrum techniques are best suited to share the band with amateurs. 38/ BSN devices satisfy this description. Notably, ARRL favorably cited the (since deleted) secondary unlicensed PCS ("UPCS") allocation in 2390-2400 MHz as "a compatible arrangement … negotiated to permit the use of the 2390-2400 MHz band by both Amateur Radio Service and Part 15 Asynchronous UPCS." 39/ Compared to UPCS, BSN devices would operate over shorter distances, use significantly lower power, employ similar frequency agility techniques, and would be no more ubiquitous than UPCS devices were envisioned to become when ARRL commented favorably on that allocation.

- 2495-2496 MHz. No service is designated to operate in this band, as it serves as guard band between high-power BRS operations above 2496 MHz and satellite service below 2495 MHz. While it is only one megahertz of spectrum, it could be combined with other spectrum to provide additional flexibility.

- 2300-2305 MHz. Amateur radio enjoys a secondary status in this band; 40/ there is no primary service. Similar to the 2395-2400 MHz band, this band is generally deemed undesirable for many commercial operations due to the need to share with amateur radio, the need to protect sensitive NASA receivers at Goldstone, California, and the lack of a second separated band for pairing. These factors are not issues for BSNs, however. First, BSNs would satisfy all NTIA

37/ SCRRBA Reply Comments, filed in ET Docket No. 94-32 (June 29, 1994) at 9 (attached to comments filed Dec. 17, 1994).

38/ *NTIA Final Report* at Section 2.

39/ Comments of ARRL, filed in RM-10166 (Aug 1, 2001), at n. 7 (opposition to petition for rulemaking filed by AeroAstro).

40/ Like some of the other candidate bands, this band is allocated to the amateur service in many countries, which would aid in international harmonization.

criteria for non-interference with NASA's operations. 41/ Second, Amateur radio licensees conduct weak signal operations at 2303.75 – 2304.75 MHz, but ARRL has acknowledged that these operations could successfully coexist with "low powered devices that operate over short distances," 42/ a description that fits BSN devices. The weak signal operations should be robust to interference from BSNs by virtue of highly directional antennas often pointed at high angles of elevation and due to their narrow bandwidth (typically on the order of 3 kHz) as compared to the higher bandwidth (about 1 MHz) of BSN devices.

Finally, GEHC notes that the Commission has long anticipated that a new allocation would eventually be made in the 2300 – 2305 MHz band. In a 1999 policy statement, the Commission expressed its intention to hold this band in reserve, pursuant to a 1993 statutory requirement to maintain a significant portion of spectrum in reserve for allocation after a ten year period that ended March 2, 2006, "until a future time, when new technology or other changes may increase the opportunities for new operations in these bands."43/ BSN devices present just such an opportunity, and GEHC's instant request for a new allocation here is consistent with the Commission's statement that it would "be receptive to petitions for reallocation of the reserve spectrum bands." 44/

41/ *See NTIA Final Report*, at Section 4 (stating that commercial operations should be under 1 watt and noting that "transmissions from a terrestrial source (e.g., mobile vehicle, hand-held portable, or a point-to-point fixed link) in general have less potential for causing unwanted interference since the RFI path is often blocked by terrain"). Because NTIA also expressed concern about transmissions from aircraft, further study may be needed to determine if restrictions on the airborne use of BSNs would be necessary.

42/ ARRL, Petition for Rulemaking, RM-10165 (May 7, 2001) at 3 (quoting an NTIA analysis).

43/ *Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium*, FCC Policy Statement, 14 FCC Rcd 19868 (Nov. 22, 1999) at ¶ 28.

44/ *Id.*

CONCLUSION

GEHC urges the Commission to move expeditiously by preparing a Further Notice which, consistent with the record in this proceeding, would propose the new spectrum allocations and rule changes necessary to make the next generation of wireless medical devices a reality.

Respectfully Submitted,

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APPENDIX A

ENGINEERING ANALYSIS:

Sharing Spectrum Between BSN Devices and High Power, Long-Range Systems

Due to BSNs being fundamentally low-power and short-range they can be expected to coexist well with higher-power, long-range (HPLR) systems provided the following separation criteria are met, assuming (under the worst-case) zero excess link margin for the victim system.

1) The BSN transmitter must be sufficiently separated from the HPLR receiver such that the power of the BSN signal in the bandwidth of the HPLR receiver measured at the HPLR antenna is at most equal to the thermal noise power in the bandwidth of the HPLR receiver plus the noise figure of the HPLR receive chain from antenna to demodulator.

2) The HPLR transmitter must be sufficiently separated from the BSN receiver such that the power of the HPLR signal in the bandwidth of the BSN receiver measured at the BSN antenna is at most equal to the thermal noise power in the bandwidth of the BSN receiver plus the noise figure of the BSN receive chain from antenna to demodulator.

Condition #1 is sufficient to guarantee quality of service for the HPLR system. Condition #2 is sufficient to guarantee quality of service for the BSN.

The maximum distance of separation required for condition #1 to be met at 2.4 GHz can be estimated as follows: Assuming a 15 dB noise figure for the HPLR receive chain and a HPLR receiver bandwidth equal to or narrower than the BSN bandwidth, and using the most conservative assumptions of free space loss and 0 dB of excess margin in the HPLR link budget, the signal power from a BSN device transmitting with a uniform power spectral density over a 1 MHz bandwidth at -10 dBm EIRP would have negligible effect on HPLR receivers separated from the BSN device by 250 meters or more. Under the more realistic assumption of path loss exponent, n, equal to 3 vs. free space (n=2), the effect would be negligible beyond only 9 meters.

Under the same assumptions, a –30 dBm BSN transmitter operating at 430 MHz would have a negligible impact on HPLR receivers separated by more than 140 and 11 meters for the n=2 and n=3 cases, respectively.

In order for condition #2 to be satisfied, substantially more separation distance would be required as illustrated by the following example. Assuming a receiver sensitivity of –85 dBm and minimum required signal-to-noise ratio ("SNR") of 10 dB for the BSN, and assuming a HPLR transmitter EIRP of 25 W with a signal bandwidth less than or equal to the BSN receiver bandwidth, separation of 10 km would be required for free space propagation (n=2) at 2.4 GHz or 100 meters for path loss exponent n=3 at 2.4 GHz. At 430 MHz, the minimum spatial separations are 56 km and 560 meters, respectively.

In order for BSNs to operate at a somewhat closer distance to HPLR systems, they would likely have to operate with some excess link margin compared to that required for a quiet ambient environment. For example, assuming 20 dB of excess BSN link margin for the scenario above, separation of 1 km would be required for free space propagation (n=2) at 2.4 GHz, or 22 meters for path loss exponent n=3 at 2.4 GHz, and 5.6 km or 120 meters for n=2 and n=3, respectively, at 430 MHz. Note, however, that these separations are all still significantly more than required to satisfy the reciprocal non-interference condition #1. The conclusion is that as distance is reduced before the BSN can interfere with the HPLR system, the HPLR system will interfere with the BSN and cause it to vacate the channel.

If low-power BSNs are to share spectrum on a secondary basis with HPLR systems, the amount of spectrum allocated for BSNs will have to be significant enough to provide a high level of confidence that the aggregate residual spectrum (*i.e.*, spectrum unused by primary HPLR systems) will be sufficient to support the BSNs in all areas at all times. The factor by which total allocated spectrum must exceed the amount actually required for BSNs will depend on how fully utilized the spectrum is by incumbent HPLR systems. For this reason, spectrum allocated for services such as WCS, BRS and EBS – that are expected to become ubiquitously deployed – could probably not provide a reasonable expectation of sufficient residual spectrum availability, despite the large amount of potential spectrum to be shared.

Federal Communications Commission

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