Hogan Lovells LLP
Columbia Square
555 Thirteenth Street, NW
Washington, DC 20004
T +1 202 637 5600
F +1 2020 637 5910
www.hoganlovells.com

March 7, 2014

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: WT Docket No. 12-268, *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*

Dear Ms. Dortch:

In its comments and reply comments in this proceeding, GE Healthcare ("GEHC") urged the Federal Communications Commission ("Commission") to ensure that wireless medical telemetry service ("WMTS") operations can remain in television Channel 37 with adequate protection from harmful interference.[1] In particular, GEHC warned that the profound shift in 600 MHz band usage following the reverse and forward auctions will create a heightened risk of interference to Channel 37 WMTS operations that, if not addressed, could cripple thousands of WMTS systems and jeopardize patient safety throughout the county.[2] To avoid such a catastrophe, the Commission should adopt rules in this proceeding that adequately protect Channel 37 WMTS operations from nearby transmissions.

GEHC now writes to respond to an *ex parte* letter filed by Broadcom Corporation ("Broadcom") that takes issue with a technical analysis submitted by GEHC last year.[3] In its letter, Broadcom disagrees with a number of GEHC's technical claims,[4] submits an alternative technical analysis,[5] and suggests that unlicensed technologies can operate co-channel with, and in close spectral

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[1] *See* Comments of GEHC, WT Docket No. 12-268 (filed Jan. 25, 2013) ("GEHC Comments"); Reply Comments of GEHC, WT Docket No. 12-268 (filed Mar. 12, 2013) ("GEHC Reply").

[2] *See, e.g.*, GEHC Reply at 3.

[3] Letter from Jennifer K. Bush, Associate General Counsel, Broadcom, to Marlene H. Dortch, Secretary, FCC, WT Docket No. 12-268 (filed Jan. 17, 2014) ("Broadcom Letter").

[4] *Id*. at 2.

[5] *Id*. at 5-6.

proximity to, Channel 37 WMTS devices without causing harmful interference.[6] As explained below, however, Broadcom's analysis includes flawed assumptions about a number of key points and, as a result, should be discounted by the Commission in resolving the issues pertaining to Channel 37 in this proceeding.

Free-Space Propagation

Broadcom claims that GEHC's assumptions about free-space propagation are "overly conservative in this context in light of attenuation that will necessarily occur in urban environments."[7] However, the possibility of free space propagation occurring between an uncoordinated portable device and hospital receiver is undeniable. Although higher attenuation in cluttered environments *may* occur, it is by no means guaranteed–especially at the shorter separation distances that Broadcom suggests. In fact, with potentially millions of unlicensed devices operating, free space propagation can be expected to be a very common occurrence.

Importantly, interference analysis for a safety of life system such as WMTS needs to take into account a realistic worst-case scenario. In this case, that is free-space propagation. In an effort to be balanced, however, GEHC's analysis does include 20 dB of building attenuation from exterior hospital walls and windows, notwithstanding the fact that this also cannot be guaranteed, as portable devices would undoubtedly be carried inside hospitals where they would routinely come within one meter of WMTS receive antennas, and at this time the reliability and security of geolocation/database or other potential exclusion zone enforcement schemes has not been proven through experience to protect a vulnerable safety of life service from interference by ubiquitous unlicensed portable devices.[8]

In contrast, Broadcom's assumption of a low-rise hospital in a flat, cluttered urban environment is unreasonably optimistic and inappropriate for interference analysis pertaining to a safety of life system such as WMTS, for which outages are intolerable. One instance of WMTS interference, for example, may cause loss of monitoring for a large portion of a hospital's patients, which, in turn, could overwhelm its medical staff and endanger the patients.

WINNER+ Path Loss Model

Broadcom states that its technical analysis used WINNER+ path loss models for TV frequencies, which are also used in LTE.[9] Specifically, Broadcom states that it used the Urban Micro

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[6] *Id*. at 1.

[7] *Id*. at 2.

[8] *See, e.g.*, GEHC Comments at 39-45.

[9] Broadcom Letter at 5.

combined LOS/NLOS model.[10] However, Broadcom's application of the WINNER+ model contains several flaws and fails to represent a reasonable worst-case scenario. As explained above, the assumption of an Urban Micro scenario is not appropriate for most hospitals. Moreover, the assumption of 10 meters for WMTS antenna height is not representative of many hospitals that may be more than three stories high, and the assumption of 1.5 meters for unlicensed transmitter height also will not always hold (*e.g.*, when the transmitter is located on even slightly higher terrain, such as a balcony, etc.). Because the WINNER+ model is very sensitive to these parameters, it generates significantly higher path loss predictions than more realistic worst-case values. Furthermore, GEHC has serious doubts whether *any* of the WINNER+ models, which were empirically derived from measurements using single or relatively small spatial diversity antennas representative of cellular base stations, can accurately represent interference coupling to WMTS systems, which have large distributed antenna systems that typically span hundreds or thousands of square meters (*e.g.*, all four sides of a hospital).

Additionally, as explained below, Broadcom attempts to manipulate the WINNER+ model to its benefit by adopting only the most favorable facets of the model (*i.e.*, the mean path loss formulae) while omitting or misapplying several other key elements (namely building penetration figures, line-of-sight ("LOS") probability and shadowing variation) that, if properly accounted for, would significantly reduce the predicted path loss (and thereby increase the required separation distances) to levels approaching or exceeding those derived from the GEHC analysis.

Like GEHC's analysis, Broadcom's analysis assumes the use of outdoor TV band ("TVBD") devices and associated hospital wall penetration loss.[11] But rather than using the building penetration value of approximately 7 dB actually suggested by the WINNER+ model,[12] Broadcom instead adopts the more favorable 20 dB value from GEHC's analysis.[13]

Additionally, Broadcom asserts that "attenuation will necessarily occur from buildings, trees, people, vehicles, and other factors."[14] In fact, such attenuation may well *often* occur, but it certainly will not "necessarily" occur and the reasonable worst-case scenario that must be considered for the purpose of determining required separation is the case of LOS propagation. GEHC understands that the "combined LOS/NLOS" path loss in Broadcom's analysis was simply calculated as a weighted average of the separate LOS and non-line-of-sight ("NLOS")

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[10] *Id*.

[11] *Id*.

[12] *See* JUHA MEINILÄ ET AL., WINNER+, D5.3: WINNER+ FINAL CHANNEL MODELS 61 (2010), *available at* http://projects.celtic-initiative.org/WINNER+/WINNER+%20Deliverables/D5.3_v1.0.pdf.

[13] Broadcom Letter at 5.

[14] *Id*.

predictions based on the LOS probability predicted by the WINNER+ and WINNER II models.[15] This is inappropriate because, in the real world, either one scenario or the other will actually arise for each unlicensed device, and the predicted path loss will be based on the corresponding LOS or NLOS formula rather than a weighted average from the two formulae. Again, in determining the required separation distance to reliably prevent interference to a safety of life system—where outages are intolerable—the only important scenario to consider is the reasonable worst case of LOS.

In particular, the WINNER II model predicts LOS propagation at least 29% of the time at the small separation distances Broadcom suggests, and at least one percent probability at distances out to 1.8 km, even assuming an urban environment. The WINNER II document highlights the uncertainty of its own LOS predictions as follows:

> *"These models are based on relatively limited data sets and/or specific assumptions and approximations regarding the location of obstacles in the direct path, and should therefore not be considered exact."*[16]

Indeed, the applicability of LOS propagation is one of the most questionable aspects of the WINNER models as it relates to WMTS systems, where the probability of LOS to at least one of the hundreds of antennae traversing a hospital would seem to be substantially higher than for the isolated base stations envisioned by the models.

Finally, even when LOS propagation is predicted, the WINNER+ model still incorporates significant shadowing variation that Broadcom neglected to include in its analysis. The path loss actually predicted by WINNER+ is a stochastic random variable. The LOS and NLOS formulas used by Broadcom are actually intended to predict only the *mean* of this random variable to which a zero-mean log-normal shadowing random variable must be added. When properly applied, this shadowing variation can be expected to *reduce* the LOS path loss predicted by the WINNER+ Urban Micro model by at least 7 dB and the NLOS path loss by over 9 dB from their predicted mean values in one percent of cases. If WINNER+ Urban or Suburban Macro-cellular models, which may somewhat better represent the actual situation for most hospitals, are applied, the predicted shadowing variation may be even higher, reducing the respective LOS and NLOS path loss predictions from their mean values by at least 14 dB and over 18 dB in one percent of cases.

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[15] The WINNER+ model adopts the same LOS prediction probability given in the 2007 WINNER II D1.1.2 document. *See* PEKKA KYÖSTI ET AL., WINNER+, D.1.1.2 V1.2 WINNER II CHANNELS MODELS 46-48 (2007), *available at* http://projects.celtic-initiative.org/WINNER+/WINNER2-Deliverables/D1.1.2.zip.

[16] *Id*. at 48.

A comparison of several alternative analyses properly incorporating the aforementioned factors is included in the Appendix below. GEHC presents these alternative analyses simply to illustrate the potential application of various path loss models to a number of plausible scenarios; they are not, however, intended to cover all realistic worst case scenarios that would need to be considered in order to actually determine a sufficient protection radius.

Number of Dominant Transmitters

Broadcom also criticizes GEHC's consideration of aggregation from ten simultaneous transmissions as being "unrealistic . . . in light of Wi-Fi politeness protocols that dictate that a device will not transmit when it detects another signal at the protection radius considered (less than 100 meters)."[17] However, Wi-Fi politeness protocols only prevent aggregation when all potential interferers are close enough to recognize and respond to each other. As described above, under realistic propagation assumptions, unlicensed devices will often interfere with WMTS from distances much greater than 100 meters and thus often be too far from each other (including, *e.g.*, on opposite sides of the hospital) for Wi-Fi listen-before-talk protocols to prevent aggregation. This is the well-known "hidden node" problem.

It is worth noting that, here again, GEHC's analysis assumed non-free space propagation (modeled using a path loss coefficient of n=2.4) for its ten-interferer aggregation case in an effort to be balanced.[18]

Aggregation from Multiple WMTS Antennas

Broadcom likewise criticizes GEHC's assumption of interference aggregation by ten WMTS antennas and asserts that "a properly designed system should not combine the signals from ten antennas, but rather should pick only the strongest signal to decode."[19] Unfortunately, this is not how most existing WMTS systems were designed. As explained in GEHC's analysis, most WMTS systems use a distributed antenna system ("DAS") architecture that aggregates signals from multiple antennas distributed throughout the hospital even though the desired signal is usually only received strongly at one antenna at a time.[20] This was a limitation of the technology when these systems were designed. Regarding Broadcom's suggestion that WMTS users change "the algorithm . . . to only take the strongest antenna signal,"[21] unfortunately this not

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[17] *Id*.; *see also id*. at 2-3.

[18] *See* GEHC Comments at 44.

[19] Broadcom Letter at 2.

[20] *See* GEHC Comments at 39.

[21] *See* Broadcom Channel 37 Analysis at 3, *attached to* Letter from Paul Margie, Counsel to Google, Inc., to Marlene H. Dortch, Secretary, FCC, GN Docket No. 268 (filed Jan. 30, 3014).

technologically feasible because the "algorithm" is embodied in the physical DAS installation—a network of coaxial cables and antennas, combiners, and other discrete components installed in the ceilings of hospitals—rather than in re-configurable software. It is also, of course, not the legal obligation of WMTS users (as primary incumbents) to modify their systems to avoid interference from an unlicensed user.

I/N Ratio

Finally, Broadcom asserts that the interference to noise ("I/N") ratio used in GEHC's analysis is "very conservative" and allows for a higher I/N ratio in Scenario 1 of its analysis. However, the negative 6 dB I/N ratio used by GEHC is appropriate because this is the level that causes 1 dB of desensitization to WMTS operations. Although this may be somewhat conservative,[22] only slightly higher levels are likely to be tolerable. Accordingly, Broadcom's assumption of *positive* 3 dB I/N, which corresponds to 5 dB of WMTS desensitization, is completely inappropriate.

The points described herein provide further evidence, consistent with GEHC's other filings,[23] that the Commission should take measures in this proceeding to protect Channel 37 WMTS operations from harmful interference. Specifically, it should adopt clear rules to ensure that the incentive auction, and the wireless environment that follows, will not adversely affect incumbent WMTS systems in Channel 37. As GEHC has stated previously, effective protection of Channel 37 WMTS requires that the Commission:

- Not allow other wireless operations (unlicensed or licensed) in Channel 37. [24]
- Adopt the Down from 51 band plan supported by Verizon, T-Mobile, AT&T, Qualcomm, and the National Association of Broadcasters.[25]
- Under the Down from 51 band plan:
    - Require licensees to coordinate the construction and operation of base stations within a certain distance of an operating WMTS system;
    - Limit the maximum allowable field strength of Part 27 base station fundamental emissions in Channel 36 and 38 to 20 mV/m/MHz, as measured at the perimeter of a registered WMTS facility; <u>and</u>

[22] Unfortunately, it is impossible to accurately estimate the amount, if any, of excess link margin in the installed base of thousands of unique WMTS systems comprising hundreds of thousands of individual antennas.

[23] *See, e.g.*, GEHC Comments at 31-35; GEHC Reply at 15-20.

[24] *See, e.g.*, GEHC Reply at 15-26.

[25] *See* Comments of GEHC, WT Docket No. 12-268, at 7-8 (filed June 14, 2013) ("GEHC Band Plan Comments"); *see also, e.g.*, Comments of Verizon and Verizon Wireless, WT Docket No. 12-268 (filed Jan. 29, 2013); Comments of Qualcomm Inc., WT Docket No. 12-268 (filed Jan. 25, 2013).

- Require a limit of 10µV/m/100 kHz for Part 27 out of band emissions ("OOBE") within Channel 37.[26]

- If a band plan is adopted that results in portable consumer device transmissions in close spectral proximity to Channel 37, impose an emissions mask that is at least as stringent as the mask currently applicable to unlicensed device fundamental and spurious emissions between 602-620 MHz until a mature protection scheme can be demonstrated to be 100% reliable and secure in protecting TV and other non-safety-of-life services from such devices.[27]

Designing the incentive auction in a manner than fails to do these things would jeopardize the WMTS operations of healthcare facilities across the country, risk the safety of millions of patients, and create societal costs that greatly outweigh any benefit associated with expanding unlicensed operations.[28]

Pursuant to Section 1.1206 of the Commission's rules, an electronic copy of this letter is being filed for inclusion in the above-referenced docket.

Respectfully submitted,

_____/s/_____
Ari Q. Fitzgerald, Esq.
Counsel to GE Healthcare
Hogan Lovells LLP
555 Thirteenth Street N.W.
Washington, DC 20004
(202) 636-5600

_____/s/_____
Neal Seidl
Matthew Pekarske
GE Healthcare
8200 W. Tower Avenue
Milwaukee, WI 53223

[26] *See* GEHC Band Plan Comments at 7-8.

[27] *See id*. at 6-7; *see also* 47 C.F.R. § 15.709(c)(4).

[28] *See, e.g.*, GEHC Comments at iii, 3.

Appendix

Comparison of Path Loss Models

Description	Single Dominant Interferer Scenarios			
	WINNER+ UMi LoS	WINNER+ UMa LoS	WINNER+ SMa LoS	GEHC Freespace
Emission frequency (MHz)	611	611	611	611
Single transmitter EIRP (dBm / 10 kHz)	-11.4	-11.4	-11.4	-11.4
Transmitter to WMTS distance (meters)	**2040**	**2190**	**3150**	**2100**
Path loss coefficient, n	N/A	N/A	N/A	2.0
WMTS antenna height (m)	15.0	15.0	15.0	N/A
TVBD antenna height (m)	3.0	3.0	3.0	N/A
WINNER+ mean path loss (dB)	114.3	121.3	121.3	N/A
WINNER+ log-normal shadowing, 99% min (dB)	-7.0	-14.0	-14.0	N/A
Path loss (dB)	107.4	107.4	107.4	94.6
Excess loss (building attenuation, etc)	7.2	7.2	7.2	20
Total coupling loss (dB)	114.6	114.6	114.6	114.6
Received interference per exposed WMTS antenna, per transmitter (dBm / 10 kHz)	-126.0	-126.0	-126.0	-126.0
Number of dominant transmitters	1	1	1	1
Number of exposed WMTS antennas per dominant transmitter	10	10	10	10
Overall aggregation factor (dB)	10.0	10.0	10.0	10.0
Aggregate received interference power (dBm / 10 kHz)	-116.0	-116.0	-116.0	-116.0
WMTS system noise floor (dBm / 10 kHz)	-110.0	-110.0	-110.0	-110.0
I/N ratio (dB)	-6.0	-6.0	-6.0	-6.0
WMTS desensitization (dB)	1.0	1.0	1.0	1.0