A summary of current U.S. and international regulations on microwaves related to cell towers

Prepared By
Dr. Joshua Dennis Booth, PhD
July 2017

I am writing this report as a knowledgeable voice for the School Board, parents, and residents of the East Hempfield school district with regard to the placement of cellular towers at Rohrerstown Elementary School and Centerville Middle School. My knowledge comes from my experience with EMP-Microwave radiation, as outlined in the Personal Background section at the end of this document. I'm also a resident of the Hempfield School District community: both a parent concerned about health issues and a homeowner concerned about property value. The numbers used here for comparison are those given for the Rohrerstown Elementary Tower at the zoning board hearing on June 19th, 2017. This report is outlined as follows. First, I give an overview of the current U.S. laws and agencies related to microwaves, cellular tower, and other common microwave devices. Second, I provide an overview of non-U.S. laws related to microwaves. The second section serves to demonstrate the most important message of this report by showing the outdated nature of U.S. regulation, and why we should be concerned about these towers being at the distance and magnitude that is being proposed by the tower's developers.

Section 1, Background, Current U.S. regulation for key microwave devices.
In this section, I provide background about both microwaves in general and cell technology. Microwaves are electromagnetic waves that vary in frequency between 300 MHz (i.e., near Radio) to 300 GHz (i.e., near infrared). At ~70-100 MHz the body maximally absorbs energy and at 3,000 MHz the energy is concentrated at the body surface. This is why there are regulations about things like radio towers but not standard household lights. Cell towers use frequency between 900MHz to 1900MHz. These waves can also vary in strength too, and this is the real issue that will be addressed in the report. In order to accommodate these variables, a measurement of power density is often used. Here, we will use the units of uw/cm2 for all examples as this is the unit given to use by the cellular tower developers, though other areas use other units. Note, the Federal Communication Commission (FCC), which is responsible for microwave regulation in the US, uses a different unit of mw/cm2 for their Maximum Permissible Exposure (MPE)[1]. Their proposed tower will have a power density of a maximum of 3.6uw/cm2. I note as someone that has done the calculations myself that this maximum is slightly higher than what most likely will be the power density on day one. This view was also shared by the cell tower developers at the zoning hearing. However, this density may increase in the future without notice if they sell broadcasting to other cell vendors or place higher wattage/gain equipment. More importantly, the **duration of exposure** is one of the largest issues up for debate in research. For students, this would be the whole time they are on campus for class and activities: seven school years, from K to 6th grade.

Let us first address the FCC and the current standards set forth by the FCC for cellular towers. The FCC is an independent agency formed in 1934 to regulate interstate communications. The FCC is funded entirely by regulatory fees paid by radio, cell, cable, television, and satellite companies for access to certain bandwidth in areas [4]. They have most notably been in the news

of late because of concerns of net neutrality in which internet companies may sell user's data. The only health concerns they regulate are those related to radio waves. The first standards were issued by the nonprofit American National Standards Institute (ANSI) in 1982. This was one year before the first commercially available cell phone was approved by the FCC in 1983. It took until 1985, when the FCC finally adopted the ANSI standard of 1982. This standard was issued in a maximum absorption of 4Watts/kilogram. In 1992, ANSI/IEEE revised the 1982 standards. These revisions considered a larger frequency and restricted environmental radio frequency exposure. They also added the concepts of "controlled" and "uncontrolled" environments. Here the "controlled" is a location where "there is exposure that may be incurred by persons who are aware of the potential for exposure…" (e.g., work environments) [5]. More important, they started to consider the duration of a single exposure: the "controlled" being an average of 6 minutes and "uncontrolled" being an average of 30 minutes. Note they do not make mention of time between these exposures but only the average exposure for a length of time. Though the FCC was given notice of these changes in 1992, the FCC only made full requirements in mid 1996. These standards state that the "controlled" power density in the 30-300 MHz should be less than 1,000 uW/cm2. The "uncontrolled" standard is 200 uW/cm2 [5]. Cell towers must only follow the "controlled" standard as they are a known structure that can be avoided [5]. Though groups have lobbied to change this standard, **the standard has not been updated for the past twenty-one years**. One government agency that has spoken up about this is the United States Department of Interior. This department wrote a formal letter in 2014 pointing out that the FCC regulation is outdated, and the department believes that the frequency limits are already having a negative impact on animals in the environment [8]. Recent updates to the FCC consumer website recommend MPE be 580 uW/cm2, but this value has not been updated in their human exposure manuals [3].

Microwaves have transformed the way we live in today's world, and cell technology is only one area in which microwave research is being conducted and regulated. Therefore, it makes sense to understand microwaves being regulated and studied in other areas, e.g., microwave ovens, full body airport scanners, and WiFi routers.

Microwaves were first researched by the radiation given off of vacuum tubes, and were aimed at radar search. By chance, an engineer named Percy Spencer working for Raytheon Corporation was exposed without knowing possible side effects to microwaves. The microwaves ended up melting food in his pocket, and the microwave oven was born. Years after the first microwave ovens were made available for use, the Radiation Control for Health and Safety Act of 1968 limited the amount of microwaves that could leak from the device to 10,000 uW/cm2 at 5cm (~1.97 inches) away from the oven. Two years later, this was reduced to 1,000 uW/cm2 at 5cm by the U.S. Bureau of Radiological Health (i.e., a limit similar to FCC's human exposure manual), and only 5,000 uW/cm2 over the device's whole lifespan [9] (up to 10 years)! This lifespan limit is only three years greater than what a student would be exposed to over the whole time from grades K-6. In fact, **the power density of the proposed Rohrerstown Elementary campus tower would be similar to having a child sit at about 12 feet away from a running 600 Watt Microwave oven all day, every school day for seven years**. However, we should note that the frequency of a microwave oven is much higher, i.e., about 2450 MHz.

Body scanners at airports are the most recent area where microwaves have cropped up in daily life. Most of the first-generation body scanners were "back-scatter" type that used low dose of x-rays [10,11]. These have actively been replaced by new millimeter scanners that use microwaves. These new millimeter scanners expose the person to approximately .01uW/cm2 to .6 uW/cm2 at various frequencies inside the microwave frequency spectrum for less than 6 seconds [11]. Despite the very low exposure and removal of detailed body images, passengers may opt for a pat-down, and **young children are not required to be scanned**. This demonstrates TSA wanting to take reasonable health precautions for the general public.

The most common place where we find microwaves is as radiation from WiFi routers. These devices are located in almost all places from coffee shops to doctor offices. Currently, the only regulation that the FCC has placed on such devices is a maximum strength as not to disrupt others and not allowing for signal blockers[1,2]. These devices have frequency 2400 MHz band that is close to a microwave oven. Note that this is why your microwave oven may interrupt your WiFi router at times. These devices have high power density in close range, but the power density reduces by the square of the distance resulting in low power density far away. For example, at about a tenth of an inch from the device, the power density is about 2.65 uW/cm2. At about 3.3 feet away, the power density is only .24 uW/cm2. **The proposed tower at Rohrerstown Elementary School will have a power density that is about 1.4x stronger than such a router, the equivalent of having a child with about one-and-a-half live WiFi routers directly beside them every school day for seven years. Imagine placing one and a half powered-on WiFi routers under your child's pillow every school night for seven years. Given the health concerns regarding microwaves, this is not likely an action you would choose to take.**

Section 2, Current Non-US regulations.

In this section, I provide an overview of the regulations on microwaves and cell towers in other modernized countries. Through these examples, I demonstrate that the U.S.'s twenty-one-year-old protection standards lag behind those more recently updated in other countries. Moreover, we have seen in the previous section that the FCC has been slow to update its protection standards even when pressured by large groups of engineers and scientists like ANSI and IEEE. Here we will see the more proactive approach that other countries are taking to protect their residents with regard to microwave public health.

I first point out the World Health Organization (WHO) that sets forth protection standards in hopes that all countries will adhere to a minimal standard of 900 uW/cm2 for cellular towers. The FCC's 1996 standard lags behind the World Health Organization's protection standard by 100 uW/cm2. Our neighbor Canada's protection standard is now 300 uW/cm2 in developed areas. The FCC exceeds this protection standard by 3.33x! Next, two countries that I will point out are Russia and China. I selected these two countries because of their history of lack of environmental and health safety regulations. Both countries have a maximum MPE of 10 uW/cm2 [12]. This value represents 100x less radiation than allowed by the FCC. Though the proposed cell tower at Rohrerstown Elementary School would be allowed by this standard, it would already be 36% of the maximum. If the proposed tower is placed without regulation from the school, the proposed tower's power density could easily exceed this limit with new

equipment or selling access to other cell providers. As we move into Europe, the regulation limits become even greater. The cause of the lower limits in Europe is because of research coming from the Precautionary Principle expressed by most countries [7], the BioInitative reports [13], and the European Union Science and Technology Options Assessments (STOA) of 2001. The BioInitative report of 2012 recommends an extremely low power density of .0006 uW/cm2, and the STOA recommending a maximum of .01 uW/cm2. It is important to note that almost no country or cell towers meet these recommendations. However, the WHO- International Agency for Research of Cancer (IARC) has classified radio frequency electromagnetic as a **possible carcinogenic to humans** based on studies related to the development of malignant types of brain cancer in humans from cell phone use in 2011 [6]. These items are almost completely ignored by US regulation committees at this time, even though millions of dollars in damages from both the land owners and cell tower owners have been paid out all over Europe. If these reports become allowable by U.S. courts, the school district itself may be open to lawsuits. Mountainous countries, such as Switzerland, Lichtenstein, and Luxembourg, have set current rules at 9.5 uW/cm2 [12], and are currently reviewing lowering limits more. More populated countries have set even lower standards on a single frequency, such as Italy's regulation of .1 uW/cm2. Other major countries like Germany and France are securing health in a different manner. While France does allow for power density between 455-955 uW/cm2 (i.e., lower by as much as 2x the U.S.'s 1996 standard), they have put laws on where towers may be placed. By law in France, no cell towers may be placed on school property. Moreover, any citizen may have their home evaluated for cell tower radiation, and the public must be informed in order to vote if a tower should be placed [14,15]. India's Supreme Court in 2013 upheld that cell towers are a hazard to life, and the removal of all cell towers at schools, colleges, hospitals, and playground in the state of Rajasthan [16]. Other countries are following these steps as the Council of Europe recommended banning all cell phones from schools.

While TSA is about on par with body scanners as other governments, other countries have been far more protective about WiFi devices. In 2015, France has banned the use of WiFi in Nursery schools (i.e., children less than 3 years old). WiFi in schools with children up to age 11 years old may only be turned on for activities that need WiFi, and must be turned off when not in use [14,15]. Though not law, The Russian National Committee on Non-Ionizing Radiation officially recommended that WiFi should not be used in school in 2011 [18]. The Israeli Ministry of Education has issued guidelines banning WiFi in classroom prior to 1st grade and limiting use similar to France up to third grade [17]. **Recalling from last section, the proposed tower will have the same power density of about 1 and ½ standard WiFi routers next to the child's head. It seems that if we should be limiting WiFi in the classroom to when we need it, we should not, in essence, be strapping it to the head of a child.**

Recommendation.

As a resident of the East Hempfield and a member of the science community, I recommend taking precautions for our children from microwave exposure. This includes not situating a tower at Rohrerstown Elementary School or Centerville Middle School. For a more in-depth look at cell phones, policy, and current research, I recommend reading [7] in its full, and paying attention to the sections on children.

Personal Background of Joshua Dennis Booth:
I hold a BS in Applied Mathematics, MS in Computational Mathematics, and PhD in Computer Science and Engineering. I previously advised CDC/NIOSH as a Biostatistician intern while focusing on statistical databases. I was a Post Graduate Researcher for The Department of Energy's Sandia National Laboratories in Albuquerque New Mexico. There I worked in the department of scalable algorithms providing scalable linear solver solutions to large scale simulations for circuits, sold mechanics, and EMP-Microwave based applications. I have published work related to large numeric solvers, power systems, and low voltage computing algorithms. I am currently an Assistant Professor of Computer Science at Franklin & Marshall College. I am a member of SIAM, ACM, and IEEE.

References:

[1] Federal Communication Commission Office of Engineering & Technology (1997). *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields.* http://transition.fcc.gov/bureaus/oet/info/documents/ bulletins/oet65/oet65b.pdf

[2] Federal Communication Commission (NA). *GPS, Wi-Fi, and Cell Phone Jammers. Frequently Asked Questions (FAQs).* http://transition.fcc.gov/eb/jammerenforcement/jamfaq.pdf

[3] Federal Communication Commission (2016). *Human Exposure to Radio Frequency Fields: Guidelines for Cellular and PCS Sites* [Consumer Guide]. http://transition.fcc.gov/cgb/ consumerfacts/rf exposure.pdf

[4] Federal Communication Commission (2016). *About the FCC* [Consumer Guide]. http://transition.fcc.gov/cgb/comsumerfacts/aboutfcc.pdf

[5] Federal Communication Commission (1996) [FCC 96-326]. *Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation.* http://transition.fcc.gov/ Bureaus/Engineering_Technology/Orders/1996/fcc96326.pdf

[6] World Health Organization, Internal Agency for Research on Cancer (2011). Press Release 208. *IARC Classifies Radiofrequency Electromagnetic Fields as Possibly Carcinogenic to Humans.* http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf

[7] Roda, C. and Perry, S. (2014). *Mobile Phone Infrastructure Regulation in Europe: Science Challenges and Human Rights Protection.* Journal of Environmental Science & Policy. pg 204-214. 37. http://ac.aup.fr/~croda/publications/Roda&Perry_EnvSci&Policy_OrigManuscr.pdf

[8] Willie Taylor, US Department of the Interior (2014). *Letter to National Telecommunication and Information Administration.* http:www.ntia.doc.gov/files/ntia/us_doi_comments.pdf

[9] Davis, A. (2016). *A History of the Microwave Oven.* The Institute – The IEEE News Source. http://theinstitute.ieee.org/tech-history/technology-history/a-history-of-the-microwave-oven

[10] Accardo, J and Chaudhry, A (2014). *Radiation Exposure and Privacy Concerns Surrounding Full-Body Scanners in Airports.* Journal of Radiation Research and Applied Sciences. 7(2). pg. 198-200. http://www.sciencedirect.com/science/article/pii/S1687850714000168

[11] Wu, T. , Rappaport, T. , and Collins, C (2015). *The Human Body and Millimeter-Wave Wireless Communication Systems: Interactions and Implications.* IEEE International Conference on Communications (ICC). http://arxiv.org/ftp/arxiv/papers/1503/1503.05944.pdf

[12] Powerwatch (NA), *International Guidance Levels.* http://www.powerwatch.org.uk/science/intguidnace.asp

[13] BioInitiative (2012). *A Rationale for Biologically-Based Exposure Standards for Low-Intensity Electromagnetic Radiation.* http://www.bioinitiative.org/

[14] Boring, N. (2015). *France: Law on Public Exposure to Electromagnetic Waves Adopted.* Library of Congress, Law Library of Congress. http://www.loc.gov/law/foreign-news/article/france-law-on-public-exposure-electromagnetic-waves-adopted

[15] France Assemble (2015). http://www.assemblee-nationale.fr/14/pdf/ta/ta0468.pdf

[16] NA (2017). *Supreme Court Stays Rajastan High Court Order on Cellphone Towers.* http://indianexpress.com/article/india/supreme-court-stays-rajathan-high-court-order-on-cellphone-towers-467990

[17] Israeli Ministry of Education (2013). *Integration of Communication Equipment and End Devices in Schools – Health and Safety Implications.* http://cms.education.gov.il/EducationCMS/Applications/Mankal/EtsMedorim/3/3-6/HoraotKeva/K-2013-3-3-6-11.htm

[18] Russian National Committee on Non-Ionizing Radiation Protection (2011). *Electromagnetic Fields from Mobile Phones: Health Effect on Children and Teenagers.* https://docs.google.com/file/d/0B1KQ639Tc1Z9TTg2WGxpTlRvb2M/edit?pli=1