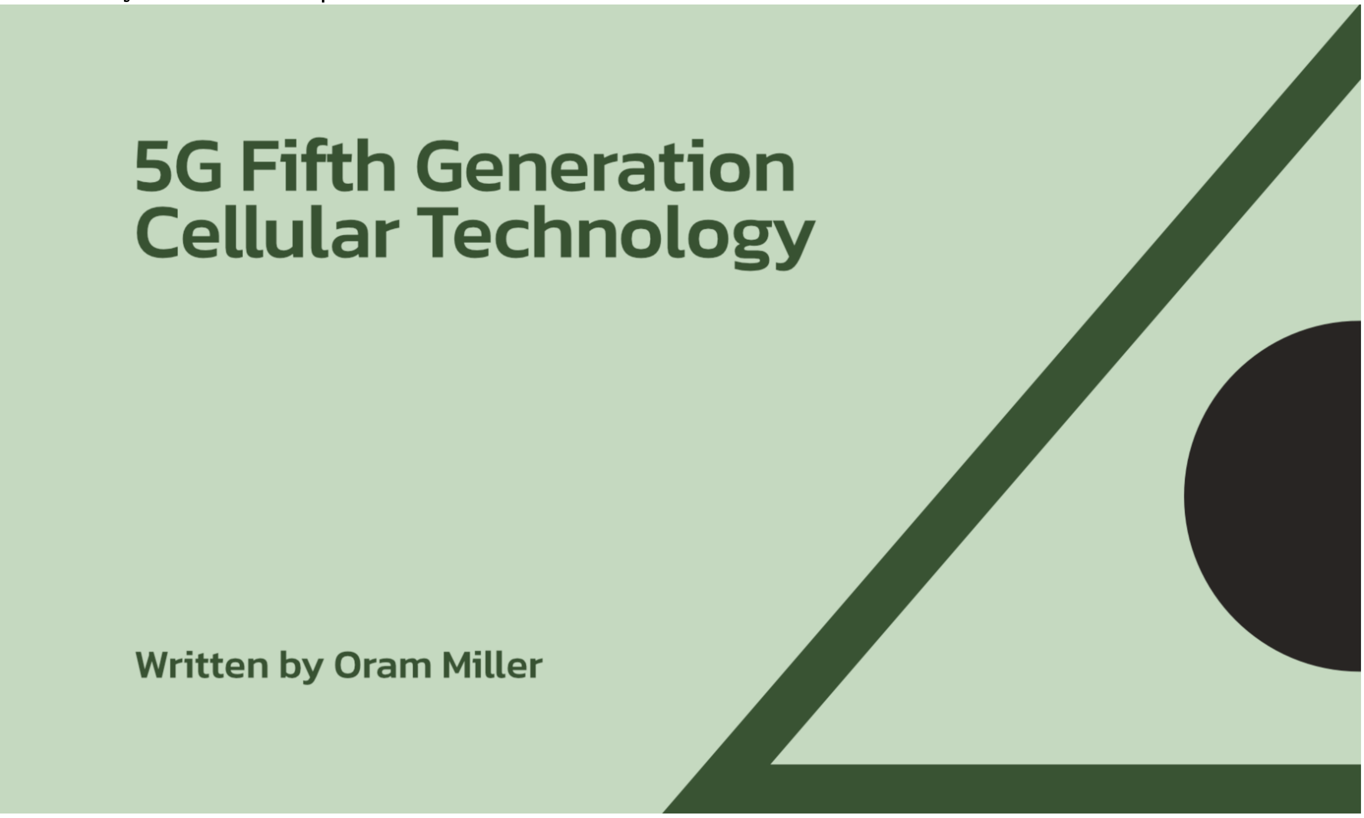
5G Fifth Generation Cellular Technology

written by Oram Miller | 4 October 2023



Update on Possible Link between FEMA and FCC Emergency Alert Test on October 4, 2023 and 18 GHz 5G

I have received many inquiries about a possible link between a nationwide Emergency Alert Test planned to be conducted on Wednesday, October 4th using 5G cell antennas and a possible activation of pathogens.

Let me first say that my comments in this update, along with everything else that I write and present in all the articles on this website, are my own opinion and not the official position of the Building Biology Institute, the organization that certified me.

I have been following this issue and have been asked about it by a number of clients. I can give a little insight into what I know about specific cellular carrier frequencies being broadcast on a regular basis by cell antennas using 4G LTE and 5G technology by the four cell carriers in the U.S., those being Verizon, T-Mobile, AT&T and now, Dish.

I have learned the following information in this update from attending four 5G industry conventions, three in Los Angeles from 2018 through 2021 (the 5G conference was not held in 2020) and the most recent one having been held in Las Vegas just this past week, September 26th-28th of this year, 2023.

This information also comes from my having read 5G industry articles and attended online webinars.

It also comes from my decades of experience as a practicing certified Electromagnetic Radiation Specialist (EMRS) in which I have tested 4G LTE and low, mid and high band 5G using RF meters. Most recently, I was a beta tester for the new Safe Living Technologies Safe and Sound mmWave 5G RF meter that measures in the high, millimeter Wave band above 20 GHz.

This information is also discussed in more detail further down in this 5G article. I list below all the frequencies currently being used by these four cell companies. I will be writing an update from all the notes I took while attending this year's 5G conference last week. That update will be posted in this article later in October 2023.

4G LTE cellular frequencies are all broadcast in low and mid band radio frequencies between 600 MHz and 2.5 MHz (or 2.5 GHz). 5G has also been deployed in the low band since 2018 at 600 MHz (T-Mobile) and 850 MHz (AT&T and Verizon), and in the mid band at 2.5 GHz (Sprint, which was bought in 2020 by T-Mobile).

In early 2022, 5G cell signals also started to be broadcast by Verizon and AT&T in the C-band, which is in the mid band between 3.5-4.2 GHz. More C-band service will be coming on line at the end of 2023 and early 2024.

Another mid band 5G service is starting later this year called Citizens Broadcast Radio Service, or CBRS, which will be broadcast between 3.45 and 3.55 GHz. This will be used by AT&T and Verizon as well as by private carriers.

The FCC is also talking about auctioning 6-7 GHz and 12-13 GHz mid band frequencies to the cellular carriers, cable companies and private businesses in the coming years.

Cellular frequencies of 4G LTE and low and mid band 5G that are broadcast in the low and mid bands have wavelengths that are between roughly 15 inches at 600 MHz down to roughly 2-3 inches as you go up to 3.5 GHz. All of these frequencies can go through walls and windows and need shielding to be reduced (though never fully eliminated) such as Y-Shield, RF-ECO and other brands of RF-shielding paint and building foils.

Then, there is 5G in the high band, called the millimeter Wave, or mmWave, band because the size of the wavelength is only 3-5 millimeters, or a quarter of an inch. These frequencies are too short to go through walls and pass poorly through windows. They are also blocked by tree leaves and other vegetation and by rain and snow. They are only meant by the cell industry for outdoor use and extend only a block or so. High band mmWave 5G transmitters are also located indoors in sports arenas, convention centers, airports, malls, metro stops, college campuses and within other public buildings. See much more detailed information about this in earlier updates in this article below.

My understanding from the reading I have done and videos I have watched is that a nationwide test of the Emergency Broadcast System is planned in the U.S. by FEMA and the FCC on Wednesday, October 4th starting at 2:20 PM Eastern Time (11:20 AM Pacific Time), lasting for a minute or so during which time a cell phone that is on will receive one text, continuing for a couple of hours. This has been twice done before, including once to all cell phones nationwide. A second message will be sent to all TVs and radios, the seventh time this has been done nationwide.

According to certain sources, there is major concern at present within the EMF community that the specific use of an 18 GHz radio signal broadcast by 5G cellular antennas throughout the country will activate certain pathogens. While there is general concern about 5G within our community, there is apparently particular concern from some sources about this Emergency Alert Test using the 18 GHz radio signal because of the biological effects it would reportedly have upon releasing certain pathogens.

For what it may be worth, I can say that I have not personally heard at any of the 5G industry conventions that I have attended nor industry articles that I have read nor online webinars that I have attended that 18 GHz is a frequency that has been allocated by the FCC in the U.S. for cellular use nor for private or public unlicensed WiFi or Bluetooth use. No cell companies that I know of in the U.S. regularly use 18 GHz as a broadcast frequency. They only use the frequencies I mentioned above and further below in this article, as far as what has been publicly presented.

That does not mean that 18 GHz is not a frequency that may have been programmed into the existing cellular network to be used during this Emergency Alert Test and at other times specifically for the biological purpose we have been reading about, but if so, the use of that frequency has not been mentioned publicly by the industry. I certainly cannot say that it has not been surreptitiously added.

Also, unfortunately, our RF meters cannot measure 18 GHz because most consumer-grade RF meters on the market today only measure up to 8-10 GHz, and the new Safe and Sound mmWave RF meter, which states on its cover that it measures between 24 and 40 GHz, has been verified to measure down to 20 GHz. But that is not 18 GHz.

I can say that if any broadcast at 18 GHz does occur on October 4, 2023 or at any other time, it would be a millimeter Wave frequency, as one client asked me. That means, it would have a very short wavelength and would not easily pass through walls, if at all. This is well known to the cellular industry, and I verified that fact in my own testing this past summer with the Safe and Sound 5G mmWave RF meter—see updates in this article below.

Furthermore, an 18 GHz signal should be easily blocked by shielding material. That is not the case, however, for lower frequencies. They are not easily blocked at all. You can still get your phone to answer a call in a Faraday cage or pouch if it uses low and mid band 4G LTE frequencies between 600 MHz to 2.5 GHz or uses low and mid band 5G frequencies between 600 MHz and 4.2 GHz to connect to the local cell antenna, but that is not 18 GHz. I have not heard or read that any other frequency besides 18 GHz is specifically being used for pathogen activation, according to sources that talk about that phenomenon.

I must emphasize that if a cell phone is on (and some say even if it is turned off), the phone will receive the text sent by the Wireless Emergency Alert (WEA) system. But that does not mean that that text came in from an 18 GHz signal. It will have come in from the standard 4G LTE or low or mid band 5G signal your phone has been normally using for the past months and years.

Beyond what I have written here, I do not know what else to tell you about this issue except to decide what to do based upon sources you have read, and make your own decision about where to be and what to do with your devices. I do not know for certain what will or will not happen. Do what you feel you need to do to protect yourself.

I can tell you that 5G mmWave cellular antennas are located in urban areas on major boulevards (and in indoor and public areas mentioned above). There are also some mmWave antennas in residential neighborhoods installed by Verizon. However, they transmit at 28 and 39 GHz, the frequencies sold at auction by the FCC, not at 18 GHz that anyone knows about. I do not know where this 18 GHz signal would be broadcast from, unless it is added to existing cellular radios across the industry in a stealth manner, which for all I know may have happened.

However, I have spoken with antenna manufacturers at these 5G industry conventions. To have a nationwide transmission from all 5G cell antennas of 18 GHz happen as feared within our general EMF community would mean the surreptitious addition of a frequency that not all 5G radios are even designed and built to transmit. Only certain ones could, and they would be the ones used for mmWave transmission, and those are limited in their deployment to major boulevards and urban areas. An 18 GHz signal certainly could not be broadcast by any 4G LTE equipment deployed in the field in the past decade and a half.

I am not saying I doubt this concern within our community, but I do not know how it could physically be possible to broadcast an 18 GHz signal from every 5G cellular radio and antenna made by all the private manufacturers, particularly those designed for low and mid band use, including in the C-band and CBRS frequencies.

I do hope the information I have presented here has shed some light upon some of the technicalities of this issue, at least regarding the issue of the physics of 18 GHz based upon what I have learned over the past five years from conferences, articles and webinars about the specifics of cellular technology. If it turns out in the long run that I am wrong, I will stand corrected. Time will tell what happens.

Lecture Slides and Replay Link for Oram's Presentation at Safe Living Technologies' Third 5G mmWave Radiation Learning Session, August 15, 2023

I presented a third lecture summarizing my field experience using the new Safe & Sound mmWave RF Meter since early June 2023, including new videos as part of the Third Safe Living Technologies 5G mmWave Radiation Learning Session webinar that SLT held live on August 15, 2023. The panel at this webinar included presentations by Lloyd Burrell, Dr. Magda Havas, Rob Metzinger, Keith Cutter, co-inventer of the mmWave RF meter with Rob, Bruce Hildesheim, and Oram.

A link to a recorded archive of that third SLT nearly four-hour August 15th Learning Session is found here. A link to a replay of the second Learning Session held on July 12, 2023 is found here. A link to a replay of the first Learning Session held on June 28, 2023 is found here.

I presented slides at the third webinar that you can link to here. As with some of the videos in my slides presented in the second webinar, videos in the latter part of the slides linked to on Dropbox in this third set of slides presented on August 15, 2023 may not show on Safari (you have audio only). If that happens, copy the link at the top of the Dropbox video page and paste it into a browser page on Firefox, Chrome or Edge (meaning another browser), and the video will show along with the audio. To see slides from my second presentation on July 12, 2023, click here. To see slides from my first presentation on June 28, 2023, click here. All PDFs include videos that you can watch by simply clicking on the image.

Check back to the Safe Living Technologies millimeterWave (mmWave) Learning page, under Education on their website, for links to copies of the slides presented by speakers at August 15th's third webinar when they are posted, including from Dr. Magda Havas, Rob Metzinger, Lloyd Burrell and Keith Cutter.

To see slides of Rob Metzinger's presentation on the second July 12th SLT Learning Session, click here. (The PDF you will download from SLT's site will also include my slides, which appear after Rob's slides in the same PDF. They are the same slides you can see using the link that I provide to my slides presented in that second seminar in the earlier paragraph.)

The next SLT mmWave Learning Session will be held sometime this autumn of 2023. Watch the mmWave Learning page under the Education tab on the Safe Living Technologies website to see the date of that fourth webinar when it is announced, by clicking here.

Lecture Slides and Replay Link for Oram's Presentation at Safe Living Technologies' Second 5G mmWave Radiation Learning Session, July 12, 2023

I presented a second lecture with new slides on my continued field experience with the Safe & Sound mmWave RF Meter as part of the Second Safe Living Technologies 5G mmWave Radiation Learning Session webinar that SLT held live on July 12, 2023. The first Learning Session was held on June 28, 2023. A link to a recorded archive of SLT's second two+ hour July 12th Learning Session is found here. A link to a replay of the first Learning Session held on June 28, 2023 is found here.

I presented slides at the second webinar that you can link to here. Videos in the latter part of the slides linked to on Dropbox may not show on Safari (you have audio only). If that happens, copy the link at the top of the Dropbox video page and paste it into a browser page on Firefox, Chrome or Edge (meaning another browser), and the video will show along with the audio. To see slides from my first presentation on June 28, 2023, click here. Both PDFs include videos that you can watch by simply clicking on the image.

To see slides of Rob Metzinger's presentation on that second July 12th SLT Learning Session, click here. (The PDF you will download from SLT's site will also include my slides, which appear after Rob's slides in the same PDF. They are the same slides you can see using the link that I provide in the previous paragraph.)

The next SLT mmWave Learning Session will be held on Tuesday, August 15, 2023 at 1 PM Eastern Daylight Time (one hour earlier than the first two). To sign up for the free webinar, click through to the mmWave Learning link under the "Education" tab on the Safe Living Technologies website. The direct link to the page is here. Like the first two Learning Sessions, the August 15th webinar will be recorded so you can watch the replay.

Lecture Slides and Replay Link for Oram's Presentation at Safe Living Technologies' First 5G mmWave Radiation Learning

Session, June 28, 2023

I presented a lecture with slides on my field experience with the Safe & Sound mmWave RF Meter as part of the Safe Living Technologies 5G mmWave Radiation Learning Session webinar that they held live on June 28, 2023. A link to a recorded archive of that two-hour webinar is found here. I presented slides that you can link to here. These slides include eight videos that you can watch from the PDF version of the lecture slides.

You can also see the presentation by SLT Founder and chief designer of the Safe & Sound mmWave, Pro II and Classic II RF Meters, Rob Metzinger, on that archived recording and download his slides here.

The next Safe Living Technologies 5G mmWave Radiation Learning Session is planned for July 12, 2023. To register for that webinar and also to watch the replay of that webinar once it has happened, click here. Scroll to the bottom of the page to register.

millimeterWave 5G Update June 19, 2023

Report of Measurement of millimeterWave 5G Cellular Signals with Safe and Sound Pro mmWave 5G and FM5 RF Meters

Introduction

I have recently acquired in early June 2023 the Safe and Sound Pro mmWave 5G RF Meter from Safe Living Technologies as one of their beta testers. I have also had the FM5 mmWave 5G RF Meter from Shielded Healing since late 2022.

I have used the FM5 mmWave Meter for more than six months on client jobs and have not found mmWave 5G signals at client's homes until just recently in an urban environment.

mmWave Measurements Taken In Southern California

This is a report of measurements taken of mmWave 5G installations in Santa Monica and Los Angeles, California in early June 2023. Both mmWave 5G arrays were mounted high upon utility and light poles on busy streets, Wilshire Boulevard (and 15th Street) in Santa Monica and Hollywood Boulevard in Los Angeles, near Hollywood.

Both antenna arrays had three rectangular elements that were independently mounted. mmWave antennas are shorter than the taller, thin 4G LTE antennas we have seen for decades. Each antenna is aimed roughly 120 degrees apart from the other two, thereby covering 360 degrees. See the three photos to the right.

Summary of U.S. 5G Deployment by Cell Carrier and Frequency Band

The mmWave array in Santa Monica is a Verizon installation. I knew this because my Verizon iPhone 14 showed “5GUW”, indicating that the antenna was transmitting what Verizon calls their “UltraWideband” service. This means the nearby antenna transmits either in the high mmWave band at 28 or 39 GHz or in the mid band for Verizon’s new C-band service.

Verizon’s UltraWideband mmWave signals can only be measured by the Safe & Sound Pro mmWave RF Meter or by the FM5 (at 28 GHz) and not by the S&S Pro II RF Meter.

Verizon’s new C-band, on the other hand, which they deployed in 2022 and 2023, uses 3.5-4.2 GHz frequencies in the mid band. That is only measured by the Safe & Sound Pro II, which measures in the low and mid cellular bands up to 8 GHz. That contains all mid band cellular frequencies of the C-band, at 3.5-4.2 GHz, and CBRS, as well as the Citizens Broadcast Radio Service, at 3.4-3.5 GHz, which is coming in later 2023 and 2024. Both high mmWave band and mid C-band frequencies are part of Verizon’s “UltraWideband” coverage.

To round out the discussion of how 5G presents itself in the U.S., Verizon also recently started using a re-purposing of their 4G LTE frequency at 850 MHz for their “Nationwide” 5G service, designated by a “5G” icon in the upper right corner of its phones but without the “UW” moniker.

T-Mobile has had its “Nationwide” 5G service at its re-purposed 600 MHz 4G LTE frequency since 2018, as well as a 2.5 GHz 5G signal in the mid band, acquired when they merged with Sprint in

2020. T-Mobile also has had sparse mmWave 5G coverage in the downtowns of half a dozen cities since 2018, which is now expanding.

AT&T has their “Nationwide” 5G coverage from their re-purposed low band 850 MHz 4G LTE frequency as well as their “5G+” high mmWave band coverage in convention centers, sports arenas and now with a growing presence in urban neighborhoods. AT&T also has C-band 5G coverage and its new CBRS 5G coverage, both in the mid band.

Finally, Dish is our new fourth nationwide cell carrier in the U.S. (with U.S. Cellular being a regional carrier in the midWest and mid-Atlantic states). Dish is deploying a fully independent 5G-only nationwide network of cell antennas using the mid and high mmWave bands. This means it has no 4G LTE technology and uses only 5G features such as standalone protocols, massive MIMO, cellular aggregation and other technologies discussed elsewhere in this 5G article. This, as with all 5G and 4G LTE Advanced technologies, means more modulation of the cellular signal and therefore more biological impact on humans and other animals, plants, insects and our environment.

What Meters Will Measure What Frequency Bands?

All 4G LTE and 5G frequencies described above in the low and mid bands will be picked up by the S&S Pro II RF Meter, along with most other RF meters currently on the market, while only high mmWave band signals used by all four carriers at 28 and 39 GHz can be measured with the S&S mmWave RF Meter, and at 28 GHz by the FM5 meter.

I knew the array in Santa Monica was a Verizon mmWave cellular array because “UW” appeared on my Verizon iPhone 14 next to “5G” and only my S&S mmWave RF Meter showed elevated RF readings. My S&S Pro II, on the other hand, showed lower RF readings in that location, meaning a low or mid band 4G LTE or 5G antenna was not nearby.

Plus, the S&S mmWave RF Meter measured very high RF readings coming from my Verizon cell phone with 5G enabled, triggered by being near the Verizon mmWave cell antenna. On the other hand, my Verizon iPhone 14 does not emit 5G signals as measured by the S&S mmWave RF meter nor the FM5 RF meter when it is not near a Verizon mmWave cell antenna.

I used both the quasi onmi-directional stub antenna (50 degrees front and 50 degrees back) and directional horn antenna (35 degrees front) with the Safe and Sound mmWave RF Meter, which measures RF signals in the 24-40 GHz frequency range.

The FM5 has a built-in antenna and measures in the 24-32 GHz range in the mmWave band. It also can be configured to measure 40 MHz to 10 GHz in the low and mid band, and has the capacity to add a higher antenna in the mmWave band when that becomes available.

mmWave Power Density Measurements

I measured the following readings in front of the mmWave antenna on Wilshire Boulevard in Santa Monica with the stub antenna:

- 520 µW/m2 at 30 feet (beneath antenna)
- 540-840 µW/m2 at 130 feet, sometimes exceeding 1,000 µW/m (the signal initially increases as you move away from under it)
- 280-310 µW/m2 at 160 feet
- 10-35 µW/m2 behind a tree

With the horn antenna, the measurements were generally lower at a given distance than with the stub antenna when pointing away from the source, and only showed elevated readings when I pointed almost exactly at the antenna. That feature helped me to confirm the direction of the source, which is the intent of the horn antenna. For instance, as I walked west on Wilshire Boulevard away from the the array on 15th Street, the signal increased as I approached another array in the other direction, on the southwest corner of Wilshire and 14th Street. The horn antenna helped me to determine that I had a second source coming from another direction.

In a seventh-floor, top floor apartment across the street from the mmWave antenna on Hollywood Boulevard in Los Angeles, in the third photo shown above, I measured 1,170 µW/m2 with the stub antenna and 242 µW/m2 with the horn antenna inside the living room with the sliding glass door open, where there was a direct view of the mmWave antenna across the street. As soon as I moved the S&S mmWave meter to the right or left of the open door where the front wall blocked the view, the mmWave reading dropped to 20-40 µW/m2 on the mmWave meter.

At the desk in the living room and in the bedroom, both behind the front wall, the mmWave reading was only 12-30 µW/m2 with the stub antenna (whereas the 4G LTE and low/mid band 5G RF reading on my Safe & Sound Pro II was 8,000 to 40,000 µW/m2 from 4G LTE antennas on the roof right above the apartment, which is why the client called me–the mmWave antennas across the street were an incidental finding).

5G Signals From These Two mmWave Arrays Now Always-On, Not On-Demand

One very important observation that I made with both mmWave 5G arrays was that the mmWave signal, as measured by both the S&S mmWave and FM5 RF Meters, was always-on and not on-demand, as it has purported to be for five years by engineers whom I met at 5G Conferences. I have reported for years in this article and in interviews that I was told by numerous cell antenna engineers that mmWave antennas sit idle, sending out a very weak beacon signal at minus 65-70 dBm, which translates to less than 0.1 microWatt/meter squared (µW/m2) until it detects a phone carried by one of its customers moving in front of it. That triggers the antenna to send out signals at full strength in a beam-formed manner (described below in this article). This was done by cell carriers to save electricity.

However, these engineers made it clear that when a customer walked in front of their mmWave antenna, the antenna only sent out its beam-formed signal to one zone at a time from among the eight to ten zones in front of it. As the phone moved from one zone to another, the first zone turned off as the second one turned on, and so on, keeping full-strength transmissions to one zone at a time (however, the mmWave antenna was capable of connecting to multiple users at once).

When the phone moved out of the antenna's coverage pattern, the mmWave antenna went idle again. This was documented in two videos posted by Brian Hoyer of Shielded Healing. Brian explained that the Verizon mmWave 5G antenna he was in front of was idle and would not be turned on until he took his Verizon iPhone out of Airplane Mode. When he did that, the mmWave antenna waked up, as shown on his FM5 meter, and his FM5 meter also showed that his iPhone started to also emit mmWave signals, as did the antenna.

Furthermore, when Brian moved away from his phone and walked from right to left between his phone and the mmWave antenna, his FM5 meter showed a lower reading on the right that increased to a higher number when he was directly in line between his phone and the antenna, and then the reading dropped again as he continued to walk to the left of that direct line of sight. This proved that the mmWave antenna was only transmitting in that one zone in front of it that Brian's phone was in.

Not any more. My two measurements so far of mmWave antennas in Southern California, one known to be from Verizon, are always-on, with a continuous signal with a rapid sound (slower than from a router, and similar to the sound of an FM radio station). The signal was consistent in strength from moment to moment and as I walked back and forth from side to side at the same distance in front of the mmWave antenna. The signal strength did fluctuate on my mmWave meters, similar to when measuring 4G LTE signals on the Safe & Sound Pro II, but not by much. Finally, the mmWave signal did not change when I turned off the 5G setting on my iPhone and when I put it in Airplane Mode (with WiFi and Bluetooth off).

This means that beam-formed 5G signals from mmWave antennas, at least the two that I have measured so far, are not idle, as they had been since 2018. However, they are also not yet nearly as pervasive as people fear, according to my testing of mmWave antennas over the past six months. I am just not seeing them in suburban neighborhoods where most of my clients live. Just because the cell industry says they need to put mmWave 5G antennas in front of every third house in residential neighborhoods in order to get 5G coverage does not mean they can afford to do so, since these installations cost tens of thousands of dollars to implement. There are, however, newer, private antennas as part of 5G and 6G going in in the years to come.

On the other hand, the deployment of always-on C-band and CBRS 5G mid band antennas and low and mid band 4G LTE Advanced small cell antennas in residential neighborhoods continues unabated, and poses the biggest threat to the health of most of us at the present time, in the opinion of many of us.

To me, these 5G mmWave RF meters are useful for all EMF consultants and those EMF-sensitive people who can afford them to know where mmWave antennas are not, and to avoid those places in more urban areas where they are.

Take-Away Points

In summary, I learned the following from these first two mmWave antenna measurements:

- mmWave 5G signals are no longer on-demand, as they have been for five years since 2018. The two mmWave arrays I have evaluated so far were always-on. I do not believe I was measuring the beacon signal.
- The mmWave signal was also present across a similar 120 degree-wide pattern, just as non beam-formed 3G, 4G LTE and low and mid band 5G signals have been for years.
- The power density of the mmWave signal was *significantly* less than what I have measured for years standing at the same distance in front of 3G, 4G LTE and low and mid band 5G cell antennas.
- The mmWave signal dissipates rather quickly and was not measurable after a city block, in contrast to 4G LTE and low and mid band 5G signals that carry at high power density levels for a mile or more.
- I am not measuring mmWave signals at most homes that I evaluate for clients in suburban residential neighborhoods, which I have measured for over six months with the FM5 mmWave meter. That means that mmWave 5G signals are not prevalent outside of high population density areas.
- What mmWave service I have seen in these two instances so far has been on main boulevards in commercial and high density residential neighborhoods in urban areas, both with foot traffic.
- mmWave service is primarily an outdoor phenomenon because mmWave signals do not penetrate walls and are blocked somewhat by glass. I could easily block the signal with my hand and by standing in an alley behind a building.
- Speedtest showed 90-100 Megabits per second (Mbps) using 4G LTE, which is faster than it

used to be (12-48 Mbps) several years ago. However, when my phone connected with the mmWave 5G antenna, Speedtest showed 2,389 Mbps. That's fast!
- Only customers with phones from the same carrier who installed the mmWave antenna will be triggered to transmit high RF levels (and be able to use the much faster download speeds).
- The power density of RF from my own phone was high around the mmWave antenna, but not higher than levels that I measure when the phone is making a call or sending a text usinf 4G LTE and low and mid band 5G signals. However, RF signals appeared to be more prolonged and less intermittent when connected to mmWave service than to 4G LTE service.
- I had cellular data turned on part of the time that I was I measuring, running an Internet radio station. I also measured with 5G turned off and also with my iPhone in Airplane mode. That eliminated RF signals from the phone, but did not appear to have *any* effect on the signals from the mmWave cell antenna, neither increasing nor decreasing their strength. The RF signal pattern from the mmWave cell antenna appeared to be relatively steady and continuous, similar to 4G LTE signals, but much lower in intensity.
- I also measured elevated RF on the mmWave meter when pedestrians walked by, who presumably also had Verizon phones that were having its 5G service activated by the nearby Verizon mmWave antenna.
- Thus, by far, the bigger harm to me and to passersby was from the mmWave RF signal from our Verizon phones, measured at 50,000 µW/m2 a few feet from the phone (and, of course, much higher when the phone is close to me), than from standing near the mmWave cell antenna itself, measured at 100 to 1,000 µW/m2.

I will continue my mmWave 5G testing and report back to you.

5G Lecture Slides Presented January 14, 2023

To download a PDF version of lecture slides that Oram presented on January 14, 2023 entitled, "A Review of 5G", click here.

5G Update March 23, 2022

To download a PDF version of this March 23, 2022 update, click here.

Introduction

Several important changes have happened in the cellular industry since my last update to this 5G article in October 2020.

First and foremost among them, an Aug 13, 2021 ruling in the United States Courts of Appeals, District of Columbia Circuit irrevocably changed the wireless world — see the full details here. The DC Circuit ruled on the constitutionality/legality (or lack of it) of Federal agencies' regulatory orders and laws passed by our elective representatives. DC Circuit rulings in such cases therefore apply to the entire country.

Specifically, in Aug 2021, the DC Circuit ruled *against* the FCC in a lawsuit that challenged the legality of FCC Order 19-126, which had been the standard of acceptable safety limits by the FCC for over twenty-five years. In August's case 20-1025, Environmental Health Trust and Children's Health Defense et al. v FCC, the judges ruled, "The Commission [FCC] failed to provide a reasoned explanation for its determination that its guidelines protect against the harmful effects of exposure to radiofrequency radiation". The DC Circuit further ruled that the original FCC Order 19-126 was "arbitrary and capricious" and, therefore, unlawful. The order was remanded back to the FCC with very specific instructions of what to do, as one can read in full here.

Read the judges' ruling on Case 20-1025 here. Read a summary of the ruling by the CHD here, and a summary of the ruling from the EHT here. Finally, read about important, immediate action steps you can take, based upon the ruling, at Wire America here.

Turning to what has happened in the past eighteen months in the domestic cellular industry within the U.S., the following took place:

- First of all, remember that 5G comes in three flavors: low band (600 to 1,000 MHz), mid band (1,000 MHz, or 1 GHz, to 6 GHz), and high band, otherwise known as the millimeter Wave (mmWave) band starting at 20 GHz.
- Verizon, and to a much lesser degree initially, AT&T both launched new 5G mid-band cellular service in the C-band at 3.7 GHz in January 2022.
- AT&T has won new spectrum at auction, also in January 2022, for mid-band service at 3.45-3.55 GHz, which they will launch by the end of 2022 and into 2023.
- Meanwhile, T-Mobile has expanded its 5G mid-band service at 2.5 GHz that it inherited from Sprint when the companies merged in 2020.
- The mid band is the "holy grail" for cellular carriers because wavelengths are shorter than lower band 4G LTE service but cell signals still transmit far, and they pass through building walls and both old and new, Low-E, window glass, which mmWave 5G signals cannot easily pass through.
- All three cellular carriers are also expanding their mmWave presence. Verizon far and away leads the pack with mmWave deployment in the past two years in almost 90 U.S. cities, extending well into suburbs.
- Meanwhile, T-Mobile and AT&T are beginning to expand their mmWave service beyond a few convention centers, stadiums, arenas, airports and similar areas with concentrated foot traffic, spreading now into more downtown urban and nearby areas.
- All carriers are also expanding their mmWave antennas into buildings to reach customers when they are indoors in public places (shopping malls, office buildings).
- All three U.S. carriers now use repurposed 4G LTE frequencies for their low band "5G Nationwide" service. Verizon recently added a low band 5G service using repurposed 4G LTE frequencies, just as their competitors have done for the past two to three years.
- U.S. carriers also continue to expand and upgrade their 4G LTE networks in the low and mid bands by installing equipment on legacy cell and small cell antenna arrays that increase speed and lower latency. This is known collectively as LTE-Advanced and LTE-Advanced Pro.
- All of these steps affect particularly electrically hypersensitive people, as well as the rest of us and biological systems in nature.

It is important to understand that 4G and 5G are terms primarily used by the marketing departments of the world's cellular carriers. Industry groups such as the International Telecommunication Union (ITU) also use 5G to define a relatively challenging set of criteria for cellular technologies based upon characteristics such as peak data rate and efficiency, the data download experience of users, latency of data transmission, reliability, mobility and bandwidth. These criteria are set out in the ITU's 2017 publication, Report IUT-R M.2410, "Minimum requirements related to technical performance for IMT (International Mobile Telecommunications)-2020 radio interface(s)," available here.

Engineers and developers working for these carriers, however, also focus on technological features that come from committee work done by members of the Third Generation Partnership Program, or 3GPP, a consortium of the world's cell carriers that provides guidance on how carriers can implement technological innovations and upgrades into the world's cellular networks. The 3GPP publishes recommendations in what are known as "Releases," which are developed and published in a staggered format. The 3GPP and the world's cell carriers are currently working on Releases 16 through 18.

These releases include integration of advanced features, such as:

- Automation of radios at cellular sites for more "edge computing", thereby cutting down on the time it takes commands to be sent from mobile devices to antenna sites, which are then processed by servers and returned to end users' devices, providing what they call "Ultra Low Latency".
- Carrier aggregation, which allows signals to be processed by multiple antennas simultaneously, also markedly increasing download and upload speed.
- Network slicing, which allows networks to simultaneously allocate slices of its signal to different phones depending upon each customers' needs.
- Cell carriers converting from 4G LTE-supported non-standalone (NSA) technology to new, enhanced 5G-supported standalone (SA) technology. Standalone technology is more integrated and operates faster and more seamlessly than non-standalone technology.
- Standalone technology allows for network slicing. Dish network's new, fourth cellular network being deployed in the U.S. is built completely on SA technology. This is possible because they do not have a 4G LTE network that they need to integrate into their new 5G network like older, legacy cell carriers, including Verizon, T-Mobile and AT&T, do, which need to maintain 4G service for their existing customer bases.
- Incorporation of Dynamic Spectrum Sharing, or DSS, by Verizon and AT&T to allow their phones to use 5G technologies when the user's device is only near 4G LTE frequencies.
- Massive MIMO, which allows for many more customers to be connected to the same antenna simultaneously at the same frequency through a process known as "spatial multiplexing."
- Verizon uses massive MIMO for their mid-band C-band service, thereby bringing focused, beam-formed signals used primarily in the mmWave band down into their more geographically expanded mid-band coverage.
- T-Mobile has already been using massive MIMO for three years for their mid-band 2.5 GHz 5G service that they inherited from Sprint.
- Conversion by the industry from Non-Open Radio Access Networks to Open Radio Access Networks (O-RAN). O-RAN provides for more optimization of the flow of information on the network, using virtualized software and greater interoperability. See a summary here.
- Moving the cellular industry's networks onto the Internet. The world's cell networks are now cloud-based, or "cloud native".
- Expansion of fixed wireless Internet service by all three U.S. major cell carriers further into residential neighborhoods.
- Increase in energy/electricity consumption by cell carriers because of increased power density levels.

These upgrades are discussed in more detail below in this update, as well as in previous installments of this 5G article, seen further below.

What Are the Biological Effects of These Advanced Cell Technologies?

All of the technological upgrades listed above have biological implications for us. We need to know how *both* cellular signals broadcast from outdoor (and indoor) cell antennas *as well as* from wireless devices that we keep in our hands and pockets affect our physiologies. We have extensive knowledge of how wireless radio frequency (RF) signals affect us in general, but we do not know the full extent to which these numerous technological upgrades in the 5G era are specifically affecting us now and will affect us in the future.

Questions remain, such as:

- What are the biological effects from these more modulated wireless signals that come indoors from outside sources?
- Which frequencies reach us indoors and which do not?
- When we are indoors, what added harm do 5G technologies have on us at close range from our own portable wireless devices when they are in use versus when they are on standby?
- What are the biological effects of wireless technologies, particularly upgraded 4G and 5G, on wildlife, insects and vegetation, essentially, the earth's bio-sphere?

Just as importantly, we need to focus as much on the harmful effects from wireless devices *within* our homes as we do on outdoor 4G and 5G cell antennas. My colleagues and I say, every time we talk about stopping deployment of 5G antennas in residential areas, we need, in the same sentence and breath, to say, "And also pay attention to the wireless devices in your hands, lap and pocket and those of your children. Let us show you how to shift to hardwired connections when you are at home, in school and at the office".

We are also hearing about so-called "wearables," where cell technology is incorporated into the skin of one's arm or implanted elsewhere on the body or head, allowing for direct connection with cell networks. These and other developments are among the many reasons we need to pause and take a deep look at where all this is headed.

Finally, I give a list, at the end of this update, of links to articles and other sources of information that I used for this specific update, as well as what I consider to be useful websites from the cell industry that you can access yourself to stay informed. You can sign up for regular emails and to be notified of informative one-hour webinars from many sources that go into great detail about the technology involved with 5G.

If you are a 5G activist, you need to stay informed about what the industry is doing technologically so we can understand the basis for biological effects. In my opinion, that way we can come to conclusions and recommendations based upon correctly understanding the technology involved. To see my list of organizations that work as activists and advocates on the issue of 5G, click on "Resources on 5G" in the Table of Contents to the left.

Learning the Cell Industry's Expanded Use of Marketing Terminology

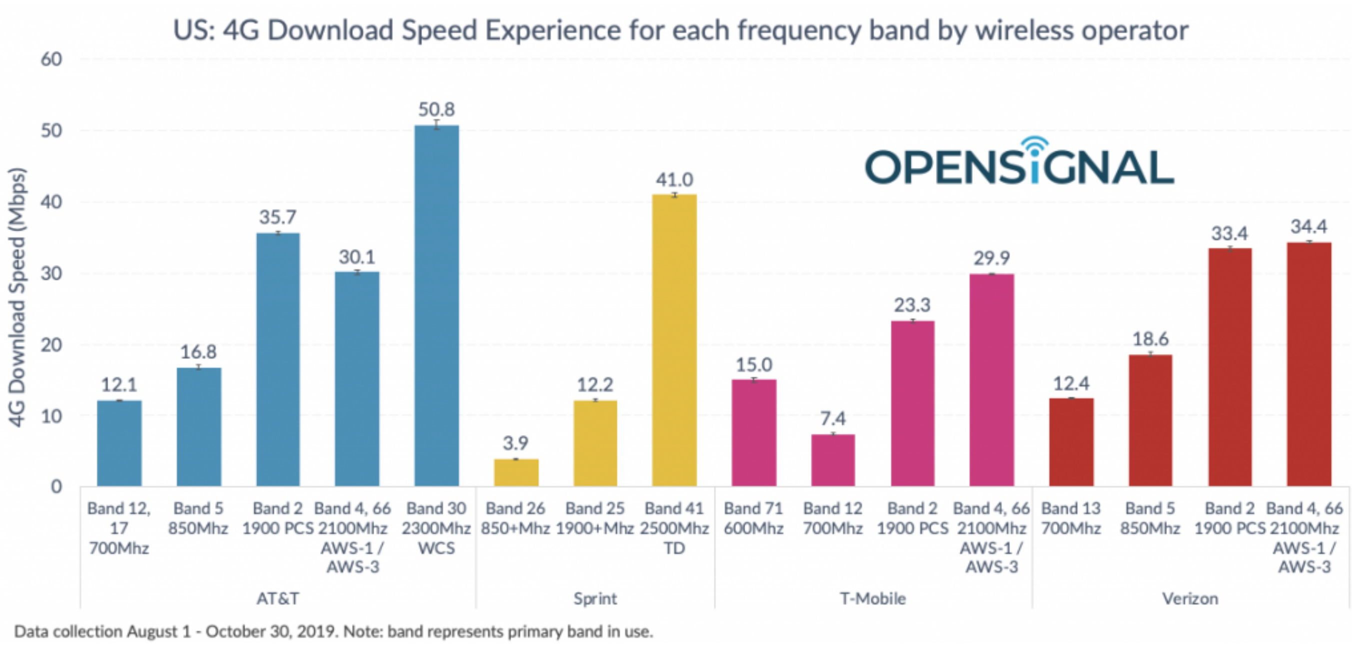
To begin with, let's learn the new terms used by cellular carriers here in the U.S. for their expanded 5G services. Remember, 5G operates differently in each of the three bands that broadcast 5G due to the physics of these different wavelengths and frequencies:

- T-Mobile now calls *both* their mid-band 2.5 GHz service as well as their more limited mmWave service, "Ultra Capacity 5G".
- Verizon now calls *both* their upper mid-band 3.7 GHz C-band service as well as their extensive mmWave high band service, "Ultra Wideband 5G".
- AT&T now calls their upper mid-band 3.7 GHz C-band and their more limited mmWave high-band service, "5G+". When they deploy their new mid-band 3.45-3.55 MHz service in late 2022 and 2023, they plan to also call that, "5G+".

These are in addition to the low band "5G Nationwide" services all three of these carriers provide using repurposed 4G LTE frequencies in the low band (and mid band for Verizon when their 850 MHz frequency is not available).

Here Are the Details

First of all, let's do a brief review. 5G is built upon the 4G LTE network. Here is a chart from Opensignal showing 4G frequencies by carrier, published in 2019 (before the merger of T-Mobile and Sprint):



Refer to the chart above to follow the frequencies used by the various U.S. cell carriers as they have begun to provide low and lower mid-band "5G Nationwide" service in the last three years:

- T-Mobile repurposes their 600 MHz 4G frequency (seen in purple in the chart above as Band 71) for their 5G Nationwide service.
- AT&T repurposes their 850 MHz 4G frequency (seen in blue as Band 5) for their 5G Nationwide service.
- Verizon also repurposes Band 5 at 850 MHz (in brown above) for their new 5G Nationwide service, where available. Where 850 MHz is not available, Verizon uses their PCS (4G) frequency at 1,900 MHz (Band 2) and their AWS (4G) frequency at 2,100 MHz (in brown in Bands 4 and 66).

Verizon and AT&T both also use Dynamic Spectrum Sharing, or DSS, for their 5G Nationwide coverage. DSS provides some of the new 5G technologies when only 4G frequencies are available. This includes carrier aggregation, which combines up to eight channels or frequencies of spectrum to provide more efficiency in data transmission, resulting in data speeds of up to 4 Gbps (4,000 Mbps). DSS service is being deployed by Verizon at their existing 4G LTE cell antenna sites.

Cell carriers therefore all now have a smorgasbord of advanced services, including Advanced 4G LTE, 5G in the low and mid bands, and 5G in the mmWave, to provide faster, more stable and reliable data coverage to their customers with lower latency by integrating many new features into their networks, depending upon where the user's device is located (rural, suburban or urban). However, we must all remember that this comes at a price to our biological health.

There is a sequence that each carrier's phones are programmed to follow to access the fastest cellular data service, depending upon the features in the phone and what services are available in the place where the user's device is located.

For example, Verizon 5G-enabled phones are programmed to first pick up mmWave service where available (in the 28 and 39 GHz band), such as in urban areas with heavy foot traffic and close-in suburban neighborhoods. If mmWave service is not available, Verizon's phones are programmed to pick up DSS coverage at 4G frequencies of 850, 1,900 or 2,100 MHz. If neither mmWave service nor DSS is available, Verizon's phones will then use standard 4G LTE coverage at their 4G frequencies of 700, 850, 1,900 and 2,100 MHz. However, that standard 4G service is now upgraded with advanced technologies, which are even more biologically active to our physiologies than exposure to 4G LTE service was previously. All 5G technologies are highly biologically active.

How Much is Low-Band and Mid-Band 5G Really Different than 4G?

Analysts say that each carrier's "Nationwide 5G" service is really more like "4G+", meaning, that at 50-60 Mbps (Megabits per second), it is somewhat faster than standard 4G LTE's download speeds of 12-60 Mbps but not as fast as the 250-300 Mbps speeds provided by mid-band 5G (such as T-Mobile's 2.5 GHz, Verizon and AT&T's C-band service at 3.7 GHz, and AT&T's yet to be released 3.45 GHz service). Nor is "4G+" as fast as the 700 Mbps to 1 Gbps speeds possible from 5G mmWave service (mostly from Verizon at 28 and 39 GHz).

This Nationwide 5G "4G+" experience provided by the U.S.'s cell carrier's is possible due to small cell antenna densification in urban and suburban neighborhoods, deployment of a speedier fiber-based backhaul network, and more automation at cell tower radios, known as "edge computing" where the network manages itself "on the fly".

Analysts say most customers won't notice much difference in data speed increases when comparing between current 4G LTE and 5G Nationwide service that is broadcast in the low band (at T-Mobile's 600 MHz and AT&T's and Verizon's 850 MHz). Low band 5G service was initially expected to be perhaps only 10% faster, according to some estimates. See Opensignal for detailed surveys of actual speed comparisons between 4G and 5G service by carrier.

It is only when customers connect in the mid band, such as with T-Mobile's 2.5 GHz service, with Verizon's and AT&T's new C-band service at 3.7 GHz, and AT&T's yet to be deployed mid band service at 3.45 GHz, and when customers also connect with Verizon's mmWave service in the mmWave band that they will notice substantial data speed increases.

All customers will notice lower latency and more reliability of their data connection with all 5G services across the frequency spectrum (low band, mid-band and mmWave) compared to 4G LTE in the low and mid-bands.

What Are the Specifics of AT&T's New 3.45-3.55 GHz Mid Band Service?

The new spectrum auctioned off by the FCC to AT&T in January 2022 is called the "Andromeda" spectrum because it does not have its own numerical designation like other cellular bands do (for instance, 850 MHz is Band 5). As such, it also does not have regional limitations and can be deployed nationwide. AT&T's deployment of mid-band Andromeda spectrum will therefore be possible in parts of the country where their C-band service is not yet available because that city's C-band service is in the second tranche coming online in 2023 and 2024, as in Atlanta and Denver.

AT&T will call their Andromeda deployment "5G+", just as they already call their limited, but growing, mmWave presence, which has only been available in arenas, stadiums, airports and convention centers in urban areas. AT&T originally only offered their 5G+ service to business customers, but they recently opened it to all customers in spring 2021. AT&T's Andromeda service will be available on Samsung and Motorola phones, but not the new iPhone SE. Andromeda and mmWave service will, however, be supported for AT&T customers on the new iPhone 14 coming out in autumn 2022.

Are 5G Signals in the Low Band Beam-formed? Does Use of Massive MIMO for C-Band Service Bring More Beam-forming Down into the Mid Band?

None of the repurposed 5G signals in the low band are beam-formed, however Verizon is using massive MIMO technology, known as Multiple Input, Multiple Output, to provide beam-formed signals for its C-band service in the mid band, particularly on the uplink side when sending data from phones to cell antennas.

Standard legacy, macro 4G LTE cell antennas in the low and lower mid band use two transmitting antennas and two receiving antennas per array, known as 2T2R. Many 4G LTE antennas have now been upgraded to “Advanced 4G LTE,” thereby doubling their transmitting capacity to four transmitting and receiving antennas, or 4T4R, as well as incorporating other features. However, 4G LTE signals at 600, 700 and 850 MHz and repurposed low-band 5G signals at 600 and 850 MHz are not beam-formed, as noted above. The photo at right shows a typical 4G LTE cell antenna array, noted by the slender antennas. A few rectangular 5G antennas are also present on the brackets. You will see newer mid- and high-band mmWave antennas on legacy 4G cell arrays.

High band mmWave antennas, on the other hand, use antenna arrays with eight antenna elements across and eight down for a total of sixty-four antennas, or 64T64R, as seen at right. These 64 antennas are housed in a rectangular box, compared to the older, but more plentiful tall, slender 4G antennas with 2X2 or 4X4 antennas seen above. Beam-forming is needed to focus these 64 antennas into a beam-steered signal sent to multiple cell phones simultaneously (that are enabled for mmWave 5G service).

Verizon's use of 64T64R massive MIMO arrays for their C-band antennas provides a beam-formed, focused signal to multiple customers' phones, simultaneously in the mid-band. This increases speeds by up to 180% for C-band customers compared to 4G LTE service. Massive MIMO and carrier aggregation, which combines C-band's 3.7 GHz with other frequencies, provide Verizon customers with 900-1,000 Mbps (1 Gbps) of download speed, similar to their mmWave service. These C-band features also provide faster coverage for Verizon's customers at distances that stretch as far as their 4G AWS service at 2,100 MHz.

When the rest of the C-band becomes available as the second tranche of that spectrum is released to Verizon and AT&T in 2023, both carriers expect to increase their data speeds and the reliability of their networks even further. These are the selling points of these two cell carriers to their customers, and the reasons why customers are choosing to purchase these new phones.

It is also important for us to know these technical details because they allow us to better understand how these updates can affect the health of electrically sensitive people and the general public.

Then there is T-Mobile’s 5G service that broadcasts in the mid-band at 2.5 GHz, which, again, T-Mobile inherited when they took over Sprint in April 2020. T-Mobile’s 5G signals provide download speeds of around 250-300 Mbps. They are also beam-formed using massive MIMO technology, just as Verizon now uses for their new C-band coverage, and which Verizon, T-Mobile and AT&T all use for their mmWave service. T-Mobile’s beam-formed 2.5 GHz mid-band service has been present for three years. It is modulated and people do react to it. A 2.5 GHz 64T64R (64Transmit, 64 Receive) Massive MIMO Unit antenna, manufactured by Samsung for Sprint (now T-Mobile) on display in 2019 at the Mobile World Congress America 5G Conference in Los Angeles is shown at right.

Meanwhile, T-Mobile and AT&T were able to triple the download speed of their re-purposed 4G LTE coverage, which they call “Nationwide 5G” service, at lower frequencies of 600 MHz and 850 MHz, respectively. Download speeds increased from 12-15 Mbps up to roughly 50-60 Mbps.

This, however, is also the same speed as the 4G service you get if you happen to be near T-Mobile’s 1900, 2100 and 2500 MHz (1.9, 2.1 and 2.5 GHz) 4G LTE transmitters. 4G LTE download speeds vary between 12 and 50 Mbps depending upon the frequency used by the 4G LTE cell tower that you are near. All three companies use four or five different frequencies for their 4G LTE service, from 600-700 MHz to 2,100-2,500 MHz, as shown in the first chart above.

Verizon Joins T-Mobile and AT&T in Providing 5G Nationwide Service Using Low (and Mid) Band 4G Frequencies

After criticizing T-Mobile three years ago for calling their repurposed 4G service at 600 MHz “5G”, and after also criticizing AT&T for calling their repurposed 4G service at 850 MHz “5G”, Verizon jumped on the bandwagon in the last year by also offering what they call their “5G Nationwide” service.

Verizon now repurposes their 850 MHz 4G frequency, like AT&T, while also using their 1,900 PCS and 2,100 AWS frequencies when their 850 Hz transmitters are not available to provide their new

“5G Nationwide” service to customers. “5G Nationwide” service offers download speeds somewhere between mmWave and C-band 5G service at the fast end, and 4G LTE service at the slower end.

Verizon Hits the Jackpot By Buying the Bulk of First-Tranche C-Band Service

The C-band within the mid band that Verizon and AT&T bought at the FCC’s auction in early 2021 was turned on one year later, in early 2022. Verizon has the bulk of the first tranche, with AT&T also deploying some of their C-band spectrum in the first tranche that they also purchased. AT&T will have much more of the second tranche of C-band service scheduled to be turned on in 2023. C-band frequencies were reclaimed by the FCC from the satellite industry, which sold that bandwidth back to the FCC for sale to domestic cell carriers.

Verizon previously had no significant 5G service below the high, millimeter Wave (mmWave) band above 20 GHz, with all of its limitations of range and the inability of cell signals to pass into buildings. That is why they spent so heavily for new C-band service, which resides in the mid band with signals that can more easily pass into buildings, when it became available for auction in early 2021. Verizon then spent all of 2021 installing this new C-band service, primarily at existing 4G legacy and small cell sites.

Cell antennas transmit in the C-band at 3.7 GHz and neighboring frequencies, all in the mid band. The C-band offers download speeds of 250-300 Mbps, which is ten to fifteen times faster than today’s 4G LTE service, whch range only from 12 to 60 Mbps. C-band service has a fairly wide reach, up to a few blocks (compared to miles for low band and lower mid-band 4G service and only a block or so effectively for high band mmWave service).

The wavelength of C-band, at 3 inches or so, can still penetrate building walls and windows (compared to 15 inches down to 5 inches for 4G signals, which can easily pass through all walls and windows). Remember, as the frequency goes up, the wavelength gets shorter.

Verizon’s C-band mid-band service is poised to compete against rival T-Mobile’s 2.5 GHz mid-band service. However, T-Mobile far exceeds Verizon in nationwide coverage of PoPs (Points of Presence), as Sprint began rolling out that service three years ago.

T-Mobile is planning on rapidly deploying its 2.5 GHz mid-band 5G service to new customers in small towns and rural areas. That means, electrically hypersensitive (EHS) people will need to watch for this deployment if they have retreated to rural areas to get away from cellular antennas/towers in more urban and suburban areas. Most of the rural deployment will likely be in towns where populations are somewhat higher, at least initially. Remember that mid-band 5G cell service does not travel the miles that low band and lower mid-band 4G service does. See more information below in this update on 5G in rural areas.

What’s New in the mmWave Band?

Regarding the mmWave band above 20 GHz, Verizon has used only that band for its 5G service, broadcasting at 28 and 39 GHz until 2022 when they launched their C-band service (along with their low and lower mid-band Nationwide 5G service, also launched in 2021).

T-Mobile and AT&T had not increased their mmWave 5G presence in the past few years beyond downtown urban areas and stadiums, arenas and other public places within a few cities, focusing instead on rolling out their low and mid-band 5G services, which all have different characteristics than 5G signals in the mmWave band. However, both T-Mobile and AT&T are now expanding their mmWave 5G service as of 2021 and 2022.

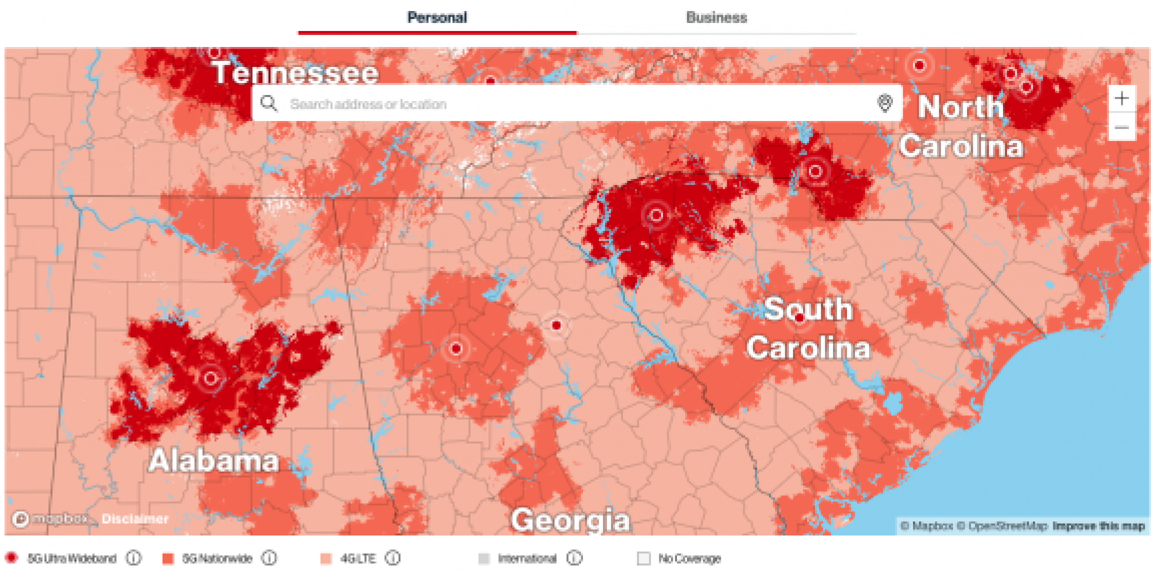
We used to be able to see exactly which streets Verizon's mmWave 5G transmitters were located on when viewing Verizon's coverage map as you zoomed in far enough in any of the 90 cities that have mmWave 5G Ultra Wideband coverage, seen here. However, when Verizon turned on their C-band 5G transmitters in late January 2022, they also began to call their C-band antennas "5G Ultra Wideband" service, thereby combining C-band antennas broadcasting in the mid-band at 3.7 GHz with their mmWave antennas, broadcasting at 28 and 39 GHz.

That means that now all you see for the designation "5G Ultra Wideband" on Verizon's coverage maps is entire neighborhoods awash in one uniform, deep red color, at least for those cities included in the first tranche of C-band coverage. This is because C-band transmitters cover a much wider area (several blocks) compared to the one block or less effectively covered by mmWave antennas.

Thus, all you see now on Verizon's coverage map in most downtowns and surrounding suburbs in those cities with a glowing red dot is a uniform deep red color without individual streets delineated with black lines, as was the case for just their mmWave coverage prior to late January 2022.

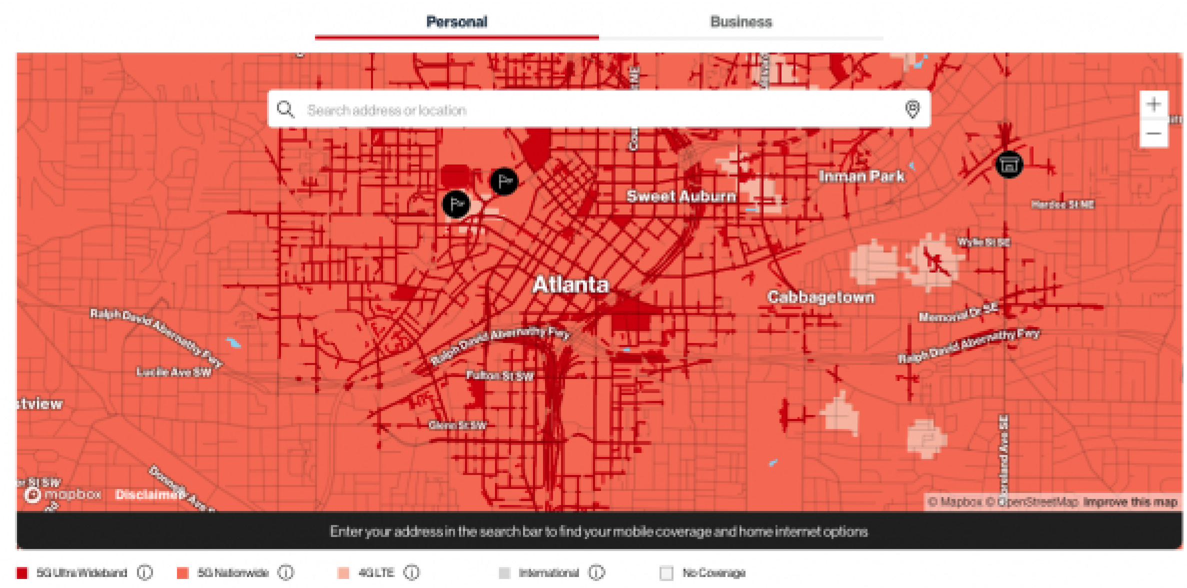
However, I have noticed an interesting phenomenon. In those cities that are not in the first tranche of C-band coverage, like Denver and Atlanta, you will notice that you can *still* see where Verizon's mmWave antennas are installed because they are delineated by dark red lines on portions of certain streets. This is helpful for EHS people to know where to avoid, at least in those cities.

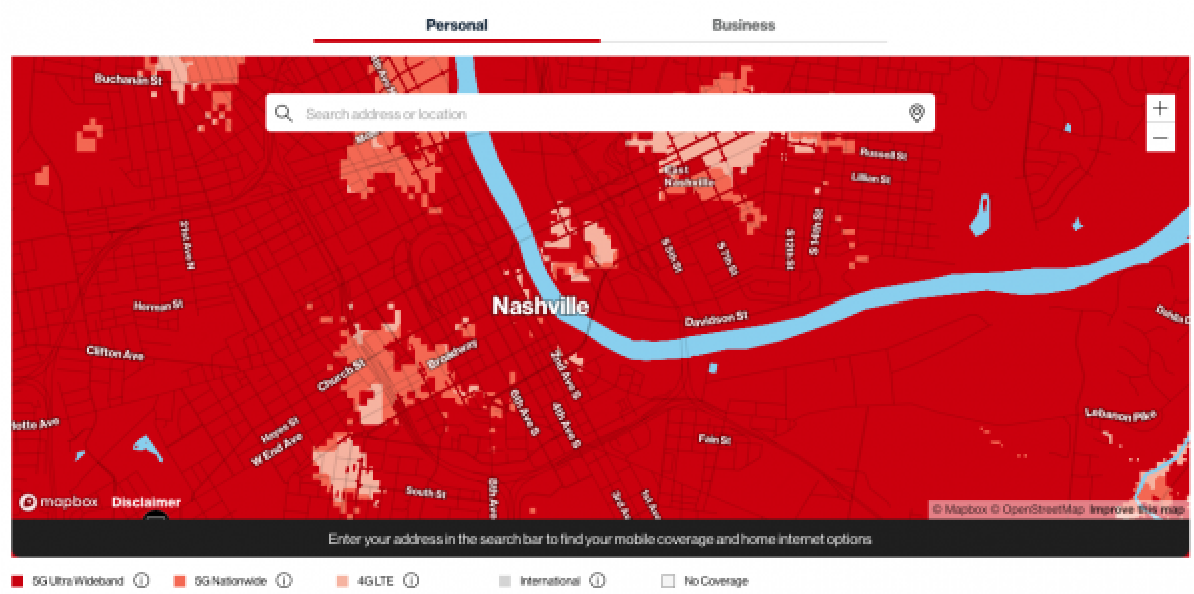
You can also tell which cities have C-band coverage in this first tranche, and which do not. Those with C-band coverage have a large swath of deep red with a glowing red dot in the middle of it, while those cities that do not have C-band coverage yet only have a single glowing red dot with no swath of dark red around it. This will all change in 2023 and 2024, when the second tranche of C-band service is released for Verizon and AT&T.



As an example, notice in the screen shot to the right showing Verizon's 5G coverage in the Southeast U.S. that Nashville, Tennessee, Greenville, South Carolina, Charlotte, North Carolina, and Birmingham, Alabama all have C-band coverage, seen as red swaths around a central red dot, while Atlanta, Georgia and Columbia, South Carolina do not have C-band coverage. Hence, they are not surrounded by a swath of dark red color like the other cities. (The orange color around Atlanta and Columbia indicates Verizon's "Nationwide 5G" coverage using repurposed 4G frequencies, which is now available everywhere but is not beam-formed.)

You can therefore still see the street-by-street deployment of mmWave antennas as dark red lines on the map below in Atlanta and other cities not in the first C-band tranche. Again, this can be helpful for electrically sensitive people living and working in those cities with Verizon's mmWave service but not C-band service.





Nashville, on the other hand, where C-band service *has* been established, has a map, seen at right, that is almost solid red, showing no distinction between the location of C-band antennas and mmWave antennas.

Remember, Verizon's mmWave antennas are also present in cities with swaths of red. We just do not know any longer where they are, at least, not from the map (nor do we know from the map exactly where C-band antennas are located in any city where they are deployed).

So unfortunately, you no longer can see exactly where Verizon's mmWave antennas are located (in those cities with C-band coverage) unless you drive around and look for them. They have a rectangular shape.

Verizon's mmWave antennas are definitely beam-formed antennas, emitting focused energy to cell users when mmWave 5G-enabled phones are in front of them. We cannot measure the mmWave cell signals they transmit with our RF meters.

T-Mobile and AT&T do not have much in the way of mmWave service, again having focused more on deploying their low and mid-band 5G service over the past three years. However, they, too, are both now expanding 5G service in the mmWave band beyond stadiums and minimal downtown coverage in a handful of cities. Click here for an updated description lower down in this article of and links to T-Mobile's and AT&T's coverage maps.

Cell companies are expanding mmWave service even into small towns (though probably not out into the countryside to any significant degree, since populations are sparse and there is no foot traffic there).

It is Important to Understand the Physics of the mmWave Band

As a review, cell signals that are broadcast in the mmWave band (above 20 GHz) have a wavelength of roughly one-half inch or less. These signals must therefore all be beam-formed in order to effectively transmit to user's devices. They do not penetrate walls and windows well at all. The signals only transmit with any significant strength about one block or so and are easily blocked by buildings, trees, and rain and snow.

It is important that we all remember that mmWave signals can only be picked up by cell phones when outdoors. Hence, they are only deployed where there is good foot traffic, such as on sidewalks in downtown areas and in public places where a lot of people walk. Cell carriers need to install mmWave antennas inside buildings to get coverage there, such as in arenas, airports and other public places. All low and mid-band cell signals, whether 4G or 5G, on the other hand, can pass through walls and windows into buildings.

You see Verizon's mmWave 5G service, which they call "5G Ultra Wideband", in almost 90 cities around the U.S. (as of March 2022) in and around downtowns and spreading out into nearby suburbs. You also find it in stadiums, sports arenas, airports, metro stops, college campuses and inside buildings. mmWave cell antennas are rectangular in shape. Download speeds with mmWave service are 600-1,000 Mbps, easily 20 or more times faster than today's 4G LTE data service.

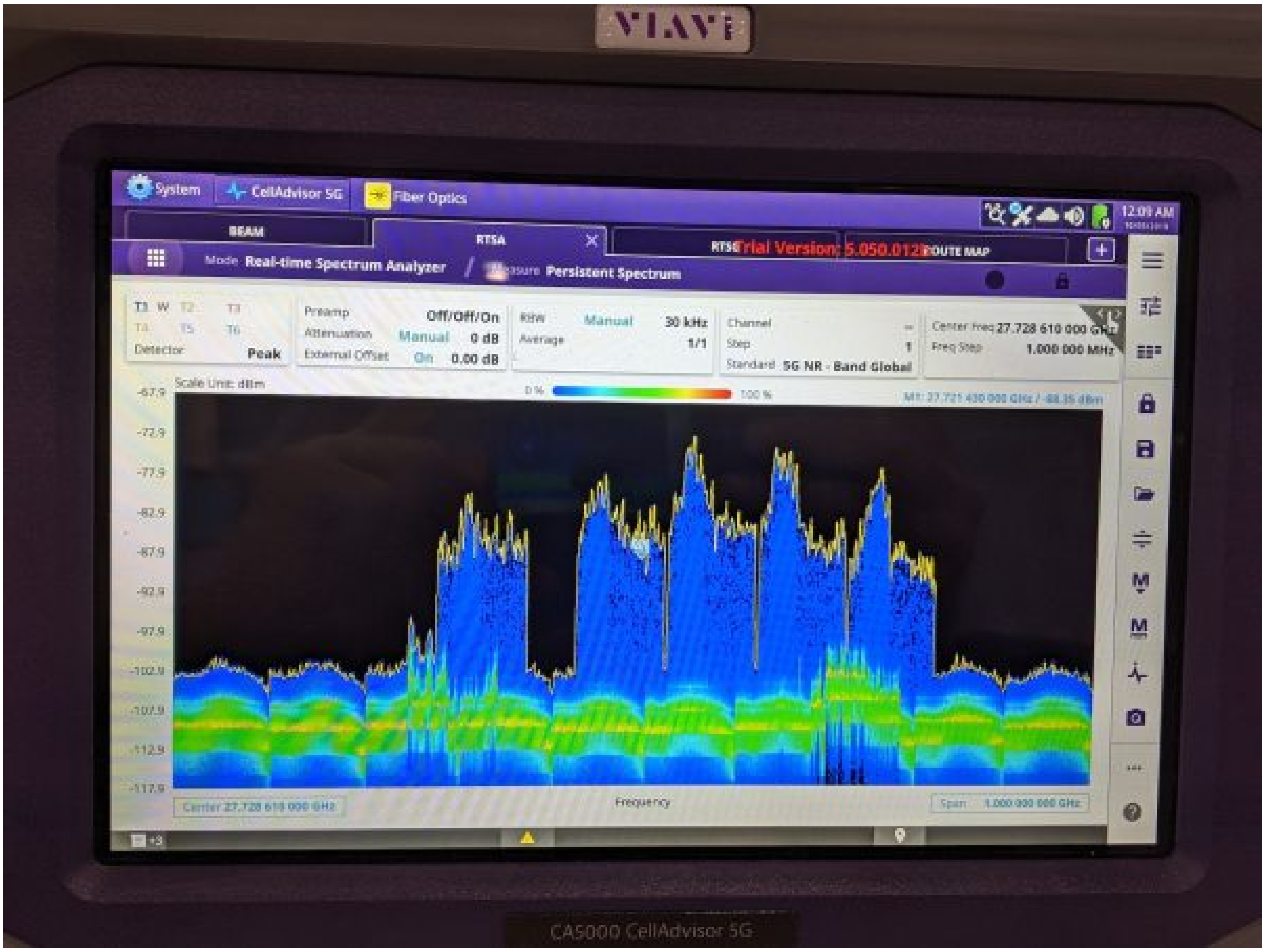
As stated in earlier parts of this 5G article, what everyone is unaware of is that 5G cell antennas in the mmWave band are for the most part, idle, except for a weak beacon signal, until someone with a mmWave 5G-enabled phone walks by using data services. Then the 5G mmWave cell antenna sends out a beam-formed signal to that phone for data activity (streaming audio or video, uploading/downloading content, etc.). However, this only happens in one zone at a time as the phone moves through its service area in front of the antenna. That means, a mmWave 5G's antenna sends out its signal only in one of the 8-10 zones arrayed in the 120 degrees of coverage in front of it, from left to right, with each zone measuring roughly 10 degrees wide when viewed from above. Which zone is active changes as the user device moves through the 8-10 zones.

Of course, in areas with foot traffic, there will be multiple users connected simultaneously to one 5G mmWave antenna, making such areas virtually inhospitable for electrically hypersensitive (EHS) people, and not safe for the rest of us.

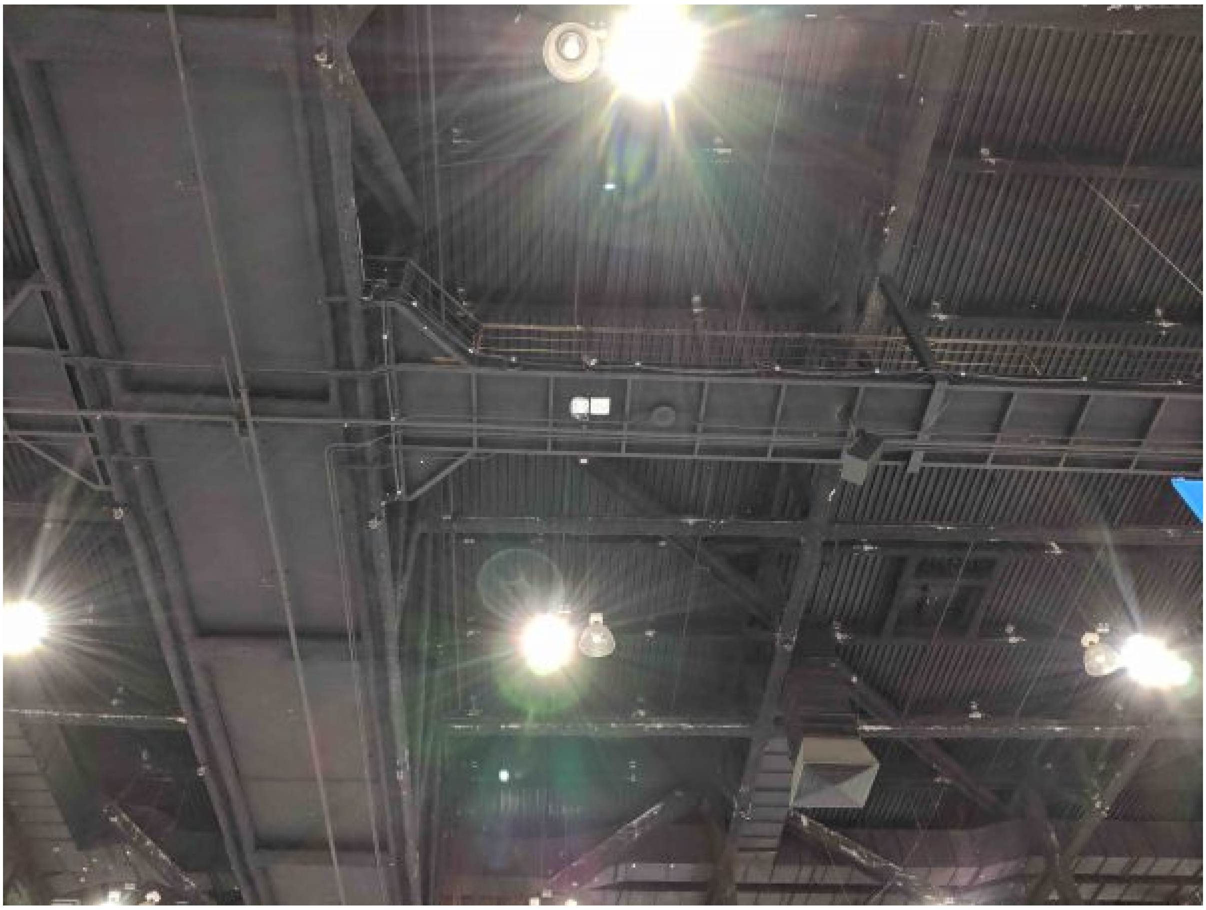
There can be no obstructions, such as a building or tree, between a mmWave 5G antenna and your phone or tablet to have a usable data connection. If there is no longer any mmWave 5G-enabled phone in front of a mmWave 5G antenna, meaning once that phone moves through its service area, that antenna becomes idle once again.

It is the case that mmWave 5G antennas do send out a beacon signal several times a second, however, the power flux density (PFD) of that beacon signal is measured at 1% of the broadcast signal strength when a connection is made to a mmWave 5G-enabled phone (mostly for Verizon customers). The strength of that weak beacon signal is measured at only -60 to -70 dBm, which is equivalent to roughly 0.01 microWatt/meter squared (µW/m2) on a standard RF meter (however we cannot measure these mmWave signals because by broadcasting at 28 and 39 GHz, they are much faster than our RF meters are capable of measuring—see below).

The image below shows mmWave 5G beacon signals on the display of a Viavi spectrum analyzer that is capable of measuring cell frequencies in the high, mmWave band above 20 GHz (the meter is shown in the RF meter section below). You will see the yellow peaks on top of blue columns measuring at -72 to -87 dBm from beacon signals being broadcast by Verizon mmWave 5G antennas in the rafters of the Los Angeles Convention Center. Notice the frequency listed in the box in the lower left corner of the screen of the Viavi spectrum analyzer, showing “Carrier 27.728 GHz” (28 GHz), the frequency that the 5G transmitter uses in the high, mmWave band.



The Verizon mmWave antenna in the ceiling of the Los Angeles Convention Center, the source of these beacon signals, is seen below as one of the white, square boxes in the center of the photo:



Compare that power density of 0.1 µW/m2 to the typical 5 to 200 µW/m2 of RF power density, or strength, that we usually measure standing in front or back of our client's houses in any suburban neighborhood. That is what I typically measure with my RF meter at clients' homes here in Los Angeles, but all cities and suburbs are the same.

Certainly to electrically sensitive people who do not use wireless devices in their homes and who are sensitive to wireless frequencies, even this beacon signal from mmWave 5G antennas causes them to react and become symptomatic. I fully understand and respect that, which is why urban areas are not hospitable for such individuals, and all cell service is harmful to all of us and to the biosphere.

From a realistic standpoint, however, I look at the fact that the vast majority of my clients, half of whom are symptomatic or sensitive and half are not, still use a cell phone. I also look at existing cellular RF saturation in my clients' residential neighborhoods already measuring in the dozens to hundreds of microWatts/meter squared.

For these reasons, as a practicing building biologist in a large city, I am not nearly as concerned about the mmWave beacon signal for the majority of my clients as I am about the beam-formed signals when data connections are in use and as I am about continued heavy use by some of them of their handheld wireless devices in their personal space. Certainly those who are electrically sensitive would not be able to live near *any* cell antenna, no matter what the generation.

In discussing the energy consumption of 5G cell technology, it was pointed out that 5G base stations (cell site radios and antennas) can put themselves into sleep mode, as part of what is termed, "ultra-lean design," when users are not present. This is done to reduce energy consumption, which will be much higher overall when many small cell antennas come online. It was not specified which 5G band this referred to, but we know that all mmWave 5G antennas power down, except for the beacon signal, when a customer with a mmWave 5G-enabled phone is not in front of it.

4G LTE cell sites, including small cells, on the other hand, "need to transmit a lot of control signals even when no one is listening—for example, at night," according to Emil Bjornson, professor at Linkoping University in Sweden, where extensive cell network research is conducted, in an article published by the IEEE, "The 5G Dilemma: More Base Stations, More Antennas—Less Energy?" This points out the fact that existing and new 4G LTE networks, particularly small cell sites in residential neighborhoods, are a big dilemma because they are always on, transmitting into nearby homes—see below. Most small cell sites still primarily use 4G LTE technology, though even that is more advanced and modulated, as they rapidly add 5G technology.

Overall, according to 5G expert, Angela Tsiang, cell carriers are asking for increased safe thresholds for cell transmission because they are increasing transmission strengths to increase coverage. This is pushing energy/electricity consumption up. New proposed rules by the FCC would allow exposure thresholds four times higher than they already are, which is currently far too high to protect human health. These higher RF levels will result in symptoms of "microwave sickness" in many, according to Dr. Lennart Hardell of the Environment and Cancer Research Foundation and Mona Nilsson, Managing Director of the Swedish Protection Foundation.

How Much 5G Will Actually Be Fully Available in the 2020s?

This is an important question what with the industry's marketing arm beating the drum on 5G, as does the larger EMF safety community, for good reason. 5G has certainly focused the public's attention on EMFs, which is always good. We as practitioners need to make people aware of the full range of EMFs in their lives, and the focus on 5G has only helped to increase that awareness.

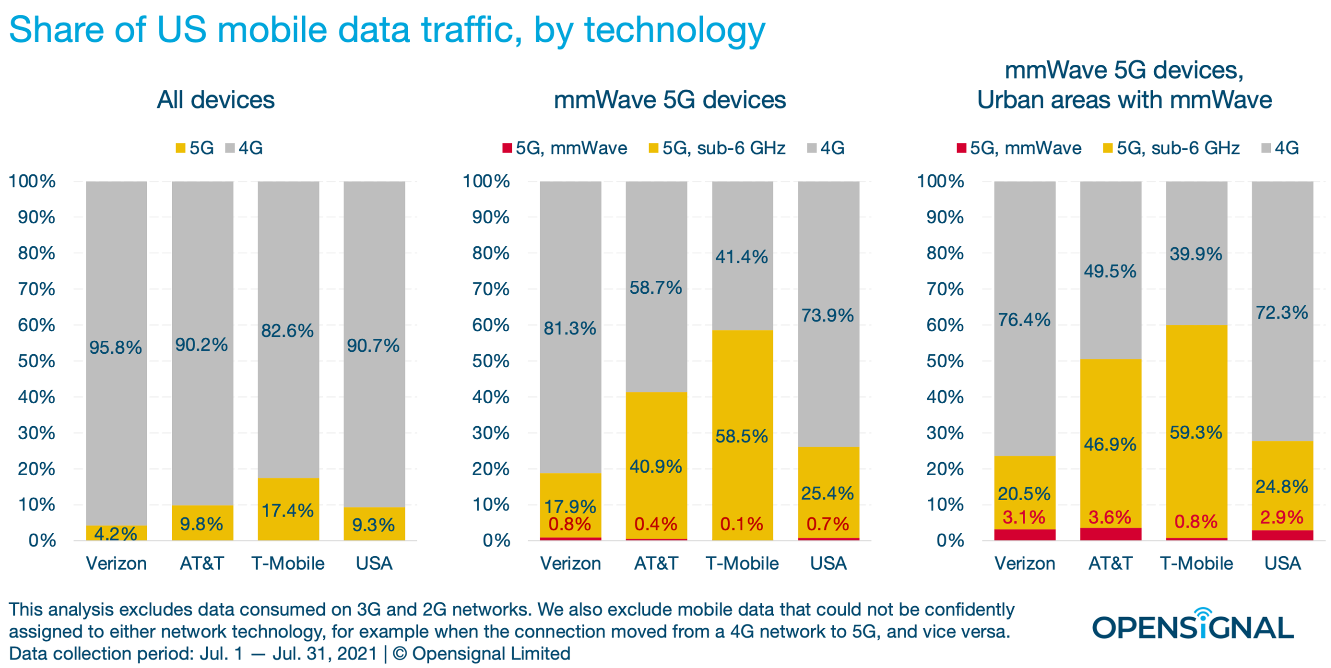
It is important, at the same time, to understand that in reality, in any given decade, we mostly see the full use of the generation of technology deployed in the *previous* decade, while the technology of the *next* generation is mostly being installed in the current decade, only to be fully realized in the next decade. Doug Dawson, wireless industry consultant at CCG Consulting and publisher of the industry watchdog blog, POTs and PANs, points out that the 2010s was the decade that 4G LTE technology was deployed while the 2020s, the decade we are in now, is the decade that 4G is being fully utilized. He reminds us that the first fully functional 4G LTE cellular antenna did not go online in the U.S. until 2018, the first year we started talking about 5G. See Doug's January 19, 2022 POTs and PANs blog post, "When will we see real 5G?" for details.

In his article, Doug quotes an October 2021 article in PC Magazine which itself quotes Ari Pouttu of Finland's University of Oulu, where a good deal of cell technology is developed. Doug said most 5G is actually made up of more 4G spectrum and moderately faster cellular service that most people don't know what to do with or need. The increased spectrum that 5G has provided has mostly helped the cell industry cope with vastly increased data usage of their overloaded 4G LTE cellular data networks. Ari Pouttu says most of the usable innovation from 5G on a practical basis is in industrial settings, where vast amounts of data need to be handled efficiently.

That means the 2020s is the decade when 5G technology is being deployed, but its data and voice usage is still only a percentage of that for 4G LTE. Ari Pouttu says each generation's technological promises won't be fully implemented for ten to twenty years, and most 5G features that we hear about now won't be realized for at least five to six years.

Opensignal is a good resource to use to follow the rollout of 5G and see how it actually compares to 4G service. They have thousands of actual cellphone users around the world collecting data for their database. Opensignal then publishes surveys every quarter showing cell usage in countries around the world comparing cell service provided by each country's carriers. Their March 10, 2022 article, "How the 5G experience has improved across 50 US states and 300 cities," gives a detailed analysis of 5G use as of early 2022. It is available here.

A chart published in July 2021 by Opensignal and seen below is most instructive at showing how much 4G LTE service we still have, at least as of summer 2021.



You will notice that when you compare 5G to 4G service in the bars on the left for all devices and all frequency bands for the three major carriers, plus USA Cellular (in the Midwest and Mid-Atlantic states), 4G service was still 82 to 95% of total data usage. That meant that 5G service was not more, as of summer 2021, than 17.4% of *all* data usage on T-Mobile, with Verizon's 5G data usage only 4.2% of their customers' total data usage, while AT&T stood at 9.8% (USA Cellular was 9.3%.)

When you break that down further into mmWave 5G service vs. sub-6 GHz 5G service (which includes both repurposed low band and mid band 5G) in the middle gray bars above, you see that mmWave service, with its beam-formed signal, comprised less than 1% of total 5G usage as of summer 2021.

That, of course, was before the switching on of the first tranche of C-band service in late January 2022, which has increased mid-band service, including Verizon's massive MIMO beam-formed signals.

Other carriers are also spending significant resources expanding their 5G service, particularly in the mid band, but also in the low and high, mmWave bands. T-Mobile has announced that it expects its total 5G footprint to be close to 50% of all of its customers' data service later in 2022 (due to continued expansion of its mid-band 2.5 GHz service, which they are putting much emphasis on).

A resource for learning about activity in this area within the cell industry, the Small Cell Forum, stated in a 2018 survey that 5G usage was expected to overtake 4G by 2024, and that "The total installed base of 5G or multimode small cells in 2025 is predicted to be 13.1m, over one-third of the total in use," and "…the vast majority of new deployments to be in dense or Hyperdense environments by 2025." This means, dense, urban areas, which are more and more becoming no-go zones for electrically sensitive people.

Whether these predictions made in 2018 will come true or not, 5G is being deployed in this decade and will become fully integrated into networks in the 2030s. Yet the industry is pushing to make 5G available to as many customers as possible, as soon as possible. We therefore certainly need to watch out for C-band and other mid band transmitters, as well as mmWave transmitters, deployed in our residential neighborhoods, both appearing as rectangular antennas. We can measure some of them with our RF meters, while others (in the mmWave band), we cannot.

Learn about efforts to educate communities and local officials about the dangers of deploying cell technology, of whatever generation, in residential neighborhoods. See links at the end of this article for organizations and individuals involved in that effort, accessed here.

Another source of cellular deployment collected by the lay public has been organized by Prof. Dr. Magda Havas in Ontario, Canada. Magda created the Global EMF Monitoring Network in 2021. Over 150 volunteers around the world follow a protocol to measure RF exposure in towns and cities with their RF meters. Data compiled by this group of volunteers is updated monthly on the Global EMF project's website. Follow their progress here.

Strand-Mounted 4G and 5G Antennas Coming to a Neighborhood Near You

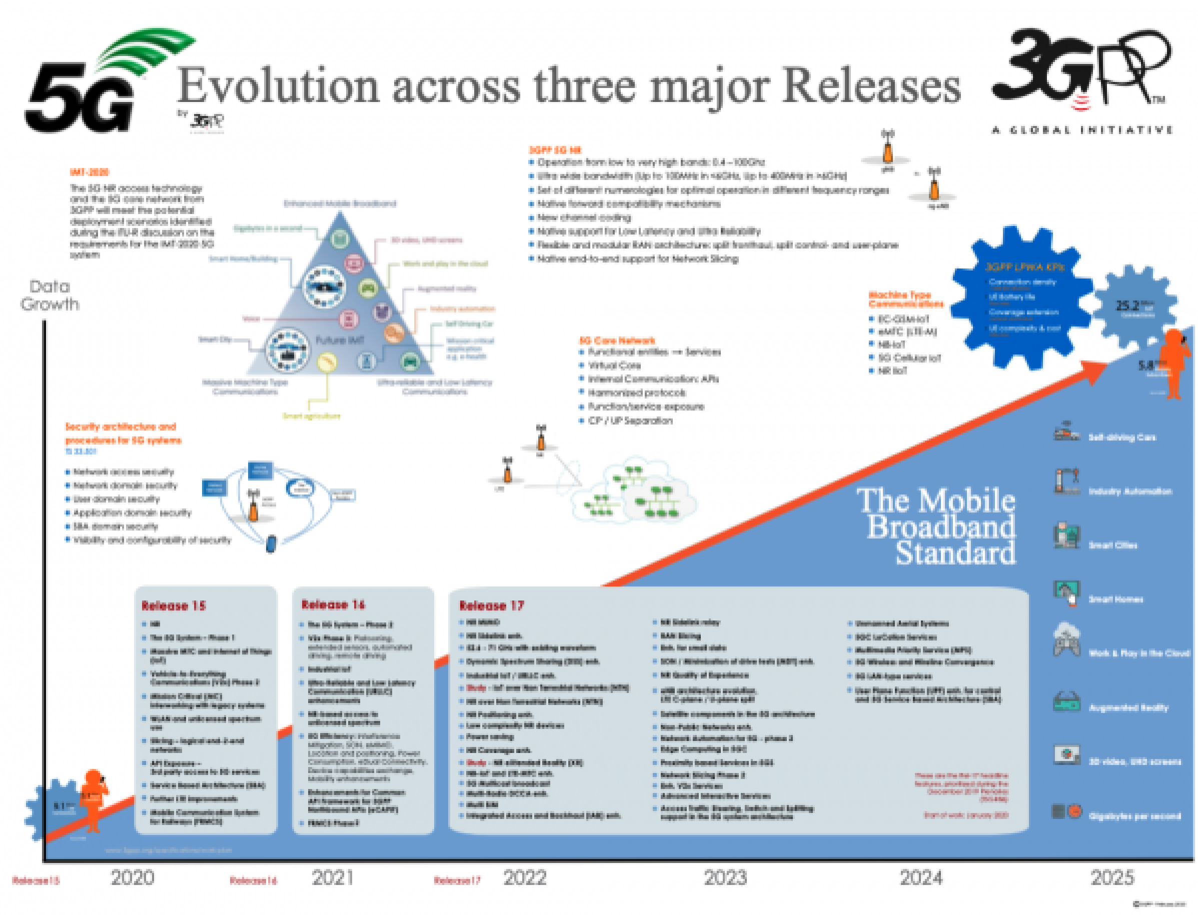
Cell carriers are using every avenue they can to deploy new 4G and 5G cell antennas in urban and suburban areas, resulting in what is termed "antenna densification" of cell service. Small cell antennas that transmit at power densities lower than legacy antennas (which are themselves spaced at one to one and one-half miles apart), are dropped into residential neighborhoods on light poles, traffic lights, buildings, electric transmission towers and utility poles. These small cell antennas are much closer together than the 1-1.5 miles between legacy antennas, often appearing every block or two. However, from the cell industry's perspective, siting small cell antennas on light poles, buildings and traffic lights requires permits, which are time consuming and provide avenues for citizen groups to protest deployment, which is the focus of our activists and advocates.

The cell industry has turned to manufacturers, such as CommScope, to provide small cell antennas mounted on low voltage telephone and cable aerial wires that are mounted above ground on utility poles. This is a way for cell carriers to streamline and bypass the standard permitting process because utility poles and the lines they carry are already in place. Examples of strand-mounted cell antennas can be seen here and here.

You can spot the rectangular cell antennas on these small cell strand mounts if you look closely. Plus, if the antenna is transmitting in the low and mid bands, whether using 4G or 5G technology, you will also be able to measure it with most RF meters, depending upon the precise frequency used and the frequency range your RF meter can pick up (see below).

How Do Cellular Engineers View "5G"?

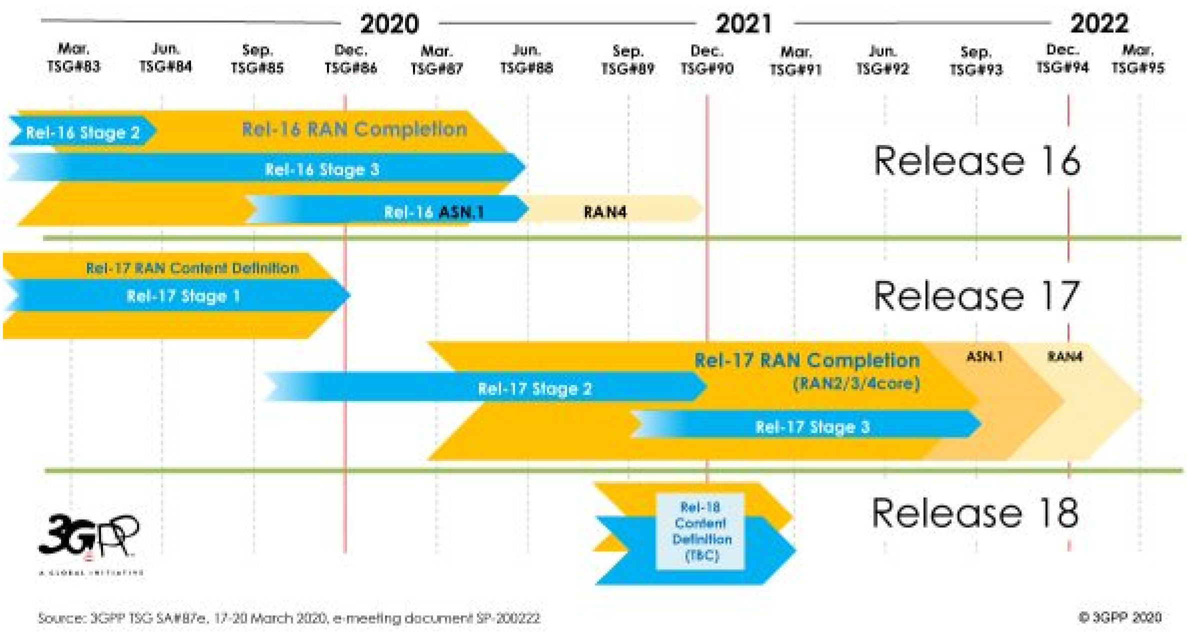
Engineers who work in the cellular industry do not use the monikers "4G" and "5G" like the rest of us do. They leave that up to the marketing guys who sell their company's services to the general public. Cellular engineers and developers, on the other hand, speak in terms of Releases 15, 16, 17 and 18.



The Third Generation Partnership Program, or [3GPP](), is a worldwide consortium of cell carriers from around the globe. It has been meeting since the 1990s to guide the industry in adopting technical standards to advance the performance of cellular devices and networks. At any given time, teams of committee members work on numbered releases who's publications are staggered as other guidelines are being worked on by other committees. If you want to know what the industry is planning for the future, this is where to look.

To the right, you will see a [poster]() published by the 3GPP in 2020 summarizing their view of 5G and Releases 15, 16 and 17. This shows you how the cell industry understands 5G. Download it directly from the 3GPP.org website [here]().

As of early 2022, Releases 15 and 16 have already been published and begun to be adopted by the industry. Releases 17 and 18 are at various stages of development. Release 17 will be released this year (2022), while Release 18, which is being called "5G Advanced," will be released in 2023 and 2024.



To the right is a flow chart published by 3GPP showing how releases overlap and are staggered.

Features of these Releases include all the technological advances listed at the start of this update. They also include topics such as security, industrial automation, artificial intelligence, machine-type learning, vehicle-to-everything connectivity, and private and public networks.

All of these technologies have potential biological implications that we must learn about. We must know the specific biological effects of each of the features listed in these releases, because these influence the technology that shapes and configures the RF signals being broadcast from modern day cellular radios and antennas.

Besides the information found on the 3GPP website, you will find a good synopsis of Releases 17 and 18 from Ericsson by clicking here.

Why Is Apple's New iPhone SE Not Carrying mmWave 5G Service?

Apple's new iPhone SE is designed for simplicity and affordability, costing less than half what a new iPhone normally costs. That means, its components are priced more affordably, including its antennas and processors. As such, it will not support mmWave service, which requires more costly components (it will also not support AT&T's new 3.45 GHz mid-band service).

This will mostly impact Verizon customers, but only for mmWave service, because the iPhone SE will connect to Verizon's (and AT&T's) new C-band service at 3.7 GHz, thus providing lower cost access to faster mid-band speeds. This shows Verizon's emphasis on its new mid-band presence, although they continue to roll out their mmWave service, as well.

Can We Measure 5G With Our RF Meters?

As I have written extensively before, we can measure some of the 5G frequencies available today while we are not able to measure others. This is simply due to the physics of the wavelengths and frequencies of radio waves.

If you look carefully at the range that your RF meter can measure and then pay close attention to the frequencies transmitted by each cell carrier for their 4G LTE and various flavors of 5G services, you will know whether your meter can measure a particular cell signal or not.

Most consumer-grade RF meters measure between 27, 200 or 800 MegaHertz (MHz) at the low end and 8 to 10 GigaHertz (GHz) at the upper end. Since no U.S. cell carrier transmits signals for consumer-grade cell service below 600 MHz, their low band 4G LTE and repurposed 5G cell signals in the low band between 600 and 1,000 MHz will be picked up by all RF meters that start lower than 800 MHz.

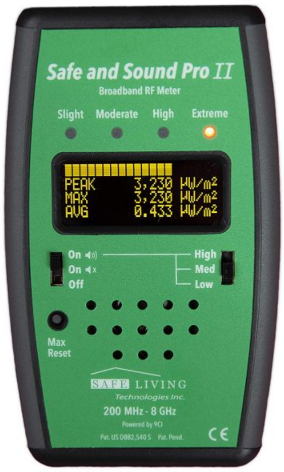
Gigahertz Solution's HF35C, which starts to measure RF frequencies at 800 MHz, however, will not measure T-Mobile's low band 4G signals, nor their 5G signals, at 600 MHz. Nor will the HF35C measure 700 MHz used for 4G by Verizon and AT&T.

Gigahertz Solution's HF38B begins at 700 MHz and should therefore pick up 700 MHz 4G from AT&T and Verizon, but not T-Mobile's 600 MHz 4G nor its repurposed 5G at that frequency.

Gigahertz Solution's HFE35C and HF59B RF meters start at 27 MHz, and will therefore pick up all low band 4G and 5G frequencies, as will most other popular RF meters on the market.

U.S. cell carriers transmit 4G LTE up to 2,500 MHz (2.5 GHz), which will be picked up by all popular RF meters.

As we get up into new 5G signals in the mid band at and above 2,500 MHz, however, those signals may not be picked up by some RF meters. To review, T-Mobile's mid-band 5G service is at 2.5 GHz, and Verizon and AT&T's new C-band service is at 3.7 GHz. AT&T's new mid-band acquisition, going



live in 2023, is at 3.45-3.55 GHz.

The Safe and Sound Classic II and Pro II RF meters measure accurately up to 8 GHz, so they will pick up these frequencies easily. The Acoustimeter and Acousticom2 will likewise pick up all mid-band 5G signals, as they also measure up to 8 GHz. The Cornet ED88t and Tri-Field TF2 should also pick up these mid-band 5G signals because they, too, reportedly measure up to 8 GHz and 6 GHz, respectively.

Finally, while the Gigahertz Solutions HF35C, HFE35C, HF38B and HF59B RF meters will measure T-Mobile's 2.5 GHz 5G service, because they measure up to 2.5 GHz (and really measure up to 3.3 GHz), those RF meters are not expected to pick up Verizon's and AT&T's C-band service at 3.7 GHz nor AT&T’s new 3.45 GHz service.

Bear in mind that *none* of these RF meters can measure 5G service in the millimeter Wave (mmWave) band above 20 GHz. As I have written previously, we know of several meter manufacturers and individual engineers hard at work on developing affordable RF meters that can measure 28, 39 and 60 GHz signals, as well as other mmWave frequencies yet to be auctioned off by the FCC.

Spectrum analyzers sold by Viavi, Rohde and Schwarz and others are used by the cell industry to monitor their radios and antennas broadcasting in the mmWave range, but they retail for $35,000 to $85,000 each. Viavi’s spectrum analyzer is shown at right. Several of us have demo’d them at the booths for these retailers at the Mobile World Congress America/Los Angeles 5G trade shows in Los Angeles in 2019. We were able to see the beacon signal on the spectrum analyzer at -60 to -70 dBm for Verizon’s mmWave antennas mounted up in the rafters near the ceiling of the Los Angeles Convention Center. See this described above, with a photo of the display on the Viavi spectrum analyzer showing the beacon signal of Verizon’s 28 GHz mmWave 5G antenna.

What Should We Be Paying Attention To Regarding Health Effects from Advanced Cell Technology?

As we focus on the impact that 5G technology has on our health, an important related question for all of us is, are we possibly focusing on a new generation of cell technology while ignoring the continued presence of and harmful impact from previous generations of cell technology that are still far more prevalent than we think? We rightly read and hear a lot about 5G, which is necessary to know about because of the detrimental biological impact that it produces. I praise the hard work of EMF activists and advocates around the world for bringing this important issue to the public’s attention. They have certainly done a great job, judging by the number of calls and emails I and my colleagues receive on a daily basis asking about 5G. You can find a list of these organizations further down in this report, in the section entitled, “Resources on 5G,” linked to here and from the last item on the Table of Contents to the left.

In addition, in my opinion, there tends to be a certain degree of genuine misunderstanding and confusion concerning what is truly going on with 5G. This is quite understandable because this is a vastly complex subject. Beam-formed signals in the mmWave band are very damaging to our health, to be sure, but they do not yet constitute the majority of cellular data or voice traffic and will not come close to being the majority type of signal for years to come, if ever. We need to keep in mind that mmWave signals realistically do not travel more than a block or two and are currently limited to downtown urban areas with a lot of foot traffic and surrounding areas (mainly from Verizon). Remember that mmWave antennas also only transmit when a 5G-enabled cell phone comes in front of them, and only in one 10 degree-wide zone at a time. Your house is therefore not being "blasted" with mmWave 5G signals, and it is quite likely your house does not even have a mmWave 5G antenna in front of it.

However, we now have the deployment of massive MIMO, beam-formed signals in the mid-band with the advent of C-band deployment by Verizon and AT&T in late January 2022, as well as MIMO, beam-formed mid band signals transmitted by T-Mobile at 2.5 GHz (initiated three years ago by Sprint). Both of these signals are more prevalent, are quite modulated, may be always-on, travel farther than mmWave signals, and can penetrate into buildings because of their longer wavelength (in contrast to mmWave signals, which, again, cannot pass through walls or windows). They are deployed on both legacy cell arrays located every 1-1.5 miles as well as on small cell arrays in residential neighborhoods.

C-band signals are turning out to be a game-changer for electrically hypersensitive (EHS) people in a not so helpful way, and will also impact the rest of us. Many EHS people have reported an increase in symptoms while traveling and living in their suburban and urban neighborhoods since the C-band was turned on in late January 2022. We can still shield C-band signals, perhaps somewhat more easily than lower frequency 4G and repurposed 5G signals due to the C-band's shorter wavelength. However, EHS people definitely notice it when they are outdoors, and even when indoors for some of them. This is disconcerting, and more C-band and other mid band deployment is coming in 2023 and 2024, as noted above.

What has been as significant a health risk in the past two to three years from what I have seen is the deployment of many more lower power small cell 4G LTE and low and mid-band 5G antennas in residential neighborhoods as part of "antenna densification". These small cell antennas are placed in between legacy, macro 4G LTE antennas, which broadcast at 800-1,000 Watts and are separated from each other by one to one and one-half miles. Legacy 4G LTE antennas will remain the backbone of the cellular network for all three main, established U.S. carriers for years to come.

These small cell antennas, on the other hand, broadcast at somewhat lower power densities and are intended to take the data load off of older, established legacy 4G antennas.


Small cell 4G/low and mid-band 5G

antennas are located deep in residential neighborhoods, broadcasting at 100-400 Watts. I show two examples here in Los Angeles at right. These small cell antennas in front of people's homes wreak havoc on second floor bedrooms in the front of the house, where many of us have measured RF levels in the tens of thousands of microWatts/meter squared of RF power density, well above our acceptable RF levels for sleeping areas of less than 10 microWatts/meter squared.

Both legacy, macro and small cell 4G LTE antennas are always-on and transmit fully across the entire 120 degree-wide space in front of them, not just in one 10-15 degree-wide zone, like on-demand mmWave 5G and higher mid-band antennas do.

Thus, in my mind and in the opinion of other consultants, small cell 4G LTE antennas that are dropped into residential neighborhoods in front of people's homes with strong always-on coverage can be as problematic as mmWave 5G antennas. And now, C-band and other mid band cell antennas are adding to all that.

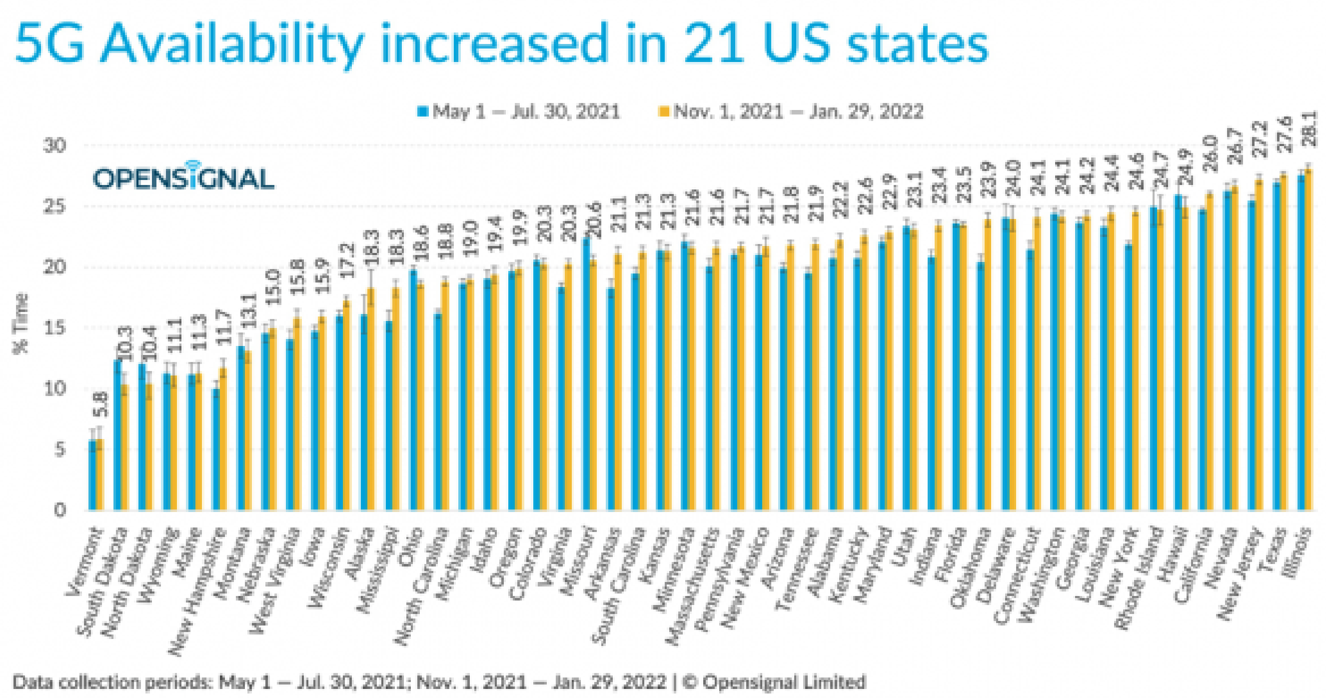
The bottom line is, cell antennas of *any* generation are all bad, but we should understand which type of antenna is located where and what frequency it is using to better understand potential adverse health impacts and how to shield against it, which I discuss further down in this article here. Those parameters determine the characteristics of the signals being transmitted.

Electrically Sensitive People Retreating to Rural Areas for Protection

Many electrically hypersensitive (EHS) people are moving to rural areas because they are too symptomatic in urban and suburban neighborhoods. The cell industry puts cell antennas where customers are located. That is, after all, their business model. Most of the deployment of 5G in all bands as well as upgrades of 4G LTE are going into densely populated urban areas. mmWave signals, as you have learned, can only be received outdoors and so their antennas are being deployed where heavy foot traffic occurs, as well as inside public buildings. Mid-band deployment in the C-band and related frequencies are bringing beam-formed signals into suburban, residential neighborhoods.

Until now, EHS people have been able to retreat to rural areas to get away from most of this. However, the cell industry, having moved well along on their 5G deployment plans in urban and suburban areas, are now focusing on expanding Advanced 4G LTE and 5G coverage, in all bands, in rural areas. If you are EHS, you are probably still relatively safe out in the country, away from other people (except for the occasional legacy 4G/low-mid band repurposed 5G cell antenna that covers a large area). You will not have mmWave antennas out in the country.

To see which states have the least rural 5G coverage to date, go to Opensignal's March 10, 2022 article, "How the 5G experience has improved across 50 US states and 300 cities," available here. They say, "Smartphone users have a diminished 5G experience in sparsely populated U.S. states," and "we…once again found that our 5G users in sparsely populated U.S. states had a comparatively reduced 5G experience compared to our 5G users in more populated states." That included slower 5G download speeds and also a harder time finding a 5G signal. See the graph below.



Opensignal does report "signs showing that U.S. carriers are planning to address the challenges of providing a good 5G experience in small rural states." However, that progress is spotty and not consistent, which is good news for EHS people. Read Opensignal's full report to see the states where improvement in 5G coverage has not yet occurred, also shown in the graph above.

Pay Equal Attention to Wireless Devices In Your Home, Hand and Personal Space

Furthermore, more EMF consultants and advisors should, in my opinion, also mention the need to pay attention to the wireless device in people's hand, pocket, on their bedside table and so on when talking about 5G antennas outside their home. I am not being critical of the good work being done by activists, who work tirelessly to spread the word about these technologies. All who speak out in the EMF community and to family and friends deserve our praise for raising awareness of this issue.

I would only add, as I always have, that we need to *also* pay attention to the strong RF-producing devices we keep within our personal space that constantly transmit invisible, silent, and odorless radio frequencies that are just as harmful to our bodies at subtle and gross levels as signals from outdoor antennas.

What should we therefore focus upon as EMF practitioners and as the public at large? I would say, first, focus on what wireless devices you and your clients have in their pocket, hand, next to their head and inside their houses, in bedrooms, kitchens, at desks, baby's cribs, etc. If they are worried about 5G, make sure they also take care of all the portable devices they have in their possession. All those devices produce RF energy at higher levels than what comes into their house from outside.

Second, how close is their house to legacy, macro as well as repurposed small cell 4G LTE antennas on the street in front of their house or apartment? Right now, legacy and small cell 4G LTE antennas are quite problematic because they are always on and much closer to people's houses. Plus, all new, upgraded 4G LTE antennas transmit what is called, 4G LTE Advanced signals, which are far more modulated than they used to be. Finally, do they have any rectangular mid band and mmWave 5G antennas, whether strand mounted or pole mounted, near where they live, work or learn?

More modulated means how radio signals are generated within a cell antenna's radio and how they are transmitted, using technologies provided in industry Releases (15, 16, 17 and 18) meant to increase speed, reduce latency, and allow more slicing, optimization and automation of the processing of the signal. Cellular transmissions are more digitized and polarized than they used to be as a result.

EHS people were already reacting to this higher degree of modulation from 4G LTE and repurposed 5G antennas, which is a big problem, even before the C-band was turned on in early 2022.

I suggest that we not think in terms of the numbers 4G or 5G. I suggest we simply call them "cellular signals", or "4G/5G", stating that antennas are now more modulated than they were previously. If you can pick up a cell signal on your RF meter, it is 4G LTE, increasingly with some low and mid-band 5G mixed in. We must pay attention to both power density as well as the modulation of the signal, regardless of the signal strength. But in addition, your client needs to pay as much attention to the wireless devices in their pocket, hand, next to their head, and rooms inside their house as they do to outdoor cell antennas.

Links to Cell Industry Websites for Detailed Information, Blogs and Webinars

There are many valuable websites for learning the details of how the cellular industry plans to implement 5G technology and upgrade 4G LTE technology. You can sign up and attend one hour-long webinars, presented by many of the sites below, to deeply learn the details about the technology. You can also sign up to receive regular email updates from many of these industry news sources on the latest in the field, including webinar announcements.

Here are sites that have been helpful for me to keep up with what is going on:

- FierceWireless
- POTs and PANs
- Rohde & Schwarz
- Viavi Solutions
- RCR Wireless News
- PCMag
- Opensignal
- Mobile World Live
- 5G Americas
- Qualcomm
- Nokia
- Small Cell Forum

Links to Educational and Activist Organizations on 5G

Links to websites of organizations that are educating the public and government officials about 5G can be found further down in this report, in the section entitled, "Resources on 5G," linked to by clicking on "Resources on 5G" in the Table of Contents to the left.

Sources of Information for This Update

Besides attending the last three Mobile World Congress America/Los Angeles 5G Conferences held in Los Angeles in the past four years (not held in 2020), I researched this information in trade publications and webinars sponsored by the 5G industry (presented in the list above). You will find specific references for the information in this update here, here, here, here, here, here, here, here, here, and here.

In addition, for a review of how the FCC is dominated by individuals who come straight from the industry they are tasked with overseeing, read Captured Agency: How the Federal Communications Commission is Dominated by the Industries It Presumably Regulates, by Norm Alster and published by Harvard University.

(End of March 23, 2022 update.)

Links to 4G LTE and 5G Maps for U.S. Cell Carriers

*Here are links to **4G LTE/5G maps** for the three major U.S. cell carriers, **T-Mobile**, **AT&T**, and **Verizon** (T-Mobile merged with Sprint in April 2020), as well as **US Cellular**, plus a word about **Dish Networks's** cellular network deployment (this information is updated as of March 24, 2022):*

- To see a map of **T-Mobile's** 4G LTE and 5G service, click here. T-Mobile's "5G Ultra Capacity" coverage is their own millimeter Wave (mmWave) service that they installed in 2019 in downtown areas of six major cities, plus the much more extensive mid band 2.5 GHz 5G service they inherited from Sprint when they merged with them in April 2020. Both are beam-formed signals, but only the 2.5 GHz signal, with a wavelength of 5 inches, can get through walls and windows (the beam-formed millimeter Wave signal with a wavelength of one-half inch, however, cannot). They call it, "A more reliable connection in crowded locations", meaning, they put these 5G Ultra Capacity antennas in urban areas where there is a lot of foot traffic. That is in dark purple on the map, concentrated in denser parts of cities and surrounding suburbs. However, you cannot tell which antennas are broadcasting in the mmWave band, at 28 and 39 GHz, and which are in the mid band at 2.5 GHz. You can look at an archived view of T-Mobile's website's coverage map from 2019 to see the relatively small extent of their mmWave 5G coverage in parts of downtown Los Angeles, New York, Cleveland, Las Vegas, Dallas, Cleveland and Atlanta by clicking here. I checked back to that page several times during 2019 and 2020 and saw no change in T-Mobile's mmWave coverage maps until they merged with Sprint in April 2020, likely due to a focus on their Nationwide low band 5G rollout at 600 MHz. Thus, we do not know if T-Mobile put up more mmWave antennas in those six cities or anywhere else beyond the coverage you see in these archived 2019 maps. (Update 3/24/22: T-Mobile is now extending their mmWave, beam-formed 5G service beyond limited service in downtown areas of six cities.) The bulk of their 5G Ultra Capacity today is likely their 2.5 GHz coverage (although mmWave service is now also included in more areas). T-Mobile's 2.5 GHz 5G service is more extensive than its mmWave 5G service and has properties of cell signals in the mid band, not the high band, (farther reach, passes through walls and windows), however, it does also use beam-formed massive MIMO (Multiple Input, Multiple Output) antennas arrayed as 8X8, just as they use for mmWave service above 20 GHz. Next, T-Mobile's "5G Extended Range", available throughout suburbs and rural areas in most of the rest of the country, is medium pink on their current map. This is their repurposed use of their 600 MHz 4G LTE signal, and represents only a slight increase in speed over standard 4G LTE service at that frequency. They say it is available "indoors and out", as signals at 600 MHz have a wavelength of about 15 inches and easily go through walls. Download speeds are "Faster than 4G LTE speeds in more places." The signal is not beam-formed, but it is always on and somewhat more modulated than older 4G LTE. However, bear in mind that all 4G LTE antennas are being upgraded to "Advanced 4G LTE", which is itself more modulated than previous 4G LTE broadcast technology, and therefore more potentially harmful to us. T-Mobile's 5G Extended Range and 4G LTE signals are always on, broadcast from traditional legacy cell towers as well as newer small cell antennas that are now closer to homes in residential neighborhoods.

- To see **AT&T's** 4G LTE, 5GE and 5G+ coverage map, click here. What is listed on their coverage map as "5G" in lighter blue is their repurposed 4G LTE 850 MHz signal. This is extensive throughout the country but is only slightly faster than 4G LTE. Like T-Mobile's "5G Extended Range" service, AT&T's "5GE", as it appears on your phone, is a non-beam-formed signal that is, however, more modulated than older 4G LTE (and is like the Advanced 4G LTE that existing 4G LTE transmitters are being upgraded to). AT&T's millimeter Wave 5G service, on the other hand, called "5G+", which is now available to all of their customers since April 2021, is now available in "select high-speed zones and venues in over 20 states across the U.S.", according to their website. This means in certain cities as well as inside convention centers, sports arenas and stadiums in the downtowns of certain major cities as well as a growing number of airports. (That would be parts of downtown Los Angeles, West Hollywood, in Dodger Stadium and in San Diego for those of you in Southern California, and in parts of Menlo Park, Oakland, Redwood City, San Bruno, San Francisco, San Jose and in Oracle Park in Northern California.) This is seen as an emblem that looks like a "+" sign inside a circle on their coverage map. To see a list of those cities that have coverage, go to their coverage map. You will see a box in the upper left corner labeled, "Wireless coverage". In the lower left corner of the box, you will see "5G+ Available". A pop-up box will appear labeled, "Available high-band *5G+* venues" that lists states. Click on a state to see a list of cities, then click on the city to see the venue(s) within it that have AT&T's 5G+ service. There are 22 states listed as of March 2022 (up from 16 states as of November 2021). You will also see these circles with a "+" sign inside of them show up in these 22 cities as you zoom into the national map. Click on the emblem to see the exact location and name of the venue. Venues appear to be sports arenas, convention centers and airports.
- To see **Verizon's** 4G LTE and 5G service map, click here. Verizon calls their millimeter Wave 5G service "5G Ultra Wideband", which is "Available outdoors" in almost ninety cities (as of March 2022), seen on the map with glowing black dots. You used to be able to zoom in on any city with a glowing dot to see street coverage of their mmWave antennas, shown as black-lined portions of streets. However, with Verizon's launch of their mid-band C-band 5G coverage in late January 2022, they now include their C-band service with their mmWave service in their "5G Ultra Wideband" coverage. In those cities that allowed the first tranche of C-band coverage, you now only see a wide swath of red to indicate this 5G Ultra Wideband mmWave and C-band coverage, meaning, you cannot distinquish between C-band and mmWave antennas and can no longer see mmWave antennas on individual streets. However, in those cities that are not in the first tranche of C-band coverage, like Denver and Atlanta, you will notice that you can still see only mmWave antennas as dark red lines on portions of certain streets, which is helpful for EHS people to know where to avoid. You can also tell which cities have C-band coverage in this first tranche, and which do not. Those with C-band coverage have a large swath of deep red with a glowing red dot in the middle of it, while those cities that do not have C-band coverage yet only have a single glowing red dot with no swath of red around it. (That will change in 2023 and 2024, when the second tranche of C-band service is released for Verizon and AT&T.) In addition, Verizon also now has its own "5G Nationwide" service, which they say, "Includes 4G LTE coverage" and like their competitors, is repurposed 4G. Verizon repurposes their 850 MHz signal for their "5G Nationwide" service. Where 850 MHz is not available, they use their 1,900 MHz PCS signal and their 2,100 MHz AWS signal. None of these repurposed 4G signals for Verizon's "5G Nationwide" service are beam-formed. Verizon has the most extensive mmWave coverage of any company and they are pouring millions of dollars into expanding it. They went from 70 cities in autumn 2021 to almost 90

cities by March 2022. I noticed this service spreading into suburbs of the cities they cover (when I could see only the mmWave antennas in all cities they cover). However, remember, Verizon's mmWave coverage is only available outdoors (mmWave signals cannot easily penetrate through walls or windows) and it is weaker than all 4G LTE signals or 5G signals in the low and mid bands (with their new C-band service), meaning it only realistically extends a block or two and is easily blocked by buildings. We have learned that mmWave 5G antennas sit idle except when a customer with a mmWave 5G-enabled Verizon phone walks or rides in front of it, and then, the beam-formed signal is only beamed into one ten degree-wide zone at a time among the 8-10 zones in front of each mmWave 5G antenna as the person walks/rides from zone to zone. The mmWave antenna then reverts back to idle mode when that person walks or rides through its service area, only sending out a beacon signal at -65 to -70 dBm, equivalent to roughly 0.1 microWatt/meter squared. (Your cell phone in your pocket regularly puts out hundreds of thousands to millions of µW/m2 at close range, which is very harmful, and we routinely measure 5 to 50 µW/m2 or more of RF exposure on people's lawns from distant 4G LTE cell towers, much stronger than the 0.1 µW/m2 emitted by an idle mmWave 5G antenna.) To be sure, millimeter Wave 5G signals are certainly harmful, more-so than 4G LTE, but please be aware of the physics regarding precisely how it actually works along with where it is available, and where it is not. We recommend that we think of this whole topic as combined "4G/5G", taking into account the harm from all generations of technology and frequencies.

- Two more cellular networks exist in the U.S. The first is US Cellular, with coverage in the Midwest and mid-Atlantic states. They partner with another network for customers to have coverage outside their primary service area. Their 4G/5G coverage map is available here. They say, "UScellular® 5G uses a spectrum that isn't blocked by walls or barriers the way other carriers' 5G can be." That means to me that they are not using millimeter Wave frequencies, which are blocked by walls and windows, but since they also say, "UScellular 5G is so much faster than today's 4G it virtually eliminates latency, responding in what seems like real time", that probably means they are using mid band frequencies for their 5G, such as 2.5 GHz. Those signals are beam-formed.
- Finally, Dish Network is building out their new cellular network, advertising themselves as "America's first cloud-native 5G network." The FCC required the development of a fourth cellular network in the U.S. as a condition for allowing the T-Mobile/Sprint merger to take place in 2020. Dish has a deadline to build out their network, and they are using all new 5G-compatible technology for their cellular radios and antennas, including full Standalone (SA) 5G technology. They plan to cover 70 percent of the U.S. population by June 2023, starting with a beta test network in Las Vegas. Read about their progress here. They will use AT&T and T-Mobile's networks in the meantime as they build out their own network of antennas, bringing us back to four national cellular networks.

(End of cellular coverage map links for the U.S.)

Note: *Here is a* ***brief update****, dated 10/29/20, which gives new information since my last update, found below, on 8/17/20. I discuss Verizon's new 5G service and the introduction of Apple's iPhone 12 with 5G service.*

Update 10/29/20

Verizon has launched their new "5G Nationwide" service. They have also expanded their "5G Ultra Wideband" service within cities with existing service, and are also expanding mmWave 5G service from 35 to 60 cities by the end of this year, 2020. Verizon's new "5G Nationwide" service uses their lower existing 4G frequencies in the low- and mid-bands and is another example of the mis-application of the 5G term. This is according to cellular industry consultant and insider, Doug Dawson. More about that below.

Secondly, in a recent blog post, Doug discussed Apple's introduction of 5G service on their new iPhone 12, being offered by several cell carriers. Doug reminded us that it is still all 4G, just at slightly faster speeds in new spectrum bands (and truly faster in the limited mmWave band coverage, which is still very sparse). He says, "…what's being sold as 5G is just a repackaged version of 4G. The new features from an upgrade in cellular specifications will get rolled out over a decade, like we saw with the transition from 4G to 5G. In terms of the improvements of these new phones, we're probably now at 4.1G, which is a far cry from what 5G will be like in ten years." 5G signals in the mmWave band in certain neighborhoods of select cities received by Apple's iPhone 12s sold by Verizon, T-Mobile and AT&T is faster indeed than 4G, but only reliably received outdoors and still only in very select neighborhoods. See here and here for mmWave 5G coverage maps for Verizon and T-Mobile, respectively.

Doug gives a synopsis in his iPhone 12 article of where 5G is right now and how it really is still 4G masquerading as something new. I recommend that readers of this article read Doug's iPhone 12 article, and other articles he has written on 5G, to get a good understanding of what is truly going on.

Regarding Verizon's "5G Nationwide" service, which uses DSS, they say, "5G Nationwide, meanwhile, uses a different, low-band spectrum that involves dynamic spectrum sharing (DSS). DSS is a technology that allows 5G service to run simultaneously with 4G LTE on multiple spectrum bands. With DSS, whenever customers move outside Verizon's high-band Ultra Wideband coverage area, their 5G-enabled devices **will remain on 5G technology using the lower bands**. By deploying both technologies together, Verizon is able to use its full portfolio of current spectrum resources to serve both 4G and 5G customers, maximizing their customers' 5G experiences on the Verizon network." This quote is found in the FAQ section on their coverage map page in response to the question, "What is the difference between 5G Ultra Wideband and 5G Nationwide?" (**Bold** emphasis added to point out that Verizon seems to have upgraded their 4G equipment in the low- and mid-bands to the more modulated 4G LTE Advanced technology, which they are calling "5G technology". I presume that is what they mean.)

It is confusing when cell companies call 4.1G technology "5G", with only slightly faster speeds at low- and mid-band frequencies. We cannot be complacent about that, however, because it means we are exposed to more modulated signals from small cell antennas closer to our homes in residential neighborhoods, and those low- and mid-band "5G" signals are always-on, wide in their dispersal and now more modulated if they are really 4G LTE Advanced technology. These new, close 4G signals are harmful, as is having a phone in one's hand and next to one's head, even on standby in our pockets.

(End of 10/29/20 update. I will provide a longer update in the future.)

*Note: Here is an **Important Update**, dated 8/17/20, with new information about the planned deployment of true 5G features, and how the technology we have today is actually 4G LTE being deployed in new spectrum bands, for the most part. True 5G features will be coming within a few years. Read on for details, as I start the update in the next paragraph:*

Update 8/17/20

As we continue our efforts to slow the spread of 5G in our communities and in the skies above us, it is important to stay informed about the details of just what 5G entails and how it relates to existing 4G LTE technology. You have heard me mention in interviews and in this 5G article that we may not have the full picture within the larger EMF safety community of what 5G really is… *(Update continued below by clicking here.)*

To download a PDF version of this August 17, 2020 update, click here.

*Note: To see links to **5G Coverage Maps** for each U.S. Cell Carrier, click on item #6 in the Table of Contents to the left, entitled, "How Each Carrier Has Deployed 5G as of May 2020".*

*Note: **This article has been updated several times now** since I attended a 5G trade show in Los Angeles in October (2019) and since I have reviewed cell industry literature on the latest developments on 5G deployment in the United States. I have attended this 5G trade show twice in the past two years, in 2018 and 2019. I listened to lectures and visited booths sponsored by cell antenna manufacturers and several cell carriers. The trade shows were attended by 22,000 engineers and others in the 5G industry. It was very interesting to see this issue from their perspective and to learn exactly how the technology works in great detail.*

***To download a newly updated synopsis of this entire article in PDF format**, complete with pictures, click here. **To download the three-page "Brief Summary on 5G"** that opens this article, click here. **To download the "Summary Points on 5G"** at the beginning of this article, click here. Feel free to distribute these documents as a summary of the information in this article.*

***This updated article includes a brief opening summary, followed by new summary points and summary tables at the start of the article.** They encapsulate the information as I understand it at the time of this update. You can then read below in the revised text for important details and background information. I have also expanded upon and edited the text in this article compared to earlier versions. More paring down of existing text is needed, but that will have to wait until I have more time at a later date.*

It is very important *for readers of this article to understand that the topic of 5G is extremely complex and the technology is constantly evolving. What you read below is accurate to the best of my knowledge as of the date of each update. However, the one constant that you can depend upon is that the information will change and be preempted by new knowledge and further changes by industry. Please do not rely on the details that you read below as cast in stone and certain for some time to come. Expect continued evolution of the technology by industry, along with changes and further evolution in my understanding of that technology. New information comes in almost daily. Check back periodically for further updates.*

Note: ***Additional Resources on 5G****, including* ***interviews with Oram on 5G*** *and links to other articles, can be found at the end of this article by clicking here.*

I will also mention that I recently conducted **four new interviews on 5G** recorded January through April 2020 that are now available. They are:

The most recent is a one-hour ***5G-interview*** *with* ***Ann Louise Gittleman****. Recorded April 1, 2020, this is part of Ann's "The First Lady of Nutrition" podcast series. The interview is entitled, "Is There Any Connection Between Coronavirus and 5G?", accessed here.*

The ***second 5G-interview****, recorded in early February 2020, is on Green Street Radio with* ***Patti and Doug Wood****, heard live in New York City on WBAI, entitled, "EMFs, 5G and You! A Conversation with Oram Miller", accessed here.*

The ***third 5G interview*** *is with* ***Lloyd Burrell of ElectricSense****, available by clicking here. This was recorded in early January 2020. I should tell you that Lloyd usually offers the interviews of his guests to the public for 24 hours, and then makes them only available to subscribers of his EMF Experts Solutions Club thereafter. However, Lloyd has made an exception and* ***extended access to our 5G interview to readers of this website****, by clicking here. I thank Lloyd for his generous offer, and urge my readers to support him by subscribing to his EMF Experts Solutions Club, by clicking here. You can also sign up for Lloyd's free newsletter to be notified of his upcoming interviews with guests on EMF topics, by clicking here.*

The ***fourth EMF/5G interview*** *is with* ***Patrick Timpone*** *of One Radio Network. Patrick interviewed me on February 24, 2020 on EMFs and 5G Technology. The interview is entitled, "Oram Miller—Creating Safer Spaces for Those with Electrical Sensitivities". The 42-minute audio interview can be accessed by clicking here.*

Opening Brief Summary of 5G

The 5G that everyone fears is in the high, millimeter Wave (mmWave) band (above 20 GHz) and it is beam-formed. That type of 5G is only being deployed on certain streets in downtowns and surrounding residential neighborhoods in select cities. It is also being deployed in sports stadiums, arenas, airports, college campuses, metro stops and other places where large numbers of people congregate.

That mmWave 5G signal is on-demand, meaning it is only transmitted when a smart phone enabled with 5G for mmWave service asks for a connection. The mmWave 5G cell signal sent out by that antenna is only 10 degrees or so wide. If you live next door to a house where that 5G-enabled phone is calling for service and you don’t have one of those 5G-enabled phones yourself, that signal to your neighbor’s 5G-enabled phone will not come into your house.

It is important to realize that mmWave 5G service is only expected to be successful as primarily an outdoor service in select areas within urban areas. It is not considered by industry to be a “coverage spectrum”, as is the case with 4G and 5G service in the low and mid bands (see below). 5G service in the mmWave band is more limited and does not work well indoors. Customers of mmWave service, particularly with Verizon, will have their data service seamlessly switched back and forth between 5G and 4G, because mmWave 5G service is still quite spotty—although cell carriers are hard at work expanding that mmWave 5G service in urban areas.

As of 2/23/20, the mmWave type of 5G service is only offered by Verizon on certain streets in select areas of 34 cities, by T-Mobile on certain streets in select areas of 6 cities, and by AT&T, known as 5G+, on certain streets in select areas of 35 cities (but only to business customers thus far). Sprint does not have 5G service in the mmWave band, but their pending merger with T-Mobile is looking like it will go through. All three cell carriers with 5G service in the mmWave band are planning to expand their 5G service in each city that they currently serve and to add new cities.

You lose the mmWave 5G connection on a 5G-enabled phone when you move the phone around. When you move the phone, it connects back to 4G LTE service. 5G is primarily for downloading data, not voice service.

The bulk of 5G service in the US, on the other hand, is being broadcast in the low and mid bands (600 MHz to 6 GHz) from 5G small cell radios and antennas. These are being placed at existing 4G LTE macro cell sites, which are located roughly 1-1.5 miles apart, and in residential neighborhoods as stand alone small cell antennas across the country. T-Mobile and AT&T have 5G holdings in the low band and are in the process of installing low band 5G radios and transmitters, which do not send out beam-formed signals (but are highly modulated—see below) over large areas. T-Mobile plans to cover up to two-thirds of the U.S. population with their low band 5G service, and AT&T wants to provide low band 5G service, called “5G Evolution” or “5Ge” to all their customers nationwide by mid-2020.

Sprint’s 5G holdings (now a part of the T-Mobile network since T-Mobile acquired Sprint in 2020) are exclusively in the mid band, at 2.5 GHz. They can use beam-formed signals, which, again, are only on-demand and narrow.

Existing 3G and 4G macro cell antennas transmit cell signals at up to 1,000 Watts. These macro cell antennas spray always-on RF signals out into a neighborhood in a cone that is roughly 120 degrees wide and high, stretching for miles. This is what we have had for a couple of decades. This 4G network is the foundation of 5G and will remain in place. New 4G macro antennas are being installed, and 5G antennas are being placed on existing 4G cell tower arrays. Existing 4G equipment at macro cell sites is also being upgraded.

Many more new small cell antennas are also being installed *between* macro cell sites on residential streets. These new 4G LTE-Advanced and 5G small cell radios and antennas broadcasting in the low and mid bands likewise send out RF signals that are always-on with a 120 degree-wide signal that passes deep into nearby houses and apartments.

These 4G and low and mid band 5G radios and antennas transmit signals that are lower power than macro cell sites, at 10 to 100+ Watts, but they are much closer to people's homes. As a result, we are now measuring higher RF levels in client's homes, especially in second story bedrooms, up to tens to hundreds of thousands of microWatts/meter squared (uW/m2) from these new antennas. The building biology profession and EMF experts around the world say 10 microWatts per meter squared or less is safe for sleeping areas (actually, 0.1 uW/m2 is our "No Anomaly" level for sleeping areas).

The real danger is that these 4G LTE-Advanced and low and mid band 5G cell signals are far more modulated than 3G and 4G signals were in the past. That means, more data is being sent into the same airspace at the same power density and frequency but at faster download speeds. 5G signals in the mmWave are also highly modulated. This modulation of 4G LTE-Advanced and 5G cell signals at all frequencies makes them more biologically active and potentially harmful for all biological life, including humans.

In addition to all that, your cell phone and the myriad wireless devices in your home and personal space emit RF signals close to you and your family that are also highly modulated. These devices include all the things people like to use these days, such as cell phones, tablets, WiFi-enabled routers, TV streaming devices, computers, printers, baby monitors, thermostats and many others. What people don't understand is that these signals are just as harmful to us as 4G and 5G cell signals coming in from outside, particularly because they are also now more modulated than in the past. WiFi is a heavily modulated signal, and therefore particularly harmful on a cellular level.

All RF signals are invisible, silent and odorless. You don't know they are there until you purchase an RF meter and measure them for yourself or hire an EMF professional to evaluate your home for EMFs. For most people, that is the only way they realize RF signals exist at high levels in their living and work space, and at schools.

We say, pay attention to wireless devices in your homes, offices and schools at the same time as you organize to oppose small cell antennas in your neighborhood.

Remember three strategies regarding the use of wireless devices: reduce use, increase distance, and favor hardwired connections whenever and wherever possible, such as when you are home.

A Note About a Possible Correlation Between Coronavirus and 5G

I would like to share a few words about a topic that is on everyone's mind right now within the EMF community. That is, is the current Coronavirus pandemic related to 5G? These thoughts on the subject are written on April 1st, 2020 and updated on April 5, 2020. A lot has already transpired with this pandemic in the past three to four weeks. We can only speculate at this time what life will be like one to two months from now.

My answer at this moment is, conceivably yes, it could be. In fact, the very beginnings of the pandemic may indeed have been accelerated by the massive deployment of 5G in the large metropolis where it first emerged, the city of Wuhan, China. However, I do not support the idea that 5G is the sole cause of the outbreak in the first place nor that it is the only reason why people are getting sick.

At this point in this article I need to mention that there is a strong appeal that has come across our desks on April 5, 2020 from Prof. Joel Moskowitz, Americans for Responsible Technology and other prominent 5G activists that we are getting blowback from the mainstream cell industry to our efforts to alert the public about the dangers of 5G and all RF signals by making claims about a connection between 5G and the current viral outbreak that we are experiencing. It is in that light that I ask that you please be responsible in how you choose to disseminate this information. I would echo my colleagues in asking you to couch what you say about 5G in terms of science, pointing out the clear evidence of harm that wireless devices and radio signals have on the human physiology and other life forms. That will help in the efforts of our activist colleagues to educate the general public about the dangers that wireless causes. In the following discussion about the issue of a possible correlation between 5G and the current virus, I am trying to be responsible by following science and reporting on what appears to be objective evidence put forward by sources who have done likewise, particularly, Paul Doyon in his recent article. Now, on to the rest of this part of the article.

There certainly appears to be a correlation between the fact that Wuhan was one of three cities designated by the Chinese government for a highly accelerated push to implement an extensive rollout of 5G (and likely, also 4G LTE) antennas in neighborhoods throughout the city. The three major Chinese cell companies installed more than 10,000 new antennas in late 2019 and early 2020 in Wuhan in an effort to "saturate" the city with 5G coverage, and tens of thousands more throughout the country. That 5G coverage was turned on nationwide on November 1, 2019, just weeks before the outbreak there. In all, China has deployed over 130,000 new 5G antennas throughout the country in the months leading up to the outbreak of the virus in Wuhan. By contrast, the U.S. has a total of 10,000 new 5G antennas, so far. (I misspoke about this comparison in my recent 5G interview with Ann Louise Gittleman, where I mistakenly said China had 10,000 antennas nationwide by the time of their outbreak. The number was 130,000.)

Paul Doyon, an Electromagnetic Radiation Specialist and founder of the website, EMF Refugee, has a unique vantage point on this subject. He teaches in China and lived there the past year and a half, witnessing this process firsthand. He is fluent in Japanese and says he also speaks and reads basic Chinese. He wrote an excellent article on this topic, entitled, "China, 5G, And The Wuhan Coronavirus: The Emperor's New Virus", accessed by clicking here. You can also link to Paul's most recent post on the issue of a possible CVD/5G link on his blog, EMF Refugee, by clicking here. I suggest that you to consider Paul's article for an insider's view on how this pandemic began and the interesting and possible correlation between the virus and the heavy deployment of 5G in the pandemic's epicenter, Wuhan, and subsequent hotspots within and outside that country.

I especially appreciate Paul's opening statement, entitled, "A Synopsis of the Article" in which he makes it clear that he, himself, does not believe that 5G causes Coronvirus illness outright. Rather, he states, "I am not saying that 5G is causing the coronavirus (COVID-19)…Rather, what I am suggesting here is that the 5G wireless radiation is most likely a large factor most likely because it may very well be (1) weakening people's immune systems, and also (2) making the virus more virulent. There is ample evidence to support both of these hypotheses or theories." Read his article for his detailed and very thorough analysis.

Other experts have added their voice to this intriguing correlation. They include Thomas Cowan, MD, a nutritionally-based integrative physician based in San Francisco. In a lecture posed on YouTube, Dr. Cowan quotes author and EMF expert, Arthur Firstenberg, who wrote The Invisible Rainbow. Arthur and Dr. Cowan point out that every time industry has implemented a large-scale deployment of electrification in our country and the world, we have had an outbreak of illness, often viral-related. This goes back to the Swine Flu pandemic of 1918/1919, and repeats itself throughout the ensuing century, most recently with the deployment of satellite-based RF and terrestrial-based 4G/5G transmissions. See Dr. Cowan's ten-minute talk on the subject by clicking here. Order Arthur Firstenberg's excellent book, "The Invisible Rainbow", and learn of his important work, particularly with 5G-related satellite deployment in space, by clicking here.

Arthur has written an important comprehensive review of his own on the possible connection between the Coronavirus and massive deployment of 4G, 5G and other radio frequency transmitters. This includes in Wuhan, China itself as well as compelling evidence involving the outbreak of Covid-19 and massively upgraded ship-wide WiFi and 5G coverage on the Diamond Princess cruise ship, as well as other evidence. Read Arthur's detailed account of these and other possible connections in his article, "The Evidence Mounts", available by clicking here.

Furthermore, in support of a relationship between human exposure to wireless devices and adverse effects on the human immune system, Electrical Engineer and researcher, Prof. Trevor Marshall, wrote to me the following in a private email, dated April 10, 2020. Prof. Marshall is a researcher on the effects of wireless frequencies on human health: "Most of the peer reviewed papers I have published in the past decade explain how microbes in the human microbiome cause human Chronic disease. I tweeted (several weeks ago) a link to one of the papers showing WiFi causes mutations in E-Coli and other nasty pathogens in the lab. Here it is: https://twitter.com/trevmar/status/1234081541183066113. It is scientifically reckless not to explore whether Electrosmog is an environmental factor in the Coronavirus pandemic. Terms such as 'conspiracy theory' are not scientifically appropriate. Additionally, our 2016 paper 'Electrosmog and Autoimmune Disease' demonstrated that people with a weakened immune system are particularly sensitive to Electrosmog."

Additionally, a thorough review of the possible correlation between the presence of 5G antennas in the millimeter Wave band and the number of Covid-19 cases and deaths has been explored by Magda Havas, PhD. and Angela Tsiang. From Angela's post, "Below is statistical evidence showing that exposure to mmWaves used in 5th generation wireless communications is a significant factor in increasing the rate of cases and deaths in COVID-19. To be clear, 5thGen did not cause COVID-19." Prof. Havas' analysis poses the question, "Is there an association between covid-19 cases/deaths and 5G in the United States?" To see Dr. Havas' analysis, click here. In that post, Dr. Havas states, "Angela Tsiang reassessed the state data and differentiated between states with and without mmWave 5G. Her results are below in a table and two graphs." You will see Angela's assessment in Prof. Havas' article.

My own take on all this is that there is indeed a possible correlation between the current pandemic and the worldwide deployment of 4G/5G, though I favor the understanding that any RF technology has a harmful effect on the overall ability of a person or society to maintain wellness. I agree with Paul Doyon in that I also do not support the notion that 5G *caused* the Coronavirus outbreak. I am impressed by the connections that Arthur Firstenberg makes between the steps taken by industry throughout the decades to electrify our nation and world and the adverse impact that that has had on human health, time and again. This includes the recent deployment of wireless technologies, as investigated so thoroughly by Paul Doyon. The correlations laid out by Arthur and more recently by Paul are convincing arguments, in my mind.

At the very least, I firmly believe that all RF has a harmful impact on our immune systems and predisposes us to illness. That is a proven medical fact, as outlined by the links provided above by Prof. Marshall to his own research, and abundant evidence linked to elsewhere in this article and on this and many other websites. In that way, the explosion of 4G LTE-Advanced and 5G antennas worldwide in the past few months and years has most likely predisposed the human population to illness, which in the current case, is being expressed as a viral pandemic. Granted, there are many other factors at play (heavy cigarette smoking among Chinese and European men, obesity, other underlying illnesses, and close human contact leading to exposure to a virus that we don't have prior immunity to), however heavy use of wireless devices and exposure to RF and other EMFs in living and work spaces has its own role to play, as well, most likely by weakening our body's ability to fight an infection.

My entire 5G article describes how 5G is really broken down into different frequencies and bandwidths. Each has its own unique set of protocols and shaping of the radio frequency signal with each application of 4G LTE-Advanced and 5G cellular technology. The bottom line is we have an explosion of heavily modulated radio signals saturating every square inch of habited, and more and more, uninhabited space on earth. This affects our physiologies in adverse ways, not the least of which is diminishing the strength and proper functioning of our immune systems.

That is why, as I say repeatedly throughout this article, we implore you to reduce use, increase distance, and favor hardwired connections wherever and whenever possible. History will prove this to be a wise strategy to follow, just as we don't smoke or use DDT, asbestos, or lead in gasoline any more in many parts of the world.

Reducing exposure to wireless frequencies indoors and shielding what frequencies come in from outside could very well help to spare you from succumbing to the current wave of illness. Learn how to identify EMF and RF sources within and outside your home, or hire someone to do that for you. Then, take steps to convert to hardwired connections for voice calling, texts, Internet access, streaming media (TV), music speakers, baby monitors, thermostats, security systems, and every other communication modality in your home and life, as I detail in my article, Safer Use of Cell Phones, found here.

Summary Points on 5G

- My primary goal is to provide information to those who are electrically sensitive to help them understand how 4G and 5G work, how to measure it, and how to protect themselves from the radio frequencies (RF) that 4G and 5G emit. I leave activism and advocacy to others who have the time to devote to that effort.
- As you take steps to oppose the deployment of 4G and 5G antennas near homes in residential neighborhoods, you must also pay attention to RF sources, and other EMFs, within your own

home. EMFs and RF are silent, invisible and odorless. Follow these three rules: Reduce use, increase distance, and favor hardwired alternatives wherever and whenever possible.

- 5G has three parts: The high, millimeter wave (mmWave) band and the low to mid bands.
- The low to mid bands are contiguous and range from 600 MHz to 6 GHz. Those frequencies have been used for 1G through 4G LTE (first through fourth generation) cell service for forty years.
- The high, mmWave band starts at roughly 20 GHz and has never been used for cell service in the U.S. until now.
- The gap between 6 and 20 GHz is filled with radio frequencies used in the U.S. for decades for other purposes, including satellite, aviation, military, radar, police and other needs. The FCC has not allocated frequencies in that gap for cell service in the U.S.
- 5G, fifth generation cell service, is not the same as 5G on your router, which is shorthand for 5.8 GHz, a WiFi and cordless telephone frequency. 5.8 GHz, along with 2.4 GHz, are unlicensed frequencies allocated to router and cordless telephone manufacturers by the FCC so they can sell devices that transmit radio frequencies without the purchaser needing an FCC license to operate them.
- The 5G that everyone knows and fears, with beam-formed signals that are focused and can harm your skin, eyes and other organs, is in the high, mmWave band (and also in the mid band down to 2 GHz).
- 5G service in the high mmWave band, which some people call “true 5G”, is currently limited to some streets in certain neighborhoods within select cities, as well as places where lots of people gather (stadiums, arenas, convention centers, city centers, airports, college campuses, parks, metro stops). That is where the most customers are, so that is where industry is focusing its mmWave 5G deployment. Those cell carriers that have 5G service in the mmWave are in the process of expanding their coverage in those urban areas.
- 5G in the mmWave band has the fastest download speeds (1,000-3,000 Megabits per second, or Mbps, which is also 1-3 Gigabits per second, or Gbps, and beyond) but it is not the predominant deployment of 5G in the U.S.
- The bulk of 5G in the U.S. is in the low and mid bands. That type of 5G is really “4G Enhanced” or “5G Lite” with 30-900 Mbps (Megabits per second), with most new service realistically averaging 100-200 Mbps. That is roughly three to six times the download speeds we now have with 4G LTE, which currently averages 20-30 Mbps.
- 5G in the low and mid bands already now covers much of the U.S. and that is expanding rapidly.
- Cell signals, whether 4G or 5G, in the low and mid bands can easily pass through walls and they travel far, up to many miles. They are considered by industry to provide true “coverage spectrum” for customers in wide geographic areas because they cover such large distances with moderately faster download speeds compared to current 4G service.
- 5G in the low band does not use beam-forming but it does use advanced technologies, such as: carrier aggregation; 4T4R (four transmit, four receive) Multiple Input, Multiple Output (MIMO) radios and antennas vs. 2T2R MIMO radios and antennas used with current 4G LTE service; License Assisted Access (LAA); LTE-Machine Type Communication (LTE-M); Narrowband Internet of Things (NB-IoT); and 256 Quadrature Amplitude Modulation (QAM). All of these advanced technologies push more cell signals into the same airspace at faster speeds with far more modulation than current 4G cell technologies.
- Modulation of cell signals has harmful biological effects on *all* life (WiFi signals within your home are also heavily modulated—don’t use them—use hardwired Ethernet connections, instead).
- This modulation of cell signals transmitted in the low and mid bands from new 5G and 4G LTE-Advanced small cell radios and antennas popping up everywhere probably accounts for the majority of people living near these antennas who report the onset of health symptoms not

experienced previously.

- 5G signals in the mmWave band also cause symptoms, but their deployment in certain areas of urban neighborhoods is more limited compared to 5G and new 4G LTE-Advanced antennas in the low and mid bands.
- 5G in the mmWave band, which is limited in the U.S. to metropolitan areas with high population densities, is on-demand and only sends its signal to a small slice in front of each antenna, roughly 10 degrees wide, and *only* when a 5G-enabled phone that operates in the mmWave band calls for a connection. That mmWave 5G signal will only go into that house where a 5G-enabled phone is located, not into neighbor's houses.
- 5G in the mmWave band is not considered by industry to be a coverage spectrum serving large geographic areas like 5G and 4G service in the low and mid bands is. 5G in the mmWave band is expected to be most successful in limited urban areas and primarily for outdoor use. It does not pass into buildings well at all. When you move a mmWave 5G-enabled phone, it reverts back to 4G coverage.
- The *biggest* number of new small cell antennas popping up in suburban residential neighborhoods have 4G Advanced LTE technologies. That includes all the technologies listed above (carrier aggregation, 4X4 MIMO, LAA, LTE-M, NB-IoT, and 25 QAM).
- These 4G LTE-Advanced radios and antennas can be switched to 5G at a later date with a software upgrade. If the 4G/5G antennas are in the low band, that is, below 2 GHz, the 5G signals will not be beam-formed with massive MIMO capabilities.
- Specifically, many new radios and antennas being installed at small cell sites have Dynamic Spectrum Sharing (also known as Dynamic Spectrum Switching), or DSS, which allows the antennas to send out 4G or 5G signals at the same time from the same antenna at the same frequency, depending upon the needs of the user's cell phone. It is said that cell phones will smoothly switch back and forth between 5G (if it is available) and 4G. Again, if the 4G frequencies are below 2 GHz, then the 5G service will not be beam-formed but it will certainly be modulated, which has its own deleterious health effects.
- This is how cell carriers are deploying 5G in the U.S., by piggybacking it onto existing and new 4G technology and antennas.
- If you are therefore not near a city center and you see a new antenna go up on a utility or light pole in front of your house, chances are it is a 4G LTE-Advanced antenna, but through DSS, it can also have 5G capabilities.
- If, on the other hand, you are near a city center, you can have a pole in front of your house that may have two or three 4G antennas inside a cylindrical covering on top of the pole, broadcasting in the low or mid band, along with a flat, pizza box-sized rectangular antenna mounted a bit lower on the pole broadcasting 5G in the mmWave band—the signal of which will be on-demand and narrow.
- 4G antennas mounted inside the cylindrical covering on top of poles or appearing as short, two-foot long narrow antennas will be always-on and send out wide coverage that is shaped like a 120 degree-wide cone in front of it. Download the synopsis of this article to see photos of 4G and 5G antennas, by clicking here.
- Cylinders usually have two to three 4G LTE antennas back to back inside of them, pointing up and down the street if there are two. Those signals will catch houses on either side of the street. If there are three antennas inside, some will point directly at nearby houses in a diagonal direction. 4G small cell antennas can also look like a narrow, short flat panel, roughly two feet high.
- Existing 4G LTE macro cell antennas are placed one or two miles apart. They look like the traditional thin, tall antennas we have seen for years. They transmit at up to 1,000 Watts Effective Radiated Power (ERP). Their signals travel up to 1 to 1.5 miles (and farther).
- 4G Advanced LTE and 5G small cell antennas in residential neighborhoods transmit at up to 10 to 100 Watts ERP (sometimes more), which is lower than 4G LTE macro cell antennas, but

they are much closer to people's homes and their cell signal is always-on. RF levels of tens to hundreds of thousands of microWatts/meter squared have been measured in second story bedrooms in the path of nearby 4G and low/mid band 5G small cell antennas.

- We can measure 4G LTE-Advanced and 5G antennas in the low and mid bands with our existing RF meters. Our RF meters only go up to 8-10 GHz. The low and mid bands stop at 6 GHz, so we can measure 4G LTE-Advanced and 5G antennas transmitting in those low and mid bands.
- 5G in the mmWave band starts at 24 GHz. We don't have accurate RF meters to measure those frequencies (but remember, their signals are idle until called for by a 5G-enabled cell phone). You need spectrum analyzers to measure those higher frequencies and they are very expensive. Lower cost (under $1,000) RF meters to measure 5G in the mmWave band are in development by several engineers and companies.
- Presently you need a different cell phone to receive 5G cell service at these different bands. Current cell phones that receive 5G in the low and mid bands cannot receive 5G in the high, mmWave band and vice versa (that will change in the near future).
- See item #6 in the Table of Contents to the left, entitled, "How Each Carrier Has Deployed 5G as of May 2020" for specific information on 5G services provided by each of the major cell carriers throughout the U.S. You can also see a list of 5G service in U.S. cities on the website, Android Central by clicking here.
- All four U.S. cell carriers are deploying massive numbers of 4G LTE-Advanced small cell antennas in urban and suburban residential neighborhoods—that is the predominant deployment of new cell antennas near homes. 5G activists are saying they are seeing as many, or more, cellular permit applications for new 4G small cell service in residential neighborhoods as 5G. However, remember that these new low and mid band 4G small cell antennas will all have the capacity to be switched to 5G service in the future with a software update.
- We can shield our homes against 4G LTE-Advanced and 5G signals in the low and mid bands with RF-shielding paint, building foil, metal mesh insect screen, window film and RF-shielding fabrics.
- We can shield mmWave 5G signals with only paint and foil. Mesh screen and fabric don't work as well at blocking mmWave frequencies in the mmWave band as they do at lower frequencies. The one exception appears to be Aaronia's Silver Mesh fabric, which reportedly maintains its shielding capabilities above 20 GHz. It is available here.
- Finally, the strongest RF signals many of you encounter now and will encounter in the future are not from antennas outside your house. They come from the many wireless devices we keep inside our homes, close to our head and body.
- First and foremost among them is your cell phone. RF levels can be as high as 1 to 2 million microWatts/meter squared (uW/m2) at close range from a cell phone or cordless telephone. Cell phones also emit strong RF on standby, 24/7. At the very least, disable your Bluetooth and WiFi on your cell phone. Remember, these signals are also more modulated now than they used to be.
- Right now, 5G-enabled cell phones transmit back to 5G cell towers using 4G technology, but that will change, where your cell phone itself will be sending back data signals using modulated 5G technology.
- The strength of an RF signal drops off exponentially with distance, but it can still be quite strong from a current cell phone on standby, over 5-10 thousand uW/m2 at 4-5 feet, beyond arm's length. We say, RF power densities above 1,000 uW/m2 are an extreme biological anomaly for sleeping areas, and we want our clients to be down to 10-100 uW/m2 as much as possible (and below 1-10 uW/m2 for children and electrically sensitive people.) See my profession's Building Biology Evaluation Guidelines by clicking here.
- RF, and other EMFs, are silent, invisible and odorless (unlike cigarette smoke). You don't know

these frequencies are present in your house and personal space until you purchase an RF meter, especially one with sound, and see for yourself how strong they are right near you. See a list of suggested RF meters by clicking here and then scrolling all the way down the article to click on item #11 in the Table of Contents to the left, entitled, "Radio Frequency Fields".

- I cannot emphasize enough the possible harm to people's health coming from the various wireless devices many of us use and have in our homes. Pay attention to this while you also organize to halt deployment of small cell antennas in your neighborhood.
- Remember these three recommendations for cell phone and wireless use: Reduce use, increase distance, and favor hardwired connections whenever and wherever possible. You can put your cell phone in Airplane mode, making sure WiFi and Bluetooth are off while in Airplane mode, and do most every function on your cell phone on a different, hardwired device when inside your house. That includes talking, texting, emailing, audio and video streaming, and using various apps. See below in this article and elsewhere on my website for recommendations on how to do that.

Introduction

One of the most worrisome aspects of our modern society is the coming of fifth generation cell technology, known as "5G". Much has been written about the potential health effects for electrically sensitive and non-sensitive people alike, not to mention animals, insects and our entire biosphere. Concern is mounting. How can we avoid 5G? How can we measure it? How can we protect ourselves from it in our homes and when we go outside in public places? Where are we safe?

The first thing we need to do is to learn what 5G is and what it is not, how it works, how it is being deployed, and what its characteristics are. Every ten years or so, the cell industry releases a new generation of technology. For over forty years we have evolved from simple voice service to high-speed audio and HD video data transmissions, where virtually all tasks you could do on a computer can now be done on a handheld device. Communication is virtually instantaneous and many people can't be without their mobile phone or tablet.

There is one important misconception that needs to be cleared up right at the start. Don't be confused by the designation "5G" on your router. That is 5.8 GHz, which is a WiFi and cordless telephone frequency (along with 2.4 GHz) used for decades for WiFi and Bluetooth signals transmitted to and from routers, cordless telephones, cell phones, tablets, laptops and many other devices. It is not directly part of fifth generation cellular technology, also known as 5G, although it is peripherally involved as part of the "IoT", or Internet of Things.

WiFi and all of these wireless devices, however, are themselves harmful to your health and the use of WiFi in public places will be substantially expanded as part of the overall technological evolution that is 5G. That will be outside of your house and you have control over whether you use WiFi inside your house or not—see below. When you use WiFi from a router or other wireless device now or at any time in the past, that 5.8 GHz RF signal has been inside your home without you being aware of it for decades. 2.4 GHz was allocated by the FCC in 1998 for manufacturers to use as an unlicensed frequency without the need for consumers to apply for an FCC license to operate their cordless telephone or WiFi-enabled router. 5.8 GHz as a WiFi and cordless telephone frequency was added by the FCC as a second unlicensed frequency in 2003. A third unlicensed frequency, at 60 GHz, has also been introduced and is now used for WiFi on certain routers.

Finally, bear in mind that my primary goal as a Building Biologist and Electromagnetic Radiation Specialist is to provide information to my EMF clients and those people who contact me, especially those who are electrically sensitive, to help them understand how 4G and 5G work, how to measure it, and how to protect themselves from the radio frequencies (RF) that 4G and 5G emit. I leave the issues of activism and advocacy to the many other competent people who have the time to devote to that effort to alert the public to the dangers of these new 5G cell technologies. However, I do provide resources and technical support to activists and advocates.

I also impress upon my clients and those who contact me that they must pay attention to RF/wireless sources, and other EMFs, within their own home, including wireless devices that they keep close within their personal space. EMFs, including RF, are silent, invisible and odorless, so you don't even know they are there, whether coming in from a 4G/5G small cell antenna outside your home, or from a wireless device inside your home, until you measure them. Learn about what is in your home and personal space and follow these three rules: Reduce use, increase distance, and favor hardwired alternatives wherever and whenever possible, including within your home and work space.

Summary Tables

I present the following summary tables at the start of this article as a quick, though comprehensive summary of how 5G, including expanded use of 4G, is being deployed throughout the U.S. The information is presented by cell carrier, frequency and type of technology. Background information is presented below.

For those living in other countries, you will still find this information useful if you focus on the frequencies and technologies discussed below and then find out what frequencies your country's cell carriers are using.

What Frequencies Are Each U.S. Cell Carrier Using for 5G (and 4G)?

Let's first divide the four major 5G players in the U.S. into three groups, depending upon the frequency band in which they operate for new 5G service. Those three groups would be low band, mid band and high, or mmWave, band.

Low band 5G Cell Service (600 MHz to 1,000-2,000 MHz, or 1-2 GHz)

- Low band 5G from T-Mobile at 600 MHz
- Low band 5G from AT&T at 850 MHz
- All carriers are also installing 4G small cell antennas with highly modulated LTE-Advanced technologies transmitting in the low band that convert to 5G with software upgrades
- Specifically, Verizon will be using Dynamic Spectrum Sharing (also known as Dynamic Spectrum Switching)(DSS) to allow all their 4G low (and mid) band transmitters to switch seamlessly between 4G and 5G, depending upon need of the cell phone user (email/texting/web surfing with 4G vs. more real-time streaming video with 5G). That involves Verizon's existing low band 700 and 850 MHz 4G frequencies.
- Verizon and other carriers are also using EUTRAN-NR (New Radio) Dual Connectivity (ENDC) to transition from the existing 4G LTE-based radio core to a solely 5G NR (New Radio) core for the processing of all voice and data connections by their wireless customers nationwide. This situation where both LTE and 5G NR cores can be used is called non-standalone, or NSA, protocol. It will be in place until such time as carriers build out a completely new 5G NR Core (5GC), called standalone, or SA protocol. SA protocol allows upgrades at existing 4G macro cell sites and new 4G small cell sites to 5G technology with a software update.

Mid band 5G Cell Service (1-2 GHz to 6 GHz)

- Mid band 5G from Sprint at 2.5 GHz (2,500 MHz)
- Mid band 5G Verizon (and other carriers) at 5.2 GHz
- FCC to auction more mid band spectrum to all four carriers in CBRS (Citizens Band Radio Spectrum) band, at 3.5 GHz, and C-band, currently used for satellite TV transmissions, at 3.7-4.2 GHz
- All carriers are also installing 4G small cell antennas with highly modulated LTE-Advanced technologies transmitting in the mid band that convert to 5G with software upgrades. They are also upgrading existing 4G equipment on their macro cell towers with new, more modulated LTE-Advanced equipment.
- As in the low band, Verizon will be using Dynamic Spectrum Sharing (also known as Dynamic Spectrum Switching) (DSS) to allow all their (low and) mid band 4G transmitters to switch seamlessly between 4G and 5G, depending upon need of the cell phone user. That involves Verizon's existing mid band 1,900 MHz 4G frequency.
- As in the low band, Verizon and other carriers are also using ENDC in the non-standalone mode in the mid band to transition from the existing 4G LTE-based radio core to a solely 5G NR, standalone core, allowing introduction of 5G technology at existing macro cell sites and new small cell sites with a software update.

New WiFi Service just above 6 GHz

- FCC set to open 6 GHz to cell carriers for expanded public WiFi 6 coverage for next-generation devices
- FCC will auction spectrum between 5.9-7.1 GHz
- This will be additional unlicensed frequency, adding to existing unlicensed frequencies used for WiFi and cordless telephones by router and cordless telephone manufacturers at 2.4 and 5.8 GHz, and by some router manufacturers at 60 GHz

High, or mmWave, band 5G Cell Service (at 28 GHz and 39 GHz, and other mmWave frequencies)

- T-Mobile
- AT&T
- Verizon

The Summary Tables continue below.

You will notice that T-Mobile and AT&T are the only two companies presently with 5G spectrum in both the low and high/mmWave bands. However, the two types of 5G are completely different, as you are seeing. Also, AT&T's mmWave "5G+" service is only open to business customers.

With the T-Mobile/Sprint merger appearing to be closer to approval, the combined company would have 5G holdings in all three bands. Right now, Sprint is the only company with 5G service in the mid band (not the low band) and none in the mmWave band, however it will soon have company when many more carriers purchase spectrum in the 3.5 and 3.7-4.2 GHz frequencies of the mid band. The mid band offers what the industry calls the "sweet spot" because it "offers an excellent combination of wireless signal distance, building penetration, and bandwidth" according to FierceWireless.

Verizon is the only company with 5G spectrum almost exclusively in the mmWave band. They also have some holdings in the 5.2 GHz range, which is at the upper end of the mid band, using LAA (Licensed Assisted Access) technology and it will join other carriers in bidding for spectrum in the Citizens Band Radio Service (3.5 GHz) and C-Band (3.7-4.2 GHz) spectrums. Verizon says it is deploying its mmWave 5G spectrum on many small cells that will be "concentrated in 'hot spots' or small areas within metro areas, which is where Verizon says the most demand exists." (from FierceWireless).

However, Bruce Kushnik says in his critique of cell industry hype entitled, Verizon Claims 31 Cities with 5G: The Reality Is Verizon has "0" Cities, that Verizon and other companies claim to be "in" so many major cities, when in fact, that coverage is in reality, very spotty…at least, for now. Bruce poses the question, "How can you say you are in a city when you don't have basic coverage of most of the city?" He goes on to say, "More importantly, these maps show that the coverage isn't just spotty, it's virtually non-existent. If you actually purchased a (5G-enabled) phone and started walking down the streets making a call or watching a video, you would continuously lose a (5G) signal (and be switched back to relatively slower 4G LTE)." This is the same experience mentioned by reporters for Wired magazine when they tested 5G phones in major cities.

What Verizon hopes will make a difference to their customers is that in addition to their mmWave 5G service at 28 and 39 GHz, the company will also be using Dynamic Spectrum Sharing (also known as Dynamic Spectrum Switching) (DSS) this year (2020). DSS allows cell carriers to send out either 4G or 5G signals at the same time on the same frequency in the low and mid bands. That will allow Verizon to begin broadcasting 5G along with 4G signals on the 4G frequencies the company already has in the low band and in the lower end of the mid band, which are 700, 850 and 1,900 MHz.

Verizon will provide either 4G or 5G service depending upon the demands of customers' phones. Such needs could be email, texting and web surfing using a 4G connection and more real-time streaming of video using lower latency provided with 5G. The phone would automatically make that decision. DSS antennas are small enough to fit inside of phones. DSS allows cell phones to switch seamlessly back and forth between 4G and 5G technologies using 4G and 5G signals sent by small cell antennas at the same time over the same frequency.

That is how Verizon plans to blanket half the U.S. population with (low and mid band) 5G by the end of 2020. In fact, DSS is how all carriers plan to roll out 5G in the low and mid bands since the availability of new spectrum is so limited in the U.S. Instead, they will piggyback it onto existing 4G LTE (which again, are only in the low and mid bands).

Of course, any 5G signal being sent out at any of these low band frequencies will not be beam-formed, because in Verizon's case, their 4G frequencies (700, 850 and 1,900 MHz) are all below the 2 GHz cut off point below which beam-forming technology is not used.

Therefore, when Verizon says it will be using 5G along with 4G at its existing 4G frequencies, the broadcast technologies will include those listed above for 5G in the low band with all their modulation, but not beam-forming.

Also, since there is no 4G in the high, millimeter Wave band, there is no "spectrum sharing" for 5G signals in that band. (However, it may be the case that phones will be able to toggle between 5G service in the mmWave band and 4G LTE service in the low band).

AT&T is simultaneously upgrading their existing macro cellular ("cell tower") equipment with both 4G LTE-Advanced and 5G radios and antennas. They will broadcast primarily at their low band frequency of 850 MHz, as well as at their other existing 4G LTE frequencies.

Meanwhile, Sprint has deployed many thousand massive MIMO macro antenna arrays in nine cities across the country (see below for a list of those cities) for its 2.5 GHz mid band 5G service. I say macro antenna arrays (what we call "cell towers") because Sprint is not yet installing small cell antennas in residential neighborhoods like other carriers are. Its new 64X64 massive MIMO 5G radios and antennas are only going up on existing 4G LTE macro cell sites within Sprint's network. That means 5G New Radio and 4G LTE service will both use Sprint's existing 2.5 GHz 4G LTE frequency.

Another important development is that all cell carriers currently provide 5G service using a non-standalone (NSA) application of the 5G New Radio (NR) broadcast standard that is based upon the existing 4G LTE core. That reportedly has allowed carriers to introduce 5G across all spectrums more quickly.

Over the coming years, however, all cell carriers will be switching to what they call a standalone application of 5G NR standards. That means it will be based upon a 5G core, not a 4G LTE core as it is now. This will enable cell carriers to upgrade new equipment to 5G technologies with a software update. The radios and antennas being installed now at small cell antenna sites all have this capability, but for now, 5G is based upon the non-standalone 4G LTE core. Verizon is planning to make the transition to a standalone 5G New Radio (NR) core this year, 2020 — which is another way in which Verizon plans to cover 50% of the U.S. population with low and mid band 5G service by the end of 2020—with other carriers following suit in the coming years. Again, that low and mid band 5G service will be piggybacked onto their 4G LTE antennas and radios. This is supplemental to their mmWave 5G service currently only available on certain streets in select neighborhoods in 35 U.S. cities.

All four carriers are applying for permits to put lower power 4G LTE small cell antennas in residential and urban neighborhoods to supplement their more powerful existing 4G LTE service on macro cell antenna sites already mounted on towers, poles and buildings over the past decade. Some California 5G activists have told me that most of the permits they have seen for new small cell antennas in residential neighborhoods are for 4G equipment, not 5G. However, these new 4G small cell antennas are more modulated and will be able to be upgraded to modulated 5G service in the low and mid bands.

Also remember that carriers will be installing new radios and antennas that have the capacity through Dynamic Spectrum Sharing (DSS) to share 4G and 5G technologies at low band frequencies used for years only for 4G.

All of this has implications for what we need to watch out for and how we can protect ourselves, including the fact that these new 4G LTE signals, and new low band 5G signals, being sent out from new small cell antennas will be always-on, wide, highly modulated, and close to houses. They will not on-demand and narrow, as is the case with beam-formed 5G signals sent out in the mmWave and mid bands.

All four carriers have 4G LTE transmitters that use frequencies between 600 and 6,000 MHz in the low and mid bands, as they have for years. These are the frequencies in which Dynamic Spectrum Sharing will be used for customer’s new 5G-enabled phones to switch between 4G and 5G service. To see a list of 4G frequencies used by cell carriers in the U.S. (and around the world), click here (4G is used between 700 MHz and 2,500 MHz.) Scroll down to the section entitled, “United States and US Territories (FCC band plan)”.

New small cell 4G antennas being deployed in neighborhoods in the U.S. also now use

Advanced LTE technologies. These include: 4X4 MIMO antennas; carrier aggregation; License Assisted Access (LAA); LTE-Machine Type Communication (LTE-M); Narrowband Internet of Things (NB-IoT); and 256 QAM — defined below. All of these technologies increase data download speeds and the number of cell signals and information broadcast in the same airspace. Since all new 4G antennas will have the capacity to be upgraded to 5G through software changes made possible by Dynamic Spectrum Sharing, or DSS, the kind of 5G a particular antenna transmits will depend upon the frequency band in which the 4G antenna is broadcasting. 4G is only used in low and mid bands, so an upgrade to 5G on a 4G antenna in the low band would not involve beam-forming, whereas an upgrade to 5G on a mid band 4G antenna could use beam-forming and massive MIMO. In that case, however, the signal would be on-demand and narrow.

Again, it is the always-on, wide beam cell signal from low band 4G and 5G that is a real hazard, because houses will be bathed in that always-on RF signal broadcast from the front of the small cell antenna. Even though the strength of each small cell antenna is 10-100 times lower than the strength of cell signals currently emitting from existing macro 4G LTE cell antennas (“cell towers”) located a mile or more apart, the big problem is that these small cell antennas are much closer to people’s homes. These low and mid band frequencies can easily pass through walls (due to their longer wavelength), resulting in much higher RF signal intensities in indoor living spaces — see below.

In addition, all new 4G LTE-Advanced and 5G cell signals are far more modulated than past generations of 4G cell technology. It is important to remember that signal strength is not the only factor to consider in terms of health effects. These new transmissions utilize polarized, pulsed signaling. This modulation and pulsed signaling may account for recent increases in health symptoms in residents living near new small cell antennas. Reports are emerging that certain people are reacting to new cell antennas, whereas they did not react to previous 4G LTE technology used for years.

Finally, we can measure these low and mid band small cell 4G LTE-Advanced and 5G signals with existing RF meters. We can also shield against the RF they produce. Low and mid band 4G and 5G are a big danger to individuals in our opinion living in nearby homes, causing as much, or possibly more, potential harm as on-demand beam-formed 5G signals in the mmWave band, which are more limited to only certain streets in select neighborhoods in several dozen urban areas — see below.

The bottom line is small cell antennas of any generation, fourth or fifth, don’t belong in our residential neighborhoods.

How Each Carrier Has Deployed 5G as of May 2020

- **T-Mobile** now provides *low* band 5G coverage to roughly 200 million people. Click here for a coverage map of T-Mobile's nationwide low band 5G service.
- Nationwide low band 5G service is available on Samsung Galaxy Note10+ 5G and and One Plus 7T Pro 5G McLaren phones.
- T-Mobile's *high* band, mmWave 5G offerings are only available in limited dense urban areas in six cities: New York, Los Angeles, Las Vegas, Dallas, Cleveland and Atlanta. Click here for a coverage map of T-Mobile's more limited mmWave 5G service.
- T-Mobile's mmWave 5G service is available on Samsung Galaxy S10 5G phones.
- To see a map of T-Mobile's 4G LTE service, click here.
- To see a map comparing T-Mobile's 4G LTE coverage with that of AT&T and Verizon, click here.
- **AT&T** provides low band "5G Evolution" (5GE) coverage to "550 markets". This shows up on many AT&T phones purchased in the past year or so. This is *not* 5G service in the mmWave band. It is considered to be enhanced 4G LTE (which itself is not safe, as all of 4G is not safe)
- AT&T is planning for nationwide coverage of their low band 5GE service by first half of 2020. (However, rival carriers have been successful in May 2020 in having a judge bar AT&T from using the term "5GE" to name their new low band cell service. This is because it is no more than enhanced 4G LTE.)
- Low band 5GE service is available to all AT&T customers (on new phones). Their website says, "We've made changes that are already bringing faster speeds to the latest devices on our LTE network." It goes on to say, "Enabling faster speeds on our existing (4G) LTE network", and "Our improvements are already enabling faster speeds on our existing LTE network." This means, AT&T's low band 5GE service is being built upon their existing 4G LTE network. See here for more details.
- Click here for a list of 26 phones that connect with AT&T's 5G Evolution service.
- Samuel Contreras at Android Central says, "5G Evolution is the marketing name AT&T has given to its LTE Advanced network. While this represents the best of 4G with MIMO support and fiber optic backhauls, it really has nothing to do with 5G (in the mmWave band)." He goes on to say, "5Ge is really a type of 4G most providers refer to as LTE Advanced. It's also a technology that all of the other major US carriers are already using." (Referenced here and here.)
- To see coverage maps for these 550 markets in which AT&T has launched 5GE service listed by state, click here and scroll down to the section entitled, "What is 5G?". You will see links to 24 states.
- AT&T also provides 5G service in the high mmWave band, above 20 GHz. This is completely different from their 5GE service in the low band.
- This is true mmWave 5G, known as "5G+". You need a different smart phone in order to receive AT&T's 5G+ service than you do to receive their 5GE service, although new modems coming out in the next year or two will enable new phones to access 5G in both bands.
- AT&T's 5G+ service in the mmWave band was previously only available to business customers, but is now available to all customers as of early 2020. They say, "While the initial launch of our 5G+ network is modest, speeds, coverage and devices will improve." This service is currently available in certain areas within 35 cities in 17 states.
- Click here to see AT&T's 4GLTE, 5GE and 5G+ coverage map.
- **Verizon's** 5G service is entirely in the mmWave band above 20 GHz (primarily 28 and 39

GHz). Verizon provides what they call “Ultra Wideband 5G” service on certain streets within limited dense urban areas in 35 cities. The company has also deployed limited 5G service in 16 NFL stadiums with plans to cover all 32 by the end of 2021.
- Verizon also has some upper mid band holdings at 5.2 GHz, and it is planning, along with all cell carriers, to bid on the new 3.5 and 3.7-4.2 GHz mid band spectrum coming up for auction by the FCC this year (2020).
- Verizon’s Ultra Wideband 5G service is available on Samsung Galaxy Note10+ 5G, LG V50 ThinQ 5G, Samsung Galaxy S10 5G and Motorola Moto Z4 phones. Verizon plans to provide 20 models with 5G capabilities in 2020.
- Verizon is also installing, as are all carriers, new 4G LTE-Advanced small cell radios and antennas in the low and mid bands that are capable of transmitting 5G signals with a software update. Any 4G/5g antenna transmitting below 2 GHz will not send its 5G signals via beam-forming.
- Click here for Verizon’s 5G service map. It does not give you the street by street specificity that 5G coverage maps do on other carrier’s websites (or on Verizon’s own website in the recent past). However, if you click in those neighborhoods with red squares (indicating “5G Ultra Wideband near these city landmarks”), you will actually see a street map. On this map, the pink background is “4G LTE” coverage, which is almost universally filled in, while streets and other areas marked in red have “5G Ultra Wideband” service.
- Click on the map and roll downwards on your scroll wheel to zoom out. You can left click on the map, hold your finger down on the left side of your mouse, and grab and drag the map to move around and see other neighborhoods in any direction.
- You will notice that not all streets have red lines indicating 5G service. In fact, most do not, even in major U.S. cities like Los Angeles or New York. Even in those cities, there are many neighborhoods without any red lines, indicating that Verizon’s 5G service (in the mmWave band) is still quite spotty, as Bruce Kushnik says in his article on the true extent of Verizon’s 5G deployment, and confined mostly to downtowns and adjoining areas in the cities where it is deployed.
- Certainly more neighborhoods will have Verizon’s mmWave 5G service in the coming years, but they will be confined to certain urban areas and not be widespread in most residential neighborhoods throughout the U.S. What will be deployed in residential neighborhoods nationwide, as pointed out above, will be massive numbers of low and mid band 4G and 5G small cell antennas.
- **Sprint** has merged with T-Mobile. T-Mobile, with Sprint’s assets, is now the only company in the world that provides 5G service in the low, mid and high mmWave bands, although the characteristics of how that service works and how it may affect you differs depending upon the frequency band it is broadcast in (low vs. mid vs. high, mmWave bands).
- Sprint only has 5G service at 2.5 GHz in the mid band. It has no frequencies in the mmWave band (although its new parent company, T-Mobile, does have mmWave service in six cities — see above.)
- Instead, Sprint provides mid band “True Mobile” 5G service in large areas within nine cities: Atlanta, Chicago, Dallas-Fort Worth, Houston, Kansas City, Los Angeles, New York, Phoenix, and Washington, DC.
- Sprint’s 5G antennas are currently only being installed at their existing 4G LTE macro cell antenna sites. Sprint is contemplating also installing 5G small cell antennas in neighborhoods at some time in the future.
- Click here for more details about Sprint’s current mid band 5G service, which uses massive MIMO antennas and is capable of beam-forming.
- Sprint’s 5G service is available on LG V50 ThinQ, Samsung Galaxy S10 5G and HTC 5G Hub phones.
- Sprint customers will be required to turn on VoLTE (Voice over LTE) in order to receive 5G

service.
- In addition to their mid band 5G service, Sprint has upgraded and added to their existing 4G LTE network (in the low and mid bands) to create their new "LTE-Advanced" network, discussed here. It reportedly provides 2X faster 4G service in cities throughout the U.S. on the list seen here and on their national coverage map here.
- On their national map, which provides a great deal of street by street specificity, click the "+" in the upper left corner to zoom in. When the box, "Coverage depends on your device" comes up, choose "No thanks, show me all coverage". Then click on "Legend" to see their cell coverage, including 5G and various types of 4G service.

How Do the Three Frequency Bands Differ by Characteristics?

Low band

- 600 MHz to 1,000-2,000 MHz, or 1-2 GHz
- Longest wavelengths (15 to 12 inches as you go from 600 to 1,000 MHz)
- Currently used for 4G LTE and new 5G service (dubbed "Enhanced 4G" or "5G Lite" by industry)
- Moderately faster frequencies (meaning, faster data download speeds than existing 4G, increasing from 20-30 to 30-250 Mbps, or Megabits per second, but slower than high, mmWave band 5G download speeds)
- Signals travel the farthest, up to seven miles for 4G macro cell signals
- New low band 5G signals touted to cover "hundreds of miles" from a single tower (see here for reference)
- The cone or plume of the RF signal coming out of 4G and 5G low band antennas is wide, up to 120 degrees side to side and top to bottom
- Signals are always-on, bathing houses and urban areas with continuous RF
- Signals can pass easily through walls deep into homes and commercial buildings
- Easy to measure with currently available RF meters
- Shielding is possible with paint, foil, window film & screen, and fabric

Mid band

- 1-2 GHz to 6 GHz
- Wavelengths still long (12 to 4 inches as you go from 1 to 6 GHz)
- Currently used for 4G LTE and new 5G service (dubbed "Enhanced 4G" or "5G Lite" by industry)
- Moderately faster frequencies (meaning, faster data download speeds than existing 4G and low band 5G, increasing to 100-900 Mbps, but still slower than high, mmWave band 5G download speeds)
- Signals still travel for miles
- Signal plumes or cones are wide, up to 120 degrees side to side and top to bottom
- 4G LTE signals are always-on, bathing neighborhoods with continuous RF
- Can still pass easily through walls deep into homes and commercial buildings
- Beam-forming possible for 4G LTE-Advanced and mid band 5G service
- Also easy to measure with currently available RF meters
- Shielding is still possible with paint, foil, window film & screen, and fabric

High, or mmWave, band

- Above 20 GHz
- Wavelengths very short (one-half inch, or only several millimeters—mm—long)
- Currently used for new 5G service only (no 4G service at these frequencies)
- Faster frequencies (meaning, fastest data download speeds, up to 1,000-3,000 Mbps, or 1-3 Gbps)
- Signals travel a few blocks, or up to one square mile
- Signals are only beam-formed
- Signals are narrow, 2-15 degrees wide
- Signals are idle until sent out on-demand when requested by a mmWave 5G-enabled handheld device (or fixed wireless Internet Consumer Equipment Unit for Verizon's wireless Internet service)
- Cannot pass through walls or windows into homes and commercial buildings unless beam-formed, and even then, passage is difficult through walls and glass, especially Low-E glass
- 5G hand-held device (cell phone) must be relatively stationary to stay connected
- Primarily an outdoor service
- Cannot be measured at all with currently available RF meters
- Shielding not as easy. Only paint and foil (and Aaronia Silver Fabric) are expected to be effective
- Not used previously for cell communication (only military, radar, satellite TV industry)

Bands Considered by 4G vs 5G Service

Finally, now that you have some understanding of the characteristics of each frequency band, let's separate them once more by defining how 4G LTE and 5G services are being used in each band:

Low band (600 MHz to 1-2 GHz)

- 4G LTE and 4G LTE-Advanced service will continue in this band using macro antennas
- 4G LTE transmits from existing macro cell antennas ("cell towers") at up to 1,000 Watts Effective Radiated Power (ERP)
- 4G LTE-Advanced and 5G signals also transmit from small cell antennas at 10 to 100 Watts ERP
- Average existing 4G LTE download speeds roughly 30 Mbps
- 4G LTE service for all carriers began to be upgraded to "LTE-Advanced" in 2017
- Low band 5G and LTE-Advanced service provides faster download speeds of 30-250 Mbps
- Low band 5G and 4G LTE-Advanced radios and antennas use 4X4 (4Transmit,4Receive) MIMO (Multiple Input, Multiple Output) radios and antennas, carrier aggregation, License Assisted Access (LAA), LTE-Machine Type Communication (LTE-M), Narrowband Internet of Things (NB-IoT), and 256 Quadrature Amplitude Modulation (QAM)
- These new technologies introduce more modulation, which is more biologically active
- Housed in vertical cylinders and short, thin vertical antennas
- Beam-forming not possible in low band (cannot beam-form below 2 GHz)
- Multi-band dual-connectivity and Dynamic Spectrum Sharing (DSS) will allow new phones to stay connected to 4G LTE and 5G networks simultaneously, switching back and forth as needed (if 5G is available)
- Low band frequencies are considered a "coverage" band, covering large geographic areas and serving large segments of the population
- Low band 5G can cover hundreds of square miles from one tower (I presume with multiple

antennas pointed in different directions—see here for reference)

- Always-on, wide 4G LTE-Advanced and low band 5G signals from small cell antennas considered by activists and advocates to be as big a problem from a health standpoint as 5G in the mmWave band for people in residential neighborhoods and apartment/condo buildings because new small call low and mid band antennas will be numerous and too close to residents

Mid band (1-2 GHz to 6 GHz)

- 4G LTE and LTE-Advanced service will continue in this band using macro cell antennas
- 4G LTE transmits from existing macro cell towers at up to 1,000 Watts Effective Radiated Power (ERP)
- 4G LTE-Advanced and 5G signals also transmit from small cell antennas at 10 to 100 Watts ERP
- Average existing 4G LTE download speeds roughly 20-30 Mbps (Megabits per second)
- 4G LTE service for all carriers began to be upgraded to "LTE-Advanced" in 2017
- Mid band 5G provides faster download speeds of 100-900 Mbps
- Mid band 5G and LTE-Advanced radios and antennas use 4X4 (4T4R) MIMO, carrier aggregation, LAA, LTE-M, NB-IoT, 256 QAM (all defined above) plus massive use of AI (artificial intelligence)
- Housed in rectangular boxes resembling pizza boxes
- Beam-forming is possible in mid band (can beam-form above 2 GHz)
- Beam-formed 5G uses 64X64 (64Transmit, 64Receive) Massive MIMO
- Also uses dual connectivity and Dynamic Spectrum Sharing (also known as Dynamic Spectrum Switching) (DSS) technology for new phones to stay connected to 4G and 5G simultaneously
- Mid band frequencies are also considered a "coverage" band, covering large geographic areas serving large segments of the population, but smaller than coverage provided by low band towers
- One mid band tower covers several square miles
- Mid band 5G signals can be beam-formed, and are therefore on-demand and much more narrow than always-on, wide low band 4G and 5G signals
- Always-on, wide 4G LTE-Advanced signals from small cell antennas in the mid band considered by activists and advocates to be as big a problem from a health standpoint as 5G in the mmWave band for people in residential neighborhoods and apartment/condo buildings because new small call low and mid band antennas will be numerous and too close to residents

High, or mmWave, band (above 20 GHz)

- This is what people think of when they hear the term, "5G"
- Provides data download speeds of 1,000 to 3,000 Mbps (1-3 Gigabit per second, or Gbps)
- Uses 64X64 (and higher) MIMO
- Broadcasts only from small cell antennas transmitting at 10 to 100 Watts
- Housed in rectangular boxes resembling pizza boxes
- Antennas will be placed on poles, towers and buildings at existing macro cell sites alongside 1,000 Watt 4G LTE antennas
- Will also be placed with 4G antennas and on their own on standalone poles in some neighborhoods and inside apartments and condos
- Uses beam-forming exclusively
- Not considered a coverage service. Only a supplemental service, covering smaller geographic areas, roughly one mile or less radius
- Primarily deployed in dense urban areas and public places: stadiums, arenas, airports, college campuses, metro stations

- Not expected to be deployed in rural areas any time soon
- Considered to be supplemental to always-on, wide beam 4G LTE-Advanced small cell transmitters that easily pass into buildings
- High, mmWave band 5G regarded more as a health threat to residents in neighborhoods when we are outdoors

What Are The Dangers From Wireless Transmitters In General?

The wireless transmitters in mobile devices emit intermittent and now, continuous radio frequency (RF) signals at close range to your body. These signals are silent, invisible and odorless (unlike cigarette smoke). They are very harmful to all of us cumulatively on a cellular level, whether we are aware of it or not.

Our governmental regulatory agencies are, unfortunately, captured by industry and incorrectly tell us these devices are safe while hundreds of independent research studies prove otherwise. You are on your own and need to follow three simple rules to stay safe, recommended by the Building Biology Institute and the EMF safety community at large: reduce use, increase distance and favor hardwired connections whenever and wherever possible.

Furthermore, a landmark opinion piece was published on October 17, 2019 in Scientific American entitled, We Have No Reason to Believe 5G Is Safe. It was written by Professor Joel Moskowitz, PhD, Director, Center for Family and Community Health at the School of Public Health, University of California, Berkeley. In that article, Dr. Moskowitz sites more than 500 research studies that have "found harmful biologic or health effects from exposure to RFR (radio frequency radiation) at intensities too low to cause significant heating" (of human tissues near a cell phone) and hence, too low to cause symptoms in many otherwise healthy people.

As a result of this and similar research, over 240 scientists worldwide have signed the International EMF Scientist Appeal, calling for tighter limits on radio frequency radiation exposure for the general public. These 240 scientists have published more than 2,000 peer-reviewed research studies among them on the adverse health effects of radio frequency EMFs. That petition can be found at EMFscientist.org.

The appeal states, "Numerous recent scientific publications have shown that EMF affects living organisms at levels well below most international and national guidelines. Effects include increased cancer risk, cellular stress, increase in harmful free radicals, genetic damages, structural and functional changes of the reproductive system, learning and memory deficits, neurological disorders, and negative impacts on general well-being in humans. Damage goes well beyond the human race, as there is growing evidence of harmful effects to both plant and animal life."

Dr. Moskowitz discusses the damaging effects of long term, low-level exposure to modulation from signaling (polarization and pulsing) emitted by 4G and 5G cell frequencies (and especially from WiFi transmitters) and how this is particularly harmful to the biological functioning of human cells. He calls for new, more stringent limits on human RFR exposure, particularly from cell phones held at close proximity to the head and body, even when only on standby. Recent research conducted by the U.S. National Toxicology Program (NTP) found clear evidence of cancer and DNA damage in laboratory animals when exposed to radio frequency radiation. This was independently corroborated by the Ramizzzini Institute in Italy testing exposure of laboratory animals to even weaker RFR levels than did the NTP study.

Dr. Moskowitz states, “Nonetheless, without conducting a formal risk assessment or a systematic review of the research on RFR health effects, the FDA recently reaffirmed the FCC’s 1996 exposure limits in a letter to the FCC, stating that the agency had ‘concluded that no changes to the current standards are warranted at this time,’ and that ‘NTP’s experimental findings should not be applied to human cell phone usage.’ The letter stated that ‘the available scientific evidence to date does not support adverse health effects in humans due to exposures at or under the current limits.'”

In the opinion of many of us within the EMF safety community, the FDA and FCC are clearly bending to corporate interests in spite of strong evidence showing harmful effects. Many of us feel, with good reason, that the FCC is a “captured agency”. For instance, reports exist that in the mid-1980s, the cell industry wanted to deploy cellular technology, developed by the military in earlier decades, for civilian use. They reportedly pressured the U.S. government to move any oversight over health effects caused by cellular technology out of the NIH and EPA, agencies that have medical researchers, and place that function in the hands of the Federal Communications Commission, or FCC. The sole function of the FCC is to allocate frequencies to broadcasters. They had no medical researchers on staff who can oversee health effects from human exposure to radio frequency radiation (RFR).

That move of health oversight from agencies that have health researchers to an agencie that does not was done on purpose. This information is according to Dafna Tachover, EMF researcher and attorney licensed in New York and Israel who lectures on the adverse health effects of 5G. Her website is Wearetheevidence.org.

You cannot therefore tell me that any claims by the FCC that chronic long-term use of wireless devices is harmless can be trusted.

Bolstering that point, Dr. Moskowitz states, “Little is known (about) the effects of exposure to 4G, a 10-year-old technology, because governments have been remiss in funding this research. Meanwhile, we are seeing increases in certain types of head and neck tumors in tumor registries, which may be at least partially attributable to the proliferation of cell phone radiation. These increases are consistent with results from case-control studies of tumor risk in heavy cell phone users.”

Dr. Moskowitz goes on to say, "5G will not replace 4G; it will accompany 4G for the near future and possibly over the long term. If there are synergistic effects from simultaneous exposures to multiple types of RFR, our overall risk of harm from RFR may increase substantially. Cancer is not the only risk as there is considerable evidence that RFR causes neurological disorders and reproductive harm, likely due to oxidative stress."

How Can We Protect Ourselves From Wireless Sources?

We can protect ourselves, as I have said before, by following three general principles: reduce use, increase distance and favor hardwired connections whenever and wherever possible. Here is a brief list of steps you can take to protect yourself from radio frequency EMF exposure from devices you do have control over:

- Cut back on your use of wireless devices when away from home
- Make changes to the settings of your cell phone, disabling features you don't need — they send out powerful, harmful bursts of radio frequency invisibly and silently right into your body, almost constantly these days
- This primarily includes Bluetooth and WiFi
- I have recently learned that some cell phone manufacturers regularly harvest data from your phone, triggering it to send out data in bursts of RF while the phone is on standby without you knowing it
- This is in addition to the numerous downloads, updates and notifications that go on in the background sending out RF bursts from your phone in your pocket and on your bedside table as the phone and cell tower establish an "electronic handshake"
- use hardwired (corded) landline telephones instead of cordless telephones
- use hardwired Ethernet connections or Multimedia Over Coaxial Alliance (MOCA) adapters for Internet service
- If you use network adapters to get Internet in rooms distant from your router, you must also insert capacitive dirty electricity plug-in filters (Greenwave or Stetzer) at the same time to mitigate the dirty electricity caused by network adapters. Whole house dirty electricity-reduction technologies also exist
- Replace WiFi and Bluetooth with hardwired connections for your desktop or laptop computer, mouse and keyboard, streaming TV, thermostats, music speakers, baby monitors, security and surveillance systems, and any other communication needs. Be sure to then disable the WiFi on your computer
- We even have hardwired connections for Mac and Android cell phones and tablets

These items and more are available through many retailers. I have links to several of them on my EMF Products and Order Codes page. These include Amazon, Safe Living Technologies, LessEMF, and ElectraHealth. You can read about specific hardwired workarounds by linking to my Safer Use of Computers page, accessed by clicking here.

Remember that you must then disable WiFi and Bluetooth on your router, computer, tablet or smart phone. Plugging in an Ethernet cable *does not* automatically shut off WiFi or Bluetooth on these devices. You must do that manually. If you do use hardwire connections between your devices and routers, you will have faster, more stable, secure and healthy data connections.

How Will 5G Work?

Cell companies will build upon their existing 4G LTE network of macro cell towers by trying to place additional lower power “small cell” antennas on street lights, buildings, power lines, lamp posts, house attics and rooftops in residential neighborhoods, wherever they can get them closer to customers. Small cell antennas will contain both 4G LTE and new 5G equipment transmitting at existing low and mid band frequencies. These will be the predominant type of antennas deployed throughout most of the country. Select cities will also have 5G antennas transmitting at new high, or millimeter Wave (mmWave) frequencies.

New technologies will be employed to speed data traffic transmitted at existing low and mid band frequencies, essentially making 4G LTE somewhat faster in what is being termed by industry, “enhanced 4G” or “5G lite”. This is also known as “LTE-Advanced”. These enhanced technologies include: carrier aggregation and spectrum aggregation, beam-forming (down to 2 GHz), massive MIMO (Multiple Input, Multiple Output), License Assisted Access (LAA), LTE-Machine Type Communication (LTE-M), Narrowband Internet of Things (NB-IoT), and 256 QAM.

According to engineer William Hoult, “Spectrum aggregation (SA) is a means of providing higher data rates to the end user. Rather than sending data on one carrier, data is sent on multiple carriers to one device at the same time. As an analogy, think of a one line highway full of cars and each car is carrying bits to the user. Carrier aggregation (CA) is like adding another lane to a highway, so twice as many bits can be carried to the user. This adding of lanes to the highway is called carrier aggregation. In practice, there may be two or three lanes. If there are three lanes, then the download speed will be three times faster, say 3 seconds instead of 9 seconds.”

QAM, or Quadrature Amplitude Modulation, is a modulation technique that crams more data throughput into the same airspace over the same frequencies. QAM mixes amplitude modulation (AM) with phase modulation (PM). Previously, 16-QAM and 64-QAM were used. There is a balance between how many data points, 256 in this case, are able to be used without requiring much more transmit power and getting distortion. That is why 256 is used and not higher numbers.

All of this involves a great deal of AI, or Artificial Intelligence, to help the network function more and more autonomously. This means creating autonomous network management more at the “edge”, where cell phones and antenna radios are located, rather than managing the network solely from mainframe servers at the “core”.

Secondly, cell companies will expand into the high, or mmWave band above 20 GHz (Gigahertz), starting with frequencies at 24, 28 and 39 GHz. This is known as the millimeter, or “mm”, band because the wavelengths are small, about half-an-inch (just a few millimeters) long. This is what most people think of when they hear the term “5G”, but remember, 5G will also include a great deal of enhanced 4G LTE signals in existing low and mid band frequencies. Also, there will be no cell service in the U.S. in the gap between 6 and 20 GHz, although that region is well populated with radio waves from other sources, including radar, satellites, military, aviation and other uses.

There is much open bandwidth at these higher mmWave frequencies. They haven’t been used by the cell industry before now, because signals in the mm band above 20 GHz don’t travel easily through walls like cell frequencies do in the low to mid bands. But as more and more people do more computing and communicating through wireless devices, we are running out of bandwidth at existing frequencies, at least with current technology. There is also an increased demand, whether real or perceived, for faster downloads and more real-time experiences such as with VR and AR, or Virtual Reality and Augmented Reality. There is a lot of open bandwidth in the high band range, which cell carriers haven’t been able to access until now, along with much faster download speeds and much lower latency. All this comes at a cost to human health, as you will see.

5G pertains primarily to data transmissions and less to voice or texting. Cell signals carrying voice and simple SMS texts use much less bandwidth and are sent using older 3G and 4G LTE technologies. 3G is being phased out, and voice and text will still be sent over low and mid band frequencies using 4G protocols but managed by 5G networks. Some carriers are incorporating VoLTE, or Voice over LTE, which uses 4G/5G technologies.

What Are the Physics of 5G Signals in the Millimeter Wave (mmWave) Band?

In order to pass through walls, window glass, rain and even moisture suspended in air, 5G signals in the mm wave band need to make use of advanced technologies that have been in development for decades and not available until now. These include beam-forming, which uses many small antennas (up to 64 transmitting antennas and 64 receiving antennas, and more) that all focus their signal on one or more user’s mobile devices in a coordinated, narrow beam that is only 2-15 degrees wide.

Many mobile devices can be contacted in the same air space, but that focused beam has health impacts, which you have read about through the larger EMF safety community and which are discussed below. These include harm to skin and eyes. 4G signals, on the other hand, cover a much wider swath of 120 degrees in front of macro and small cell antennas and are quite harmful in their own right.

What Are the Characteristics of Existing 4G LTE Cell Antennas?

Existing 4G LTE macro cell antennas, commonly known as “cell towers”, send transmissions at power levels up to 1,000 Watts of Effective Radiated Power (ERP). These can travel up to several miles allowing 4G LTE macro cell antennas to be spaced up to 1 to 1.5 miles apart. About 300,000 4G LTE cell antennas/”towers” currently exist in the U.S. with many more planned, primarily at existing and new macro cell sites.

Existing 4G LTE macro cell antennas are about three feet tall and about ten inches wide. You see these skinny antennas mounted on poles, towers and buildings, pointed in various directions. Each slender antenna contains 4 or 16 antennas, which are larger than new 5G antennas in the mmWave band because the wavelengths of existing low and mid band 4G LTE signals are 4-15 inches in length.

Massive Multiple Input, Multiple Output (MIMO) in 5G Compared to New, Enhanced 4G LTE (“5G Lite”)

Since mmWave signals above 20 GHz have such short wavelengths, they cannot pass through normal building materials. Signals therefore need to be beam-formed in order to get through walls, as I have said. That is where “massive” Multiple Input, Multiple Output, or MIMO, comes in.

Right now, existing 4G LTE macro cell antennas use 2T2R (two transmit, two receive) or 4T4R (four transmit, four receive) transmitting antennas on each 4G LTE cell antenna array (also known by many as a “cell tower”). That defines the maximum number of signals each array can transmit in any direction, with about ten or so mobile cell customers served per individual antenna. Cell carriers are upgrading existing 4G equipment that have had 2T2R antennas with 4X4 antennas in what is known as “LTE-Advanced”. This doubles the amount of signals in a given air space.

Cell antennas in the high, mmWave band, on the other hand, must use multiple small antennas arrayed in a square or rectangle, up to 8 or more across and 8 or more high. That allows 64 or more antennas to simultaneously send signals that can be shaped electronically, using phased array, to send the combined signal from all 64 of them in one direction or another. This process is called beam-forming or beam steering. AI (artificial intelligence) in the radio beneath (or embedded within) the antenna directs the whole process. Multiple signals can be sent out at once to multiple handheld 5G-enabled user devices. This is the only way that 5G cell signals in the mmWave band can penetrate walls and windows, and not very well at that.

Beam-forming using Massive MIMO can also be used down to 2 GHz. Thus, Sprint uses this technology for its 2.5 GHz 5G service. As explained below, they are able to devote 32 antennas of the 64 transmitting antenna array to 4G and the other 32 to 5G, or with a software change, all 64 antennas can be devoted to 5G. This is all at the

2.5 MHz frequency. What differentiates the 4G from the 5G signal? The amount of modulation and pulsing that occurs in creating and shaping the cell signal. Modulation and pulsing of cell signals, as you will see below, have a significant impact on our health and are a great concern to 5G activists and advocates.

mmWave 5G Signals Are On-Demand and Narrow

One important distinction to understand between 4G LTE and 5G technology is that 5G signals in the mmWave band are sent on-demand. This is misunderstood by many who think 5G beam-formed signals in the mmWave are always-on. Instead, they only transmit when a 5G-enabled device calls for a connection. Then the 5G signal is sent out in a narrow beam using beam-forming technology. Otherwise, the mmWave 5G small cell antenna is dormant (except for a weak, intermittent reference signal—see below). 5G small cell antennas using the mmWave band will not be sweeping the neighborhood with strong, focused beam-formed signals, as some think.

4G LTE Signals Are Always-On, Wide and Strong

4G LTE signals, on the other hand, do bathe a neighborhood with strong, always-on RF energy at widths of 120 degrees. They are every bit the culprit as 5G signals are in this story.

I was told by engineers at the conference that a beam-formed 5G signal is sliced into ten or twelve narrow beams, each roughly 10 degrees wide. Since the signal is broadcast at up to 10-100 Watts, it does not go as far as a macro 4G LTE signal at 1,000 Watts. The industry says small cell signals at 10 to 100 Watts travel roughly 1-1.5 blocks, however Verizon has measured 1+ Gbps (Gigabits per second) data download speeds at 28 GHz at half a mile. Newer beam-formed 4G and 5G signals can cover up to one square mile.

Also, while manufacturers are saying that the industry wants to keep power output from small cell antennas low to keep electricity consumption low in an effort to minimize operating costs, reports are surfacing from 5G activists that cell carriers may exceed the 10 to 100 Watts ERP for the strength of the transmission of their small cell antennas in the future. It turns out, however, that RF measurements taken by building biologists and others with RF meters currently on the market today show extremely high RF measurements in second story bedrooms just dozens of feet from 4G LTE-enabled small cell antennas transmitting even at 10 to 100 Watts.

We need to understand that 4G LTE signals from small cell antennas are, as I have said, always-on regardless of the power density, whether 10 or 100 Watts, as on new small cell antennas, or 1,000 Watts, as on existing macro cell towers. Small cell antennas with 4G LTE transmitters would therefore send out a constant RF signal that is 120 degrees wide and shaped like a cone. Again, even though it would be transmitting at 10-100 Watts, the 4G LTE signal from one of those small cell antennas could be as close as 30-100 feet from your house at the second story level, creating very high RF levels of several hundred thousand microWatts/meter squared of RF power density that we have measured in second story bedrooms from these 4G LTE and low band 5G signals.

How Will New Cell Phones Work in a 5G World?

New cell phones will have 4G LTE, 5G and WiFi receivers and transmitters. Your phone will connect to whichever antenna provides the strongest connection wherever you are located. Inside most homes in the world today, this would be a WiFi network. However, if you have 5G technology embedded in your new phone, you will connect to a nearby 5G small cell antenna if one is close to your house in your network…provided your phone is stationary.

Only certain phones are currently being sold that offer 5G, whether in the low, mid or high band. It all depends upon which frequencies your carrier has 5G service. This is spelled out in detail in the tables above. New phones from T-Mobile, for instance, that operate in their low band 600 MHz service cannot pick up the much faster 5G service offered in the mmWave band in the six cities they have deployed their mmWave 5G service. The same is true for AT&T's 5Ge service in the low band vs. their 5G+ service currently offered only to business customers in 25 cities (soon expanding to 35 cities). New modems being introduced in 2020 and 2021 should be able to bridge this gap and allow T-Mobile and AT&T customers to access both carrier's low and high band 5G service with future phones. If and when T-Monile merges with Sprint, the combined company's phones will also be able to access Sprint's mid band 5G service at 2.5 GHz. Verizon customers can only access 5G service in select cities using that company's new 5G phones.

You don't have to purchase a phone that has 5G capability. If you do, you can disable that service. At the present time, all 5G-enabled phones send data back to a 5G antenna using 4G technology, however, with Dynamic Spectrum Sharing (DSS), phones will be able to send data back with a 5G signal. Everyone in our community is concerned with that, but please be aware that the 4G signal that invisibly and silently passes into your body almost constantly now from your phone when it is in your pocket or beside you all day is already very harmful, and now ever more so as WiFi and 4G signals become more and more modulated.

What happens if you are electrically sensitive and someone with a 5G-enabled phone visits your home? Their phone would connect to a nearby 5G antenna if there is one and indeed draw that mid band 5G or 4G beam-formed signal into your house, but only if their phone is stationary. If their phone moves, it will tend to lose its 5G connection and connect instead to a local 4G antenna, as it does now.

Beam-formed 5G signals in the mmWave band are therefore best received when the 5G-enabled cell phone is stationary inside someone's house, or better yet, if it is outdoors. When the phone is moved around, it will be passed from one zone to another coming from the 5G antenna, or it will be passed back to a nearby 4G LTE tower or to an indoor Wi-Fi network (if the user has the password) with data flowing at slower speeds. (Dynamic 5G where the 5G small cell antenna can track the phone as it is moved around is not yet possible, but engineers expect that to happen within a few years.)

The fast 5G download primarily happens when the 5G-enabled phone is kept in one place or moved outdoors. Journalists for Wired magazine lost the 5G mmWave signal and were switched back to slower 4G when they walked into stores when testing 5G mmWave data downloads in test cities. They only received the faster 5G signal when they were outside on the city sidewalk. Remember, 5G service in the mmWave band will be limited to certain areas within select cities. See coverage maps for mmWave 5G service above.

Also, 5G-enabled cell phones do not currently send data back on 5G mmWave frequencies, according to engineers with whom I spoke. They use 4G LTE frequencies and protocols when sending data back to a 5G tower. That will change soon.

Alasdair Phillips wrote a very succinct piece recently saying that 5G in the mmWave band will primarily be deployed in dense urban areas. It is not considered by industry as a carrier or blanket network because it does not go as far nor does it penetrate building materials as sub-6 GHz signals do, which are now 4G LTE and will be expanded and upgraded to 5G.

4G LTE antennas on existing macro cell towers can locate your phone down to 50 feet. If the cell industry gets its way, small cell antenna arrays with 4G LTE transmitters will appear on every block, able to locate your phone down to 3 feet. Then, massive amounts of data can be uploaded using 5G transmitters on the same small cell antenna (that is already happening with existing 4G equipment). Harvesting that data, data that we willingly provide through social media and other platforms, will be (and already is) worth trillions of dollars to the cell industry as new income in the coming years. That is why the cell industry is pushing so hard for the installation of 4G antennas in every neighborhood, so they can better locate your phone to extract data, not to mention the surveillance and other issues that become possible with the massive movement of data. 5G connections allow that, particularly with "fixed wireless."

Fixed wireless, as opposed to mobile wireless, is a big component of 5G. I am told by 5G activists that cell carriers are planning to compete head to head with existing cable and telephone companies that provide wired Internet service to homes and businesses over coaxial cable and telephone lines. Cable and telephone companies are regulated by Public Utility Commissions in every state, capping how much they can charge customers for delivery of Internet data.

Cell carriers, on the other hand, are not bound by these restrictions because their “last mile” is wireless. That means, they are unregulated and can charge whatever the market will bear, without restriction. Cell carriers are laying thousands of miles of fiberoptic cable to bring terabytes of data to their small cell antennas for pennies. That data will then be sprayed into residential neighborhoods wirelessly, bathing homes in high-strength radio frequency signals at close range.

Characteristics of 5G Transmitters Relative to Your Health

What many people do not know is that 5G antennas in the high band only transmit beam-formed signals when mobile devices initiate a connection. That means, if we consider mobile wireless service in a residential area, 5G signals will not sweep through neighborhoods like 4G LTE signals do. Engineers and 5G activists know this.

4G antennas, on the other hand, will be always-on, constantly spraying homes with hard-to-shield radio frequencies at very close range. Those signals will all be more modulated as 4G service is upgraded to LTE-Advanced service. Granted, the effective radiated power of these 4G LTE antennas will be lower than is currently the case from 4G LTE cell antennas on existing macro cell sites, but instead of a mile away, the 4G antenna on the small cell antenna on your street will be 30-100 feet from your bedroom window. RF readings have been measured in the hundreds of thousands of microWatts per squared meter in these rooms, especially second story bedrooms, well above the building biology recommended safe level of ten microWatts per squared meter or less in sleeping areas.

Bear in mind, however, that while mobile wireless 5G transmitters on small cell antennas in residential neighborhoods will only transmit when mobile devices initiate a connection, consumer equipment units (CEUs) mounted on or inside customer’s homes to bring wireless Internet into the home will draw a relatively constant beam-formed connection. That is how Verizon’s 5G Home wireless Internet service works. Their 28 GHz small cell antenna mounted on a utility pole sends a signal to a CEU on a customer’s wall or inside their window, which then sends the Internet over an Ethernet cable to their modem/router. That router then distributes the Internet data inside the home using traditional WiFi and Ethernet jacks.

Thus, if you are electrically sensitive, we would advise you to stick with your hardwired Internet service from the cable or telephone company. We have strategies to help keep those services hardwired without the need for WiFi. Again, see my article, Safer Use of Computers for details.

As more and more fixed wireless devices go into residential homes and businesses, along with the use of new 4G/5G hybrid cell phones, 5G signals will increase in neighborhoods, especially in dense urban areas. 5G signals to fixed and mobile devices in neighbor’s homes will be narrow, so try to avoid bringing these devices into your home if you want some degree of protection. See below for information on shielding materials.

The bottom line is, if you live in or visit a city and regularly walk on city streets, you will be bathed in 4G and 5G signals at close range, much closer than 4G LTE signals have been in the past for most of us. The cell industry is focusing most of its investment dollars in establishing 5G service in dense urban areas first because that is where the bulk of their customers are. It is a matter of economics for them.

5G Small Cell Antennas Transmit a Weak Reference Signal

I learned at the 5G industry conference that small cell mmWave 5G antennas send out what industry calls a reference signal looking for a 5G-enabled device. Those bursts last 10 or 20 milliseconds and occur a few times a minute. To conserve power, the reference signal is reportedly very weak, designed to be 1% of the power or strength of RF signals when data is being sent.

To determine how strong that reference signal actually was, we measured the reference signal from 5G antennas at the conference center using equipment at two booths on the recent trade show floor. We used $35,000 to $60,000 spectrum analyzers to measure 28 GHz 5G signals coming from antennas in the rafters of the Los Angeles Convention Center. Those antennas were not part of the show. They have been installed by a particular cell company for attendees of all the trade shows at the Convention Center who are also customers of theirs to use. We measured the 28 GHz reference signals at power densities of -60 to -70 dBm, or decibels per meter.

When you compare that -60 to -70 dBm signal to the unit of measurement we are used to using, it is equal to 0.1 to 0.01 microWatts/meter squared. You can see that equivalence by clicking here and scrolling down on the chart to -60 dBm and then scrolling over to the column for uW/m2 (microWatts/meter squared).

In the case of an actual beam-formed mid or high mmWave band 5G antenna, that -60 to -70 dBm would be the strength of a 5G reference signal that you would measure outside a house coming from a 5G small cell antenna located in front of the house. Again, that would be equivalent to 0.1 to 0.01 microWatts/meter squared of RF exposure.

The walls and window glass of your house would then block that weak RF signal from entering the house. Granted, no one wants to have any RF coming to their house from any source, but a signal that weak and at that wavelength would not penetrate walls very well. That 0.1 to 0.01 microWatt signal would also be considerably overshadowed by RF signals coming from distant 4G LTE cell towers within a mile or so of most homes. I routinely measure at least 5-20 microWatts/meter squared, and often substantially more, of RF signals when standing in front of almost every urban and suburban home I evaluate in my EMF practice here in Southern California. Those 4G signals have a much longer wavelength and do penetrate the walls and windows of every house. You have to be out in the country, far away from people and therefore, far from 4G cell towers, to avoid nearby 4G LTE towers found in every urban and suburban neighborhood for the past several decades.

In fact, in most homes that I evaluate, I also routinely measure 20-150 microWatts/meter squared of RF in second story bedrooms, where neighbor's houses don't block the signals coming in from nearby 4G LTE macro cell towers. How do I know that these RF signals are from 4G cell towers and not entirely from routers in my client's home or neighbor's homes? By the high-pitched squealing sound that I have learned to associate with 4G cell towers.

I have seen and heard this on my Gigahertz Solutions HF59B RF meter (and now also on my Safe & Sound Pro II RF meter) for years. You can hear these RF sounds for yourself by listening to audio Wave files of RF sounds on the website for Safe Living Technologies under their Education tab, and then by clickin on EMF Sounds. You can access that page on their website by clicking here. The sound of WiFi from my client's router or a neighbors router is sometimes mixed in, but the strength of the WiFi signals, especially from the neighbor, drops off significantly with distance and it is much weaker, one-half a Watt, compared to the strength of a distant 4G macro cell tower transmitting at up to 1,000 Watts.

That is the environment in which we live in any city or town in America with four networks overlayed in every neighborhood from four cell carriers. That is before small cell antennas of any kind are added to the mix. We already have a toxic soup of 4G LTE signals right now. Fifth generation (5G) cell technology to be implemented over the coming decade will add many more 4G LTE and 5G small cell antennas to our neighborhoods, especially in dense cities, if they are not stopped through citizen efforts.

I certainly don't want to be misunderstood here. I am in no way saying 5G antennas in front of people's houses are safe. I am merely pointing out that the bigger danger, in my opinion, is from low and mid band 4G and 5G small cell antennas for all the reasons given above. Just be sure not to use a 5G-enabled phone in your own home if you live near a city's downtown and have a mmWave 5G antenna in front of your house. If you do, or if someone else in your house does, you or they will bring that beam-formed 5G signal into your home when you are using your phone. Otherwise, it won't come in.

However, the low and mid band 4G LTE-Advanced and 5G signals certainly will pass through your walls and windows if you are unlucky enough to have one of those small cell antennas in front of your house. I have already personally measured them and the RF levels are high. All of this needs to be opposed in terms of deployment of any antennas in residential neighborhoods and avoiding RF and other EMF sources in your own home.

How Can We Measure 5G?

Current RF meters can only measure RF signals up to 8-12 GHz. That means they cannot measure 5G signals in the high mmWave range. They can, however, measure 4G, new 4G LTE-Advanced and even low and mid band 5G transmitters planned to be installed on small cell arrays outside homes on city streets.

Existing RF meters that measure in the super-20 GHz high mmWave band are really spectrum analyzers. According to RF experts such as Peter Sierck, Prof. Trevor Marshall and others, they are expensive, they only measure in average mode and they only use diodes for measurement. They are considered by these experts to not be sensitive enough for 5G for our purposes. New, affordable RF meters designed to specifically measure mmWave 5G signals above 20 GHz are, however, under development by three different groups. The hope is to get their cost below $1,000.

You can put your RF meter in front of your chest and turn around in a circle in place. If the RF signal on your meter drops when your back is to the antenna and increases when you turn so that you are facing it, and if the RF signal level and sound increases as you walk towards it, that is proof that that is the source. You will also have other signals mixed in from stronger 4G cell antennas farther away that all sound the same (a high-pitched squeal), but you can use your hands to block the signal on different sides of the RF meter and use your body. The water in our bodies and hands is an excellent shield that blocks RF signals. This helps determine the direction of RF sources.

If you have an RF meter and you measure a signal from a new small cell antenna near your house, you are measuring 4G LTE-Advanced or 5G transmitters in the low to mid band range, not signals above 20 GHz. Yet, as I mentioned above, these low to mid band 4G and 5G frequencies are still quite harmful. Thus, there is more to be concerned about than just beam-formed signals above 20 GHz, which is what most people are presently focused upon. At least, we can measure RF signals below 6 GHz in the low and mid bands.

When deciding how to measure 5G, then, remember that you will be able to measure existing 4G frequencies and new 5G frequencies in the low and mid bands. RF meters that do that include several affordable models that are relatively accurate and have good quality sound. These include:

- Safe & Sound Classic RF Detector (Please use coupon code CHHOM when ordering)
- Safe & Sound Pro II RF Detector (Please use coupon code CHHOM when ordering)
- Acousticom2
- Acoustimeter
- Gigahertz Solutions HF Series RF Meters (Please use coupon code CHHOM when ordering)
- Cornet Improved Tri-Mode (Hi/Low Frequency) Electrosmog Meter (ED88t Plus)

- Tri-Field TF2

Which are the best? It is obvious that the more you pay, the better the sensitivity and quality of the meter. You get what you pay for. If you are highly electrically sensitive (EHS), you owe it to yourself to spring for a more expensive, and therefore, more accurate and sensitive RF meter. That would include the Safe and Sound Pro II, the Acoustimeter, and the Gigahertz Solutions HFE35C (the Extended model, with the UBB27 omni-directional antenna). Each of these RF meters has accurate sound. That is critically important in determining what the source of RF is that you are measuring. You need to learn what RF sounds like. Listen to the sounds on Safe Living Technology's website, again linked to here.

How Can We Protect Ourselves From 5G?

4G and 5G signals can be shielded by various materials, depending upon the frequency of the signal. That is why it is important to know that 5G will come in three frequency ranges. In the low and mid bands, RF-shielding paints, copper mesh, aluminum building foil, window film, and most RF-shielding fabrics are all relatively effective at blocking RF, if you are careful in your analysis and application of the material.

In the super-20 GHz mm wave high mmWave band, however, only paint and building foil will be effective. Copper mesh and most fabrics, on the other hand, lose their effectiveness above 12-18 GHz. The only exception that we know of is Aaronia's Silver Mesh fabric, available here.

Besides paint and building foil, you can best protect yourself in your own home by not purchasing a 5G-enabled cell phone, keeping cell phones off when at home, and using hardwired alternatives for all your devices, as mentioned above. Do not bring new 5G-enabled wireless devices into your home, such as new routers and smart speakers. Opt out of your electric, water and gas utility's smart meter programs, if possible. If not, shield your smart utility meters with a smart meter guard, such as from Smart Meter Guard or Smart Meter Covers.

Hire a building biologist to measure the RF levels inside and outside your home and help guide you on how to shield effectively and find hardwired alternatives to wireless devices. We can also trace and help repair/reduce/eliminate other forms of EMFs. Find a building biologist in your area at the Find an Expert tab at the top of the Building Biology Institute website.

Also be aware that industry experts doubt that the economics of 5G will allow large scale deployment by the cell industry of 5G in rural areas any time soon. These experts feel 5G will be mostly concentrated in dense urban areas, where most customers are located. EHS people need to avoid areas of high population density. If you are electrically sensitive, you need to consider living in a rural area away from other people. Reports in the industry say that cell companies will not invest in putting mmWave antennas in rural areas. What will go up in rural areas are small cell 4G LTE-Advanced antennas and low and mid band 5G coverage. That will primarily be close to towns. It would be rare that a cell carrier would put up a small cell antenna in front of only one or two homes in a rural area, unless they are trying to provide coverage for travelers on the highway. So, don't live near major roads when out in the country. Existing 4G LTE antennas in rural areas can already be a problem. Remember, any new or existing 4G or 5G antenna in the low and mid band can be measured with our existing RF meters.

In my opinion, every electrically sensitive person should own an accurate RF meter and learn how to use it properly. Measure any place you plan to live or spend any length of time in to be sure RF levels are acceptable for you. See my list above of recommended RF meters. We recommend nighttime RF levels be below 10 microWatts per meter squared, and as close to 10-20 microWatts in the daytime. That is hard to achieve in most residential areas, let alone in a city. I routinely measure 50-150 microWatts in upstairs bedrooms in suburban areas from distant cell towers (and sometimes from WiFi in my own client's home—we then endeavor to educate them about the need to switch to hardwired Internet connections and then shut off their WiFi most or all of the time).

What 5G Will Mean to Our Health and to the Health of Our Planet

The most troubling aspect of the deployment of RF signals in the high mm band above 20 GHz is the particular effect that short and long term exposure to these frequencies is expected to have on human health. The short wavelength of these signals means they will not penetrate much deeper than the skin, but the skin itself is a large organ with it's own integrity and biological properties. Exposure to signals in the mm band is known to harm skin, as well as the eyes.

Some report that the helical nature of sweat glands provides a path for mm Wave frequencies to penetrate deeper into the body than only skin deep. Researchers speak about "Brillouin Precursors." These can open small channels through the cell membrane, inducing a large electrostatic potential in the process. (See Jeremy Naydler's article here.) People are already reporting adverse health effects in cities where 5G signals in the mm band are being tested.

We are quite concerned about the massive increase in RF signals that will bathe particularly our urban and suburban environments in ever-increasing amounts of microwave energy as 5G is deployed, threatening the health of people, animals, insects, plants and even microorganisms. We encourage you to learn about and join efforts to slow and halt the deployment of 5G. It must be properly tested. It will, in my opinion, ultimately be deemed to be harmful, just as cigarette smoke, lead, asbestos and GMOs were all found to be harmful. See Recent EMF News on this site for links to websites with information on the dangers of long term exposure to existing wireless signals, both outside and inside your home.

Right now, we are still in the middle of our honeymoon with wireless/cellular technology. Most people don't feel any ill effects, or they and their doctors do not notice the connection between symptoms they do have and the EMFs they are exposed to. Researchers have shown that wireless devices are harmful to 100% of cells and tissues when holding cellphones at close range next to your head and body, even from a call as short as two minutes. These researchers estimate that two-thirds of the population can repair that damage when they sleep at night. Yet, one third of people cannot repair that damage, which is a staggering number. Those individuals often go on to develop frank disease.

That is your real risk. Unfortunately, you don't even know how high the RF exposure is from devices in close proximity to your body because they bathe you in silent, invisible RF signals throughout the day and sometimes, at night if you charge your cell phone on your bedside table. Remember, follow the principles to reduce use, increase distance and favor hardwired connections wherever possible.

Unfortunately, in my opinion we haven't yet reached critical mass, as we had to do with tobacco, asbestos and lead in gasoline, where enough people had to get sick and die before the public demanded action from regulators and industry, although we are getting there. Sadly, we are not at that point with the public at large when it comes to wireless devices and almost everyone wants to use them. We have indeed seen this movie before.

What Do 5G Activists Say?

5G activists recommend the following points:

- Neither 5G nor 4G antennas should be deployed in residential neighborhoods near homes.
- 5G antennas should be restricted to existing macro cell sites.
- 5G antennas should also be restricted to commercial and industrial sites.
- 5G antennas should have at least a 250-foot setback from residential homes.
- 5G antennas should be placed above roof lines, not below 150 feet.
- 5G antennas should not be deployed without environmental impacts being conducted first.
- This includes impacts on human health.
- Favor, support and utilize hardwired connections to buildings and within homes, schools and businesses.

Resources on 5G

See links to 5G resources at the end of this article.

In particular, you can purchase the online course entitled, **5G: Understanding the Technology & Protection Strategies** (IBE 221.4) published by the Building Biology Institute, available by clicking here. Download a free three-page summary Fact Sheet of the online 5G course at the same link and by clicking here.

To learn more about and support the work of 5G activists around the nation and world and to learn more about 5G, go to such websites as:

- SafeG
- The 5G Summit
- Building Biology Institute
- 5G Crisis
- What is 5G?
- We Are The Evidence
- Environmental Health Trust
- Electromagnetic Health
- Americans for Responsible Tech
- Cellphone Taskforce
- Telecom Power Grab
- My Street, My Choice
- Physicians for Safe Technology
- Parents for Safe Technology
- Wireless Education
- Re-Inventing Wires: The Future of Landlines and Networks

One of the best resources of information on the debacle of wireless use without testing or taking into account the needs of electrically sensitive people is the documentary, Generation Zapped. It is available from a number of sources linked to from the home page of this website in the Recent EMF News section.

Scientists are circulating a letter warning of the potential health risks of 5G. Access the letter at https://ehtrust.org/scientists-and-doctors-demand-moratorium-on-5g-warning-of-health-effects/.

Finally, here is an interesting article from an industry magazine, Computer World, published on September 29, 2018 by Mike Elgan, entitled, "Why 5G will disappoint everyone — Wireless connections that are 20 times faster? What could be disappointing about that?". Read the article by clicking here.

Additional 5G Resources From Oram and Other Sources

The website for the Building Biology Institute (BBI) is home to many online courses, including a course on 5G, written by Oram and a team of a dozen experts from within and outside the Building Biology profession. See these offerings at the Courses tab at the top of the BBI website, then click on the Electromagnetic Radiation page link. There you will find the link to the 5G online course, **"5G: Understanding the Technology & Protection Strategies"**.

For a free three-page preview and summary Fact Sheet of the 5G online course, download it from the BBI website by clicking here.

Another 5G resource is an audio interview of Oram conducted by Camilla Rees of ElectromagneticHealth.org. In the interview, entitled, **"Insights on 4G/5G Antenna Densification: Oram Miller, BBEC, EMRS"**, Oram goes into great detail on what 5G entails, how 4G is a big component of it, and how you can measure and protect yourself from it. To link to the free interview, click here. Camilla serves on the Advisory Board of the Building Biology Institute and was one of our contributors and editors of the Institute's online course, 5G: Understanding The Technology & Protection Strategies, mentioned above.

Josh del Sol, who brought us Take Back Your Power, teamed up with Sayer Ji, co-founder of GreenMedInfo to bring us a series of interviews with over 40 experts on **The 5G Crisis: Awareness and Accountability**. This series of interviews was available for free viewing during the week of August 26 through September 1, 2019 and again during the first week of June 2020.

The full summit is still available for $99, which provides online access only (no DVD version is available at this time). When you register, you will receive a PDF entitled, "7 Essential Ways to Make Your Home Safe from 5G and EMF Radiation" as a free gift. This guide was updated by Josh with help from Oram and colleagues at the Building Biology Institute.

To purchase the 5G Summit, click here or on the banner at right:

If you purchased the 5G Summit in the past, you were also eligible to purchase the **4 Solutions Masterclass**. That included **four additional presentations on *The 4 Levels of Solution to 5G*, including a presentation by Oram**. At the present time, the only way to view this and the other three presentations was if you purchased the entire 5G summit and the 4 Solutions Masterclass when they were available for purchase. (The entire 5G Summit is available for purchase once again, but unfortunately not the 4 Solutions Masterclass at the present time). The 4 Solutions Masterclass may become available once again in the future. If and when that happens, we will notify you through this website. If you already purchased the 5G summit and the 4 Solutions Masterclass in the past, you can access those interviews through your account with HealthMeans. I encourage you to watch my presentation in the 4 Solution Masterclass to see a thorough overview of 5G.

(This is a continuation of the update dated 8/17/20, begun at the top of this page.)

It may therefore be useful for us to refine our understanding of how 5G works and consider using proper terms if our understanding is not quite correct, which I believe it is not. In my opinion, doing so would clear up misunderstandings within our community and have the added benefit of helping engineers and researchers outside of our community to better accept our point of view. I think we do ourselves a disservice when we appear to not know the true facts about the workings of 5G.

One resource that has helped me to really understand what is going on in the 5G industry is the writings of Doug Dawson, President of CCG Consulting. Doug is a cellular industry watchdog who is a consultant for telecommunications carriers. He is a member of the "Fiber-To-The-Home Top 100" list of leaders, advising clients on how to bring fiber communication networks to homes, which we also support.

Doug writes a daily blog on the state of telecommunications in the U.S., "POTs and PANs, Broadband for All", found by clicking here. I encourage you to sign up to receive his daily posts. Doug is a straight shooter who has been commenting upon the evolution of the cellular industry, particularly as it moves from 4G to 5G.

Doug is not a fan of how 5G is being rolled out and marketed, claiming that the business model for 5G is faltering and that investors are getting nervous that the use cases touted a couple of years ago by industry are not materializing. Doug said in June 2020 that the cell industry had stopped growing over the preceding two years. In December 2019, he wrote, "The reality is that the big cellular companies are struggling to find a business case for 5G. They are starting to realize that a lot of people aren't willing to pay more for faster cellular data." In May 2020, Doug wrote, "They still have not built a business case for 5G that justifies the cost of deploying dense networks of small cells…There is no business case for spending the money for dense fiber-fed networks since cellphones are not designed for big bandwidth applications…The FCC has approved new WiFi spectrum that when coupled with WiFi 6 technology promises a magnitude improvement in WiFi performance. Once people start using the new WiFi there is going to be little interest in paying a monthly subscription for something that can be done well with off-the-shelf routers."

Doug points out many facts that can help us to more fully understand how this technology works and what we are truly dealing with at each step in the unfoldment in the technology. The benefit of that, in my opinion, is to have a clearer understanding of what we are really being exposed to in the deployment of this technology and how we can better shield ourselves from its effects.

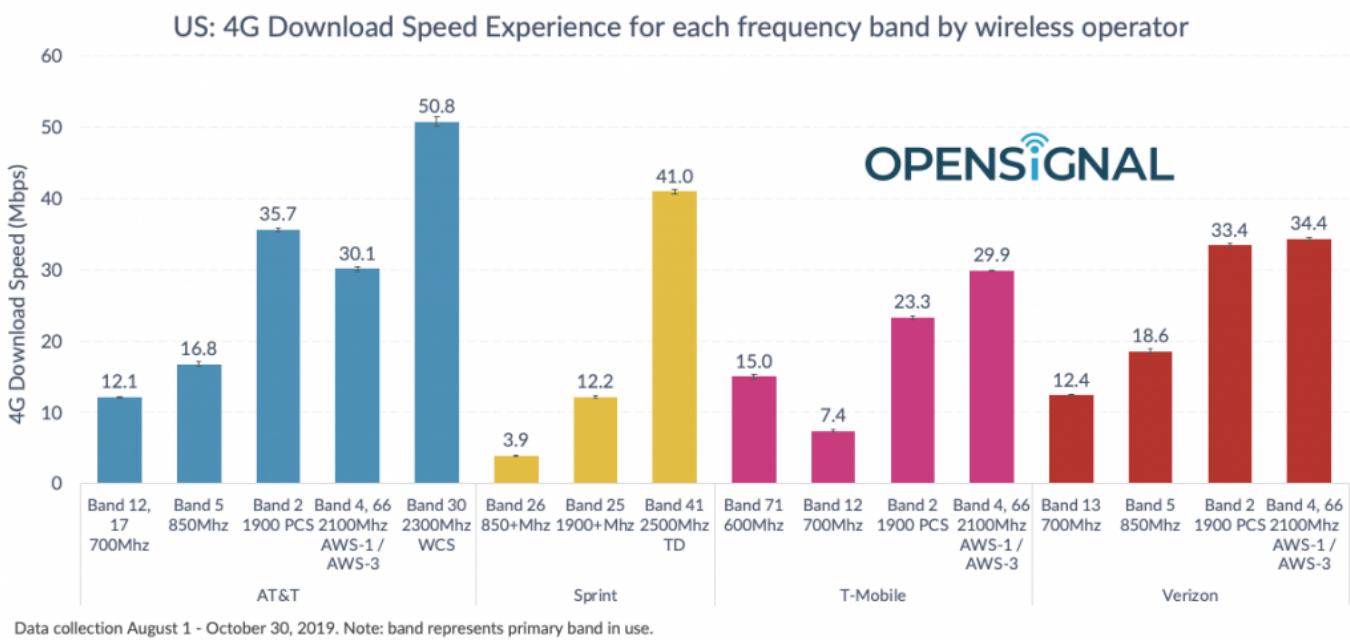
Doug says that in reality, it takes a full decade for the cellular industry to fully implement all the features agreed to in its forums. He says it was not until 2018 that the first cell tower became operational that contained all the features of 4G LTE. Cell carriers had been implementing 4G features into their antennas and phones throughout the 2010s, but none of the antennas and phones fully adopted all 4G features until we began the decade of 5G in 2018.

Doug says we are now two years into the era of 5G, and all four cell carriers in the U.S. are touting faster service using 5G, when in fact, no cell antenna or cell phone has any of the 13 features agreed to by the cell industry for true 5G service as defined by the 3rd Global Partnership Project (3GPP), a worldwide forum of cellular carriers. Only AT&T and Verizon are beta testing the first true 5G feature that is to be incorporated into phones, called Dynamic Spectrum Sharing, or DSS, in certain test sites (Northern Texas for AT&T and Minnesota for Verizon). Doug wrote in May 2019, "It might be a decade until we see a full 5G cellular installation. There are 13 major specifications for improvements between 4G and 5G and those will get implemented over the next decade."

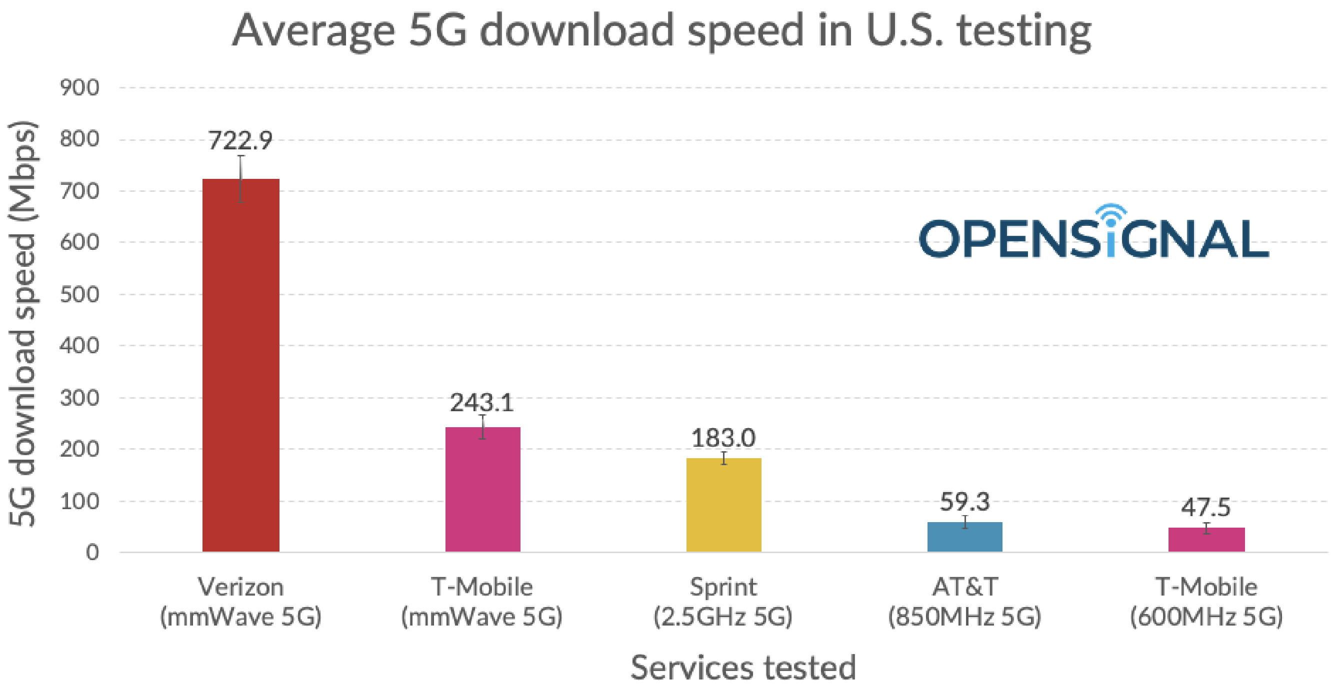
What do we have instead? Doug says that industry is misusing the 5G moniker when in fact they should be calling it 4.1 G. Current data speeds are only marginally faster than 4G in the vast majority of places. What we have, according to Doug, is somewhat faster 4G LTE service, deployed in new spectrum bands and being called, "5G". He wrote in April 2020, "To date, each of the major carriers is in the process of implementing new spectrum bands they are labeling as 5G – but the technology being delivered is still 4G that happens to use different spectrum bands. The carriers are at least a few years away from deploying any features that can be said to be 5G, such as frequency slicing or dynamic spectrum sharing."

In April 2020, Doug also wrote, "To date, each of the major carriers is in the process of implementing new spectrum bands they are labeling as 5G – but the technology being delivered is still 4G that happens to use different spectrum bands." In February 2020, he wrote, "Most of what is being called 5G is the introduction of new bands of spectrum. New spectrum does not equal 5G – the 5G experience only comes with 5G features. Existing cellphones cannot receive the new spectrum bands, and so the carriers are selling new phones that can receive the new spectrum and labeling that as 5G."

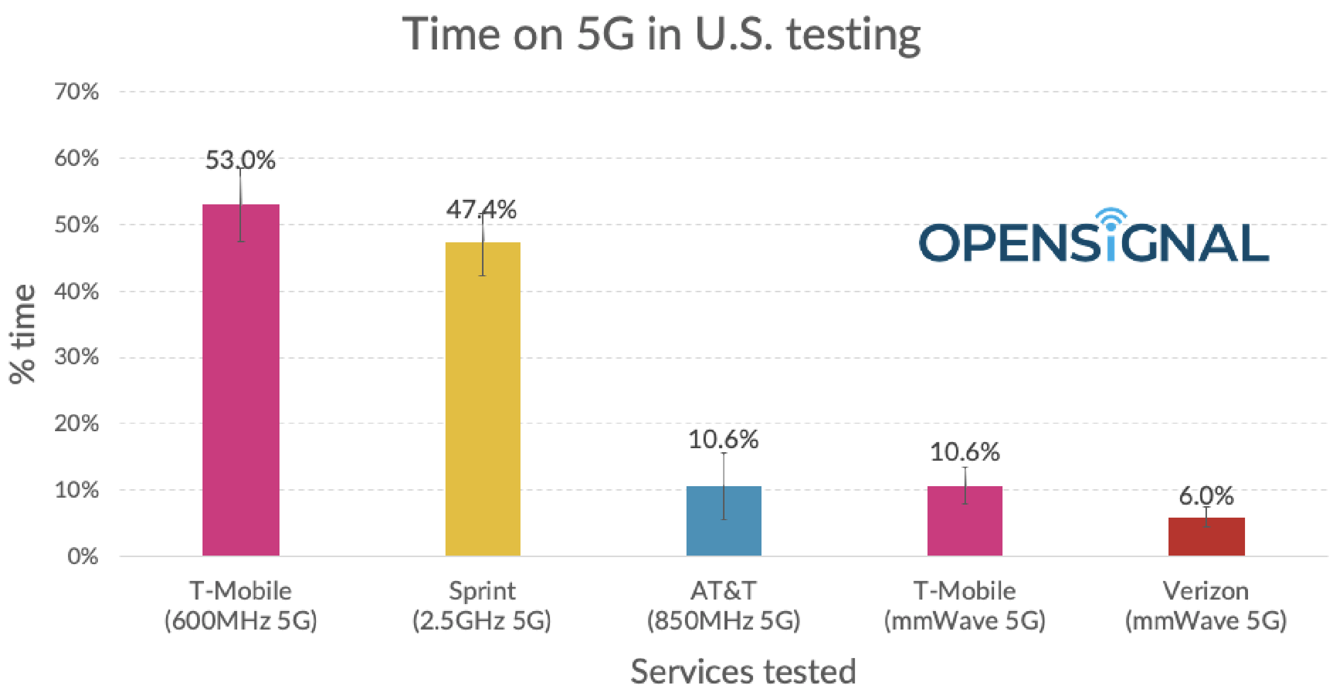
According to OpenLink, average 4G data speeds in the U.S. have hovered between 3 and 50 Megabits per second, or Mbps, during the past decade. See the chart below. The faster the 4G frequency, the faster the download speed. These are the speeds we are used to for our cell phone data transmission of streaming audio, streaming video and our apps.



According to OpenSignal's testing conducted in December 2019 through January 2020, however, when we should be seeing blazing fast data download speeds from new "5G" service, speeds have only averaged 47 to 59 Mbps for T-Mobile and AT&T's low band "5G" service (called "5GE" by AT&T), respectively, and customers could find that service just over half the time (53%). Sprint's mid band "5G" service was somewhat faster at 183 Mbps and customers could find it 47% of the time. Verizon's 5G service in the mmWave band does deliver faster 722 Mbps download speeds, but that service could only be found 6% of the time and it is only available outdoors on a few downtown city streets. See the charts below. Cisco predicts that average download speeds in the U.S. will only increase to around 70 Mbps overall by the year 2026.



Source: Opensignal 5G tests in U.S. city downtown areas, December 2019 – January 2020.



Source: Opensignal 5G tests in U.S. city downtown areas, December 2019 – January 2020.

Some of the 13 5G features that Doug points out that are still in development in labs are:

- DSS (Dynamic Spectrum Sharing), which will connect cell phones to 4G LTE or 5G in a single data path
- Frequency slicing, where cell antennas will assign bandwidth based upon user's needs
- Ultra-low latency, providing almost instant transmission times between cell phone to server and back to cell phone, giving more "real time" experiences
- Integrated Access and Backhaul, where small cell antennas will simultaneously connect to phones and to other nearby small cell antennas

- Cell phones connecting to multiple cell sites simultaneously
- Carriers fully switched over to Standalone (SA) 5G technology, rather than the Non-Standalone (NSA) technology they currently use

None of these features are in any phones yet (except for the beta testing mentioned with DSS). These features are, however, expected to be deployed in the coming years until they are fully deployed by 2028 or so, when we will be talking about launching 6G. Doug says that as each feature is introduced, you will need to buy a new phone to make use of it. That means that existing phones that you just bought a year or two ago will become obsolete as each new feature is introduced.

Doug wrote in January 2020, "Most of the 5G features that will make 5G special are still three years or more into the future. For now, the carriers are selling 5G phones that don't include 5G features. The carriers are instead placing the supposed 5G customers into new spectrum bands to give them a good data experience. Over time, as 5G features are introduced, 5G should have better performance than 4G. What the carriers are not telling the public, though, is that the majority of cellular connections made for the next decade are going to be 4G.

"5G will be introduced in fits and starts. Carriers will release a 5G feature, but when first introduced almost no handsets will be able to use it. The first customers with phones enabled for a given feature will have a great experience. Over time, as more people use the new 5G features, the higher traffic volumes will lower the performance seen by the early adapters. We're going to go through this cycle over and over until a decade from now the handsets sold will include the full set of 5G features. The uneven performance for 5G will baffle customers when they don't get the same features and experience as others that own slightly newer phones."

What Doug indicates the cell industry is primarily doing right now is three things: "Introduce small cells, introduce new spectrum, and finally introduce 5G features." The reason is an explosion of data usage in the U.S. of 36% per year in recent years, according to Cisco, with a doubling of data usage every two years in certain U.S. urban areas. Cell carriers cannot keep up with the demand for data bandwidth, and downloads and streaming are slowing in many areas.

To deal with this immediate bottleneck, cell carriers are trying to offload cellular service from their network of 300,000 existing macro 4G LTE cell antennas at traditional cell sites. These are spaced 1 to 1.5 miles apart and send out signals at up to 1,000 Watts of Effective Radiated Power, or ERP. Besides having cellular data service offloaded to WiFi in people's homes, the principle strategy is to install small cell antennas in residential and urban neighborhoods between existing macro antenna cell sites. Doug says, "The main goal of first-generation 5G is to increase network capacity to handle that growth."

These small cell antennas use 4G LTE, as I have reported for the past two years, even though the industry is calling some of them "5G". That is what activists are finding when they review permits for small cell sites at city halls submitted by vendors on behalf of cell carriers. They are permitted as 4G antennas, not 5G. However, this new equipment has the capability to be upgraded to 5G service with software upgrades when new features are introduced into cell phones and more of these phones with true 5G features are in circulation, which is planned for later this decade.

Thus, true 5G service won't exist in the U.S. for 2-3 more years, at the earliest. We must ask, what does this knowledge mean to us in the EMF safety community? Here are my thoughts.

First, after following the deployment of this technology over the past two years, whatever it is called, attending 5G industry trade shows, reading 5G literature and websites, and talking with activists, I realize that what is being introduced into most neighborhoods right now is 4G, not true 5G. Doug Dawson is corroborating that. 5G features will come, but the industry is misusing that term right now. These are truly 4G antennas with only slightly faster speeds in most areas. These antennas are broadcasting in the same 4G frequencies we have been using for two or more decades, as well as in new spectrum bands that industry is mislabeling as "5G". As Doug pointed out above, since existing phones can't pick up signals in these new spectrum bands, customers are being sold new phones with what is being incorrectly called, "5G".

I therefore suggest that we be more correct in our terminology and at least call these new antennas "4G/5G", or better yet, use the term "small cell antenna" and leave any use of the letter "G" for generation out of the description. Rather than calling them "5G", I suggest we say, we don't want RF-transmitting small cell antennas in residential neighborhoods. Call them "4G/5G" if you must use the letter "G".

This also means we should realize that the dreaded beam-formed 5G transmitters that we fear will be put up in our suburban neighborhoods right in front of our homes blasting microwave signals into our bedrooms are actually only located close to urban centers, and they only transmit when a cell phone with millimeterWave 5G capability calls for a signal. That only happens when someone with a mmWave 5G-enabled phone is walking or standing outdoors. MmWave 5G signals simply do not penetrate into buildings well, as I have written in my 5G article for some time. Go to coverage maps on the websites for Verizon, T-Mobile and AT&T (the three companies that have service in the mmWave band) to see if mmWave so-called "5G" antennas are anywhere near you. You will find they are only near downtown areas of certain cities. Click here and then click on the websites for the various companies to find your city (if your city is even on the list). You will be surprised at how little mmWave "5G" there truly is. Doug does not expect there will be much more of that particular deployment, certainly not into suburban or rural areas.

Doug wrote in June 2020, that he had recently seen a survey asking if the reader was satisfied with their 5G service. Doug wrote, "Question 6 was: 'A 5G connection is more reliable and reportedly 100 times faster than 4G.' There is nobody in the industry who thinks that 5G is going to be this fast for most people within 2 years, and perhaps not even within 10 years, or possibly ever. The cellular companies might never invest in the fiber needed to put a small cell site every 1,000 feet in city neighborhoods, suburbs, or anywhere rural.

"A more honest question would have been: The cellular carriers have introduced millimeter wave spectrum in small sections of big city downtowns. This technology is as much as 50 times faster than 4G cellular. It requires a user to buy an expensive new phone and it only works outdoors within perhaps 500 feet of a cell site. Do you think you would pay extra for a phone and a monthly fee to use this technology if it comes to the neighborhood where you live or work?"

In May 2020, Doug also wrote, "What the Chairman (of the FCC) and the carriers are never going to say out loud is that 5G is an urban technology. All of the coolest features of 5G only work when cell sites are close together."

Doug also wrote in January 2020, "The big carriers are all deploying 5G hot spots with millimeter wave technology in dense urban centers. This technology broadcasts super-fast broadband for up to 1,000 feet. The spectrum is also super-squirrely in that it doesn't pass through anything, even a pane of glass. Try as I might, I can't find a profitable application for this technology in suburbs, let alone rural places."

Finally, in February 2020, Doug wrote, "What about millimeter wave spectrum – is that 5G? No, it's just another new frequency band. The characteristics of millimeter wave spectrum are so different from traditional cellular frequencies that it's even hard to call this a cellular frequency. The frequency is 10-30 times faster than traditional cellular frequency. It only travels short distances, mostly under 1,000 feet from a cell site. It needs line-of-sight and can be easily blocked by any impediment in the environment. It's not going to pass from outdoor transmitters into buildings. It's easier to understand millimeter wave spectrum if you think of it as a broadband hotspot that is mounted outside, and which can be received by special phones designed to use the frequency."

So, if mmWave "5G" antennas, which are beam-formed, are mostly deployed in downtown areas of certain cities, what are we seeing in front of our homes in residential neighborhoods throughout the country? These are new, always-on 4G small cell antennas that may send out 10 to 100 Watts or so, less than the 1,000 Watt power of existing 4G macro cell sites placed 1-1.5 miles apart, but the RF signal from these small cell antennas is much stronger to us because the antenna is so much closer to our homes. These small cell antennas and other localized antennas are the true danger that we face.

We need to continue to push for hardwired connections, both in neighborhoods to homes, and within homes. In August 2020, Doug wrote, "The vast majority of data traffic is still carried over wires and the gulf between the data carried by each technology is widening every year…In 2020, only a little more than 4% of all of the data traffic in North America is carried wirelessly. For wireless technology to be a pure substitute for wireline data, wireless networks would have to be capable of carrying a much bigger share of data – many times what they carry today. The laws of physics argue against that, particularly since landline data usage is growing at an exponential rate. It's hard to envision wireless networks in our lifetime that can handle the same volumes of data as fiber-based landline networks."

In July 2020, Doug wrote, "Cellular networks today carry less than 5% of all US broadband. Even the majority of data passed through cellphones is handed off to landline networks through WiFi. In North America this year, Cisco predicts that in 2020 there will be 77 exabytes per month carried by landline networks compared to 3.4 exabytes carried by cellular networks. By 2022 that will grow to 109 exabytes for landline networks and 6 exabytes for cellular networks – the gap between the two technologies is rapidly widening. There is no scenario where cellular networks can somehow steal away a lot of the traffic carried by landlines."

Make no mistake about it. Cellular frequencies are harmful, no matter what generation they are. The new technologies being developed in labs today by the cell industry will bring more modulation, more pulsing, more polarization to the radio frequency (RF) signals that they transmit when they are deployed in coming years. We must insist on a halt to their deployment, particularly in residential neighborhoods, so that we can study the health effects on humans, animals and our biosphere. This includes the deployment of satellites into space. Regardless of what generation of cell technology we are dealing with, or when these technologies are supposed to be implemented, we need to inform people about their impact on health.

We must also pay attention to the numerous wireless devices in our own homes and within our personal space. Read articles and watch interviews I have done on the harm of invisible, silent and odorless RF and other EMFs right in our homes and pockets. Click here and here. We must find hardwired ways of communicating and follow three simple steps recommended by my profession, the Building Biology profession, and by others in the EMF community when it comes to the use of wireless devices, including cell phones, tablets, laptops and the like: reduce use, increase distance, and favor hardwired connections whenever and wherever possible.

To download a PDF version of this August 17, 2020 update, click here.