Defining and Discussing the Radio Spectrum
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Robert J. Marks:

Greetings, and welcome to Mind Matters News. I'm your broadband host, Robert J. Marks. Today we're going to talk about the radio spectrum as a natural resource. When we think of natural resources, we think of things like forests, oil, and gold. Some natural resources are renewable. Forests, for example, are a crop and can be replanted for use by future generations. The supply of gold and oil, on the other hand, is not renewable. The supply is finite. Once all the oil is used up, it's gone. Once all the gold is mined, it's gone. At least all of the gold here on earth, no new supply is going to be made available. Land is a natural resource. Although available land is finite, it can be used and then repurposed. A similar non-renewable but finite natural resource we rarely think about is the radio frequency spectrum used for a multitude of purposes.

This includes things like broadcasting of TV and radio and weather forecasting, and the use of your cell phones. If you're old enough, you know what FM radio is. You can tune to different stations on your FM dial, but the number of available stations on the FM radio band is not limitless. Once the band is filled up, there is no more room for radio stations unless a station goes off the air and makes room for another one. This is kind of what's happening to the entire electromagnetic spectrum. It's being filled up and there's little room for new users. This is not good news. The spectrum today is in high demand. That's you and me, of course, using spectrum for our cell phones. Broadcast media for TV and radio stations need the spectrum. The military uses the electromagnetic spectrum for communications, and yes, radar, radar uses the electromagnetic spectrum. So the EM spectrum or radio spectrum is also needed for so-called radiometers. Radiometers are used to predict the weather. And spectrum is needed for telescopes, radio telescopes to observe the cosmos.

So how are we going to manage this traffic jam? Our guests today are top experts in all things spectrum. Dr. Andrew Clegg received his PhD from Cornell University and is our guest. He is currently with Google, where he works on spectrum engineering issues in support of the company's wireless projects. Before Google, Dr. Clegg served at the National Science Foundation. While at the NSF he created and ran the Enhanced Access to Radio Spectrum program. And of course, the success of any program is proportional to its acronym, and this is a really good acronym. Enhancing Access to Radio Spectrum has an acronym of EARS, E-A-R-S, so that's kind of cool. Also joining us is Dr. Austin Egbert. Dr. Egbert received his PhD from Baylor University, where he is currently a research scientist for the wireless and microwave circuits and systems program. Regular listeners to Mind Matters News know that Dr. Egbert is the director and the editor of this podcast. So both of you, welcome, and let's go ahead and just start with the fundamentals, just the basics. Dr. Clegg, Andy, if I could, describe the spectrum. What is the spectrum?

Andrew Clegg:

Well, first, thanks for having me on the podcast, Bob, I appreciate being here with you and Austin. You did a pretty good job in your intro of explaining what the spectrum is. It really is the collection of frequencies that are used to provide all of these different services that go out over wireless devices and systems. So like you mentioned, our cell phones require certain frequencies. Radars require certain frequencies, dispatch radios, fire and police radios. They all require their own frequencies. They can't generally talk on the same frequency at the same time at the same place without causing interference to each other. And traditionally this hasn't been a huge issue, because you think about it, back when Marconi around the early 1900s was just first coming online with radio broadcasting and ship to shore communications and things, there weren't that many users of the spectrum.

But we've come a long way in the last 125 years or so, and we now rely on a daily basis for the radio spectrum for just so many things. You don't even think about it because it's invisible, but we rely on it for so many things. And the number of things we rely on it is growing and the amount of spectrum that's used by our devices, individual devices, is growing itself. So you talk about cell phones, that's one of the biggest growing demands. We all want faster download speeds. We want to be able to stream videos on demand. And videos used to be low resolution, 640 by 480 pixels, and then they became HD, 1080 by 1240 pixels, and then they became 4K, so even four times as amount of information has to be streamed. So as we just go for more apps and more streaming and more things, our cell phones are consuming more spectrum, but national defense is taking more spectrum as we want better radar systems to monitor incoming missiles or incoming aircraft or all sorts of things.

Our skies are getting more crowded with airplanes, and so we have more air traffic communications, we have more air traffic control radars, and on and on and on. So all of these things take spectrum, and we're getting to the point where there really are no good new frequencies that aren't already being used by somebody. And let me just say, when I say good frequencies, the radio spectrum spans a very large range of frequencies. But just like in real estate, there are some areas of the spectrum that are better than others, more desirable from a number of technical perspectives, and those are the ones that are under the greatest demand. And so we've reached a point where in order to fit more people and more uses into the spectrum, we have to find ways to use it more effectively. We have to share those resources. So a number of things we have to do, and that's a lot of the technical development in the spectrum field right now, is, how do we make do with the spectrum we have and use it more efficiently?

Robert J. Marks:

So in a way, all electromagnetic frequencies are the same, from AM radio frequencies all the way up to light waves. It's just the number of vibrations per second that it has.

Andrew Clegg:

Yeah, the phenomenon itself is the same. It's electromagnetic signals. And so it's the same spectrum, it's the same phenomenon I use for AM radio as FM radio, as TV, as cell phones, as radars. And like you say, it's just a difference in the frequency, the vibrations per second, that the radio waves use. We call that measure hertz, H-E-R-T-Z. That's one vibration per second. But typical radio waves that we use for commercial systems often deal in the gigahertz range, so a billion oscillations per second. That's the sweet spot of the radio spectrum, but it's actually even more interesting than that, in that it's not just the various radio signals are the same phenomenon, but it's also the same phenomenon that allows us to see things with our eyes. Visible light is just also a manifestation of spectrum. Of course there it's something like 500 trillion oscillations per second. It's a much, much, much higher frequency than radio waves.

But the phenomena is the same, electromagnetic waves. Same thing with x-rays we use at the dentist office. That's an electromagnetic wave that's even higher in frequency. If you go back down a little bit lower, there's infrared waves that we feel as heat lamps, or depending on the frequency, it's also the invisible light coming from the LED that controls the remote for your TV. That's infrared radiation. And ultraviolet, things that cause suntans and sunburns, ultraviolet light is even higher frequency than visible light. All of these things are the same phenomenon, electromagnetic waves, and they just differ in frequency from one another. But today we're talking about radio waves, which are the lowest frequency electromagnetic waves. And we're going to be concentrating on the radio spectrum because that's the one that we all use on a daily basis the most, and is the topic of how we fit more things into the limited amount of radio spectrum we have.

Robert J. Marks:

You know, one of the things that still blows my mind is the range of frequencies, like you talked about megahertz. That's 10 to the sixth vibrations per second. To give an idea, if you took 10 to the sixth seconds, that's a little more than a week. If you go to a billion seconds, that is 33 years. Many times we hear something going in the kilohertz, the megahertz, or the gigahertz, and we say, "Ah, that's not a lot of difference." But the difference is astonishing. So again, 10th to the sixth is about a week, 10 to the ninth is 33 years, a billion. I have celebrated, Andy, my two billionth birth second.

Andrew Clegg:

Very nice. Very nice. Did you have 2 billion candles on your cake?

Robert J. Marks:

No, no, I didn't. But the party was very short. Yeah, and then a trillion is 33,000 years.

Andrew Clegg:

Yeah.

Robert J. Marks:

So just the phenomena of these things vibrating this fast, a trillion times a second, just is phenomenal.

Andrew Clegg:

Yeah. Yeah, maybe we should go through the units that are used to measure frequency. That might be interesting.

Robert J. Marks:

Yeah, go ahead. That'd be ...

Andrew Clegg:

Okay. so hertz, like I mentioned earlier, that's the fundamental unit. It's named, by the way, for a German physicist who first discovered the transmission of radio waves in a lab. But anyway, a hertz is one vibration per second. So the wave goes up and down once per second. Then the next unit that's used is the kilohertz, and that's 1,000 vibrations a second. And there are radio waves in the kilohertz range or hundreds of kilohertz of range, AM radio is down that way.

Robert J. Marks:

So on the AM radio dial, that's in the kilohertz?

Andrew Clegg:

Yeah. So the AM radio dial goes from 540 kilohertz, so 540,000 vibrations per second, up to 1,700 kilohertz, which is 1.7 million vibrations per second. And so you can switch to the next unit at that point. And that's megahertz, which means 1 million vibrations per second. And shortwave radio and things like that and some of the aircraft communications and stuff are measured in the megahertz or hundreds of megahertz. And then once you get to 1,000 megahertz, that's equal to one gigahertz. That's a billion times a second. And that's where you typically are around the beginning of the ranges used for cell phones and stuff. There are some cell phone frequencies below a gigahertz, but a gigahertz and higher tends to become the favorable part for cell phone transmissions. And then you go even higher, you get to 1,000 gigahertz, and that's called a terahertz or 1 trillion vibrations per second.

And not much activity in the spectrum at those very, very high frequencies of a terahertz. There's a lot of scientific use up there and experimental use, for example, radio astronomy and remote sensing. You were talking about weather forecasting and things, some of that type of sensing is done in the many hundreds of gigahertz up to terahertz and above. And it's interesting to mention that, because one potential solution to spectrum crowding, since most of the crowding tends to be at the tens of gigahertz and below, is to move up to these higher frequencies and the hundreds of gigahertz to a terahertz and beyond. But that would be good because there's lots of available frequencies up there, but the technology isn't quite there yet. The efficiency of devices that can transmit at those frequencies is very, very low. So you would wear down your cell phone battery in a matter of a few minutes if you had to rely on frequencies that high. The transmit efficiency is only about 5%. So 95% of your battery power would go into just wasted heat and other things.

Robert J. Marks:

Oh, that's right, and energy is proportional to frequency, right?

Andrew Clegg:

Yes, energy is proportional to frequency, but also just the fundamental devices, the electronic devices become less efficient at higher frequencies, at least the stuff that we use today. So it's one of the reasons why we haven't gone to higher frequencies. There's other problems too, that the atmosphere starts to absorb higher frequencies. Depending on where you are, the atmosphere can almost look like a brick wall to some of these frequencies. So you have problems with transmission distance. Antennas become more directional, so your signal tends to be all focused in one particular direction and not in all directions, which under certain circumstances is a good thing, but not at all if you're walking around with a mobile phone and things like that. So anyway, that's why moving to these higher frequencies, very, very high frequencies, a terahertz range, we're not quite there yet with the technology, but that's one potential long range solution to the spectrum crowding we were talking about.

Robert J. Marks:

Well, I think that all frequencies have their own special properties. For example, I can go through my house and go to room to room and my cell phone still works. So those radio waves in the microwave frequency go through walls. But if you get really high in the frequency spectrum, up to visible light, light doesn't go through walls. So different things happen, different things happen at different frequencies. And one of the battles, as I understand it, is that there is a sweet spot for cell phone transmission and such, and that there's a lot of controversy going on now as to who gets to use this sweet spot in the frequency transmission. I think it's, is it the S band that is really important?

Andrew Clegg:

So it is, it's the upper S band. Now, of course I'm a believer that this claim about a sweet spot in spectrum really is more of a trick of the cell phone companies. They've exhausted the lower frequencies, and so they've claimed that if you move a little higher it's the sweet spot. And so they've convinced the regulators they need more spectrum there. I think it's a little bit of a specious argument, but there is some truth to what they say. The idea is that at the lower frequencies there's less bandwidth or fewer frequencies themselves available at the lower frequencies. And as you go to higher frequencies there's more bandwidth available, more range of frequencies available. But as you go to higher frequencies, the propagation characteristics aren't quite as good. As you noted, you have problems going through walls and the atmosphere could become a consideration, rain and other factors can absorb.

And so the argument is there's this sweet spot where the propagation characteristics are still generally favorable and the amount of spectrum that's available is good too. And so they've come down to the three gigahertz, three to four gigahertz range, roughly speaking, as being the sweet spot in the radio spectrum. So there's been a tremendous amount of activity in this range in the last few years in the United States and in other countries. So that's what they call at the moment the sweet spot, and that's the upper S band. S band typically is defined as two to four gigahertz. So three to four gigahertz is a sweet spot.

The challenge we have here in the United States is that the three gigahertz, or about 2/3 of the three gigahertz range, is heavily used by our Department of Defense for military radars, typically ship borne, airborne, and some ground-based radars. And so here in the United States, as we've been trying to get more spectrum for cell phones in the three gigahertz range, we've had to work very closely with the US government and particularly the military to try to share some of these frequencies with their radar systems in a manner where the cell phones don't interfere with the DOD. But at the same time, the DOD's operations don't place too many constraints on the cell phone operations.

Robert J. Marks:

Okay, so that's the future. That's the spectrum sharing that we're up against. Let me ask you a question. We hear about microwaves all the time. There's microwave ovens, cell phones use microwaves. Is that right? What's a microwave? What frequency is that?

Andrew Clegg:

Yeah, not well-defined, but a rule of thumb has been that anything over about a gigahertz of frequency is called a microwave. Microwave just means small. And as you go to higher and higher frequencies, the wavelength, the distance between the crest of the waves, because they're vibrating faster and faster, becomes less and less. And so they call these smaller waves microwaves. And so the rough approximation, rule of thumb, has been that above a gigahertz is a microwave. So yes, cell phones do use microwaves. Now, there are cell phones that operate below a gigahertz. In fact, there's cell phones, T-Mobile is heavily invested in spectrum that goes down to 600 megahertz or so. There are 600, 700, 800 megahertz cell phones in the United States, 900 megahertz in other countries. But most of the bandwidth available to cell phones today is above a gigahertz.

And so it's technically, or at least by rule of thumb, considered microwave. But it doesn't mean that it's the same effect as your microwave oven. So your microwave oven cooks food, and it does it very well, and it does use microwaves. It uses a frequency of about 2.4 gigahertz, and there are cell phone frequencies roughly in that range, not on the exact same frequencies. But your wifi, for example, operates at the same frequency as microwave ovens. But the radio waves don't cook you. And the difference between a microwave oven and a radio signal is in the power and how concentrated spatially that power is. So your microwave oven is designed, it has a cavity inside. You open the door and there's this box shaped thing inside where you put your food. And when you want to heat your food, you close the door again.

And if you ever notice, when you look at the door of your microwave oven, it always has a metallic screen over it. And that metallic screen basically keeps the radio waves inside that cavity, inside your microwave oven. That screen, the little holes in the screen are much smaller than the wavelength of the radio signal used to heat your food in the microwave oven. When you turn your microwave oven on, a very high power radio transmitter, typically in the hundreds to maybe 1,000 watts or even more, transmits a signal into that cavity. And because that cavity is closed on all sides and it reflects radio waves, it sets up a very dense radio wave environment where the radio waves are just bouncing inside that cavity. They're not escaping, they're not expanding out into space. They're all concentrated right in that little cavity. And they work very well to cause the water molecules in your food inside the oven to start vibrating.

And so a microwave oven has been set up very carefully to be very efficient at causing the water molecules inside your food to vibrate when that very high power radio signal goes off and when it's just concentrated inside that cavity inside your microwave oven. So that's how a microwave oven heats. And even though your cell phone uses frequencies or may use frequencies around the same frequency of your microwave oven, number one, they use much lower power. A typical cell phone is using about 2/10 of one watt instead of 1,000 watts. So it's using 5,000 times less power. And that power is also not purposely concentrated inside a specific cavity to make it bounce around as intense as possible.

When you turn your cell phone on, the signal goes off in all directions and dissipates and things. So the amount of power that you're exposing yourself to from use of your cell phone is thousands and thousands of times less than what a microwave oven is exposing the food to. And so that's why even though you're using the same frequencies, you're not being affected, you're not being heated like food in a microwave oven.

Robert J. Marks:

And that's the reason we read what sounds like an urban myth, that cell phones cause brain cancer. All they do is heat up your ear, is that right?

Andrew Clegg:

That is correct. So there is to my knowledge, I'm not a medical doctor, but there is no credible body of evidence that indicates that cell phones cause any kind of cancer. And in fact, if you think about it this way, 20 or 30 years ago hardly anybody had a cell phone, and today everybody has a cell phone. And in fact, as far as wireless devices go, everybody typically has well more than one wireless device, including a cell phone. I think there's more cell phones in the country than there are people. So if there was a relationship between the use of cell phones and brain cancer, for example, you would have seen in the last 10 or 20 or 30 years just an explosion in the occurrence of brain cancer in the population. And there's no evidence that that's happening. And so there appears to be no body of evidence that indicates that the use of cell phones, 5G, 4G, whatever, causes any cancer.

And to that point, 5G really isn't anything different than 4G. They all use roughly the same frequency spectrum. Some of the 5G systems use higher frequencies, but it's the same technology, it's all electromagnetic waves. There's no reason to believe that any of these systems cause any kind of adverse health effects, except the FCC does regulate or does publish guidelines on how strong of radio fields you should be exposed to. But it doesn't do it on the basis of cancer. The FCC has determined there's no basis to believe that any of this causes cancer. They haven't indicated that there's any basis to believe this causes cancer. Instead, they do this on the basis of heating. Doctors believe there could be health effects associated to heating of the inside of your body. Some of the studies they've pointed to are the impact on sperm counts in males where their testicles have been exposed to high heat, hot baths, things like that.

And so there's an assumption that it's possible that heating your tissue inside could have adverse health effects, but the amount of heating that your cell phone creates inside your body is very low, and it actually is regulated. So before any model of cell phone can be offered for sale in the United States, it has to undergo what we call certification. And in the certification process they use a fake head that has insides that are designed to act like the insides of real heads, and they put a cell phone up to the ear of the fake head and they transmit the cell phone just like you would if you were on a call going on and on and on for hours. And they have a temperature probe inside the fake head that moves around and maps out the heating inside the head caused by that cell phone.

And any heating that they detect has to be below a level that's regulated by the FCC. The amount of radio energy absorbed by the head has to be at or below a maximum level that the FCC dictates. So any cell phone you use has been tested already to make sure that it's not causing heating inside your head. And again, it's not proven that even if it is causing heating that it's necessarily causing any detrimental effect. But to be on the safe side, they've made sure that cell phones that are marketed in the United States meet these requirements.

Robert J. Marks:

Would using ear buds diminish the exposure of your ears to radiation?

Andrew Clegg:

Maybe or maybe not. They actually test the earbuds as well, because sometimes the radio energy can actually ... So if you're using wired headphones, sometimes the radio energy can actually travel along the wire and into the earbud inside your ear. And then the earbuds themselves, they're not using cellular signals. Your phone is the one using the cellular signals, but your earbuds are communicating with the phone typically by using Bluetooth, which is another type of radio signal. And Bluetooth uses frequencies close to microwave oven frequencies. And so now you're inserting a radio transmitting device inside your ear itself.

So again, these have to meet the exposure guidelines. They're not shown to cause any adverse health effects at all. They're also regulated as to how much heating they cause. But the key in the amount of radio energy you absorb is typically distance. So if you insert something inside your ear, you're even closer to the inside of your body than holding something up against your ear. So you could argue that overall the exposure caused by sticking something in your ear is more than what's caused by holding your cell phone up to your ear. But again, all of these are regulated and ensure that the amount of radio energy absorbed doesn't exceed a certain amount that the FCC has deemed to be safe.

Robert J. Marks:

And of course, the best procedure is to use speaker phone just to get the cell phone away from you if you are paranoid.

Andrew Clegg:

Yep. If you're paranoid, use a speaker phone. In some ways speaker phones, if you're driving, they're safer anyway than trying to hold the phone up against your ear. In a lot of states that's already ... In fact, I would maintain that the danger of you crashing due to holding a phone against your ear while driving is much, much, much, that's a proven danger compared to unproven danger of any adverse effects coming from the cell phone signal itself.

Robert J. Marks:

Okay. Let me ask you, speaking of paranoia, if you believe people such as Snowden, he says that the government can track your cell phone and monitor your cell phone no matter where you are, whether or not your cell phone is on or off. I don't know the truth of that. Maybe you do, but let me ask you this question. If you were to place your cell phone inside a microwave oven, and of course not turn the oven on, just place it inside the microwave oven, would this block any ability of anybody to monitor what was happening on your cell phone, assuming that people could eavesdrop on it?

Andrew Clegg:

Okay, so yeah, that's a big assumption. Yeah, I wouldn't want to get into whether the government can eavesdrop on your phone or not.

Robert J. Marks:

Okay.

Andrew Clegg:

That's a complicated issue. Certainly tracking cell phones is possible. We do it all the time so that we can get map directions and all sorts of things so you know where to get your Uber Eats delivered to and things like that. So cell phones can certainly, most of them have GPS receivers built into them and things like that. And who has access to those data? That's a government secret that I don't know anything about. But having worked for the government for a number of years, I think most people put more credence into the government being able to do things than the government can really find a way to do. So I'd put it that way.

So the question is if you put your cell phone inside the microwave oven. So the answer is generally yes, that would block the cell phone signals from getting in or out at most frequencies, because the microwave oven is designed to keep frequencies inside, keep radio waves of a certain frequency inside. But your phone wouldn't be of much use because you couldn't access it, you couldn't listen to it, you couldn't receive anything or transmit. So yeah, it would be ...

Robert J. Marks:

The last thing you want to do is stick your head inside a microwave oven.

Andrew Clegg:

Exactly. But as soon as you open the door to stick your head in there, of course you're now letting radio frequencies in and out. Now, some of the 5G frequencies are very high frequencies that could potentially leak out of the microwave oven. Microwave oven is designed to basically shield frequencies in the 2.4 gigahertz range because that's the range they work at. So at some of the higher frequencies, some of the 5G systems, they thought that the 5G systems operating in millimeter-wave frequencies, which are 20, 30 gigahertz range, were going to be a thing. But they haven't taken off, pretty much for the reasons we discussed earlier. Propagation characteristics aren't very good at those frequencies, and the battery efficiency is very low as you go up in frequency.

And so the millimeter-wave 5G really hasn't been much of a success. But the point is that some of those frequencies might be able to leak out of a microwave oven because a microwave oven is designed to keep lower frequencies in. But again, that's a farfetched thing. You'd need a 5G base station very close to your device because they don't propagate very far. But those are some of the considerations.

Robert J. Marks:

So I thought of an experiment I can do, I haven't done it yet. But if I have a Bluetooth headset and I put my cell phone inside the microwave with a podcast going or something and close the door, that should block the podcast, right?

Andrew Clegg:

It should, yes. So yes, and the Bluetooth, if you're using Bluetooth headphones in particular, yes, because Bluetooth also operates in the 2.4 gigahertz range. It reminds me of one time I was visiting my dad, and he has a cordless phone. And the cordless phone was one of these cordless phones that operates in the two gigahertz range, it's a 2.4 gigahertz. 2.4 gigahertz, if you haven't figured out, is a popular place for various unlicensed devices and industrial devices like microwave ovens and Bluetooth and wifi.

But he was heating some water to make some tea and he was on the phone, and he opened the microwave oven to get his tea out and his call cut off instantaneously as soon as he opened the door. And it was because the base station for his cordless phone ended up being on one side of the microwave oven door and he was standing on the other side of the microwave oven door, and it just instantly cut off the connection between the two. So yes, you would not get Bluetooth out of your microwave oven. Now, of course I don't recommend this experiment unless you're extremely careful, because you could accidentally turn the oven on and zap your phone and all sorts of things.

Robert J. Marks:

That's what I would be afraid of. My muscle memory would kick in and I'd turn it on.

Andrew Clegg:

Yes, exactly, hit the one minute switch or something.

Robert J. Marks:

Exactly. Exactly.

Austin Egbert:

Unlike the videos that were popular online around when wireless charging became a thing, putting your phone in the microwave will not charge it, at least not in a useful manner.

Andrew Clegg:

Not in a desirable manner.

Robert J. Marks:

I saw a great fake video where they put a microwave, not a microwave but a cell phone, down next to some kernels of popcorn. And then they stopped the video, they took out the kernel, and they put a popped kernel in there so that when you played it back it looked like the microwave was popping the popcorn. That was really ...

Andrew Clegg:

Yeah, phones ...

Robert J. Marks:

That was a deepfake.

Andrew Clegg:

Yeah, phones can't pop popcorn.

Robert J. Marks:

Okay, last question. I'm going to bring Austin in here. Austin, one of the things about the low frequencies in the kilohertz is AM radio. There is a movement now of getting rid of AM radio. In fact, Ted Cruz, my senator here from Texas, is sponsoring a bill to prohibit car manufacturers from discontinuing AM radio, which I think is a terrible idea. I think that that should be left to the free market. But anyway, that's what he's doing. How come these car makers are discontinuing AM radio?

Austin Egbert:

So one of the claims, at least one of the reasons behind it, is with electric vehicles being electrically powered, they end up generating a decent amount of interference at a number of frequencies. And some of the frequencies at which they're generating that interference end up overlapping with some of the AM radio band, where it can impact the signal quality that's received by the AM radio. So you end up not being able to hear the stations as clearly as you otherwise could, or maybe not be able to really make them out at all. There are ways to get around that through additional filtering and things like that in the radio systems themselves, shielding them from the rest of the car so that it has a cleaner feed from the car's antenna.

It's mostly just a matter of cost. And I think a lot of the auto manufacturers were weighing the cost benefit analysis and went, "How many people still listen to AM radio and is it worth putting X number of dollars of extra components in design into our vehicles to make this still work out?" And at least initially a lot of them were looking at cutting them. I think recently many of them have backpedaled and said, "Yeah, we'll go ahead and keep using AM radios in the vehicles."

Robert J. Marks:

Yeah, we'll see what happens. See, I'm old enough to remember, I think this was in the, oh gosh, I'm going to surrender my age here, in the late '50s, early '60s when they had broadcast television and they used to have prop planes, propeller planes, and we would be watching Gunsmoke on television through the air. It wasn't streaming or anything, it was regular broadcast television. And a propeller airplane would go above and it would totally destroy the video and the audio signal that we were watching. And it was because the prop plane had this engine which was generating electromagnetic waves, apparently in the same spectrum as the broadcast television was. And so this seems to me to be the similar case that we're talking about the banning of AM radio.

Austin Egbert:

Yeah, and I know Andy had actually listened into some of the congressional hearings on the topic. So Andy, I don't know if you have some more you'd like to add to the subject?

Andrew Clegg:

No, it's a good summary you gave, Austin. Yeah, it really is, it's principally the charging circuits in the cars that cause a lot of noise on the AM band. And like you said, the car manufacturers were like, "Well, who listens to AM radio? Is it worth all the extra money?" And so they just decided to take AM radios out.

But the politicians got involved and said, "Hey, some farmers rely on AM radio for weather warnings and other people like to listen to talk radio and things like that, so maybe Congress should get involved." I'm not a big fan of Congress getting involved in detailed spectrum issues, but there is something to say for keeping AM. I like to listen to AM radio in the car sometimes. At night I like to see how far away I can hear stations because those frequencies' signals bounce off the ionosphere. And it's cool to be driving through Virginia and hear stations from Illinois and New York and things like that.

But yeah, it's an interesting thing, and I don't know if people have noticed at home or not because again, I don't know how many people still listen to AM radio at home, but the same thing is happening inside our houses. All the power supplies, typically it's power supplies, the things that power our TVs and computer chargers and phone chargers and everything, they also make a lot of noise that interferes with AM radio. And it's getting harder and harder to listen to AM and shortwave radio in homes because of the amount of noise. Another thing that generates a lot of noise is LED light bulbs, because they have little power supplies in them. And I think it was this month, I believe August 1st, something, they've now banned the manufacture, sale, and importation of incandescent bulbs. So we all have to use something that is not the traditional light bulb that never generated any noise. And so yeah, we're dealing with it not just in cars, but in homes and everything. So radio noise is becoming a problem.

Robert J. Marks:

Well, I've got to admit, I haven't listened to radio in the car for, I don't know, at least a year. I'm a streaming podcast guy. I enjoy those more because I can control the content better.

Andrew Clegg:

Well, you know, Bob, that's what the car manufacturers are, one of the arguments they're making, is that hardly anybody listens to the radio, they listen to streaming instead.

Robert J. Marks:

Well, this has been great. Thank you, guys, this has been a lot of fun. I've learned a lot. We've been talking to Google Spectrum expert Dr. Clegg, and also another spectrum expert, Dr. Austin Egbert, who is a research scientist at Baylor University, and this has been fun. We're going to continue this. We've got a lot more to talk about in terms of the spectrum. So until next time, be of good cheer.

Announcer:

This has been Mind Matters News with your host Robert J. Marks. Explore more at mindmatters.ai. That's mindmatters.ai. Mind Matters News is directed and edited by Austin Egbert. The opinions expressed on this program are solely those of the speakers.