When the Government Controls the Spectrum

https://mindmatters.ai/podcast/ep255

Robert J. Marks:

Greetings and welcome to Mind Matters News. I'm your electromagnetic absorbing host, Robert J. Marks. The U.S. government is in charge of the spectrum in the United States, who uses it, and even the call letters of the stations. During college, I was a disc jockey at a 50,000 watt radio station, WPFR. The PFR stood for Paul Ford Radio. Paul Ford was the man who built and owned the station. I also worked at WKZI. KZI stood for KZ Illinois where the station was located. In both cases, the call letters started with W. This is required by the U.S. government. In 1912, the United States met with other countries and do letters out of a hat. The U.S. was given the letters W, K, N and A. The letters N and A were given to the military stations, but K and W were assigned for commercial use. All commercial stations East of the Mississippi River had to start their station call letters with a W, and stations West of the Mississippi with a K.

Interestingly, the W assigned to the U.S. is the only letter in the alphabet. And think about this, this is deep. It's the only letter in the alphabet that has more than one syllable. The other letters have one syllable. So this was bad for radio and TV announcers that had to learn how to say W. And if you want to find out whether a broadcaster is a pro or not, the broadcaster will say W instead of W. So it's WPFR, not WPFR. So that's a good filter if you're listening to somebody who's on a local radio station. By the way, Canada got the letter C for its commercial stations.

Government control of the spectrum continues today and is way beyond just assigning call letters. The government dictates who can broadcast over what channel and what frequency band, but the spectrum today is pretty crowded. It turns out the government needs to do something. The spectrum is all used up, especially in the very useful and popular bands. We have the perfect people to talk about this today. Today our guest is Google Engineer, Dr. Andrew Clegg. Joining Andy and me is Dr. Austin Egbert. He's a research scientist at Baylor University. Andy, who determines what frequency bands are assigned to who and how do they do it?

Andrew Clegg:

Well, that's an interesting question with a little bit of history behind it. I won't go into too much history. But in the decades past, there were typically enough frequencies to go around for everybody. And so pretty much the first person who applied for a particular frequency or band or whatever, would be given that frequency. And that worked for quite a while until maybe starting 40, 50 years ago. It started to become harder to find frequencies, particularly for broadcast stations, for dispatch services and other systems. And so the FCC went to a process of basically comparing the different applications. People have pejoratively called this a beauty contest, but the FCC would look at the applications, look at what the applicants were planning to use the frequency for, it would make a determination as to which one served the public interest better based on a variety of factors or whatever, and then give that entity the license for that frequency or that band.

But then some economists started looking into this, and they realized that you really should find a way to give spectrum to those who value it most. And the argument would be that those who value it most are, from an economic standpoint, the most likely to put the frequency to the best and highest use. And so the economists recommended to the FCC that in cases of competing applications for frequency band or frequency, that the FCC should go to an auction process where the entities who want that band or

that frequency have to bid against each other, and whoever comes up with the highest bid ends up winning that band or that frequency. And so in 19-

Robert J. Marks:

So if I could interrupt-

Andrew Clegg:

Sure.

Robert J. Marks:

... the criteria changed from how do we best service the public as opposed to how much money we can make.

Andrew Clegg:

That's a cynical way of looking at it, but not a bad way of doing it. In 1994, that's when the FCC held its first auction, which was basically the first auction in the world for radio spectrum. And one of the earliest bands that was auctioned for spectrum was the PCS bands, which are basically personal communication services, which is a form of cell phone is basically essentially 2G if you're thinking in terms of generations. And they auctioned the 2G spectrum, and they ended up making billions of dollars selling the spectrum. And people suddenly realized, "Look at how valuable radio spectrum is. We can make billions of dollars by auctioning."

Robert J. Marks:

So I have a question.

Andrew Clegg:

Sure.

Robert J. Marks:

Is it literally paying for the frequency band or is this renting it? Does there have to be a renewal at some point?

Andrew Clegg:

Yeah, so it's renting it. The FCC never sells. The spectrum is considered to be essentially government or communal property, it's like a national park or something. So you lease the frequencies, you don't own it, you license the frequencies from the FCC, you're granted a license to use the frequencies if you're the highest bidder. And then there's what the FCC calls an expectation of renewal. So your license period may run 10 years or 15 years in some cases. And the expectation is that as long as you've met some basic build out requirements that you've deployed and you've covered a certain fraction of the population and things like that, that your license will be renewed. Now, the kicker is they don't have to pay again. So those entities who won PCS licenses in 1994 have never had to pay for that spectrum again. It was basically a one-time payment. Their licenses continue to get renewed, but they don't have to pay money for the spectrum again, which is kind of one of the things I think is a bit of an oddity about the auction process.

And so since 1994, the FCC has basically gone to auction whenever there have been competing applications for radio bands or radio frequencies. And when you're talking about radio bands that have been designated for new cell phone systems, for example, the technical rules are such that the bands can be used for cell phone systems. Cell phone systems are very valuable, they generate a lot of money for the Verizons and AT&Ts and T-mobiles of the country, and so those are natural bands that end up being auctioned. And the amount of money raised at auction keeps going up every year.

And in fact, a couple of years ago, we had an auction for the 3.7 GHz band. So there was a lot of spectrum, 280 MHz of spectrum, which is a lot of bandwidth, and it was almost entirely clear spectrum. The entities that were using that spectrum had to go to different frequencies. And so the cell phone companies didn't have to share those frequencies with anybody. And so that went to auction, and the auction generated a little over $80 billion in winning bids for that spectrum, plus the entities had to pay another 14 billion on top of the 80 some billion in order to relocate the incumbents that were in that band to other frequencies. So the winning bidders in that auction paid a collective 90 some billion dollars to access that spectrum.

Robert J. Marks:

Now, let me ask you-

Andrew Clegg:

Sure.

Robert J. Marks:

... Andy. Were the bidders cell phone companies? Who were the bidders and who won?

Andrew Clegg:

They were. The large winner in the auction was Verizon, but AT&T won some spectrum, T-Mobile won some spectrum, some spectrum speculators. One spectrum that is people who were funded to go in and win spectrum and then hopefully resell it later or basically sublet it to others ultimately getting a profit, they also won some. But yes, it was generally the big three cell phone companies that won the spectrum.

Robert J. Marks:

The big three being Verizon, AT&T and who?

Andrew Clegg:

And T-Mobile.

Robert J. Marks:

And T-Mobile. Thank you.

Andrew Clegg:

They were the big winners. And it's interesting. I'm not an economist, but I think we've gotten to a point with the volume of spectrum is so high that no startup could ever afford to compete in an auction for that type of spectrum. And so we will only get the types of networks that Verizon, AT&T and T-Mobile believe that we should get because they're the only ones that have the kind of money and knowledge to

go in and win at these auctions. And the other argument is the money goes to the U.S. Treasury. It doesn't go to the FCC. The money raised at auctions generally goes to the U.S. Treasury. There's some exceptions, some details. If there were government users of the spectrum before the auction that have to be moved somewhere else, some of the auction money can be used to reimburse the government users. But for the most part, the money goes to the U.S. Treasury.

And $90 some billion sounds like a lot of money. But in terms of the $30 plus trillion of debt the U.S. has, that $90 billion is just kind of a drop in the bucket. Wouldn't it be better if the network operators, instead of giving that money to the government, could actually use it to build out better and better networks? So there are some people who argue, "Maybe the auction idea isn't all that great," but at the moment, Congress loves it because they love seeing this money come in, and they occasionally use it for pet projects and things like that. Congress is big on this. It's notable, the FCC's auction authority expired several months ago, and Congress has yet to reauthorize it. It's just one of the many dysfunctional things about Congress. I think it'll get reauthorized at some point before too long. But anyway, yes, auction is the way that competing applications are now sort of adjudicated at the FCC.

Robert J. Marks:

For clarity, this is only for use of this spectrum in the United States, right?

Andrew Clegg:

Correct. When you win an FCC auction, it is only for spectrum that is used in the United States. Specifically, there are other countries that dabble in auctions as well. But internationally, countries have decided that they will not auction satellite spectrum because the satellite operators basically argue that it would just be too logistically complicated and too expensive to have to go to an auction for the same frequency band in potentially 190 different countries and try to win that band in 190 different countries so you could offer your satellite service worldwide. It would just be too complicated and too expensive. And so countries have generally agreed that they will not auction satellite spectrum.

Robert J. Marks:

Is there any commonality in the assignment from country to country? I read, it's kind of an amusing joke about an athlete that went to Mexico and he bought this great AM radio and that he returned it and he says, "Why did you return it?" He says, "Well, I don't need this. It only picks up Spanish stations. I can't understand Spanish."

Andrew Clegg:

Right.

Robert J. Marks:

Is there a commonality of use and requirements from country to country?

Andrew Clegg:

So in a way, that's what the International Telecommunication Union is for. They are an agency of the United Nations, and 190 some UN member countries participate in the ITU, and they create the radio regulations, which is an international treaty that says, "Hey, this band will be used for this. This ban will be used for this. This ban will be used for this." And the idea is if every country allocated the same band to the same services, then economy of scale gets better. So if every country allocates the same bands

for cell phones, then cell phones can be made with those bands in it, and those same cell phones can be sold all over the world.

So we attempt to do that the best we can, but the reality is the allocations don't end up being totally harmonized around the world, which is okay. The treaty allows countries to choose their own bands the way they want, but the cellular bands, so for example, the original cellular bands were in the 800 MHz range in the United States, whereas in Europe, they were in the 900 MHz band.

So back in the day when you took your U.S. cell phone over to Europe, it wouldn't work because you don't have the same frequency band. Now, cell phones have a lot more bands built into them. Your typical iPhone or Pixel phone or whatever will have both European and American bands built into them as well as Asian bands and things like that. But the reality is it would be cheaper to manufacture a cell phone if you could minimize the number of bands you have to support in the phone because you've got to have antennas that support each band and all sorts of things. So the ideal is to have the bands harmonized around the world, but the reality is they're partially harmonized at best.

Robert J. Marks:

So I'm going to be going to Italy in a few months. Is my cell phone going to work in Italy? Do you know?

Andrew Clegg:

So as long, Bob, as you've bought a new cell phone in the last 10 years, 15 years, it should work fine. It'll have the European bands built into it. Now, if you're talking about your old analog brick phone that you've kept from the 1980s, no, that will not work in Italy.

Robert J. Marks:

Let me address a kind of sticky subject. I don't know if you guys are going to have any thoughts on this, but it turns out, according to Gentlemen's Quarterly, the majority of porn is currently watched on mobile devices. And so a lot of the demand that we have for extra spectrum is due to porn. 84% of PornHub traffic is from mobile devices, is viewed on mobile devices. And the estimate of the percent time that is used for porn on mobile devices is 13 to 20%. So a lot of the demand that we have extra spectrum is generated from people that want to watch pornography. And that's disturbing to me. I have no idea what to do about it. Is just one of these things that goes along with demand and it has to be addressed.

Andrew Clegg:

Well, I guess interesting statistic to bring up, but I'd have a couple of aspects on that. One is, spectrum use reflects the reality of what today's consumers want to do. And if that's what they want to do, I guess the cell phone companies have to adjust. But the other thing is, a lot of that traffic is probably WiFi based instead of cellular network based. And WiFi, we were talking about densification in an earlier discussion. Everybody has their own WiFi node in their home or apartment or office building or whatever. And so that spectrum gets reused very efficiently. And so to the extent that they're just reusing WiFi spectrum 2.4 or five GHz or now six GHz or whatever, that isn't driving as much of a spectrum crunch. But if they're out and about using the macro cellular networks for that kind of data consumption, then yes, that can drive spectrum demand, and you could say that spectrum demand under those circumstances could be driven by pornography. It's an interesting way to look at it.

Robert J. Marks:

It really is. But I guess the United States, the First Amendment is going to allow this. So it certainly has allowed the proliferation of porn, but that's a topic for another time. The other concern that has been made about the selling off of spectrum is that it is spectrum that is used for military purposes. The spectrum is used for military radar, it's used for communications.

And there was a recent pushback on this from a guy named General Charles Q. Brown. He is the Air Force chief of staff, but he has been testifying in front of Congress to be the next chairman of the Joint Chiefs of Staff. So this guy is going to be the number one military person of the United States. He says, this is a quote, "That part of the spectrum that is auctioned off is where we have many of our capabilities across the Joint Force. If we had to vacate that, we'd lose that capability, and would have to figure out how to regain that capability. And that will take time and cost money." So what about the claim of General Charles Q. Brown that he's troubled that military bandwidth is being auctioned off for commercial use?

Andrew Clegg:

It's a legitimate concern, right? I mean, I think that quote is most likely specifically about the three GHz band.

Robert J. Marks:

Yes. In fact, it's the 3.1 to 3.45 GHz band.

Andrew Clegg:

So in the most of the world, that band is not used by the military as much. It's either not used at all by their military or not used much. But that band is used very heavily by our military. In fact, the whole three to basically 3.65 GHz band is used by our military for shipborne radars, airborne radars, land-based radars and things. And they've already been required to share the 3,550 to 3,650 MHz portion with the citizens broadband radio service. They didn't technically lose that spectrum. They can still operate in it more or less like they used to. But because it's shared spectrum, it's always now going to be contested between CBRS and the DoD use, although again, DoD gets priority in that band.

And then they lost the next lower 100 MHz, 3.45 to 3.55 when the 3.45 GHz service was auctioned off by the FCC. And now they stand to lose the 3.1 to 3.45 GHz band because basically the FCC, the DoD, and private industry is looking at, "Could the DoD either share that band or be moved out of that band?" And so they continue to lose bandwidth around three GHz. And they do have a lot of systems that operate in that band. And so I think General Brown is right, but the reality is the DoD is facing the same spectrum crunch that everybody else is. And so it's a universal problem.

Robert J. Marks:

Now, Austin, I know you have some very interesting perspective on the selling off of U.S. military frequency bands. Could you elaborate on that? I think this is very interesting.

Austin Egbert:

So my view on it is a little bit different in the sense that if the DoD is concerned about losing access to that spectrum and needing to come up with some other way to make their systems work without having a reserved chunk of spectrum available to them, to me, I'm concerned that the DoD doesn't have the capability to ensure robust access to the spectrum that they need without relying on domestic regulations to reserve that spectrum for them.

Robert J. Marks:

This gets back to the idea that this auctioning off of the spectrum is only valid in the United States. It is not valid in adversarial countries, China, Russia, anywhere else.

Austin Egbert:

Exactly, or even in Europe or other allied nations.

Robert J. Marks:

Yes.

Austin Egbert:

So like Andy mentioned, this band has been reserved for DoD use in the United States, but not necessarily abroad. And so I mean, I don't know about anyone else. I would prefer that our military systems didn't rely on everyone playing nicely with their systems and making sure that they work because there's going to be people in the world who don't want United States Department of Defense systems to work in the way that they're supposed to. And so to me, this seems like a red flag of if the DoD saying, "We need everyone to really play nice with our systems to make sure we can do the stuff we need to." You might as well just show up at a country and say, "Hey, we'd really like you to stop doing something because otherwise we're going to be sad about it," and expecting them to comply. It doesn't seem like a very militaristic way of approaching this type of problem.

And you mentioned General Charles Brown, I think part of his quote is that if they had to vacate that spectrum, in the interim, they would lose that capability and they'd have to figure out how to regain it, and they said that would take time and cost money. But at the same time, I think that's exactly what they probably need to do, is they need to revisit this problem and actually look at, "How can we ensure that we're able to use the spectrum regardless of what regulations are in place in a given environment? What reservations are made? How can we show up somewhere and get the job done with whatever is available to us not having to rely on predetermined spectrum bands and just presuming that everyone else is going to play nicely with that?

So he's saying, "It's a problem that will lose the capability in the meantime." And I think there's probably a short-term issue that shows up there, but I think long-term, if they can make this shift and don't approach it as just, "Now we're moving to this band," but instead reevaluate how they're considering spectrum usage and move towards just a more adaptive dynamic on the fly management of their technologies, that I think it will benefit them significantly in the long run. So it may just be this is the final push they need to come up with a really robust system that they'll be able to use to their benefit in the long term.

Robert J. Marks:

And I guess to add to your point, I don't think the DoD is being told to vacate that spectrum. Aren't they still sharing that spectrum with the auction spectrum?

Austin Egbert:

Yes. So that's how it's working currently in the band that's governed under Citizens Broadband Radio Service, CBRS, as there's a system in place where domestically, anyone who's wanting to use that spectrum has to go through a spectrum access system. They would send in a request and say, "I'm at XY location. I want to use these frequency bands." And the system will evaluate everyone's requests, do

tons of number crunching, and based on its knowledge of where DoD systems are in the world at the moment, will send back an answer of, "Yes, you can transmit within these power levels," or, "No, you can't transmit."

And the system even has additional protections built in. So for instance, you can't just rely on DoD systems to know where they're operating because there's national security concerns of you don't want everyone to necessarily know what you have positioned where. So there's also a functionality built into this management system that will detect the presence of DoD radars if they come online, and there's a very short timeframe within which it has to kick out any of those spectrum users who aren't DoD systems to make sure that they still have that capability.

Robert J. Marks:

I guess the analogy I have is that if the DoD had total control of this within the United States, it's kind of like, "I'm at one end of the hall, and I'm concerned a fire will start at the other end of the hall, and I want that hallway to be totally cleared of any interference." And they don't like the idea that there's going to be other users in that hall to clutter up the path in case a fire breaks out that they can't get to that fire. On the other hand, if the DoD goes to any place else in Europe, Russia, China, whatever, that hall is going to be cluttered because we have no control over what clutter is in that hallway. And I think your point is, Austin, that it would be best if we learned how to operate within that clutter, even organized clutter better than it would be if that hall were totally clear.

Austin Egbert:

Exactly, because otherwise raising this issue is basically just the DoD coming out. It's like in Star Wars, there's the one port on the death star that you fire a missile there, everything comes down. This is the DoD saying, "Hey, if you show up and bring over a bunch of licensed equipment that's good in Europe, bring that over domestically, set it up near our radars. We'll be powerless to stop you from interfering without physical force or interfering with whatever you're trying to do." But if you were to deploy that, it would have apparently significant issues for their systems.

Robert J. Marks:

I thought your perspective was very interesting. One last question for both of you. It turns out that the demand for spectrum has been increasing exponentially. If you look, there is no case where exponential increase continues forever. It has to level off. It was like the Covid epidemic. They said that there was an exponential rise in Covid cases. When is it going to level off because it can't continue? When is the demand for spectrum going to level off? Are we getting close or what do you think?

Andrew Clegg:

I hope it continues to increase so that I have job security.

Robert J. Marks:

Because as long as it increases that we have to find ways to mitigate it.

Andrew Clegg:

It's exactly right.

Robert J. Marks:

Austin, do you have any thoughts on that?

Austin Egbert:

I agree that it doesn't seem like it's sustainable long term. I have no insight into when it may start to level off. That's the type of prediction that one can make in a vacuum based on present knowledge, and then something revolutionary comes out, and all of the former predictions just go out the window. It could be something as simple as somebody comes out with a brand new widget for an iPhone or Android phone or something where it's like, "This is the best thing since sliced bread and everyone wants to use it all the time," and now your usage just explodes. Maybe it ends up being where they switch to a different frequency range, somebody figures out how to fix some propagation issues or signaling, and we start using LiFi or things like that, and offload some spectrum usage somewhere else where-

Robert J. Marks:

You used the word people weren't going to know what it is.

Austin Egbert:

LiFi is basically WiFi, but with frequencies that are closer to the visible range of light. It's more line of sight, you need a direct transmission. I think I've heard rumors that there's been some standards development on that front trying to get closer to being able to deploy something like that. So spectrum usage may go up, but it may be in bands that we aren't currently using. And so that exponential curve may happen, but that doesn't necessarily mean it's going to keep causing problems. And I mean, then there's always the chance you just have some revolutionary technology come out of nowhere.

There's been a lot of news recently about LK-99, which is allegedly a room temperature superconductor that has been developed. It's not clear that it is or isn't at this point. There's a lot of conflicting reports. Things have been trending towards, maybe it's not, but it could be the structure's really complex. So there's a lot of uncertainty. Six months ago, nobody would've been expecting that the world would be talking about the potential of a room temperature superconductor, and if it turns out to be what it is or ends up working in some capacity or not, it could have a huge impact on what the world of technology and electronics looks like in three or four years time. So there's a lot of uncertainty still in play to be able to try and make a forecast like that.

Andrew Clegg:

And I think, Bob, another thing, I generally am not a big advocate right now for higher frequencies. When you go to 30 GHz and above up to three THz, which is the upper range of the regulated radio spectrum, there's a tremendous amount of bandwidth with very good reuse opportunities. Right now, there's a reason why we don't use it. The energy efficiency is very low, propagation is very poor, and stuff like that. But we have a lot of smart people, we'll probably figure out better ways to make use of it. There's more spectrum there than there is in all of the rest of the radio spectrum combined many times over. So maybe that plays a role.

We do sort of come up with new technologies that make significant leaps in spectrum usage. We went for dispatch radios. We went from single frequencies to trunking systems that greatly increased spectrum efficiency. I saw some statistics lately from Light Reading, I believe, showing that the rate of increase in demand for wireless bandwidth is slowing. So are we getting to the point where we're saturated with the number of videos that we're already watching that we're not needing that much more? And everybody has a phone already. So I don't want to say that we're getting saturated, we don't

need more spectrum, but I think there are ways out of our spectrum challenges. And almost certainly it will rely on the development of new and improved technologies for the future.

Austin Egbert:

And along those lines, Andy mentioned with everyone having phones, there's only kind of so much video content you can maybe consume at any given time, even if efficiency improvements are kind of slowing down in the spectrum usage space. I know that video encoding is still a fairly active field in video compression. Within the last year or so, there's been a new video compression standard that's starting to roll out to devices that greatly reduces the amount of data that you need to transmit a given video signal with the same or better quality as what we're used to now.

And so there's situations where something like that could potentially end up causing a drop in the demand for spectrum just because you're able to either send the same quality video using much less data, or maybe it'll stay the same, and we'll just scale up the quality of the video that we're sending. But there's other aspects where we can kind of claw back more efficiency in how we're using the spectrum, whether it's on how we manage it at the physical layer in terms of using the frequencies or whether that's a couple layers up the network stack in terms of how we're handling the data we're trying to transmit.

Robert J. Marks:

We don't know what the future is, but we do know that it's going to be mind-blowing and exciting. So that's always a good place to be. Andy, Austin, thank you very much. This has been a lot of fun talking to you. We've been talking to spectrum specialists, Dr. Andrew Clegg, who is at Google, and Dr. Austin Egbert, who's a research scientist at Baylor University. Until the 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.