

SIGNALS RISING ON DIY RADIO INFRASTRUCTURE



**THE FINAL STRAW RADIO
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This week, an interview with members of Signals Rising, who provide education and support around radio technologies including meshtastic networks as alternative communications or in disaster relief scenarios. Check out their website for resources and ways to get in touch.

<https://signalsrising.org/>

Other resources:

<https://flipperzero.one/>

<https://github.com/sharebrained/portapack-hackrf>

A project Signals Rising is collaborating with:

<https://www.indigenousprotectormovement.com>

Search for this interview title at **<https://thefinalstrawradio.noblogs.org/>** to find links to further resources on this topic, featured music, the audio version, and files for printing copies of this episode.

TFSR: Hello everyone, and welcome to this week's interview on The Final Straw Radio. Today, we're speaking with a few members of Signals Rising, a group providing education and support around radio and other communication technologies. Today, we'll be discussing their work and digging deeper into some of the technologies they educate folks about, including Meshtastic networks, which are a form of radio communication that allow for inexpensive, encrypted messaging without a lot of power use. This makes mesh radio technology ideal for disaster relief, as well as being a vibrant open-source community where there's a lot of development and experimenting taking place. Can y'all please introduce yourself, give your pronouns and share a little bit more about Signals Rising?

Andrew: My name is Andrew. My pronouns are he/him.

Chia: My name is Chia my pronouns are he/him.

Danny: And I'm Danny. My pronouns are she/her.

Lorenzo: Right on! My name is Lorenzo Serna. My pronouns are they/them. I am part of Signals Rising. I think I have a title. It's Executive Director, but really, it's a title that I use to try to just fundraise. I would say that I'm this crew's biggest fan. I heard the ideas in random conversations, and I was like, "Yeah, that makes sense." I just started feeling like, "what do you need?" Then I began trying to figure out how to make that happen and just trying to support as I can and learn as I can, because I'm learning so much by just being around and listening to their ideas and watching them become real before my eyes.

Chia: We're part of collective called Signals Rising. We operate primarily in the United States, where we've been working to empower mutual aid groups and community organizations with communications infrastructure. We provide hardware trainings on how to use the hardware and try to design communication systems that expand and extend the capacity of folks to operate in difficult circumstances. And additionally, we're doing trainings on how to use different kinds of communications hardware, whether that's your BaoFeng, GMRS radio, we'll work a little bit with HF, ham radio, digital communications systems through those modes, and also through Meshtastic and kind of anything hacky that we have our fingers in.

Lorenzo: For me, I come out of the climate space, did a lot of climate work, and different defenses, awareness raising, all this stuff you know, to petitions, begging on the street. I feel like that time is almost over, and we talk a lot about resilience

communities. What we're doing at Signals Rising is that we're creating resilient communities for the climate disaster we all know is here. So I'm just really excited to be part of this and be able to support strengthening all these different communities across the country and the world. when it comes to that. People just need good information, and we're a crew that has good information and be able to support that information, get into communities and watch it happen. They're creating their own communications networks. They're able to communicate without relying on anything, but what they were able to pull and do together, which is how we survive almost everything in the end. I'm thankfully part of it and that's really all I have. It's like we get to help support communities, and their journeys to become resilient as the current situation unfolds, and we're able to do that. So, yeah, it's awesome.

TFSR: Would you want to talk a little bit more about what some of those technologies and systems are for folks that aren't familiar, like BaoFeng? Meshtastic?

Chia: Yeah, BaoFeng is kind of your handheld radio. It's very similar to a walkie talkie that you get at Walmart. It can operate on those same frequencies as well as others that are open for public use. So you can communicate on the Family Radio system, which is what the walkie talkies operate on. You can communicate on GMRS frequencies, which are frequencies that overlap with the Family Radio system, but you can use more power and an external antenna so you can broadcast a little further, and you can use them on ham radio frequencies that can access repeaters and operate on different frequencies that can travel ever so slightly further on an open terrain. Meshtastic radios are digital communication systems. So you manipulate a radio with your cell phone through Bluetooth, and you can do point-to-point encrypted text messaging, kind of share small data packets through that system. And the radios are very low power, very inexpensive. They're part of the Internet of Things band, so they use the same radio as the smart refrigerator, dishwasher, whatever has got a little radio in it. They're mass produced, very inexpensive, very low power, and very accessible to the general public.

TFSR: Cool. Thanks for that. And before we hopped on the call, you were showing us this little vape that you converted into a Meshtastic node. So I kind of gather that when you say they're low power, that means both that they don't have a ton of power that they're putting out, but they're not using a ton of power, right?

Chia: That's right. They can operate on just a small battery that you could find in a vape pen. You can power them infinitely with a very small solar panel, and they

operate with line of sight, so they're not going to travel from the ground, 30 blocks away in a city, but what they can do is communicate to a rooftop antenna, which can rebroadcast that 30 blocks away.

Danny: I think it's worth also mentioning that because there's solar power, there's the opportunity to recycle. So one of the things that we've been doing a lot is including in our builds, recovering batteries from stuff like disposable vapes and discarded vapes, discarded single use electric products, mobile phones, this kind of thing. So there's an opportunity not just to have a low-cost device that a lot of people can access by buying it, but also that you can scavenge components, 3D print your own parts, make use of like an Altoids tin or something. That's part of their attraction to us, is that you can get their costs down really, really low.

TFSR: So with them being able to be so cheap, are you finding that they are replacing other forms of technology, like cell phones and the internet, or are they kind of stepping in, in cases when those technologies are out of commission, are not useful for some reason?

Chia: I'd say it's definitely a slow mode of communications. So you can't text message, "hi" and then another message, "how are you?" And then another message, "When are we meeting up?" You'd want to group that all into one message. So it doesn't work like our normal cell phone communications work. You can't do voice over it. It doesn't work like Signal where you can have rapid messaging. But what it does do really good at, is operate in areas where there's no cell coverage. So we're talking about out in the desert, where you can drop a solar power node on a mountaintop and then get coverage all throughout that area, around the mountain, and stay in communication with groups that are out there. You can link towns that are close together, that don't have regular cell phone reception. On the Arctic, there's an indigenous group we're going to be trying to set up a communication system for soon, probably using Meshtastic, and it works when the grid goes down during power outage or some natural- or human-made disaster.

Lorenzo: I'm in Minneapolis, Dakota territory, and there's an indigenous movement has organized patrols in the Little Earth community, which is the biggest urban indigenous community in the country and was created from the roots of AIM, which started here. There's lots of history there. They do their own community patrols, and they're providing basically first aid to people within Little Earth, which sometimes does turn into first responder Narcan support for people overdosing and trying to help them through that. Also, just helping people across the street. They're literally in the community every day, but they do a lot of really intense first

aid work, and they do use radio communications, and they had been. We were able to support them to strengthen those communications. The way they said it is like, there's blind spots in their community where if their patrols are out and they're trying to radio that they need something, that they wouldn't hear it. Those blind spots don't exist anymore from our collaboration. Then also, the way they said it is that it helps them respond quicker to emergency situations within the community. They can respond quicker than an ambulance or the police. They can show up with the first aid materials or just like people support as needed. They can do that just a little bit faster than they could before, and that's enough. I think that's what it is. It's their network now, their radios, and they're just out there every day. It's pretty incredible.

TFSR: Yeah, that's great.

Danny: I think this kind of applies to all of the radio technologies that we use. They provide parallel structures, to answer your question about if they're replacing or complementing. Meshtastic is a really great example of a technology that can provide a parallel structure to cell phones, WiFi, the general internet. In the same way that we organize communities in other ways- politically, or with care, or community growing agriculture- we see these radio technologies as a way of complementing and creating a parallel structure to traditional tech. Meshtastic in particular, is a really accessible way of providing that technology, that structure on the side of existing tech and existing organizations. So it's not necessarily replacing, but it has the potential to replace, has the potential to complement, can be there when traditional or corporate or State provided systems fail. It can also provide an alternative to people that don't want to use those.

Chia: People think about all different times that they're not able to get cell reception unexpectedly, when they're out on a hike or when they're at a music festival. Sometimes you just want to leave your cell phone home, and that's a really nice way to check out from the rest of the world and stay in contact with your small circle of friends that you're with.

TFSR: And in those kind of cases, are people carrying a Meshtastic device and able to use it kind of like a pager or for occasional text messages when the network sends them something?

Chia: Yeah, there are a lot of devices that you can attach a screen to, or that come pre-built with a screen and a small keyboard. Some devices have a GPS in them, so if you're out on a hike with friends, you know where each other are. Meshtastic will

share your GPS coordinates with whatever private channel that you want to share that with.

TFSR: Would y'all be able to share a little bit more about one of the times you've helped a community implement Meshtastic? What did that look like with the setup, and then how did people wind up using it? Also, once it was set up, were there any unexpected things about how the devices were performing in reality, either technically or to do with the physical limitations of the printing, maybe the locations you put them up, or anything else?

Chia: Yeah, so we've deployed them to a number of groups that were operating out in the desert doing water drops and medical work for migrant communities. Folks have been using more traditional walkie talkies to stay in touch with one another, and they were operating in really, really rough terrain. We got them a couple Meshtastic repeaters they were able to drop on mountaintops and that gave them area coverage. Sometimes they go beyond that area coverage and they need to add those kind of repeaters that extend their area operations. But it is really interesting, the way these kind of networks have grown spontaneously. They're open channels that people use. So all these different kind of radio, hacky, ham radio, nerd folks have been setting up city wide networks. So if you're listening, there's probably some people in your area that are playing with these radios right now and building spontaneously with whatever rooftop access they have, a network that you can probably plug into. When we were setting up a network here in New York City, we could talk with folks that were using tiny, small rooftops that we had access to. Then we started doing it a little more intentionally, getting access to much taller rooftops in central areas. And all of a sudden, when we'd put one of those nodes up, it would connect dozens of new folks that all had these tiny little networks that we didn't know existed because they weren't talking with one another. So the one node was able to connect another 30 people. And every time we'd put up another one, there's all sorts of people that were just using their radio to talk a block away with their friend, and all of a sudden, now they can talk with the rest of the city. So it's fun. It's exciting, building these networks, and you build a social network at the same time.

Andrew: I'd add, part of what we're trying to do is build climate resilient communities. Along with that, basically comes creating these mesh communication systems that are more hardened. The infrastructure is more hardened than our regular 3D printed case that you just carry in your pocket. We want them to be able to withstand hurricanes on the East Coast, for example, and down south and wherever the hurricanes are. Then out on the west coast where there's earthquakes

and forest fires and different things. A lot of that's still kind of in the experimental phase, where we're trying to find the right hardware to make it weather the storm, basically. Whatever the storm is.

TFSR: When you are talking about some of these experimental cases, it brings me to another question. If someone is interested in getting involved with Meshtastic, but they're not quite that familiar with either radios or open-source technology, how would you recommend approaching it? Then also, having been around open-source stuff before, I know sometimes the community can be a bit hard to stay up to date on changes, because people are so rapidly, iterating, creating new things. So do you have any recommendations for folks that are maybe a step or two removed from that level of involvement, and just want to make a simple mesh device, play with it, and then kind of know where to go to stay up to date if there are big changes?

Chia: There's dozens or maybe hundreds of different iterations of Meshtastic devices that people are coming up with. You find a huge number of designs that are out on GitHub, things like that. But you don't have to go that DIY route. There's also probably a dozen different ready-made products that are out on the market. You can find a lot of them on the website, rokland.com or seedstudio.com, and then connecting with the community. A lot of this stuff happens through discord channel. You can look up Meshtastic discord and you can find a sub channel, that's inside that Meshtastic discord channel that probably has your local area. All those folks that are in your area, you can meet through there and start to build out a network with them, learn from them, ask them questions. There's channels that are just about hardware and learning about how to use it. And if you're a programmer, you can participate in the open-source development of the software as well through their GitHub.

Danny: I think one of the really attractive things about Meshtastic is that it provides to the community what ham radio does. Like this ability to communicate off the traditional grids and in a more personal way. But the barrier to entry is really, really low. The cost barrier is really, really low. Ham radio has a not undeserved reputation for being the preserve of wealthier, older, white guys. And also, just the amount of knowledge you need to start off is much higher. Generally around the world, you need a higher level of knowledge, you need to take an exam, you need to prove something and you need to buy some expensive equipment. I mean, maybe it's just a small handheld, but often, ham radio can be really expensive. Whereas Meshtastic, you can buy this device for \$20 and then you can flash it from a web page. You just visit the Meshtastic documentation. You plug it into USB, you do

1-2-3-4, you choose which device you've got, and it's done. You can start sending people messages. I think that's the biggest draw for me, is how low the barrier to entry is. It has a really diverse user base. It's really easy to get into. It's really cheap to get into, and it provides a lot of the same things, if anything more (because of the fact that it's a mesh and it can send over long distances and in difficult terrain) than traditional amateur radio text can.

Andrew: I'd add to that most people (in the United States, at least) have smartphones now, and the metastatic app is just available for free on whatever Play Store you probably use. You just download that app and then you connect to it from your smartphone to the Mesh node. You can get these mesh nodes, like Danny was saying, for pretty cheap. You can solder on all these extra dongles that do all these things and stuff. But to start off with, like, it's pretty simple. You can actually order these things for like, \$8 off the internet. Some of the boards are pretty cheap, and the pins are already soldered, and all these things. If you need that, if you don't know how to solder stuff. But just assuming you already have a cell phone, the overhead's pretty affordable.

One more thing. The website's a really good resource for that to get started. There's a lot of information on the Meshtastic website. They mentioned Discord, which is good for finding people in your area, and also, just remote help. Then there's the usual YouTube tutorials, which are very helpful a lot of time when doing all types of projects. So you can search around the internet and find good resources.

TFSR: **Could we take a second and dig a little bit more into what mesh networks are generally? Because I think my first exposure to mesh networks in any significant way was with the New York City mesh project, which I believe is just (well, maybe not only at this point, but) a WiFi mesh project that is designed to enable people in New York to have access to WiFi using similar, but not exactly the same technology, as Meshtastic. Then I think the most commonly seen version of a mesh is something Google might be trying to sell you to get more WiFi coverage inside your home. So what are some of the differences between that kind of mesh, when applied to WiFi, and then Meshtastic. Then when we're talking about nodes and the devices themselves, what is the role of a single device within a Meshtastic network? And how does you owning a device contribute to the network?**

Chia: Yeah, so most people are familiar with mesh networks through WiFi, right? They have a WiFi extender that that gets their router going a little further. Maybe they have it out next to their front door, so they can get it when they're working in the garden. This is relaying the data transmissions that are coming from your router

to whatever device you're using, probably your cell phone, and that is a mesh network. You can add additional access points that extend that network further. Every Meshtastic node, if you have standard settings, it's going to retransmit a message, if it receives one. So if you put a node up on your rooftop because you're having trouble getting out from your desk at home, that's going to give an area of coverage all around your neighborhood, and it's also going to connect you out to the wider network. And all you need to do is flash the standard software, and that device is going to start retransmitting. That also works if you're at a protest or something like that, where there aren't any rooftop repeaters available, and the marches are snaking around. If a bunch of people have Meshtastic nodes and they're configured to the same channel, each one of the radios that are in their pocket are able to retransmit the signal that you're trying to send out. One thing that folks may not understand is that a device doesn't need to be able to decrypt a message to retransmit it, so you can send the private message to your friend or affinity group, and other radios are able to retransmit that message without being able to read it.

Andrew: One thing I would add is I think the most obvious difference between the mesh and the WiFi is the radio frequencies that they work on. One's in 900 megahertz, and WiFi is up in the gigahertz, like 2.5 to five gigahertz, something like that. That'd be the most obvious difference there, right?

Chia: And those frequencies have different properties, right? They're able to transmit at different power levels. These kind of WiFi signals can pass through walls. The Meshtastic radios they're not going to pass through walls so well, but they can travel a really, really long distance if they have that line of sight.

Danny: I think it's worth also mentioning that this stuff is automatic. That's one of the really cool things about Meshtastic is that you could form a mesh with a walkie talkie with your friends, and you could have one person standing on a hill. You could have one friend in one valley and another friend in the other valley, and you can hear both of them. They can't hear each other. You could relay messages to them. I mean, even without a walkie talkie, right? You could just be passing messages between them. Meshtastic is completely automatic. It has an algorithm that (depending on a few settings, which it comes with, some default settings) when it hears a message, it sends it out again. So a node, as in a Meshtastic radio can go down, can be disconnected, can run out of power, can be blocked, can be destroyed, and other nodes will automatically route around that, if possible. So that's one of the really attractive features that you don't have to configure any of this stuff. It just comes out of the box. So three, four of you could go hiking, each have a Meshtastic node in your pocket, and if you end up spreading out over a long distance without you

having to change anything automatically, one node will forward messages onto others and sort of self-form a network. Rather than with the example of a home WiFi mesh. Often you have to set it up, make a config, understand how it's working. With Meshtastic, it does it itself. That really lowers the barrier to getting started.

Chia: Yeah, and you could compare that with a great project that's NYC Mesh, that's sharing internet that they lease direct from the backbone to thousands of people around New York City, but that's done through very intentional routing that's programmed. So if someone's joining the network, they have to connect specifically to a hub or somewhere close by that's going to specifically relay that transmission to a different hub that eventually gets back to the backbone of the internet, so you can access the internet. Whereas we're talking about more of an intranet that's trying to communicate within our own network, right?

TFSR: So if I'm understanding correctly, we can think of Meshtastic as being kind of a group of friends that are shouting things to each other across the hills, like in terms of that's about how much data you're going to be able to pass around. You're not going to be screaming to your friends all of the information to make up a whole picture or something. You're just going to be saying, "I'm walking to the left," and that next friend will say, "So and so is walking to the left," but they're not going to relay a whole picture of a possum. So is there a way, as someone who's using a Meshtastic node, to get information from the big internet, or put information onto the general internet? So if I was maybe in a disaster scenario, and I just wanted to get some local community's information out to the wider world, but I might not have enough mesh nodes to go all the way from my town to where my grandparents live. Is there an easy way to do that?

Chia: Folks have been extending networks because it works through line of sight. It could go really far. Folks have been experimenting with ways to extend that through drones. They use balloons. They set the world record for the longest transmission with a balloon that went like 150 kilometers. Something like that. So you can extend it out in an emergency if you need to. And what you're hoping to do is get it to somewhere that has our standard communication system, or a ham radio. So integrating a few different types of communication systems into a network to prepare for a disaster, I think is really important. It's not to say that this is going to supplant HF radio. That was so critical in something like Hurricane Maria, where the islands lost all power, and the only way to get messages out was through ham radio from Puerto Rico. But within Puerto Rico, you could have a Meshtastic network, and folks have been working on that kind of stuff down there, so that everyone can

communicate with the one guy that's got a ham radio that can communicate with the outside world. Then the ham radio people can relay those messages further out.

Danny: There are projects to do that. So Meshtastic is built on a system called LoRa, which just means long range, and it's just like the radio tech that's built on. There are several LoRa projects like LoRaWAN or LoRa wide-area network, which exists to bridge the internet and LoRa. If you search for LoRaWAN, (L, O, R, A, W, A, N) then you'll see that there's actually already lots of networks available. There's commercial LoRaWAN networks. You can pay \$1 a month or something, and you can put 100 sensors from, say, around your farm or around some forest land, and they'll connect. And there is LoRaWAN gateway, and they can send messages over the internet. And Meshtastic. Meshtastic is like a layer on top of LoRa which attempts to do the sort of self-forming networks. But there are projects, particularly MQTT which is essentially a message format system. That's a building block for setting up these networks which connect cheap, low cost, Meshtastic devices. It's not as mature. People are experimenting. People are making their own little projects. There's not quite as big of a sustained project to connect these things together, but it's definitely a possibility.

TFSR: Have you been involved in any projects that are using that kind of capability?

Chia: The Meshtastic system here in New York has some nice analytics websites that folks have set up. There is a lot of publicly available software that someone can put onto the internet and work for their own network that are available on GitHub that you can find through the Meshtastic discord. And that helps you to understand, kind of map out how the network is operating. If there are nodes that are polluting the airwaves with unnecessary transmissions, you can figure that stuff out through the analytics table, and those kind of things are useful. You can also connect cities together through that. So the possibilities are there. They're pretty interesting.

TFSR: And then for folks that are listening to this on the radio, if you go to The Final Straw's website, we will include links to as many of these things as possible. I did want to follow up on something that we've touched on a little bit but haven't dug more into. Could we talk a little bit more about security and encryption? I know one of the advantages of Meshtastic is that it is legal to be encrypted on it. So can you share a little bit more about how that encryption works between devices?

Chia: Yeah, each radio self-populates with a private security key and a public security key. Public security key is the way that it acknowledges itself to the wider network, and then the private security key is used to send direct messages to one another and to group chats. You can create a group channel, share the private security key of that channel with your friends through Signal or traditional cell message, and each device is able to use that key to decrypt the message. So you can connect through a wider network with an encrypted message that only your friend or community can read. There're different reasons to do that. Like we've talked about, sharing your position with your friends, your family. Maybe you don't want to broadcast where you live to the whole network. You can set up other interesting components that can share different data with your community as well through that, whether it's a weather station, or some sort of alert. Someone I know in San Diego got their raccoon camera with a trigger that sends a Meshtastic message every time a raccoon gets caught in the raccoon trap. It sends a message out to the network that "there's a raccoon in the trap. You better go check the trap." You can add these kind of devices, because they're so inexpensive, to all sorts of different things in your life, and that can help your community to operate.

Danny: So from a technical side of things, the kind of encryption Meshtastic uses is called AES-256, or the Advanced Encryption Standard 256 bits. So that's generally considered to be completely secure, like it's unbreakable, and you can also prove that it's unbreakable. So as long as you keep the key secret, you can pretty much guarantee that message you send, it doesn't matter how far away, those in the middle can't decrypt that packet. They will forward it on, not knowing what it is. There's no key management. If your device gets lost, gets stolen, if it gets taken, if you're interrogated, and that key is discovered by the person that wants to discover it, all the messages you sent in the past or that anyone sent can now be opened completely. So unlike with Signal or a lot of internet based secure messaging systems, there's no key management structure. So there's no way of rescinding keys that have been exposed, updating keys, sharing new keys with people. It's a fairly all or nothing-at-all approach.

TFSR: **So what happens to the messages on the device? Like if you're an exit node and you're the recipient of the messages, I assume you can delete them, but storage wise, do you just have a bunch of encrypted messages that stay in your device, or do they get transmitted and then gone?**

Danny: So generally, the devices are really low-power and they don't have a whole lot of storage. You can't really expect that the messages will be stored, especially if you don't have a cell phone or a computer attached to the radio. In general, I think

it's called an ephemeral messaging system. There's no database. They're not stored somewhere, but you also don't have control over that. So that's something to bear in mind. It's not like Signal where you can do disappearing messages or you can guarantee that on the device is encrypted. You still need to be careful. It's not a magic bullet for securing and it's certainly not an authenticated messaging system. It leaves a lot to the user. It can be secure if you know how to use it and you're sensible.

Andrew: I wanted to add, as far as we're talking about encryption, aside from the technicalities of how it works, it's interesting that you can get such a cheap piece of technology that does this kind of encrypted communication. In the United States, it's very hard, or just generally illegal for regular amateur radio people to do encrypted communication. You need special licenses, or some really expensive commercial licenses and things like that. So this allows people to use encryption over radio, using mesh, without having to go out of your way and do all the other hoops and stuff, or generally just illegally transmitting encrypted stuff, which might get you in trouble.

Chia: Yeah, but dealing with those kind of security limitations, it's very easy to create a new private channel and share that with your friends before you go out hiking. And if you're just getting the habit of making a new channel every time you go out with your friends, you can be confident that only your friends have that key.

TFSR: Okay, to kind of change topics a little bit, at least in my local community, people are pretty excited about Meshtastic networks. I've been trying to learn a little bit more about scanning. I used a railroad scanner for a number of years, which was fun and, on the rare occasion, also informative. I'm trying, personally, to get more up-to-date on scanner technology, but I was wondering if there are any other applications of radio that any of y'all are excited about that are maybe a little bit less on the radar than mesh, that you'd like to talk about? Like ham radio, if you want to share anything about that.

Chia: A lot of folks, especially emergency responders from local community groups, like to listen to the deployment of Fire, EMS, or Police, so they can help respond in areas where the State is slow to respond to folks. So they're able to provide care. People use traditional scanners that are listening to certain frequencies. They also use software-defined radios to listen to these kind of broadcasts. It can be really helpful for first responder folks.

Danny: Just to expand on that a little bit, I think software-defined radio is the most exciting thing happening at the moment to amateur radio. And actually, just in tech in general. It's one of the coolest things that's been going on. The whole thing kicked off with these cheap digital TV sticks that you could buy, and someone discovered that you could repurpose them to listen to basically anything within a certain range. Analog radio, to ham radio, to Meshtastic, to satellites. You could receive weather broadcasts from satellites, this kind of stuff. And that's now evolved this massive field. If you search for anything online, on social media about software-defined radio, you get people who are communicating with each other at number stations. You can hear airport traffic, like the digital aviation and maritime transponders, weather balloons. It's an endless list. What used to just be a police radio scanner that that you might get, or an aviation aircraft airport radio scanner, people are doing the same thing, but for everything, and discovering so much cool stuff going on, finding new uses for it. I saw the other day, a group that had used SDRs and radios to create a really low-cost medical imaging system. \$20,000 and they'd managed to replace a half a million-dollar radio imaging system for cancer. And this is just always off the shelf tech. So, yeah, it's really cool, it's really exciting, and it's also really accessible. You can buy this \$20 stick and reprogram it with three clicks and an app. It's an incredible, interesting field.

TFSR: Do you know if they have instructions or a narrative about how they did their imaging online? I would be interested to look at it.

Danny: Yeah, they published a paper. They use something called beamforming. They created a phased array, which is essentially using lots of radios together and lots of antennas together, and putting the slight delays between them so that you can essentially steer where you look with the antenna without actually having to move it. I studied electrical engineering at university, and when I was studying 20 years ago, that was the kind of thing the military was using for radar. That was not the kind of thing you did on your desk for \$100. It was the reserve of people going into really high-end stuff. And now someone in high school can buy five SDR dongles, plug them into their machine (even an old machine) and be playing with this stuff. There's also a really interesting interchange and overlap between Meshtastic, and then SDR as well, where people are holding stuff on or emulating or expanding the boundaries of things. Yeah, it's really cool.

TFSR: I love it. It's really exciting. Do you have links and stuff that you can share?

Danny: Sure, definitely, I can. I'll send you a few that you can include.

TFSR: Cool. rtl-sdr.com.

Andrew: I might add that just a lot of the software that you can use with the SDRs are open source, and so they're just readily available if you know what you're searching for. They can do a lot of different stuff, like Danny was saying, but it's very accessible software.

TFSR: I think that's the challenge is to know what exactly to be searching for. I have tried. When I was first getting set up to play around with SDRs, I was having weird, weird, but also super basic problems where it was like, "Oh, I just had the wrong connector." But yeah, the resources are out there. Oh, and Danny has shared the link.

Andrew: If you're having trouble with this stuff, I would just say, stick with it. I mean, I think all of us encounter issues when we're trying to learn new stuff. I know I do. Sometimes it feels like I just need to give up and give my brain a second to regroup, and I come back to it, and it's just like, "oh yeah, the USB was just a charging cable. It wasn't a data cable." Just small things like that get in your way, and you don't realize it, but eventually you'll get through it, and you'll be really excited for everything that comes out the other side.

TFSR: I feel like, sometimes the most helpful thing you can do for yourself is just take a day or a half hour to go for a walk and let your brain not actively work on the problem. Passively work on the problem, so you can come back and be like, "Ah, I got it."

Danny: Yeah. It just occurred to me that we didn't mention that there are two projects that have made this stuff really accessible, which is worth mentioning. One's called Flipper Zero and one's called PorterPack, which is basically the same thing, but more advanced. You may have come across Flipper Zero before. Whereas before maybe you needed to know what kind of antenna connector and charging cable and power supply and everything you needed, now you can buy one box that has the Flipper Zero, which is an SDR, essentially, but it has a screen, it has the buttons and everything all in one box. You buy that, you get going. You can do cutting edge stuff on it. You can download new software into it really easily. And that's really exciting to me. The annoying learning curve of spending three hours trying to figure out why Linux won't install this one package you need, it kind of gets around that and gets you straight into playing and just like developing a passion. I think all of us didn't get into this because we're going really deep into the tech. None of us are Meshtastic developers. We all picked up the tech because it solves problems. When

you get passionate about solving a problem with a tool or some tech, you pick it up really quickly. I think that's what's really compelling and inspiring about SDR.

TFSR: Are there any other like forms of radio that you think are worth talking about? We mentioned a little bit of ham. I believe y'all mentioned another kind, but I don't recall it. You mentioned that the traditional ham radio community is maybe not quite as welcoming. Do you find that's something that's worth having in the community? It's a significantly larger investment of resources in terms of learning the equipment you need, but are you finding that folks that invest time and energy into it, think it's worth it? Or is it more something to get into, if you're really into radio?

Chia: Every major milestone in technological development in the radio world has happened because of ham radio nerds playing with this stuff and experimenting with this stuff. The folks that are building Meshtastic systems, a huge portion of them are ham radio nerds. I wouldn't say that ham radio as a community is not welcoming, but it is in the realm of an exclusive group of folks because of the cost, the barrier of entry and the ability to learn this kind of stuff. Folks are able to learn about ham radio by buying expensive radios and putting them together and learning by doing, in the past. Now there's a lot of online courses that are available, that you can study for free or for 20 bucks. They have great video tutorials to teach you about this stuff. So if you are interested in it, you should reach out to us, Signals Rising. We can help you down that path. Studying to get your technician license for ham radio is not too hard at all. You can get on their air for a \$30 BaoFeng as well. You could cram for your technician's license in a weekend. These are important tools and systems and networks that these radio nerds have put together, that are used for emergencies and that empower us to do more interesting things. The folks that aren't licensed are able to kind of come in through the coattails. I would say thank you to that community, although it is the realm of retired white men.

Andrew: I would say also that it depends how much you want to get into the radio stuff. Most people probably use a walkie talkie or something once maybe, or held one. A lot of people who use them don't actually know how to program them, or how they actually work. They're just the end user of them. If you're really interested in understanding how to improve the communication in your community with Meshtastic, then antennas and all that radio theory is very, very helpful. A technician's license, which is the entry level in the United States can really go a long way in helping understand "Why do I have to use a specific antenna? How should I pick from the different types?" because they do different things. A lot of people don't really realize how important some of these aspects of radio are. Then there's also a

bunch of other radio technology. The spectrum is huge. It goes all the way from the light spectrum, all the way to the other end. It involves radio astronomy, down to NFC cards to get into your apartment complex, or your work. All these things work off of radio. It just kind of depends what you want to do with it. It's not all just talking to someone down the street or seeing what aircraft are flying over your head. There's just so much that it entails that I probably can't go into it all right now, but just really encourage people to figure out what they fancy and go after it.

TFSR: Yeah. Like, right now, there's a mysterious cat that's been coming around my house, and she is really hard to catch. So I'm trying to figure out if it would be easier to try and make a pet scanner and put it by a box with her food, instead of going to the trouble to wrangle her. I don't think it would be easier, but it might be a lot more fun.

Andrew: Yeah, my house actually uses RFID on the animals, so they don't get into each other's food. One of the cats, eats the other one's food so it's kind of on lock down. If the cat gets close to it, the food bowl opens just for them. So it's an example of radio, really.

TFSR: They haven't figured out that if they get, like, their friend to escort them there, they might get an extra snack?

Andrew: Yeah, I think they're on to it, but we do try to keep an eye on them to make sure that doesn't happen. But it's harder.

Danny: It might be worth saying that Flipper Zero does have a pet chip scanner app available for it. So you could try that, but I think you have to get pretty close. Like, less than an inch to the where the actual chip is.

TFSR: Well, if this episode takes a while to come out, I can include my updates in the show notes. I think we're getting close to the end, but before we wrap up, I did want to ask a little bit more about some of the hardware stuff y'all have been doing. We saw those vape pens and also we can cut this if this is an inappropriate question to be asking, but I believe y'all have been doing some work on chips for Meshtastic nodes? Correct?

Chia: Yeah, we could talk about that. So through Signals Rising, we've gotten a number of grants to be able to provide these alternative communication systems. We made a small investment in building very low cost Meshtastic nodes, so we're able to distribute those. Having put a bit of sweat equity into the construction of

them, having PCBs printed and soldered up and buying a bulk order of solar panels and antennas straight from manufacturers in China, we've been able to make these devices really, really low cost. We're trying to make them as accessible as possible to mutual aid groups and community organizations that really need them. So please reach out to us at signalsrising.org if you feel like you're one of these groups that could use a hand getting this kind of stuff set up.

TFSR: Danny held one of them up to the screen, and it's like the size of, a little bit bigger than a penny. So when you say PCBs, it looked like it was a printed circuit board, but there still is maybe an element of manual assembly? Like soldering? Am I wrong?

Chia: Yeah, we've had the PCBs printed, and then add components to them, along with the micro controller. Then of course, wiring those up to a solar panel, to a charge controller, a couple of batteries, external antenna, and getting that all into a waterproof enclosure. It takes a little bit of time, but we care about it. We do it so you don't have to. You can if you want, but if putting them together sounded way over your head, reach out to us and we'll hook you up.

TFSR: Great.

Danny: I think that's one of the core things of our mission. You can make these things pretty cheap, and you can buy them pretty cheap as an individual. In our last production run, we ordered 100 which actually isn't a lot for PC production run. That really dropped the cost. We produce the main electronics part, without the battery and the enclosure, for under \$10 now. That's the power that we have as an organization that gets grant money and has volunteers. We can drop the cost really, really low so that we can afford to give these away to people that wouldn't have access to them at all. If \$20 is a lot of money for the board, and then all the extra stuff used on top, we can give and we do give away devices if you're willing to solder them. We can help you learn how to put them together. Andrew has created some incredible documentation to step you through from nothing, taking one of these boards to having it complete. That's one of the exciting things. The privilege that we have is getting grants to take those already lower barriers to entry and make them even lower by producing stuff in bulk and getting them out to people that really need it. It's a way of getting into amateur radio and off-grid communications.

Andrew: As far as cutting the cost of the hardware, the tariffs have pretty much increased our mutual aid efforts by about two-fold in cost. If anyone's got any leverage to stop that from happening, it would help us out with our mutual aid efforts.

TFSR: Well, is there anything we haven't got a chance to cover with regard to what y'all are doing there at Signals Rising? Do you want to share anything about any of the trainings that you all do?

Chia: Yeah. We try to offer community groups that reach out to us, along with individuals if they have real specific requests, with knowledge and trainings. We have made a few Powerpoints to streamline that. We can do an online training with your organization, about how to use handheld radios, how to build Meshtastic nodes, how to create a Meshtastic network, how to set up HF communications, doing digital HF communications. I bet we could come up with some more if you reach out and ask.

TFSR: HF digital communications, high frequency?

Chia: Yes. Bouncing radio waves off the atmosphere so you can talk all over the world, beyond line of sight.

Andrew: I'd say, in general, there's been an exponential increase in interest in mutual aid work in communities across the country in the last few months. We're seeing a lot of requests for hardware and training support. It's a lot to handle for such a small group like ours, and we're trying to keep up with it. It's working out. We're growing slowly. We're able to help people. And if we're not, we're pointing them in the right direction for other resources.

TFSR: Any last things to include? Links, ways of getting in touch, or any social media you'd like to mention?

Andrew: I would just mention we're a 501(c)(3) in the United States. If you know anybody that would like to donate to support our organization to train people in radio technology and also providing communities hardware, now is the time. I would really encourage everyone to support us. Support whatever group is in your community. Just go out there and support people that are doing work that's important, that can save lives and help a lot in the future to keep everybody safe.

Chia: If you work with a neighborhood organization, mutual aid group, or if you just know about them and you think they might need some kind of support from us, please help us to get put in touch so that we can build this resilient infrastructure that we need to put in place now.

Danny: The thing that I find the most interesting about this, and why I think your

listeners should find it interesting, is because some of the most interesting organizations and movements are born out of the places that oppressive power structures haven't taken root yet, or where there are gaps, or where there are cracks, and people build parallel structures, build alternate structures, build different ways of supporting each other. Amateur radio, especially with mesh networking, there's a real crossover between cool tech and that kind of way of organizing, of not necessarily confronting oppression directly head on, but finding ways around it, finding ways to subvert it, finding ways to build things next to it. That intersection between tech and that way of organizing is really cool. It's really exciting. It's really fun. It's not just a cool toy to play with, but it's a cool toy to play with that actually supports a kind of resistance. That's really important right now.

Lorenzo: A lot of organizing projects have these very long term windows, like “in a few years, we're going to be wherever.” And I'm like, “oh, cool, that's really fun.” But what I really like the most about this project is that the impacts are nearly immediate. Once we are able to work with folks, meet with folks, get them some gear, things change. The situation on the ground changes for them instantaneously. That's really powerful, and something that we're able to provide in this current moment that I think is really necessary. In support of that, we're literally changing the situation when we're invited to. Once people own their own forms of communication there's a different thing that exists there. Then they're able to really have good information that they can trust. Because it's literally their network. It's not up to some algorithm of whether you might see the message or not. It's yours and you created it. It's good information. You can act on it. That's one of the things that I think is really important to me in a lot of different spaces. Once we actually know that we can believe something to be true, we can move with that. In this current communications environment, that's really hard to know. Go make the system yourself, and then you're going to be able to trust it. I feel like we've been able to do that. So good luck everyone out there.

TFSR: Yeah, thank you for that, and thanks everyone for coming on to the call.

Chia: Yeah. And you can get in touch with us through signalsrising.org or signalsrising@protonmail.com. Thanks for having us.

TFSR: Thanks for coming. We'll have links in the show notes. And if someone is using the zine version, there will be links at the front of the text. Thanks y'all.

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