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Thank you for reading. We hope this document helps build the world we want to see.

Radio Reference for Radicals

A beginner and intermediate guide to handheld radio, tactical information networks, and communication

Twin Cities Workers Defense Alliance
Information Security and Technology
Member Group



January 2021
v2.0.0

5.2 Further Reading

level equipment. He does reviews, set up guides, and explains some basic concepts pretty well. You can check out his personal site at: <https://www.miklor.com/>

- The American Radio Relay League is the national amateur radio association in the united states. They put out news articles several times per day, have a bi-monthly magazine, and have lots of background information articles about amateur radio. They are a fantastic resource for more technical knowledge. You can find them on the web at: <http://www.arrl.org>
- Hamstudy.org is a great place to test out your radio knowledge, especially if you're considering getting licensed. They have flash cards for every possible question on the license test, with explanations on why answers are right or wrong. Going through these really help correct misunderstandings one might have about how radio works. Visit them at: <https://hamstudy.org>
- If packet radio is your thing, one man wrote a detailed guide in the late 80s that introduces some basic concepts pretty well. Computers have gotten a little more complicated since then, but this is still worth a read. Find it at: <http://www.choisser.com/packet/>
- Burner phones are a lot more complicated than people realize, and there are a lot of ways their protective layer can be peeled back by a skilled attacker. Crimethic has written an article about burners worth reading if you're interested in trying to get one: <https://crimethinc.com/2017/03/27/burner-phone-best-practices>

Prowords - Procedure Words. Special terms that have specific meaning.

Rx - Receiver. The “listener” in a call.

SDR - Software Defined Radio. A radio whose traditional analog components are done through digital electronics.

Sigint - Signals Intelligence. Information gathering by listening or intercepting communications.

TDR - Transciever Dual Reception. Also known as “Dual Watch”, this will listen to two channels at once.

Transceiver - A radio that can both transmit and receive.

Tx - Transmitter. The “sender” in a call.

UHF - Ultra High Frequency. A higher frequency selection of the radio spectrum with specific properties.

VHF - Very High Frequency. A medium frequency selection of the radio spectrum with specific properties.

VOX - Voice Operated Exchange. A mode bypassing the PTT where a radio begins transmission when it hears noise.

5.2 Further Reading

There are a number of websites and books out there that we have used as learning and reference material for this guide. Here we’re going to go over a few of them for those interested in further reading:

- The (Chinese) Radio Documentation Project was one of the best early manuals for Baofeng radios. Despite being nearly a decade old, it is still a fantastic reference material for technical ins and outs of Baofeng radios. You can find it at: https://www.ke4rx.org/cheatsheet/Baofeng/Manual.Baofeng_UV-5R_v1.0-annotated_by_KC9HL.pdf
- John Miklor is a radio operator who is dedicated to spreading the hobby of ham radio, especially through helping with entry

Dedicated to all of those who lost their lives in the Coronavirus Pandemic to the indifference of the ruling class. May their memories fuel us to press on.

This Document and Purpose

This document was developed over the course of the 2020 Minneapolis Uprising for George Floyd to help comrades develop skills necessary for effective communication generally and effective radio use specifically. Originally a two page help sheet, it has grown beyond the scope of a small guide and into a full reference booklet. Hopefully this booklet will be able to answer many of the recurring questions we see about radios and how to use them.

Radios are used in many different circumstances and industries, and several of the authors have professional experience with them. This document takes a broad slice of these radio cultures and puts forth what we think is a simple and clear set of tools and guidelines for radicals hoping to improve their communication skills. These principles have been field tested and adopted by several local groups already for about a year, and we hope to further educate and spread this knowledge to comrades and fellow travelers.

As one might expect from the Workers Defense Alliance, this document is written with a horizontal and distributed power model in mind. Similarly, we work under a threat model and political strategy of openly revolutionary politics towards mass action. Others may have to adapt these teachings to their own conditions.

As a final warning, this document does not go into the legality of amateur radio, as this may depend on laws in your area. Know the law where you live.

Thank you to all contributors and proofreaders for this booklet. We're interested in hearing your feedback about this guide too. Please reach out to us with any comments, critiques or questions at: <https://workersdefensealliance.org/contact>

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5 Glossary and Further Reading

5.1 Glossary and Terms

Here are a few abbreviations or specialized terms you may have noticed throughout this document, or may run into outside of this booklet. We hope this selection of terms can provide a stable reference base for readers and learners.

AM - Amplitude Modulation. An older method of encoding data over radio. Not used much anymore.

APRS - Automatic Packet Reporting System. A system and protocol for sending short text messages over radio.

Call Sign - A nickname for use over radio. Do not give your real name or other sensitive information on the radio.

Channel - A predefined radio setting, with frequency, bandwidth, and more.

FM - Frequency Modulation. A method of data encoding over radio.

Frequency - A measure of how fast the radio wave is cycling. Related to wavelength.

HF - High Frequency. A lower frequency selection of the radio spectrum with specific properties.

Infosec - Information Security. The practice of protecting information by mitigating information risks.

Opsec - Operational Security. A process of threat modeling and implementing organizational solutions to threats.

PTT - Push to Talk. The transmission button on your radio.

4.6 Trunked Radio

In the mid 90s, with packet radio maturing and the explosion of the internet, the first trunked radio systems started appearing on the consumer market. The difference between a trunked system and regular radio channels is the existence of the “control channel”, a digital packet communication channel that controls the frequencies that users operate on.

This has a function of abstracting away the frequencies and channels that people use: instead users select “talk groups” to determine who the transmission is going to, and the control channel tunes the radio of the transmitter and recipients to the right frequency to send and hear it respectively. This allows for much more efficient use of frequency space, especially in dense city areas.

Many metropolitan areas have moved to trunked systems as the technology has become cheaper and more available. Still, these transceivers cost hundreds of dollars and there are no easy ways to make Baofeng radios use trunking. If people are interested in listening to emergency services in metro areas, they will have to get different radios capable of trunking.

That said, there is one cheap and simple way to get into trunked radio. In the late 2010s, a technology called “software defined radio” (or SDR) started to finally come down to a reasonable price. SDR transceivers are still pricey, but SDR receivers are fairly cheap. If you get two of them - one to monitor the control channel and switch the other for listening, you can get into trunked radio reception for cheap. The radio of choice here is the RTL-SDR that you can pick up from <https://www.rtl-sdr.com/> for 35 USD each.

Setting these up for listening is quite a complex task though, so we will link a guide that comrades have written here in the future when it is completed. In the meantime, there is a fairly active RTL-SDR scene out there to search through.

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computers. This collection of technologies falls under the banner of packet radio, and indeed we can use it to transmit general digital signals over radio.

APRS (Automatic Packet Reporting System) is a simple protocol for transmitting text over radio - things like GPS locations, short text messages, or other announcements. You can connect your phone or other digital device (as in Multi Mode Communications and Patching with an APRS cable and VOX) to access this digital mode. There is a national network you can take advantage of if you're licensed as well.

For things beyond the most basic digital transmissions, our VOX mode won't work well anymore unfortunately. The sensitivity just isn't quick enough to get the transmission right, and we'll have to move to more specialized equipment such as the Easy Digi that control the PTT better.

Once you have your packet radio equipment, you can connect to a computer to use as a general networking device. This article talks a bit more about some of the specific things you can do with it: <https://opensource.com/article/17/9/packet-radio>. Funny enough, you can still find old bulletin board software systems (BBSes) on packet radio systems because of how well the limited bandwidth is suited to them.

Using a portable computer and power source of some kind, one could theoretically build digital connection modes through handheld radios and take advantage of everything that brings on the go, albeit with the low bandwidth afforded. We haven't done much experimenting with this ourselves though, and recognize this potential warrants further investigation.

Understanding packet radio is an interesting endeavor on its own, but it's a foundational concept for understanding section 4.6: Trunked Radio.

- Weather can be an issue if you don't prepare for it. If you're setting up a repeater in a static place, think about weatherizing it or running long antenna connection cables so you can keep the repeater inside.
- Try a few different frequency offsets to find one that doesn't cause interference with the other. This can be a process of trial and error.
- Consider using an audio mixer to achieve faux-duplex communication if you're making a bigger repeater network.
- Be sure to set up your handheld radios to use the repeater beforehand. Trying to work this all out on the day of an action is a nightmare. Using CHIRP (see section 4.2), you can program channels to transmit on a different frequency than they receive on - very helpful for setting up repeaters. If you choose to use tone squelch of some kind, radios will need to be set up for this as well.

Repeaters are a very powerful tool for improving communications networks. They do require training users and technicians though, and adding another layer of complexity is also another potential layer for failure. Think of the amount of people available to fix or direct people away from a repeater if it stops working. Do you have the right amount of personnel for something like this? Think hard about Threat Modeling from section 1.3 and PACE from section 1.4.

4.5 Packet Radio

So far, we've discussed all kinds of ways radios can transmit analog signals. Digital signals are another matter however, and we'll touch on them briefly here. In a modern context, this kind of communication often happens in data packets like you would expect to see with

1 Why Use Radio?

1.1 Basic Radio Introduction

This booklet was written with the idea that readers may already be vaguely familiar with radio or walkie-talkies. If you are a complete beginner though, let this section serve as a brief introduction to some of the base knowledge you might need.

Radios and Walkie-Talkies

Most readers are likely familiar with radio in general. Whether in the dashboard of a vehicle, in an old-school radio/alarm clock, or some other similar device, commercial radio is a way to broadcast a signal over a wide area to many possible recipients.

Technically, these devices are strictly radio receivers. Walkie-talkies are similarly able to receive such broadcast signals, but they are also able to transmit their own messages: their communication is two-way. Since walkie-talkies can transmit as well as receive, they are often referred to as "transceivers". We will simply refer to them in this booklet as radios or transceivers.

Some Basic Considerations

In general, the ability to hear a transmission is determined by the power of the transmitter and the distance between the source (sometimes called Tx) and the receiver (sometimes called Rx). The further away you are from the source and the more things between you and

them, the weaker the signal will be. (Have you ever been listening to a radio station while traveling in a vehicle and “lost” the station as you continued on your journey?) However, unlike a commercial radio station which is stationary, users of handheld radios may be moving. This means that the relative location of the transmitter to the recipient may change easily.

It may also be helpful to foreground an important point: unlike a telephone call or text message, communication using a radio is still a broadcast. There could be many devices receiving a given message. Not all of these may be intended recipients.

A final basic point to consider: if there is no real limit to how many devices might receive or transmit messages at a time, how do we prevent communication from becoming hopelessly muddled? We pick different frequencies to talk on in order to prevent this, often written in Megahertz (or MHz). These can be complicated however, so we often just refer to them by a plain name called a “channel”.

1.2 The Case for VHF/UHF Radio

Benefits to Radio

Our org has experimented with a lot of different forms of communication over the years. Before secure texting, we used a lot of runners to relay messages in person. When Signal became popular, we started relying on it - perhaps too heavily. Sometimes, it is very difficult to keep your eyes on the messages being relayed over text, and having your head up is key. Audio does this very well. This eventually led us down a path to find the best places and platforms for both asynchronous (largely text based, not time bound), and synchronous (largely audio based, time bound) types of communication.

Of all the synchronous communication platforms available, we eventually settled on VHF (Very High Frequency) and UHF (Ultra High Frequency) radio for two primary reasons - it is a relatively

4.4 Repeaters

A radio repeater works by receiving a signal on one frequency, and then re-transmitting it on another - usually with a better antenna and much more power behind it. They can be used to expand communication networks far beyond that of what handheld transceivers could do alone. Repeaters themselves can also be linked, creating a large coverage zone.

Often times, repeaters use something called “tone squelch” (also called “PL” or simply “tone”) to prevent accidental use of the repeater. This is a sub-audible signal that gets sent right when you press the PTT button that lets the repeater know that the transmission is good to rebroadcast. These can be analog signals (CTCSS or tone burst) or digital signals (DCS). They are especially helpful when multiple repeaters are present, but are entirely optional.

After reading section 4.3, you may be thinking to yourself: can we use this VOX setting to make a simple radio repeater with two transceivers? Why yes, we can. Connecting one radio’s audio out to another’s mic in with VOX enabled will make a simple repeater. The real trick is selecting everything else around the repeater. Here are some tips to keep things working smoothly:

- Look for a good place to put your repeater. The higher up the antenna is, the better effective range it will have. Consider using base antennas for repeaters.
- Try using a base transceiver to transmit. The extra power can come in extremely helpful, but recall that you need 4x the power to go an additional length of range, so this can quickly get to diminishing returns.
- Consider power needs. If you repeater is being used a lot, it will chew through batteries pretty quickly. Connecting to a constant source of power will be very helpful.

information to share between these modes. This role is critical.

Having signals intelligence on site and within radio range works ok, but often times it is better to have them off site and away from the action, connecting with people through VOIP. Additionally, scouts can move far beyond radio range, relying on some form of VOIP for communication. This poses an issue: how do we effectively connect VOIP and radio solutions?

The Baofeng family of radios have a feature that makes this kind of connection easy. Option 4 on your radio is a feature called VOX (Voice Operated eXchange) that has sensitivity rating of 1 through 10. It will bypass the PTT and automatically begin transmitting once it hears noise when on, with 1 being the most sensitive and 10 being the least sensitive. We can use this to automatically link up with any VOIP devices to allow them to both receive and transmit.

There is a special cable called an APRS cable out there that fits into both a Baofeng and your phone's aux jack (see the BTECH APRS-K1 Cable). If you connect these two and configure your VOIP platform correctly, you can enable two way communications easily. You should note that this will drain battery quite quickly though, and you should come with battery backups for both your phone and the radio if they are transmitting a lot. We have also found that the patching setup works best when hosted in a blocker car or other stable platform.

The APRS cable also has use for digital communication modes, which we will discuss in section 4.5 Packet Radio.

It might take some experimentation to figure out the best settings for this connection, but it is an invaluable tool for connecting off-site signals intelligence teams to the boots on the ground. Having a skilled signals intelligence team is another whole topic, but one that can make the difference between success and failure. With this connection though, we hope others can start to build these skills through practice.

inexpensive and distributed model not dependent on external network infrastructure, and it doesn't require you to bring a phone when using it. (The difference between VHF, UHF, and other radio is not particularly relevant here, but a deeper discussion is available in section 4.1) Some radio setups are very powerful on their own, but additionally: infrastructure for more powerful communications is available and can be constructed ourselves. We don't need to rely on outside forces for our communications needs: especially in the case of a blackout or natural disaster.

There is a reason that a lot of organizations use radio communications, and building these skills can help us in all kinds of ways beyond our immediate actions. For example, the spot report (aka SALUTE, as detailed in section 3.6) is a very important skill to build for information sharing. There was a lot of bad information going around at the beginning of the George Floyd uprising, and spreading SALUTE as an expectation helped cut down on a lot of bad reporting.

Ultimately, radio works best when it's used as a quick information sharing platform. It is not a silver bullet.

Downsides to Radio

Like any platform or mode of communication, radio isn't a perfect answer to every question. There are places where it doesn't quite fit in and you might be better off with something else.

First, consider your communication requirements. Should it be synchronous (real time, which is a strength for radio)? Does there need to be a record of communication (not something radio can easily provide without a recorder)? Depending on your answers, a text based solution may be a better fit.

Second, consider the kind of buy-in your group may need, and if they are responsible enough to provide upkeep. Maybe not everybody needs a radio, but it's worth thinking about who does need one ahead of time. We have found that individuals having their own personal

1 Why Use Radio?

radios generally works better than group sharing, but there are a few exceptions. Everybody needs to remember to bring and charge their radios, and to get the necessary programming done ahead of time.

Radios require a certain level of responsibility from their users. Accidentally pressing the talk button, talking over others, or spreading inaccurate or alarmist information can be an issue with any kind of synchronous communication, but can be particularly bad with the kind of power radio gives you. Only one person can talk at once on a channel, and the kinds of information we should be sharing on the radio takes a level of discipline from its users. This really only develops through practice.

Anybody can transmit or receive radio signals. Encryption on radios is technically possible, but often difficult in practice unless you have very expensive radios that do that. It is important to threat model your communications as in section 1.3 to see if the trade offs for encrypted synchronous communications are right for you. We have found that with the kind of information we are sharing over radio, encryption is a taxing step for a mass organization. While it is often a bad idea to solely rely on security through obscurity (hiding instead of using encryption), it can sometimes be helpful in the case of specialized equipment like VHF radios.

Like cell phones (which are technically radios!), any device emitting radio signals can be triangulated when transmitting. This is unavoidable, but unlike cell phones, radios are not constantly transmitting.

Finally, be aware of local regulations regarding the use of amateur radio. The short wave radio (HF) community in particular has a reputation of strict rules following. You may not wish to upset them - especially if you are transmitting from a stationary position. Finding rules breakers is a tradition called fox hunting, and isn't something you want to test. For more on the specifics of how radios function, see section 4.1.

4.3 Multi Mode Communications and Patching

have a charged radio ready to go and set to a channel or frequency with no transmissions or interference, and open the software up.

First, we need to download the radio's image as it stands in case we need a backup. Go to the "Radio" menu up top, and select "Download From Radio". Pick your model of radio and follow the instructions on screen. This step is critical.

Once your radio's data is uploaded to the computer, check the "Settings" tab, and go to "Other Settings". Look at the number in "Firmware Message 2", and find the image file we have whose "Firmware Message 2" setting matches that of the radio you have.

Once you've found it, keep that image up and go back to the "Radio" menu up top, and select "Upload to Radio". Follow the instructions on screen. Once it is finished, your radio should restart, programmed and ready to go.

Designing these images is important information, but beyond the scope of this document. If you choose to modify your radio image from our presets, know that there are lots of settings that can make your radio function strangely and not play well with others. It's important to let others know what kinds of changes you've made to your local expert to be sure things work smoothly.

4.3 Multi Mode Communications and Patching

As we discussed in chapter 1, radio is not a perfect solution to all of your communication needs. In fact, it is absolutely critical that our information comes through multiple different kinds of communication avenues in order to maximize our efficiency. If your communications network is well designed, these will mesh seamlessly.

When transferring information from asynchronous to synchronous kinds of communication (or vice versa), we have found that using an operator as part of a signals intelligence (sigint) team works well - someone whose only job is to transcribe and read important bits of

likely to be interrupted by electrical equipment, atmospheric noise, and other types of interference. They generally aren't great for indoors however.

UHF Ultra High Frequency (between 300 megahertz and 3000 megahertz) channels include FRS, GMRS, UHF Business band, and the 70 cm band. They work mostly on line of sight, but are better for confined spaces. In confined spaces such as buildings, a higher frequency (smaller wavelength) signal is more likely to fit in the confined space and not induce dead zones.

On a Baofeng radio, we can see which band a channel is on by displaying the frequency on options 21 for the A display or 22 for the B display. Otherwise, it's generally pretty easy to check the frequency of named channels by searching for them online.

Hopefully this section explains some of the stranger aspects of radio transmission.

4.2 Programming a Baofeng Radio

One reason we suggest the Baofeng family of radios so often is how flexible and programmable they are. To this effect, we have created a custom image file to help take full advantage of its power. Flashing any hardware is always a tricky process however, and we need to be careful when we do it. If you need help, we suggest checking out <https://www.miklor.com/> or watching tutorials on youtube. We will give a brief overview of the process here however.

Start by acquiring a programming cable and the latest version of the software CHIRP from <http://chirp.danplanet.com>. If you get a cheaper programming cable, you may have to play around with driver software on your computer, so we recommend getting a genuine BTECH PC03 cable. Once you have these things, make sure you

1.3 Towards a Threat Model

Benefits and drawbacks are good to think about, but are only really put into context when we know more about the details of how they are implemented and what threats we face. Threat modeling is a process by which potential threats can be identified, enumerated, and prioritized. You can use it in all kinds of contexts. We talk a lot more about it in our WDA training “Infosec 101: Information Security and Threat Modeling”, but we'll go over the process briefly here:

1. Have your prospective plan ready. If you're not sure where to start, just pick something. You will iterate on it at the end.
2. Consider what it is you're trying to protect. Generally we're talking about information when it comes to radio use, but even that can come from different places. List them out.
3. List your reasonable attackers. It's easy to go down the rabbit hole with state actors, so look at previous engagements and how they've played out for a baseline.
4. Diagram out all the ways to attack the information that will be out there. You can use things like attack trees for a more formal approach, but if you're not familiar with them, experiment with what diagrams works for you.
5. Apply the attackers listed in the third step to the diagram you just made. Do they have the resources and know-how to make those attacks? Do those attacks make sense with your attackers goals and politics?
6. Consider the inherent risks and payoffs to your plan. Is your security at the appropriate level for the threats you realistically face? Is it possible to tighten or loosen your operations for more effective action?

1 Why Use Radio?

7. Now iterate on it or change up your plan. Compare and contrast different plans for a better look at how things could potentially be done differently.

Obviously this is a very nuanced topic and can be iterated on endlessly. For a more in depth consideration and more on attack tree diagramming, please consider taking the Workers Defense Alliance “Infosec 101: Information Security and Threat Modeling” training. With the ability to systematically analyse threats, we hope your ability to pick and execute plans keeps you on the right path.

1.4 Communication Networks and Alternatives

Networks and Backups

As we’ve seen, communication is a complex process with benefits and downsides to doing it in different ways. The most effective forms of communication take full advantage of these aspects and build on them in different ways. One way that radios (and in particular radios that can listen in on multiple channels at once) can build on their strengths is by using different channels for different kinds of communication.

Building a radio network of communication takes a fair bit of planning, and a dash of trial and error. Consider the different needs your teams might have, their overlap, and how active they may or may not be. It is often helpful to have one very large “action channel” for interoperation, and to keep chatter and low-level communication to side channels with dual watch (see Figure 2.5).

You might also consider a repeater (see section 4.4) - if not, be sure your frequency isn’t going to set one off somewhere! Check <https://www.repeaterbook.com/> for a list of repeaters in your area.

Not every action demands the same network structure, and it’s important to think deeply about what might make a plan work or not. How many channels do you need? Do you have other equipment

4.1 The Electromagnetic Spectrum and Radio

aircraft radio. It has a lot less bandwidth available, and thus lower fidelity. Almost all radio applications these days is Frequency Modulation, and for good reason. We can define as much bandwidth as we want for fidelity in FM, and we can be transmitting at full power all the time. On our Baofeng radios, we can even see if we are transmitting on a “narrow band” as opposed to “wide band” if we see an N in the top of our display. Most channels are narrow band, but we can also access a wide or narrow bandwidth in the options menu.

Like light, radio waves can slightly bend or reflect off of objects. Radio waves are often much better at passing through most solid objects than visible light is, but this isn’t true for all objects. For other physics reasons, certain frequencies work better for passing through items or reflecting off items than others. Generally speaking, the higher the frequency, the more likely the signal is going to be blocked by dense objects.

The analogy of light also helps explain the phenomenon of antenna height. The higher an antenna is, the better signals can reach people trying to listen in - the same way a street light up high is better for illuminating an area.

There are three main sections of the radio portion of the spectrum that are important for our purposes here: HF, VHF, and UHF:

HF High Frequency (between 3 and 30 megahertz) signals have the special ability to reflect off of a layer of earth’s atmosphere (the ionosphere) on the low end of these frequencies - this is how ham radio can reach people on the other side of the earth. Handheld Baofengs can’t transmit on frequencies this low, but it’s important to note how effective they can be here. CB radio is also a form of HF radio, around 27 megahertz.

VHF Very High Frequency (between 30 to 300 megahertz) channels include MURS, VHF Business Band, Marine Band, and the 1.25 M and 2 M bands. These work best outdoors and are less

where the wavelength is in meters, and the frequency is in megahertz (or MHz). As you can see in Figure 4.1, the Electromagnetic Spectrum also includes visible light (at a much higher frequency than radio waves). For many of us, the analogy of visible light can work well in determining how effective radio transmissions can be. We will be using it here to make some simple analogies.

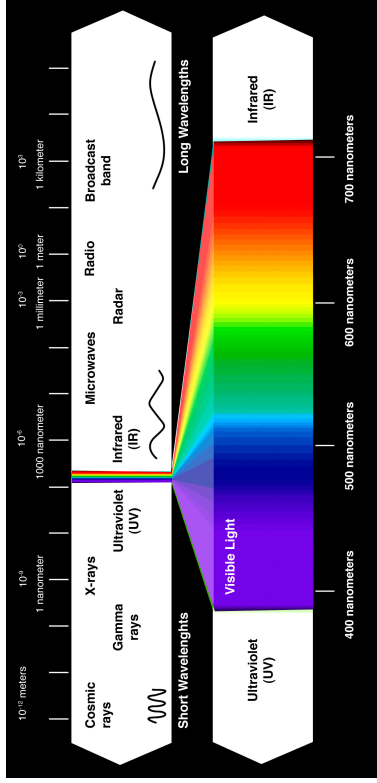


Figure 4.1: The Electromagnetic Spectrum

Transmitting Signals

So now that we know what a radio wave IS, let's talk about how we use them to transmit signals. There are two general ways that we can use radio waves to transmit a varying signal: by either modifying the amplitude of the wave (AM), or by modifying the frequency of the wave (FM). This is about equivalent if we were sending light signals to varying either the amount of light we're putting out (AM) or shifting the color of the light (FM) to correspond to differences in the audio signal.

Amplitude Modulation is an older technology not used much anymore outside of the traditional AM radio you may know, and for

available like vehicles? Do you have enough people who can fix things when radios aren't working right?

Zooming out to see the bigger picture, we also need to begin thinking about backup plans. We need to be ready in case things don't go our way on multiple levels, as according to our threat model. The acronym PACE provides a good framework:

Primary	This is our first choice in communications. A good example would be the initial channel selected for communications.
Alternate	This is what we do if the first plan isn't working out. It isn't necessarily a change in approach, but rather another path around. This would generally entail shifting to a different predetermined channel in our case.
Contingency	This indicates that something might be structurally wrong with our approach. Contingency may mean selecting a different frequency band (VHF to UHF or vice versa), or perhaps a move to asynchronous or encrypted communications.
Emergency	An emergency plan is our last resort. For a communication network, this might mean runners and face to face communication only.

Like threat modeling, you can apply PACE to all kinds of different aspects of planning. The different plans you choose will definitely be affected by your threat model, so it's important to keep that in mind. If you are further interested in how different kinds of communication platforms can connect with radios, see our advanced topics chapter in section 4.3, where we go over how to make these platforms play nicely.

Alternatives to Radio

Finally, we think it's important to touch briefly on other kinds of synchronous voice communications, which all broadly fall under the category of VOIP (Voice Over Internet Protocol). This includes programs like Signal, Discord, Mumble, Zello, and others. These all have various levels of accessibility, encryption, features, battery usage, and more between them.

The main point to note is that they all generally require use of a cell phone, which is a very important point to threat model from both a surveillance and security standpoint. The obvious benefit is that so long as you have cell phone infrastructure, you can communicate over distances that would require incredible radio power or repeaters to reach. This makes VOIP a tempting proposition for scouts and offsite signals intelligence, and rightfully so.

If you intend to use a burner phone, it is important to recognize how strict your behavior must be to separate the burner from your real life. It requires a tremendous amount of discipline and is not a plug and play solution. There are good guides about this online already, which we will link in section 5.2.

Like all software, picking a platform that is actively being developed and is open source is always a good idea. If you are choosing between apps, it's also important to either choose one that has end-to-end encryption (such as Signal), or one that can be hosted on a trusted server with TLS encryption (such as Mumble). Discord is less than ideal, as it is hosted on a large central server in reality. However, Discord and other platforms may be useful tools for people already familiar with those platforms, all depending on your threat model.

Zello has made its way into the well-intentioned activist world, but please avoid it at all costs. They openly brag about their good relationship with law enforcement and real time tracking capabilities. All conversations are advertised as permanently recorded on their central server, with playback and analytics freely available. Again,

4 Selected Advanced Topics

This chapter is going to be a little different. It's not written with the common user as the intended audience, but rather intermediate operators interested in radio and seeking to advance their technical knowledge and skills. None of these topics are covered in particular depth, and we would expect and encourage intermediate readers to continue their education elsewhere about them.

If this doesn't describe you, feel free to skim this chapter or use it as reference material. Don't worry if you don't understand these sections - they are not critical information for most users.

4.1 The Electromagnetic Spectrum and Radio

Physical Properties

So far in this booklet we have avoided the topic of electromagnetic radiation, but there are a few physics based concepts that are important to understand to figure out how radios actually work.

Radio waves are just the name for one part of the electromagnetic spectrum: a range of frequencies, wavelengths, and energies of photons. All of these terms are fundamentally equivalent ways of viewing the same principles, but in radio we often talk in frequency or wavelength of signals. For our purposes (not exact), we can define this relationship as Equation 4.1:

$$\text{wavelength} = \frac{300}{\text{frequency}} \quad (4.1)$$

so practice when you can. Reading license plates is a great way to test your skills. Even just practicing once a day will make a big difference when you need it.

Characters beyond the standard 26 letters and 10 numerals of English often have their own acrophonics specific to their region and use case. They are largely not as standardized as the International Spelling Alphabet.

Finally, please note that there is one additional official alphabet you may run into, especially in the field of cryptography. The PGP wordlist is an alternative biometric word list for reading hexadecimal data out loud. If this is something that you may foresee yourself having to read over the radio, please refer to other sources for the complete list as it is 512 words long.

this isn't even just a theoretical possibility - these are advertised features. The theoretical possibilities are much worse.

These threat modeling implications could be discussed for pages and pages, but we'll end with this: it is important to threat model your communication network, and build competence with tools beforehand. The best networks don't all use one tool for everything, and finding a good balance between different mediums is key to effective communications.

2 Basic Radio Equipment

2.1 Transceivers

Handheld Transceivers

Many stores sell walkie-talkies for cheap, often advertised with hyper-inflated range estimations and the lure of “privacy codes” to protect your information (or advertised as some sort of extra channel equivalent). We generally don’t recommend them, as these promises often fall extremely short. The range estimations are the theoretical max with the given power output and antenna, which are both severely limited in practice. “Privacy Codes” are in reality just about the opposite of what they are advertised as, more like selective listening devices. Additionally, they are often locked to one band of the radio spectrum (VHF or UHF), and do not have some of the important features we use such as dual watch. We do not recommend purchasing or using off the shelf walkie-talkies for these reasons and more. (If you already have them however, know that they are generally accessible on our recommended radios on the FRS and GMRS channels.)

The radios we recommend for beginner use are a family of radios called Baofeng (pronounced like POW-fung, with the first letter being halfway between B and P). They are incredibly cheap, powerful, programmable, and have tons of aftermarket support. They are a pretty popular brand for people looking to get into radio as a hobby, and it’s hard to argue with the price point. They may not be the most durable or highest quality radios, but it’s very easy to spread them around or go purchase a new one if yours breaks or gets lost.

3.7 The Spelling Alphabet

The International Spelling Alphabet (also known as the IRSA, NATO, and IRCO phonetic alphabets) is the most widely used spelling alphabet. It uses words to substitute for English letters (called acrophonics) in order to make spelling things easier, especially when clarity in transmission might be an issue.

This alphabet was designed to be easily understood by people whose first language is not English. These words have specific pronunciations in order to make them more understandable, and some may seem “misspelled” in order to emphasize the pronunciation required. Numerals also have specific non-standard pronunciations for this reason.

If you can’t remember a particular word, making one up on the spot is ok (such as b for boy), but using the official word ensures that characters are interpreted correctly. The official list is as follows in Table 3.4.

A	Alfa	H	Hotel	O	Oscar	V	Victor
B	Bravo	I	India	P	Papa	W	Whiskey
C	Charlie	J	Juliett	Q	Quebec	X	X-Ray
D	Delta	K	Kilo	R	Romeo	Y	Yankee
E	Echo	L	Lima	S	Sierra	Z	Zulu
F	Foxtrot	M	Mike	T	Tango		
G	Golf	N	November	U	Uniform		

1	WUN	4	FO-wer	7	SEV-en	0	ZEE-ro
2	TOO	5	FIFE	8	AIT	.	Decimal
3	TREE	6	SIX	9	NINE-er		

Table 3.4: The International Spelling Alphabet

At some point, you will almost certainly have to use this alphabet,

preventing the spread of misperceptions driven by people operating at inappropriate color codes. Ultimately, the “Why” should be the interpretation of the entire report.

Let’s look at some examples. Here’s a more formal and ordered spot report:

10 individuals (S) were seen taking pictures of buildings on the north side of Franklin Avenue (A), near the intersection of Franklin Avenue and Stevens Avenue (L). They appear to be boogie boys based on their hawaiian shirts and open carry (U), seen at 23:18/11:18pm (T), and were wearing body armor and carrying assault rifles (E).

Not every report on the ground is going to be like this though. Letters may come out of order, and information might be less specific than we would like. Here’s a more realistic spot report:

I just (T) saw 2 guys (S) driving east down lake street (A) at midtown global market (L) in a red pickup truck (E). They had a confederate flag decal (U) in the back window. Someone else here told me they were yelling “white power”, but I didn’t hear that.

Remember, you can always ask the person for followup information. If possible over whatever medium you are using, feel free to include photo or video with your report as well. If you’re not using radio, don’t forget to include things such as your call sign and intended audience that would be part of a regular call.

Spot reports are one of the best tools for stopping disinformation from spreading, and are very important for communication in any medium. The more that radicals use them, the more normal spot reports will become. The more normal they become, the less panic we will allow to spread through our networks.



Figure 2.1: Baofeng Radios

Like many electronics created in the Chinese IP framework of Gongkai, there are many different manufacturers of the most popular Baofeng radio, the UV-5R, many of whom put their own spin on the product. Be aware that we cannot guarantee the reliability of any of these specialty versions, nor the ability to program them the same as standard ones. The official Baofeng company no longer manufactures the UV-5R themselves, so we encourage you to go for a more standard looking radio. Finally, it’s important to note that the official US distributor of Baofeng products is named Baofeng Tech (BTECH), and purchasing from them is often a good way to know you’re getting a more reliable radio or accessory.

So let’s look at a few of the most popular Baofeng transceivers (shown in Figure 2.1), so we can see the differences between them:

UV-5R The UV-5R is the old standard Baofeng radio. They can be had for 20-25 USD (on Amazon or directly from

BTECH), can transmit at 5 watts power, and have an incredible amount of customizability for the money. They really can't be beat for the price, and they're the one we generally recommend for field use.

BF-F8HP

The BF-F8HP is the new standard for Baofeng radios. They can transmit at 8 watts power, come with a larger battery, and have a few extra features not found on the UV-5R. The downside is that it's more than twice the price at around 70 USD, and all that extra power only translates to about 30% more effective range. If you're looking for a nicer radio for yourself it might be worth considering, but please note that you could purchase nearly 3 UV-5Rs for the price.

UV-5X3

The last radio that might be worth taking a look at is the UV-5X3, a BTECH branded 5 watt radio in the "tri-band" category. What does this mean? There is a small number of frequencies in the 219-225 MHz range that this radio can use and most other radios cannot. You will need a special antenna as well, but if you are wanting more security through obscurity, this may be worth considering. One last feature worth noting is that you can do certain things on this radio itself that the others require a computer programming them to do - such as altering repeater offsets and CTCSS tones on channels, or altering scanning patterns. If you are a more advanced radio operator who understands and wants these things, it may be worth looking into. It is also about 70 USD though, so like the BF-F8HP it does come at a hefty cost.

All of this said, there are also higher quality brands of handheld transceivers out there as well. Icom, Yaesu, and Kenwood are all fantastic names that will serve you well, but be aware that these

any kind of communication, we should always be thinking about our platform, intended audience, and threat model.

Spot reports should seek to answer the 6 W's (Who, What, When, Where, how, and Why) in a concise manner. They distinguish facts from opinions, and help set the tone for the reporting of others. If you're getting information second hand, that also needs to be reported. The easiest way to remember how to do a spot report is the acronym SALUTE:

Size	How many people do you see? If it's a large group, estimate in reasonable increments.
Activity	What are they doing? Are they moving - and if so, in what direction? Are they setting up equipment? Standing around?
Location	Where are they? Describe their position as accurately as possible. Consider street signs, cardinal directions, landmarks, and more.
Unit	Who are they and how would you describe them? Do you see any identifying markings? Are they Law Enforcement Officers? Militia members? White supremacists? What are they wearing?
Time	When was this? Make note of the time of the sighting and communicate that. This is especially important when done in asynchronous communication as to not confuse the time the message was sent with the time of the event.
Equipment	Do the individuals you see possess any identifiable equipment? Photography/surveillance tools? Weapons? Riot gear or body armor? Vehicles?

You may notice that "Why" isn't exactly included in the acronym. This is because we are trying to distinguish facts from opinions,

Waterfall: Pinecone One please meet me at the big park statue, over

Pinecone One: Wilco, over

Waterfall: Waterfall out.

See how all of the steps were met? Let's try a less formal example:

Waterfall: Waterfall to Pinecone One [roger beep]

Pinecone One: Pinecone One, over

Waterfall: Meet up at the statue [roger beep]

Pinecone One: Wilco, over

Waterfall: Waterfall out [roger beep]

Some of these procedure words are different, but all of the steps were still there. Calling will take some getting used to, but it is much easier for new radio users when they hear others using it too. Calling is a critical tool that radio operators should be using all the time to combat miscommunication.

3.6 Spot Reports and SALUTE

So let's say you have just witnessed an important event or saw a dangerous group of people that you need to warn comrades about. How would we go about doing this? This was a common communication issue we saw throughout the uprising. The tool we need is called the spot report, also known as SALUTE.

A spot report is a special kind of report for things that might have an immediate and significant effect on planning and operations - especially the presence and movement of adversaries. Spot reports are concise, clear, and direct for ease of transmission over radio (though they can be adapted for just about any communication medium). Like

will all push to nearly the 200 USD range. They also might not be compatible with Baofeng accessories and programming setups, so we would encourage you to do your research if you are interested in taking the next step.

Vehicle and Base Transceivers

As one may have guessed from the "handheld" title, there are larger and more powerful kinds of transceivers out there as well. These either run on car power or wall power, and can easily put out 10x the power of a handheld transceiver. If you're looking for a more permanent vehicle mounting or base solution, the TYT TH-9800 is an excellent unit for a more professional radio operator. Otherwise the BTECH UV-50X2 is a quick and powerful choice with the ability to watch 4 channels at once. Each of these is about 200 USD though, and they're going to require a decent amount of work to get going correctly.

2.2 Radio Accessories

One of the reasons that the Baofeng family of radios is so popular is that there are many different accessories available for them. As a brief note, Baofeng accessories are often significantly cheaper when purchased in bulk, so collect a few friends and save a lot of money. The accessories themselves generally fall into 3 different categories: Antennas, Microphones/Earpieces, and Batteries.

Antenna

There are lots of different types of antennas out there, and upgrading the default antenna on your Baofeng is a great way to extend your effective range. Not all are made equally though, and many are manufactured for specific use cases. There's a lot that goes into

antenna design and build, and it's important to not cheap out - pick one designed for your purpose and band. Some styles you might see include:

- Stubby and Rubber Duck antennas like the type that come with Baofengs are nice for maneuverability, but often come with a cost in lost range. Never use a radio without an antenna, as it may damage the internal components - hard plastic stubby antenna are as small as you can go.
- Longer Whip and Foldable antenna are the better all purpose antenna choice. Their length give them much better reception and they will improve your range significantly.
- Retractable antenna are interesting, but are easy to accidentally damage. It's also important to extend them all the way before transmitting, as trying to talk while retracted may damage your radio. They can be helpful in certain situations.
- Wearable antenna like the Disco32 and CAATail antenna are highly flexible and insulated. They are meant to weave through clothing or PALS webbing on gear. They are fantastic for keeping things low profile, but you do miss some of the height you get from a traditional whip.
- Base antenna are essentially larger versions of antenna, meant to be put in a static positions. They will often come in multiple parts to ease installation and reception.
- Vehicle antennas can be magnetically mounted or permanently installed. There are a few lower-profile options, but often times you will see a smaller base antenna installed directly on vehicles. It's important have your antenna outside of your vehicle, as the metal surrounding you will make receiving signals much more

Handshake

A Handshake is the recipient responding. They do this to let you know that they are actively listening to the channel, and are ready to receive a transmission. They will respond with something like:

Pinecone One: This is Pinecone One, go ahead Waterfall, over.

If they are not available, they will instead respond with something like:

Pinecone One: This is Pinecone One, standby Waterfall, over.

If they are expecting to hold for an extended period of time, they will say out instead of over. This lets others know that the channel is clear for them to use and that the recipient will call the other party back when they are available. This is one of the few cases where out is used by someone who is not the initiator.

Message(s) and Termination

This is the simplest and best understood section of a call. Here is where the actual conversation takes place. Be sure to use the proword over to indicate you are done speaking and are awaiting a response. If you originated the call and do not expect a response, use the proword out instead. It is generally bad practice to use out if you did not originate the call.

For an example of a complete conversation, consider this:

Waterfall: Pinecone One, Pinecone One, this is Waterfall, come in, over
Pinecone One: Waterfall this is Pinecone One, go ahead, over

3.5 Calling

If you're just talking with a few friends you already know, it's not super important that you formalize your communication. However, if you're in a group larger than a dozen or so people, things can get very messy very quickly. We can avoid this by using a procedure named calling.

Calling is comprised of a few distinct steps:

1. Addressing
2. Handshake
3. Message(s)
4. Call Termination

Let's break it down:

Addressing

Addressing is how we let someone know that we are trying to reach them specifically. By addressing something to them, we are asking them to respond so that we know they are listening. To do this, we say something like this:

Waterfall: Pinecone One, Pinecone One, this is Waterfall, come in, over.

Notice that we are saying our recipient's call sign twice, and then identifying ourselves. This is to make it clear to our intended recipient and to everyone else listening on the channel who this call is for. As noted in section 3.2, never respond to a call that you aren't sure is for you.

difficult. Connecting your transceiver to an outside antenna will make a big difference.

- Directional antennas (parabolic, Yagi, etc.) are very helpful for specific use cases, but significantly less useful in dynamic situations like street actions. For stationary base receivers however, they can become very powerful tools.

This is only an overview of antennas, as there is an incredible amount to learn. If you're looking for a quick answer, we suggest upgrading from the stock Baofeng antenna to the Nagoya NA-771 (make sure to purchase from a reputable vendor like BTECH, as fakes are common online). Anything beyond that will be dependent on your role and situation.

Microphones and Earpieces

There are a bunch of ways you can bring your communications away from your handheld and up to you. What works best for you will often down to personal preference and the role you find yourself in. Feel free to try out a comrade's gear, and don't be afraid to switch it up. As a warning however, know that especially low quality microphones are vulnerable to feedback, so make sure to see if yours will cause that beforehand and cover the mic with your hand if they do. Here are a few of the more common types of equipment you might want to look at:

- Shoulder Mics are pretty common bits of equipment in a lot of different industries and come standard with most base and vehicle transceivers. They have a combination speaker and microphone that clips on to your clothes. They're pretty robust and work well in overt scenarios. On the downside, the audio from them is pretty loud and can alert others nearby. Some also have auxillary out for use with headsets to clamp down on

this however, so it might be possible to mitigate this depending on your other gear.

- Covert Earpieces are the classic see-through bodyguard accessory. They work very well in a broad variety of scenarios, are low profile, and keep your broadcasts private. They usually come with a few varieties of earpiece ends that allow different levels of ambient noise through, but different kinds (including custom molded ones) can also be purchased separately. We highly recommend them.
- Headsets are the traditional ear cups with a microphone in front. They're especially comfortable if you get a good pair and keep noise isolated - which is helpful if you're in a loud situation. They work particularly well for vehicle drivers and off site people. They are incredibly overt and can be harmful for your situational awareness though, so they are a tradeoff. Very nice ones for aircraft and the like can be very expensive too, so don't go overboard.
- Throat Mics are a special kind of microphone that works by pressing resonators up against your throat (think like a stethoscope). They usually come in combination with either a covert earpiece or auxiliary out to headphones for the audio. They are extremely helpful for keeping your transmissions free of external noise like wind or crowds. Another benefit is that they can pick up even the slightest whisper, which is helpful for if you're trying to keep things quiet. They can also be used with respirators or other full face masks. As a downside however, they're not particularly comfortable and can be expensive if you want a good one.
- Finally, it's important to note that you can always just use the jacks on your radio like auxiliary jacks to use whatever speakers

Emergency Term	Meaning
Break Break Break	You are interrupting in the middle of someone else's communication because you have a general emergency call to make. e.g. wait for an "over" then say "BREAK, BREAK, BREAK, [your call sign], I have an emergency message for [recipient's call sign], Do you copy, Over".
Sécurité, Sécurité, Sécurité	This is a call to alert people to a moderate safety warning. It also has priority over regular calls. Use good judgement when calling with it.
Mayday, Mayday, Mayday	This is a distress call used only in a life or death emergency. DO NOT USE THIS LIGHTLY. Emergency medical teams will be alerted.
Contact [direction]	There is a current altercation or fight with the risk of serious bodily harm or death. Usually refers to a gunfight. DO NOT USE THIS LIGHTLY. Armed security may draw their weapons in response.

Table 3.3: Emergency Procedure Words

This list is by no means exhaustive and there are many, many more prowords that we have not brought up here. Some are very specific to different use cases, some are very rare, and some may be overly formal for our use. If you hear what you suspect is a proword you are unfamiliar with, don't forget that you can always ask.

and microphones you might already own. In the case of vehicles and sound systems, this might be something to consider.

There’s no right or wrong answer here, and we encourage people to try these things out for themselves.

Batteries

The batteries on a radio will last you a very long time, especially if you are not transmitting very often. One of the authors has had a radio last for over 14 hours of use in the field. That said, if you talk a lot, your batteries will die.

The basic UV-5R battery is only 1800mAh, but bigger batteries do exist. The BF-F8HP ships with a slightly larger 2100mAh battery that is also compatible with the UV-5R, which is nice to go along with the extended power output of that model. There are also extra long 3800 mAh batteries available, but it’s critical to order directly from BTECH as many no-name brand batteries out there are fake. It’s also important to note that not all extended batteries work with the BF-F8HP, so double check before purchasing if you have a BF-F8HP.

Store spare batteries in a waterproof container to reduce risk of moisture damage. Lithium batteries can lose capacity when cold. If you are operating in cold temps, consider putting your radio inside a wool sock with a hand-warmer, or in the inside pocket of a jacket to keep them warm.

Beyond the rechargeable lithium batteries, there are also adapters for your vehicle’s lighter socket or USB charging, and adapters that allow your radio to run on AA batteries.

Having a backup battery is important if you think you’re going to be out and about for a long time. If not for you, then for a friend who might need one.

General Term	Alternate Term	Meaning
Wilco	Rodger Rodger	Means “I will comply”. Automatically implies “copy”.
Say Again	10-9	This is asking the other party to re-transmit their message.
Repeat	I Say Again	Used before you repeat something. e.g. “I require two gallons, repeat two gallons of water, over.”
En Route	Oscar Mike, 10-8	Indicates moving to a new position.
Location	20, 10-20, QTH	Used as either giving your location or asking for someone else’s.
Over	[roger beep]	Your message is finished. Also indicated by a beep on some radios.
Out	73	All conversation is finished, the channel is clear for others to use. Automatically implies “over”.

Table 3.2: Common Procedure Words pt.2

Finally, there are 4 different kinds of emergency calls you can make. They don’t have alternative terms. Use all of these with extreme caution, as they may come with serious repercussions.

Pouches

As a final note on accessories, consider a radio pouch for storage. There are dedicated pouches you can buy, but an army surplus m4 double magazine pouch is incredibly cheap and happens to fit a radio with an extended battery quite well. This will allow you to attach it to anything with PALS webbing (also known as MOLLE), and is much sturdier than the default belt clip.

A pouch also has the added benefit of shielding your radio's screen from prying eyes. If you choose to not use a pouch, you could also use electrical tape or a cut bit of a privacy screen film for monitors for the same effect.

2.3 Baofeng Buttons and Settings

The Baofeng UV-5R is a very popular and very powerful handheld radio capable of operating on many different frequencies and bands. This is the radio we recommend. However, one of the most common complaints about it from people new to radio is that it's very complicated to use. Here are some of the most common functions you'll become familiar with:

- Power/Volume Knob: The power and volume knob is on top of the radio, across from the antenna (see 7 in Figure 2.2). Be sure to keep your radio at a volume you can hear, but be aware that others might be listening too! Consider using an earpiece if you're trying to keep things quiet.
- Push to Talk (PTT): The PTT is the large button on the left side of the radio, in the middle between moni and call (see 2 in Figure 2.2). This is the button you want to press to transmit a signal. Hold it down until you are done talking.

General Term	Alternate Term	Meaning
Radio Check	QRK	Can you hear and understand me? Be sure to call someone specific.
Read Loud and Clear	5 by 5, 10-2	Response to "Radio Check" - transmission signal is good.
Signal Unreadable	10-1	Response to "Radio Check" - transmission signal is not readable.
Come in	Calling, - to -	Asking the other party to acknowledge they hear the call for them. See section 3.5 for more.
Go Ahead	[Your Call Sign]	Ready to receive transmission.
Stand-by	10-6, QRX	Acknowledging the other party, but are unable to respond immediately.
Affirmative	Yes, Correct	Same as "Yes". Avoid "yup" or "nope" as they are difficult to hear.
Negative	No	Same as "No". Avoid "yup" or "nope" as they are difficult to hear.
Verify	4-10, QSL	Asking to verify if something is correct.
Copy	Rodger, QSL	Message received and understood.

Table 3.1: Common Procedure Words pt.1

memorize and use the general terms, though you may occasionally hear an alternate term with the same meaning. While this is not an exhaustive list, it includes prowords and slang terms from many different areas where radio use is common. Like all things, the more we practice, the better we understand these terms.

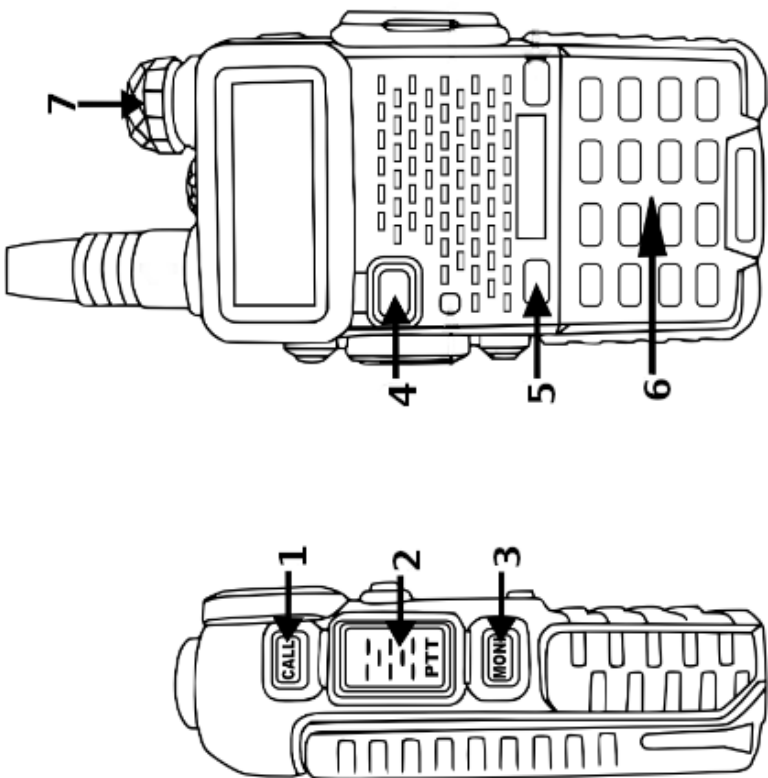


Figure 2.2: A cutout diagram of the UV-5R

- **Moni:** Push this button below PTT to cycle through the flashlight settings - on, strobe, and off (see 3 in Figure 2.2). You can also hold moni to listen to the unfiltered signal on whatever channel you are on - this is helpful if you're trying to listen to weak signals.
- **Call:** Push this orange button above the PTT to access FM radio (see 1 in Figure 2.2). Any FM broadcast will be interrupted by signals on your frequency. Hold call to activate the alarm function. Press it again to turn the alarm off.
- **Keypad Lock:** Press and hold the # key in the bottom right of the number pad (see 6 in Figure 2.2) to lock or unlock the radio. While your radio is locked, you won't be able to press any of the buttons on the front, either accidentally or on purpose.
- **Changing Channels:** Use the up and down arrow buttons at the top of the keypad (see 6 in Figure 2.2) to scroll through channels while in channel mode. This will scroll through the slot numbers to the right of the channel's name. You can also skip to whatever 3 digit slot number you want with the keypad by starting with 0 or 1. You can also use the keypad to input frequencies while in frequency mode.
- **A/B:** This button (see 6 in Figure 2.2) will switch between the upper and lower channel or frequency display. The little triangle will indicate which one you're on. This is handy if you are working on more than one channel, and will allow you to move between them easily.
- **Menu:** This button will bring you to your radio's options menu (see 6 in Figure 2.2). Scroll through the option slots with the arrows, or just type in the number with the keypad to go to that option slot number. Pressing option again will go one step in,

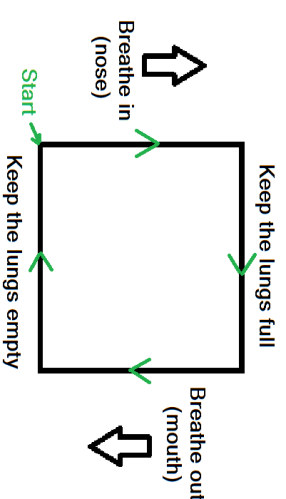


Figure 3.1: Box Breathing Flowchart

3. Exhale for 4 seconds through the mouth.
4. Hold for 4 seconds.
5. Repeat until you feel readjusted.

Try practicing this throughout your day to develop it as a habit. Take a moment to assess yourself. What color are you right now? Practice box breathing for a minute or two, and reassess. Like anything, making this check in, grounding, and reassessment a part of your daily routine will help you practice it well under duress.

Box breathing is an effective technique when used correctly, but it is by no means the only method of controlled breathing or mindfulness. Whichever method you choose, opt for one you can practice regularly to improve your communication in stressful situations, and encourage others to do the same.

3.4 Procedure Words

When using your radio, there are certain key terms called procedure words (or prowords) that are standard shorthand for communication. Using them keeps transmissions clear, simple, and short. Try to

with by the medical team. They need to be moved to a safe area and given space to collect themselves.

Code Grey is sort of a neutral zone between codes Red and Black, or an extension of code Red deeper into code Black. Under extreme amounts of stress, actions that have been practiced repeatedly into “muscle memory” can be performed even as other motor control begins to fail. Consider professional athletes, drivers, and fighter pilots - they are all experienced in Grey zone performance. Grey zone extension and training is a very interesting topic, but is largely beyond the scope of this booklet. We will leave with this takeaway: like any other skill, communication must be practiced to keep it working right. The more we can practice in stressful situations - actions, training, or exercise - the better we can get at stressful communication.

Decompressing

The biggest problem with stress at actions usually isn't the escalation, but rather the de-escalation. When people should be moving from code Red to code Orange or Yellow, they can sometimes get trapped in code Red. The elevated physical response and hyper focus can be harmful when meeting changing conditions on the ground. This goes double for communications not made face to face. Recognizing your own color code is one thing, but it's important to learn strategies to get yourself on the same page as others.

Everyone will have to find strategies that work for themselves, but one simple method for decompressing is controlled breathing. We recommend box breathing - a technique that was adapted from the yogic tradition. It helps your body synchronize with your mental state and bring you back into your surroundings.

1. Inhale for 4 seconds through the nose.
2. Hold for 4 seconds.

allowing you to manipulate that option, and pressing it again will confirm your choice.

- **Dual Watch:** This setting will allow your radio to watch for calls on both your A and B displays by constantly scanning them. You can turn this on by pressing the menu button and moving to option 7 (TDR), pressing menu again to get into the selection, and menu once more to confirm your choice. Pressing exit will cancel your choice.
 - By default this will also change your transmit display to whatever display you last received a transmission on. You can change this by going to option 34 (TDR AB) in the menu and setting it to A or B - this will give priority to the selected display when two transmissions are coming in, and keep your transmission display on whichever one you have selected with your A/B button. Consider which display is more important.
- **Channel/Frequency Mode:** The red VFO/MR button right below the left side of the screen (see 4 in Figure 2.2) will change your radio between channel mode (where you can scroll through pre-programmed channels), and frequency mode (where you can manually set the frequency). We recommend channel mode if you have channels programmed.
- **Scan:** Holding down the * key (see 6 in Figure 2.2) will activate scanning mode. This searches through the channels, looking for a signal. When it finds one, it will stay on that channel for a while before moving on. If you wish to stay on that channel, press the * key again to stop scanning mode.
- **Squelch:** This will adjust how strong a signal your radio needs to receive to play it through your speaker. You can access it from the menu at option 0. A lower number means your radio

will better catch weak signals, but you will also hear more stray static. We default to 9 for new users, but feel free to turn it down.

- **High/Low power:** Press the # key in the bottom right side of the keypad (see 6 in Figure 2.2) and your radio will switch between low and high power modes. An L will appear on your screen to indicate low power mode, using less than half the power. This may be helpful for conserving battery usage and/or keeping your transmissions within a short range.
- **Vox:** Vox is an option to automatically begin transmitting when your radio hears you speak, instead of pressing the PTT. This can be helpful for connecting external devices. You can access it on menu option 4 - lower is more sensitive.
- **Roger Beep:** This option will transmit a beep when you release your PTT button. This is a common substitution for the procedure word over for beginners, though many find it annoying and/or loud. You can access this at option 39 in the menu.
- **CTCSS and DCS:** These are two options for selective calling, helpful for accessing repeaters. If you do not know about them, do not modify them. Be sure your radio's CTCSS or DCS settings match those of your peers.

2.4 Baofeng FAQs

2.4.1 I am pressing buttons and nothing is happening. Why?

Most likely the keypad on your radio is locked. This is a feature designed to prevent users from accidentally hitting buttons they do not intend to hit, but this often confounds new users. Check the

is where you are.

Calm communication may be difficult at code Red, and it may be tempting to pull others not in your situation into code Red with you. When speaking over the radio:

- Speak slowly and do not shout.
- Do not bark orders or speak for others. Recall your threat model and stick to it.
- Use calling (see section 3.5). Remember to use emergency procedure words (see Table 3.3) if you need them.
- Give full spot reports (see section 3.6) instead of incomplete information.
- Most importantly, convey facts: do not jump to conclusions or read into intentions.

An ounce of prevention is worth a pound of cure here: setting and keeping norms for communication help prevent these problems before they even start. If we always practice good communication it will be reflexive when it is most critical.

Grey and Black

There are two more color codes that we should be aware of - that of Grey and Black. Between the two of them, Black is the more severe, but we will describe it first here before explaining Grey.

Code Black is a breakdown of cognitive processing. Extreme heart rates, erratic behavior, babbling, loss of motor control, and more are commonly seen as responses in this state. There are physiological reasons for this, but the bottom line is this: if someone at an action reaches code Black, this is a medical emergency that needs to be dealt

Yellow, Orange, and Red

Yellow, Orange, and Red are the three most common color codes we see at actions. When we study color codes, these are the ones we should be focusing on.

Active attention is the core of code Yellow. It's still largely a relaxed position without physiological changes - actively paying attention to your surroundings doesn't have to mean hyper vigilance. In condition yellow, you are watching for changes in your environment that might present a danger for you or others. This is probably going to be the standard color for most people at most actions, most of the time. Unless there is a particular and active threat near you, we should be helping people stay in condition Yellow.

Orange implies an immediate specific potential threat or danger nearby, though we are not locked on to it or engaging it. Orange implies we are still aware of our surroundings, and haven't lost control of what is going on. Our heart rate is moderately elevated, and adrenaline may be pumping. At the height of confrontation in an action, the majority of the crowd will still be at a code Orange. As a part of recognizing this state, we also need to make a decision about what we are going to do that will escalate or deescalate us from this position. In code Orange, we may have to pay more deliberate attention to our communications. Structured communication and active planning is key to both safety and preventing runaway escalation at this point.

When we have moved to condition Red (hopefully on our own terms), we have hit a "fight or flight" moment. Our heart rate is highly elevated, our limbs may be tingly or shaky, and our vision may narrow. Code Red is your body telling you that you are in optimal shape for a physical conflict, and is slowing down all non-essential services. If it is your first time in this condition, it will feel very uncomfortable, but with experience and inoculation you may feel less so. When you are in code Red, it is critical to acknowledge that this

screen on your radio as in Figure 2.3. If you see a little lock icon next to the battery icon (1), your keypad is locked. In order to unlock your keypad, simply press and hold the button with the hash symbol (#) and lock icon at the bottom right (2).

The lock icon on the screen should disappear after about two seconds, after which you will be able to use the rest of the buttons. When you are done, make sure to re-lock your device by once again holding the # button. When you have successfully re-locked your device, the lock icon will reappear on your screen next to the battery icon. Please note that the side buttons always remain unlocked, so you can push-to-talk even if the rest of the buttons are locked.



Figure 2.3: Lock feature on a UV-5R

2.4.2 I am doing a radio check and no one can hear me at all. Why?

Troubleshooting this will be most effective face-to-face with another member of your group. There are a couple of possibilities here:

1. People might not be responding because you are not directing your call to someone.
2. Check your volume. If you're using an external microphone or headset, check the connection.
3. You might be transmitting on a channel nobody is monitoring.
4. Your group's CTCSS, DCS, or other settings may be preventing them from hearing you.

First, when doing radio checks, be sure to use calling. See section 3.5 for more on this.

Be sure your microphone is plugged in all the way if you're using one. Check to see there's nothing accidentally stuffed into the jacks. If your comrade still cannot hear you and/or you cannot hear them, make sure the volume knob on both of your devices is turned up (all the way clockwise on a Baofeng). Try transmitting and receiving again. Lock your keypad if this has resolved your issue, and make sure your volume knob is not accidentally turned down as your stow your radio. Electrical tape can be used to hold your volume knob in place.

To make sure you are on the same channel as your comrades, compare the displays of your radio. Do you see the same channels/frequencies listed? If not, you need to get on the same channel/frequency. Make sure your keypad is unlocked, then use the "A/B" button to toggle between your radio's two display slots to ensure that you have selected the one you wish to change, as seen in Figure 2.4.

When the correct display is selected, use the up and down arrows to change the channel/frequency. Once the correct selection is made, confirm that you and your comrade are now displaying same channel/frequency. Try transmitting again, and ask your comrade to do the same. Lock your keypad if this has resolved your issue.

One important way to be able to measure the emotional state of comrades is by using a system of color codes to not only judge our own level of stress, but to also help connect and level with comrades who may be overwhelmed. If a comrade is out of step with others, it may be helpful to step in and check color codes with them to figure out the cause of issue, address it, and prevent panic from being spread to others. The situational awareness color code system is a great way to help codify some of these states of awareness and stress so that we have a common language.

This particular color code model may be slightly different from others floating around by combining both mental and physical characteristics, so please check with comrades about specifics about colors beforehand. Our suggested color codes include: White, Green, Yellow, Orange, Red, Grey, and Black.

White and Green

Green and White are hopefully two colors we shouldn't be dealing with at actions. Both describe threat levels too relaxed for confrontation.

White implies either asleep, over tired, or inebriated beyond the ability to become actively aware of your surroundings. If people are in code White at an action, they may be putting themselves in danger - depending on your threat model. They may need to be taken to a safe location, away from action.

Green is a relaxed state of being, not actively paying attention to your surroundings. This is the default state for how people live their lives. Ever hear that insurance fact about how most car accidents take place within 2 miles of the home? If people are on autopilot driving, they are not actively paying attention. For the most part, you should not be at Green during a confrontational action, though it may be ok for a non-confrontational one.

environment, consider shielding your microphone with your hand to muffle some of the ambient noise.

- Don't interrupt. If you hear other people talking, wait. Two transmissions made at once on the same frequency can make both of them unreadable. If there is an emergency, inform the other parties that you have an urgent emergency message. See the emergency calls in Table 3.3: Emergency Procedure Words for how to do this.
- Do not respond if you aren't sure the call is for you. Wait until you hear your call sign. This includes radio checks.
- Hesitate for two seconds before responding to someone calling you. This allows for people with emergency messages to break the transmission and use the channel. See Table 3.3 for more on emergency calling.

Once you get the hang of it, transmitting will become second nature. As always, setting a good example will make it easier for others to pick up on just by listening, so do your best to keep it clean!

3.3 Color Codes and Stress

Situational awareness and emotional stress are important for everybody to be aware of, but in the context of communications under stressful conditions they can be absolutely critical. Even small things like a harsh tone, rapid fire communication, or bad and inaccurate reporting can spread panic in ways that are damaging to the organizing and people around you. It may seem obvious to state, but how we communicate itself contributes to the message that other people understand just as much as the words we choose. Having increased communication will result in increased panic if we do not address stress first.



(a) Initial Position (b) A/B Pressed (c) Toggled Again

Figure 2.4: Channel Selection Check

If all else fails, try checking your radio's menu settings with that of a comrade's. Alternatively, you can always reprogram your radio from scratch. See section 4.2 for more on programming.

2.4.3 I am transmitting but my intended recipient cannot hear or understand me. Why?

If this is the case, first make sure you are following best practices as listed in section 3.2: especially holding the mic close to your mouth, speaking slowly and distinctly, possibly removing your mask to reduce muffling, and shielding the microphone from background noise.

If this does not resolve your issues, try moving closer to your intended recipient. Getting closer will likely improve the effective strength of the signal. The signal may often be weakened both by increased distance and obstructions (especially buildings in urban contexts), and may often be improved by elevation and longer antennas.

Consider adjusting the squelch option downwards on your radios.

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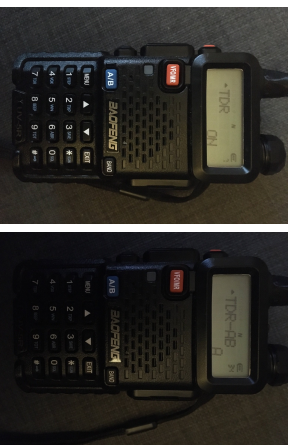
3.2 The Transmission Process

This option will allow weaker signals to come through the speaker, but will also allow static and stray signals through as well.

Finally, if all else fails, try switching channels. Interference can sometimes cause signals to become unreadable.

2.4.4 How do I configure my radio to listen on two different channels?

You will need to use the Menu to configure two different settings to enable this behavior (which is often known as “Dual Watch” or “Dual Standby”). The settings are option 7 (“TDR”) and option 34 (“TDR-AB”), as seen in Figure 2.5.



(a) TDR/7 (b) TDR-AB/34
Figure 2.5: Setting Dual Watch

With your keypad unlocked, press the “Menu” button, then use the arrow buttons to navigate to menu option 7. Edit the setting by pressing the “Menu” button again, then use the up or down arrows to toggle the setting to ON. Press “Menu” again to confirm the selection. Your radio will now receive messages that are transmitted on either of the channels/frequencies that you selected in both displays.

It is important to understand that while you can receive messages from two channels/frequencies simultaneously, you can still only

- Use the International Spelling Alphabet as outlined in section 3.7: The Spelling Alphabet. This will help reduce confusion when spelling things out. Be aware that some of these words have specific non-standard pronunciations.
- Perform radio checks to ensure your radio is in good working condition. Be sure the battery is charged and the volume is loud enough. Consider using electrical tape to keep the volume where you want it. See “Radio Check” terminology in section 3.4: Procedure Words for checking your transmissions.

Once you have a good idea of what it is you want to say, who you’re saying it to, and how you’re going to say it, you can begin transmitting. Here are some more tips on transmitting:

- Hold the mic so it is pointed at your mouth, but away from your breath - about 45 degrees and off center. This will help prevent popping noises like harsh P sounds. Keep fingers and other objects clear of the mic. Masks and other facial coverings may muffle your voice, so be sure to compensate if you are wearing one.
- Press and hold the Push To Talk (PTT) button to speak. Hesitate for a second before speaking, otherwise your first words may be missed. Release the Push To Talk (PTT) button when you have finished speaking to listen.
- Speak slowly and clearly. Radio waves and bad speakers can distort the sound of your voice, making clarity essential. Try speaking in a natural rhythm at about 100 words per minute - this is to help people transcribing to text. This is about the beat of the songs “Crazy in Love” by Beyonce, “Float On” by Modest Mouse, “Sweet Home Alabama” by Lynyrd Skynyrd, or “Man in the Mirror” by Michael Jackson. If you’re in a loud

mitting, so keep these things in mind:

- Think before you speak.
 - Check yourself emotionally with color codes. Am I at the appropriate color right now? If you're not sure, check with those around you. See section 3.3: Color Codes and Stress for more information.
 - Decide what you are going to say and for whom it is meant.
 - Make your conversations as concise, precise, and clear as possible. Avoid rambling, long, or complicated sentences. Divide it up if you can.
 - Do not use abbreviations unless they are well understood by the people listening to you.
 - Never transmit sensitive or confidential information over the radio. Threat model your situation beforehand (see section 1.3: Towards a Threat Model) for what this might include. Use a different method of communication such as Signal or asking in person for secure information.
- Use call signs to identify yourself and others. These can be International Spelling Alphabet call signs, numbers on teams (e.g. Medical 4), or nicknames. Memorize the call signs of people and teams you communicate with regularly. "Calling all stations" can be used to direct information one way at everyone tuned in to your frequency. You can also specifically call for a team leader if you're not sure who to get in contact with. See section 3.5: Calling for more on this.

- Be aware of specific procedure words and terminology. Use the general terms that are best understood by people who may not know them. Knowing these terms can assist in all of the golden rules of radio communication. See section 3.4: Procedure Words for more information.

transmit on a single channel/frequency at a time.

Without adjusting menu option 34 ("TDR-AB"), the default behavior of your radio will be to change your active channel in the display to the one that you last received a transmission on. This behavior is often confusing, so we suggest setting option 34 to either A or B. The selected display will have priority when both are receiving signals at the same time.

Press the "Menu" button again to confirm your selection, then press the "Exit" button to leave the Menu. Dual Watch should now be fully configured. Make sure to lock your keypad when finished.

2.4.5 How do I scan multiple channels to find one that others are using?

There are some situations where you might not know which frequency or channel is being used by others. Perhaps you are scouting and want to determine what frequencies an adversary is using, or perhaps you have shown up to a coalition action and need to quickly sync up with comrades. Most radios have the ability to scan through the various frequencies to find a channel that is actively transmitting and receiving. Just as a warning, dual watch will not work while scanning with a Baofeng.

To scan, unlock your keypad and hold down the * button on the right side of the keypad for about two seconds to initiate scanning. The radio will start cycling through channels until it hears a signal. Once it does, it will listen to that channel to a short amount of time before moving on. If you hear something interesting, be sure to exit scanning by pressing * again. This will exit scanning and keep your display on this channel, so be aware that this channel will be your active channel.

If you want to scan through frequencies themselves, try scanning while you're in frequency mode. You can get to frequency mode by pressing the "VFO/MR" button. Scanning works the same in this

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mode, but it's going to scan much more slowly and thoroughly.

As a final note, the channels your radio will scan is a setting only accessible by programming your radio with a computer (unless you have a UV-5XX3). If you wish to modify which channels skip scanning, you will have to edit them in CHIRP (see section 4.2)

3 Communication Strategies

3.1 The Golden Rules of Radio Communication

Anybody can pick up a radio and start talking, but a good radio operator will know how to best communicate over the medium. Some of this is situational, but there are a few “golden rules” for how to best approach communication. They are:

Clarity Know how to use your radio - your transmissions should be clear to others. Speak slower than normal, and do not spread panic or shout.

Simplicity Keep your message simple enough for intended listeners to understand. Choose your words wisely.

Brevity Be precise and to the point. Do not ramble.

Security Know what to keep secure, and do not transmit confidential information.

Of course these are only topical guidelines, and many of them overlap. Each of them have theory and nuances, procedures and language. The rest of this chapter is dedicated to building up these base understandings.

3.2 The Transmission Process

Let's take a moment to analyze the process of radio transmissions. There are a few things you'll want to consider before you start trans-