



Amateur Radio Relay Group, Inc.

Repeater Technician

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Hello,

Thank you for your interest in becoming an Amateur Radio Repeater and Site Technician. I hope that this guide will give you a better understanding of everything you'll need to know about servicing the K7RPT System (or your own clubs repeater system).

Amateur Radio groups are on the constant lookout for licensed Amateur Radio Operators who have experience in maintaining modern two-way Commercial or Public Safety portable, mobile, base and repeater radio systems. We like our Technicians to hold an Extra Class license, however, any licensed Ham, who takes the time to read, study and learn basic repeater maintenance skills, are welcome on our team. Most groups (including ARRG) are willing to train certain tech savvy persons as long as they come prepared with a solid electronic and RF skill set to the table.

The information contained in this guide can also be used to help you study, prepare and begin to obtain the necessary RF Testing tools that are required to become a repeater tech and serve your club or repeater team.

My name is Marc Peterson and I am W7PM. This guide is written from my perspective and includes my own thoughts and ideas, so don't get too hung up on any particular paragraph or section.

I worked 30 + years as a Public Safety Communications Officer and the last 20 years have been spent working specifically with Amateur Radio groups around the state, so as to help them with their own repeater system. I currently volunteer as the lead RF technician here at ARRG and it's my job to select and train each person who shows a genuine interest to fill one of our technical team positions.

Unfortunately, it is very rare to find an Amateur Operator who is already trained and experienced enough in RF Communications who is able to jump right in and start helping. In fact, I spent a year shadowing the ARRG Techs, before they allowed me to work on one of the K7RPT Repeaters. In the past 8 years with ARRG, I have broken, messed up or actually killed a repeater or its controller because I didn't study a new part or piece of gear, or I forgot to study the 30 plus year old Motorola Manuals prior to heading to a site which housed such a repeater. Every repeater Me or others mess up, can be fixed.

The repeater gear used by 90% of Amateur Radio Clubs is actually the same commercial Motorola and GE gear that Public Safety uses and can take quite a bit of abuse. Don't worry if you mess something up or break off a wire while getting into the racks to diagnose a repeater issue, you'll have people with you and together, we always get a messed-up machine running again. And if it is dead, then we most likely have a spare onsite or close by.

Experience aside; even if you are new to Amateur Radio and even electronics, if a special 'tech' someone gets on my tech radar, we will go the extra mile to befriend, train and impart all that we know about repeater and site maintenance, in the easiest way possible.

If you get picked as a prospective tech, all I ask is that you try to give us 100%, because for me, it's an exhaustive experience for me to put in a year or more of my time and energy into helping you to become a proficient repeater tech, just to have you fail to 'tech' strive. My personal goal is to help you hone your electronics skill and abilities up to a technical level where eventually the ARRG Board will trust you with keys to our radio sites. My skills are far from perfect and the younger techs that are around to assist you, often figure out a solution to any problem, including the ones I might cause.

The current K7RPT repeater system has over 20 repeaters, links, IRLP node, three Echolink nodes, a DMR and System Fusion digital system.

Our system is currently valued at about One Hundred Thousand dollars and we usually have to go work on the gear, which is housed inside secure multi-million-dollar Radio/TV and Public Safety sites. This makes our insurance costly, so we are looking for trustworthy, smart and easy-going people who can put up with each other and with me while at these professional sites.

This guide is not a complete list of everything you'll need to know about repeaters, nor are the information and requirements listed in the guide the final rule about who can or cannot serve on the technical team.

All prospective technical team members are looked at on a case by case basis and the ARRG Board has given the K7RPT technical committee chair (also our lead tech) the to pick those that will serve on the team and who he or she believes will work out best for the team.

Hams that wish to be considered for a position on the K7RPT technical team should carefully read though each page of this guide to get a basic idea of what type of person we are looking for and what type of basic electronics experience we'd like you to have before considering you for a position.

On average, it takes about 18 months of serious in-house training, plus actual site visits to become a fully vetted 'active K7RPT tech.'

It's important to us that if we spend the time, money and energy to train you as one of our technical team members, you need to be present and available to assist the team as we maintain the system and respond to repeater or link outage.

Not to be overly negative, but we aren't looking for are Amateur Operators who are into Club or Team 'titles.' There is a good chance that if you already hold more than one other position in the Amateur Radio Community, or if you have more than a couple Amateur Radio titles, then we are probably not going to consider you for a position on our tech team.

Let me explain why this is the case in a couple minutes. It's important to know that ARRG Repeater Techs come in two classification levels. **Primary Technicians** are those who make it out to 80% of our events, help out on maintenance and site trips and attend most of our in-house training classes. It is these people who are entrusted with keys, alarm codes and ultimate access to our secure repeater sites.

Auxiliary Technicians or 'non-tech-active' positions are available on a case by case basis. These types of positions are normally filled by those who can't physically assist us at our remote sites and enjoy using their own electronic bench for the testing and repair of our repeater gear. We also have physical helpers, which are not as tech savvy, but bring much needed physical labor, vehicles and gear to the table, however, they rarely want to go through the training required to align or repair a repeater.

Regular Amateur Operators, Emergency Service groups, CERT, ARES and Search & Rescue teams all rely on the K7RPT repeater system to work 24/7. If you are chosen to work on our team, I need you to be present and available when called upon to help out on projects. ARRG does many remote projects throughout the year, this includes setting up and running a portable Dispatch (Net Control) station for races, runs and of course each September is the large OMSI Science Fair where ARRG has a large presence to help introduce Amateur Radio to the public.

The main goal as an ARRG Repeater Technician has to be keeping the entire K7RPT system ready and working during a disaster. This is why I mentioned that prospective tech members shouldn't already be committed to help another group or team during or after any disaster.

If you are already heavily involved with Amateur Radio Public Service, ARES or CERT types of groups then you probably won't be a good fit with our technical team, only because we need our techs to be present and able to respond during and after an emergency. We can't have our team members being pulled in multiple directions.

Also, with being 'present' in mind, if a priority system we allocate for disaster preparedness, which is in this case is South Saddle, Sylvan (KOIN tower) and the Mt. Hood Timberline system goes down, our users expect that our technical team will respond, diagnose and repair problems by the next day or depending on the weather, whenever it is possible to get into a site.

Stuff you need right now

Every Amateur Operator needs their own **electronics bench**. This could be part of your shack, but everyone needs room to work on projects you might be given, all which can be worked on in your own time and at your own pace. For instance, once you are trained, you might be asked to convert a repeater at home, on your bench and in your own time. This type of project will require you to read and study about the repeater make/model, learn how to properly program, align and test an ex-Public Safety repeater over to Amateur Radio service.

About the Current Team

The ARRG technical team is made of about only four Primary and about ten Auxiliary technicians. We obviously need at least two more good Primary Techs to help support the system. The existing technical team leaders and trainers are getting older and we can't keep pulling the 'load' to the extent we once could.

We are in need of energetic, bright, smart people, with good common sense, that are both capable of being trained to work on our complex systems, but also able to help put together a tower and install antennas properly. This doesn't mean you'll be asked to train on climbing our towers, but being an 'all-around' physically capable technician is really what ARRG needs right now.

If after reading through the entire guide and you feel that you already meet or exceed most of the requirements listed below, including already having a well-stocked electronics bench, complete with basic RF test gear, wattmeter, etc. then please contact us at w7pm@arrg.org to be considered for a spot on the technical team. Please don't forget to include information about any current or past experience in radio/repeater maintenance.

For insurance purposes and to have access to the secure Public Safety and Radio/TV sites our repeater share space with, all full-fledged members of the team must be at least 18 years of age, however, we do have a few 'younger techs in training' who are allowed access to our facilities when accompanied by an experienced tech. We currently have a couple bright fifteen-year-old techs who help us on many projects.

Members must also be physically able to lift and move equipment that weighs at least 50 lbs. and with help from other team members, be able to lift or move much heavier 100 lb. repeater cabinets, including AGM batteries and other large equipment as necessary.

Even if you feel that you do not have current experience working on newer repeater platforms, we are interested in Amateur Operators who have good basic electrical and electronics skills, and who have the time, energy and willingness to learn more about becoming a repeater technician, by starting to train with the ARRG Technical Committee.

What it takes technically speaking?

Technicians must be able to bench test radio gear, diagnose transmitter/receiver and audio problems and make corrective adjustments to stay within FCC modulation and frequency bandwidth requirements.

Technicians will be required to learn and operate PC based radio service software tools, electronic bench test gear, including the proper use of a swr/wattmeter, frequency and deviation meter and all RF modules that are combined in our HP and Motorola Communications Service Monitors.

Using RF bench testing gear, technicians must be able to order and install proper TX/RX crystals, troubleshoot and completely align receivers, transmitters and audio circuits, adjust and program external computer-controlled Amateur Radio Repeater Controllers, including properly setting up and programming the operating principals of the repeater controller.

Technicians need to be able to build repeater to controller 9 wire interface cables, sometimes from scratch. These cables allow the controller to access proper signals to and from the repeater under construction. These include pulling audio, COR, tx and ptt signals that the external repeater controller will require to properly work.

Technicians need to know about Antenna systems, which include using proper coax or hardline, know about mobile and base antennas, their design and theory. Technicians should also know about remote radio site tower systems and proper grounding techniques.

Our work requires our techs to build and install new and reused systems, including providing ongoing site maintenance in normal to fairly extreme mountain top environments. 90% of all the work a technician does with ARRG, is work on projects that are located on your own electronics bench.

It is crucial that each technician must have access to or begin to build their own electronics work bench and stock it with the proper RF test gear to be able to properly maintain or align repeaters and work on the various mobile link radios that modern linked repeater systems utilize.

Technicians should be able to tackle a repeater conversion/upgrade from a used commercial repeater station down into the Amateur Bands.

A complete list of the basic test gear/tool items that every repeater technician should own and have available to take along with them to the repeater site is attached near the end of this guide.

ARRG has available for check out, a Bird Wattmeter w/ slugs for different frequencies and power ranges, an HP 8935 Service Monitor and an ARRG box full of patch cords, connectors, full crimp set kit – all which should be loaded up and taken with you to any repeater site.

Eventually, all technical team members should own their own set of bench gear and remote site tools.

For your personal bench, each tech should have a 13.8vdc bench power supply with Volt/Current meters. Current needs to be at least 12 amp, with 20-30 amps available.

Techs need to have their own well outfitted electronics tool kit that includes at least one, if not two VOM, a VHF-UHF wattmeter, 100-watt dummy load and other test items as listed below.

The wattmeter you chose does not have to be the highly expensive Bird line, you can buy your own VHF/UHF 100 watt/swr meter - please make sure it can do the SWR measurement as well.

Part of using the Service Monitor is to enable you to make receiver sensitivity tests, transmitter tests and most importantly, helps you align any receiver and transmitter within FCC specs. Techs need to know how to use their test gear to make measurements of both the RX and TX and to make sure the repeater is operating exactly on our assigned operation frequency.

Part of being a technician is the ability to crystal, tune and align each TX and RX section of the repeater or link radio using common test gear.

Paperwork

Members shall log all their activity on the site (via the site's ARRG Binder located near every one of our repeaters). Please include your diagnostic reasoning and write down any steps that you took to return the repeater back into regular operation.

Gear

All technical team members must have a dualband 2m/70cm mobile (with 16 Key DTMF mic) installed inside their vehicle, as well as a dualband walkie (with 16 KEY DTMF pad) so that we can make audio/signal reports over the air, while on site and going to and from the site. DTMF is key to entering controller codes necessary for each site.

For those that wish to work on both the Analog (FM) and the several Yaesu System Fusion Digital repeaters ARRG has in operation, you must have a Dualband Walkie that is dual mode and has FM and C4FM like the Yaesu FT-70DR (under \$149.00) and maybe a DMR radio. A cheap Baofeng UVB5 or UVB6

is great to start with. Both these models don't require any computer programmer and unlike other Baofeng's. Being able to program the walkie via its own keyboard is very important because you can toss in any frequency from the keypad and also enter any of the 16 DTMF keys that our controllers might require.

Ongoing Upgrades to the K7RPT System



As a technical team member, you will be required to know the basics on diagnosing and repairing all the different repeater platforms we use here in the K7RPT system.

Currently, the team is right in the middle of a ten-year upgrade project, where we are replacing many 42-year-old repeaters with newer 90's and circa 2000 repeater stations as they come available to the group. Our systems are not Earthquake ready and we are working very hard to harden our sites, by securing cabinets and gear to the walls and floors.

Over the past five years we have accomplished quite a bit already. As of March 2017, we have upgraded the following sites with new repeaters, better bracing and extended emergency power/battery support.



Timberline – Mt. Hood

In 2014 the team replaced 147.120 with a 90's MSR-2000 Station and replaced the 444.225 Mobile Split Micor repeater with a newer MSF-5000 Station. We also added 8 new 100AH Werker batteries that supplies backup power to the site since no generator is available.

South Saddle 147.320 and 442.325 plus ARPS Digi



Left: Shown on top is the ARCOM 210. With the 147.320 Quantar shown on top. This is connected to Port 1 on the Arcom. The gold box is the 442.325 UHF duplexer and below that, is the 442.325 Quantar. Both repeaters are set for 60 watts out, with about 305 watts out the duplexers to the antennas, with zero reflected when running properly.

In 2018, the aging 147.320 and 442.325 repeaters were replaced with Motorola Quantar repeaters, specialized cables and an ARCOM 210 repeater controller.

A Motorola Radius link radio was added to the

mix for further linking possibilities. Above: Shows the Maxtrac Radius UHF link radio, attached to the ARCOM 210 on Port 3. Next to that you see the SADDLE APRS Digipeater. It is a KPC-3 running on an ICOM 2-meter rig.

Cehalem Mountain

The 147.380 + 100Hz and the 443.750 + 100Hz are located at our Cehalem Mountain site. In November of 2019, ARRG installed a new tower and really powerful commercial antennas. The VHF stick is a Kathrein 7.5 dBd gain and the UHF stick is a 9 dBd gain Sinclair antenna. The repeaters most likely will both be a Yaesu DR2X. The 443.750 repeater is linked via the internet through a Yaesu lan board to 442.225 at Sylvan – KOIN.

Cedar Mill – West Hills

The Cedar Mill site is currently empty. ARRG has a dualband Comet at the 40' level of the tower. Plans to make this a Wireless Ham Mesh access point are in the works.

Wickiup Mountain – Coast Range

The newest repeater in our fleet is the 146.720 + 114.8Hz and is located on Wickiup Mountain, just above Astoria. This repeater is linked through a Radius link radio via in band standard to the South Saddle 147.320, is linked f/t to the South Saddle System and is running on a new Motorola Quantar and an ARCOM 210 Controller.

Getting a head start and learning about our systems

As stated before, some technical team members are not full-fledged repeater technicians, however, they are actually tech savvy physical helpers, who assist with antenna and tower installs. These techs are highly important because they have been taught or self-trained on installing feedlines, antennas and tower mounts, some are climbers and others don't climb.

Everyone ends up helping at a repeater site, from hauling gear or even helping other guys push an antenna tower or antennas into place-. There is always a ton of work to do. We are always converting and upgrading old commercial repeaters for use on the Amateur Radio bands.

The topics listed below are simply the broader types of equipment that are commonly used by ARRG. Past brand specific training or experience is helpful, but all past technical persons are encouraged to join the team.

The K7RPT Repeater system is primarily made up of Motorola based transmitters and receivers, but we also have some GE equipment thrown into the mix. Please look over the list and see how many items you have experience with and let us know if you wish to serve with the team.

Failing Gear

I know that repeater work seems very technical, and in most cases it can be, but even when we mess up a repeater while onsite (or one was down for whatever reason) the problems our systems deal with

more often than not, have to do with issues related to TX power output problems. Of course, this points us to look into the power amplifier deck.

The second most failed part of a repeater is probably a failing station power supply, or it's charging system is dying, and this is usually caused by a battery in the banks which is hooked, but dying or has or will short. In a multiple battery bank, one should feel that each battery is the same temp when touching. If one battery is constantly warmer than the rest, it's probably dying, so replace it.

Most repeater problems come down to simple physical (not RF based) issue. These can include an issue with the coax or hardline or its associated N connectors, which often come loose, come unsoldered, or when outside on the towers, can get corroded by water. Corrosion can be caused by even micro water droplets can be devastating, because over the years, water has been forced into small cracks or holes in or about the connectors. Once these micro droplets reach inside the connection or coax, it's bad news.

Another big issue is that when a technician in moving in and out of an equipment or repeater rack or cabinet, our bodies often hit stuff that should be left alone. When working around the antenna duplexers is dangerous, because these cans and jumper cables are pre-set and tuned onsite for best performance. Time and time again, somebody will bump a set and they go slightly off frequency and will require someone with experience to bring up a good Service Monitor with Tracking Generator, just to re-align the cans to their proper frequency. Techs must be careful when working around duplexers.

In reality, unless you actually hit a reject Plexiglas rod, or bump your hip hard into a duplexer tuning knob, they are pretty forgiving and rarely require retuning or alignment.

Another repeater issue we see is the duplexer's short jumper coax lines and connections often go bad. For example, while working on 147.320 a few years ago, I was taking off the heliax n connector from the duplexer to place onto my Bird wattmeter for a swr/pwr test, when the N connector fell right off in my hand and a cup or more of water came pouring out of the cable.

Very rarely does a fiberglass antenna radome crack enough to let much water inside, but we lost 147.320 antenna in 2012 and the KOIN antenna in 2015 due to water ingress, which resulted in corrosion and the center copper coax got ate in two.

In any case, a duplexers individual can jumper cables can go bad. These cables are usually very short and have either N male to N male, BNC to BNC or PL-259 to PL-259 fitting on the end. Warning here, the cables are perfectly tuned for the exact length and thus cut to length. Try to repair and reuse the exact jumper as long as it is still viable. These jumpers and their connectors often come loose and we have found scratchy jumper lines before, especially when they are over 20 years old. We have learned that sometimes just unscrewing the N connector all the way off and putting it back on fixes most desense or noise issues.

For example, one knows they are scratchy and not making perfect connection because of the result of the following over the air (or into a dummy load) clean signal test.

Using a walkie, key up on the repeater input and listen to the output on another walkie or service monitor— make sure the receiver audio is not turned up too high or you will cause audio feedback or squeal.

While keyed up, pick a can to can coax jumper and move it a little back and forth, if your movement causes scratchy noise over the air, unkey and remove the jumper, test it with a VOM and then clean the connector and install the jumper once again, do not over tighten the connectors.

Key up again, wiggle the jumper and the noise should be gone. If the noise is still there and it is worsened by you moving the jumper around, try the loosen, clean, reconnect trick one more time. If you have to replace the connector on one end or the other, do not cut anything off the jumper – they are cut to a perfect tuned length. If you do have to replace or build a new jumper from scratch, please use the exact length and connector type, plus make sure the cable is the same type of coax, preferably a double shielded type coax.

Luckily, the most issue we see with our aging repeaters has to do with the Power Amplifier deck or power supply, which each can be swapped out in just minutes. Most all repairs at a repeater site can be easily diagnosed and fixed, sometimes by even non-technical folks, just by them pulling out the repeater manual or looking through other posted mistakes and fixes on Repeater Builder and BAT Labs sites while they watch us advanced techs run around in circles.

You'd be surprised at how many new people who are great at pulling up a copy of a repeater manual and read about the problem, they can easily come up with a good solution. Don't be afraid to speak up and tell your site partner about ALL of your ideas, no matter how silly they may seem. Repeater Guru's often make the mistake of leaving a single wire or cable connection unplugged in after many hours of repeater work.

If you really want to be a great tech, who is able to understand our systems, learn how to diagnose and repair them on site, or how to convert one to our standard, I'd suggest that every technician go online and study all of the wonderful articles that Hams have written, that pertain to about 99% of all our repeaters, test gear and even antennas.

The library is freely available to you by visiting **REPEATER BUILDER** over at <http://www.repeater-builder.com/rbtip/>

Please take the time to read and study the guides and sub articles that pertain to the models listed below. Hint: Most techs go ahead and print out all the articles and guides for their own tech book of schematics, manuals that you will need on site. Most sites do not have Cell or internet, so don't rely on that to help you up on the mountain.

Please read and study (and even print out) the following articles:

Repeater Controllers we use (please pay attention to the sections on interfacing, aligning, setting audio and actually programming TOT, Id'ers, etc.)

1- Arcom 210

2- The RLC Club and the RLC 3

3- NHRC 7

Brands and Models of Repeaters and link radios we use

[K7RPT Repeater Linking Radio Models](#)

To link our Repeater sites together, ARRG relies on several series of Motorola and Kenwood Commercial mobile radios. These radios usually have 20 to 40 watts of output power, multiple programmable channels and the ability to be both narrowband and wideband FM.

Our go to radios used for RF linking, listed from the very oldest Maxtrac models to the new more modern CDM-1550 models are listed below. Only the models listed below come with the required 16 or 20 pin rear accessory connectors which ARRG hijacks and brings out all the proper audio/mic and control circuits required to properly interface into the ARRRG Repeaters and Arcom repeater controllers.

Popular Radios with the necessary 16 or 20 pin rear accessory connectors.

- 1- Motorola GM-300, Maxtrac, Radius Series of Mobile Radios, from \$25 to \$100 each
- 2- CDM-1550 20-40 Watt VHF and UHF mobiles, from \$150 - \$400 new
- 3- Kenwood TK Commercial Radios From \$100 - \$279.00

CDM SERIES of Link Mobiles

The CDM750, CDM1250 and CDM1550 can use the same programming cable as the Maxtrac/Radius (you just won't be able to flash with it). The proper cable for these radios has 10 contacts instead of the RJ45's 8. We believe that the pinout for this cable should look something like [this](#). The 8 contacts of the CDM series mic jack appear to coincide with the pinout of the [Maxtrac Mic Jack](#).

The radio can also be programmed or flashed with the AARKN4083A Programming/Test Cable. This cable connects to the accessory connector of the radio directly. The pinout of this cable is available [here](#).

As for the accessory connector, the connector on the back of the radio is actually a 20 pin connector. It has an extra column of pins (2), one on either side of the 16 pin connector. The software makes no mention of the pins or their use. The accessory connector uses [this](#) numbering scheme. The pinout of the accessory connector is as follows:

Mobile Radio Accessory Connector Predetermined Functionality			
Pin	Description	Direction	Comments
1	Speaker (-)		Not Programmable
2	External Mic Audio		Partially Programmable
3	Digital In #1	Input Only	Fully Programmable, 12 Active Low Only
4	Digital In #2	Output Only	Fully Programmable
5	Flat TX Audio Input		Partially Programmable
6	Digital In/Out #3	Input Only	Fully Programmable
7	Ground		Not Programmable
8	Digital In/Out #4	Selectable Input/Output	Fullt Programmable

9	Analog In #5	Special Input	Fully Programmable, Tri-state Emergency Switch
10	Ignition Sense	Special Input	Not Programmable, Active High
11	Flat RX Audio		Partially Programmable
12	Digital In/Out #7	Selectable Input/Output	Fully Programmable
13	Switched Battery (+)		Not Programmable
14	Digital In/Out #8	Selectable Input/Output	Fully Programmable
15	RSSI (Radio Signal Strength Input)		Not Programmable
16	Speaker (+)		Not Programmable
17	BUS (+)*		Not Programmable
18	Boot Control*		Not Programmable
19	Unknown		Not Programmable
20	Unknown		Not Programmable

*These pins are used in conjunction with the flash adapter cable.

If you want an easy way to connect to the Accessory Connector on these radios, you can order the HLN9242A or HLN9457A Accessory Connector kits. These include an accessory connector housing, some pins, and some wires with pins already attached. One thing to note, the HLN9242A kit also includes a pin extractor for removing previously installed pins. This kit is designed for the Maxtrac/Radius series of radios, and as a result, is only a 16 pin connector (not the 20 pin like these radios use).

[Motorola Maxtrac and CDM Radio show RSS Error 'Out of Band'](#)

Depending on which version of RSS you have, this may or may not work for you. All Motorola mobiles (which we use for all of our RF linking) will not program below 450 MHz. The radio can easily go down to 440.000 without too much issue, but when you try to enter the 443.750 repeater pair for example, the RSS pops up with an error message.

In the RSS (Radio Service Software) you can cheat it by using a secret key board hack which when used will allow you to input any frequency in the RSS transmit and receive fields.

All you have to do is hold down the shift key, enter your 440'ish frequencies in the proper RSS fields. For example, to properly enter 443, hold down the shift key and enter the first part. Then let up on the key, as the RSS will put in the period. Now press and hold the shift key again and enter 7500.

For you advanced guys out there to want to make the Maxtrac link radios remotely channel steer (change channels) you can do that on most of the Maxtrac series of radios. The Arcom Controllers can make a Maxtrac do many cool things if programmed to do them.

For advanced users who wish to change their Radius Maxtrac into a 16 or 32 channel mobile, you need to get the program GP300.EXE file, it opens up most Maxtracs to do more. While not normally needed in the case of our RF links, the following part might help you change a Maxtrac into a cooler beast.

You will need to open the GP300.EXE file in your [Hex Editor](#) and do a hex search for the lower or upper band limit you want to change.

All the band limits are in INTEL UNSIGNED LONG format and in Hz (eg. 403 MHz is 403000000 which equals to C04A0518h). So, if you are searching for the 403 MHz band limit, you would do a hex search for C04A0518 and change what it finds to the limit you want.

No CRC check is done by the RSS, so you don't have to worry about correcting for one.

With version 5 of the HVN9025 RSS, we've been told that at least the VHF portion will allow programming between 137-173 MHz, we don't know about any of the other bands.

Corrupted Codeplugs

The following applies to the GP professional series radios.

The following method can recover corrupted codeplugs, and upgrade radio models - you need the following items:

- Flash upgrade software
- Two flash upgrade dongles (ie. 25 way breakout box, with toggle switch to ground "boot pin")
- Two RIB-less programming cables
- 2 radios, one with a corrupt codeplug, or lower spec than the other, one good unit. This good unit must have a lower spec codeplug than the flash software that you are using.

Attach each RIB-less programming cable to an upgrade dongle.

Create a "Y" cable to interface between the RS-232 port on your PC and the two programming cable assemblies (upgrade dongles and their attached RIB-less programming cables). The "Y" cable needs to be complete, ie. RS-232 send and receive (pins 2,3 and ground), to the good radio, but RS-232 send only (pin2 and ground) to the bad radio.

Test communications using the utility supplied with the flash upgrade software. The good radio will give a handshake to the software and hence good comms., but the other radio (on the lead that does not have RS-232 receive) will hang and require a power off reset.

Re-flash both radios together, using the normal flash upgrade method, following the normal Motorola instructions.

If you get Motorola error codes, follow the instructions explicitly to BOTH radios, i.e remove both batteries, etc.

If you do this, and are successful, BOTH radios will have the same serial number!

If you have a number of radios to "recover" and several versions of the flash software, use the early versions first, then you can keep "upgrading" the good radio time and time again, until you reach the current latest software version - the recovered radios can be re-flashed again at the end of all this to the latest version.

If attempting to upgrade a radio model, first check with the manual that it has adequate RAM/ROM, etc. for the radio that you are attempting to turn it into.

You can use this method to change GP320 to GP340 (needs a channel switch), GP340 to GP640, GP380 to GP680, and others...

Change bandsplits (although the radio may not work in the new bandsplit). I find that a UHF unit usually gives acceptable performance 20 mhz high or lower than its original bandsplit.

This method will NOT work with the old RLN4008 rib box.

European radios will convert to American models, but not usually the other way around as the American radios usually have far smaller flash ROM/RAM than the European versions - this is due to the huge program needed to support selcall signaling, etc.

The method depends upon the good radio giving the correct handshakes to the software via the full RS-232 connection. The "bad" radio cannot reply (as its return RS-232 connection does not exist) but having sent its un-received answer the software replies anyway as the handshake has been received from the good unit. This results in both codeplugs being overwritten with ALL the information from the good radio.

Remember to realign the second radio unit, as its softspots have data from the first unit.

As with all Motorola flash reprogramming, be careful, you might want to use a portable laptop so that power outages do not corrupt both radios.

More on the Repeater Gear

Motorola MICOR Base Station and Repeater and all info on their Power Supplies and Amplifiers.
-We are retiring these, but there are still 4 in use.

MSR-2000 Base and Repeater and all info on their Power Supplies and Amplifiers.
- Mostly what we are upgrading to, so get to know them.

MSF-5000 (CXB Digital stations) Base/repeater and all info on their Power Supplies and Amplifiers.

Motorola QUANTAR VHF and UHF Repeaters.

Most UHF machines in ARRG are the MSF-5000 and it's what we are upgrading to all the time.

Motorola Mobiles we use as link radios - Maxtrac, Radius and GM 300 Radios – they are almost identical but use different RSS to program them. Motorola RSS Radio Programming Basics.

We also have a couple GE MASTRII stations in use. Repeater builder teaches any new Repeater Tech the important steps in converting a old repeater to the Ham Bands, including info on alignment and testing. ARRG uses most of the information in our own conversions.

Duplexers we use for VHF and UHF are the Motorola T 1500, Sinclair bPbr and the Telewave bPbr . On Repeater Builder you should study (and print out or save) articles on how to tune duplexers. There are even articles about how to use various models of Service Monitors.

Technician Tools - Master List of needed items Service Monitor (ARRG has one available to check out)

- Motorola 2001 B, C or D model – all have Spectrum Analyzers from \$400 to \$1000 on EBAY.
- Motorola 2002 works, but doesn't have scope/spectrum analyzer.
- Motorola 2600 is awesome, but they run \$1500 to \$4500 used on Ebay.
- IFR 500 – not recommended – but if you can get one for under \$200, might be a good starter. No scope/spectrum Analyzer.
- IFR 1000 is very old, but if you can get a good working unit, might be a good starter.
- IFR 1100, 1200 and 1500 are all good choices. They are pricier and more run used on Ebay from \$800 to \$2500
- HP /Allegiant 8935 CDMA -Nicer- has everything, including tracking generator for tuning duplexers from \$750 to \$1500 on EBAY
- Soldering Station - Weller or cheaper MPJA Variable Temp (for bench) 100Watt Weller or other Gun for field PLUS a 40-watt pencil type for repeater work on site.
- 25 or 50' Extension cord and 6 outlet power strip.
- Tuning and Alignment Tools, both metal and plastic
- Regular Electronic tools, Wire Cutters, Coax Prep tools, Crimper for Coax types.
- Note: The TV RG-59 crimpers are not used in Amateur Radio.

Computers and Programming Gear required for each Technician

A Windows Laptop for Programming the Motorola Quantar and all the ARCOM 210 Controllers

*Any Win XP to WIN 10 machines will work. Must have a CD rom and USB port, even better if it has a db9 serial port.

A FTDI USB to 9 pin Serial adapters. Please only buy the more expensive FDTI Chipset, cheaper usb to serial adapters WILL NOT WORK with the RCP or Arcom Controllers

A CABLE – SERIAL Female DBP to Male DB25 Cable to use with FTDI USB to Serial adapter and to connect to the DB 25 on the rear of the Arcom Controller for programming.

An ARCOM RCP Vers 7.011 Windows Software, plus copies of the firmware 7.011 and the updater program from ARCOM. ARRG has a License Key once downloaded. Do not download any other RCP Version or try to use any version other than 7.011 to read, or right to any ARRG controller or you could brick the controller.

A Motorola Windows Quantar program and simple serial cable with DB 9 for attaching to Quantar Repeaters which has a rear and a front DB9 female. This does not require a RIB box.

For Motorola Radio Programming

1) Second Windows DOS 6.XX Laptop – old Pentium II is fine, must have CD ROM and working serial db9 port on the back. We have DOS 6.22 if you need it. Warning – if you get too fast of a old laptop, it can cause read/write problems. This laptop is used for the DOS based Motorola Radio Service Software

to program all parameters, freqs, levels on MSF-5000 VHF or UHF Repeaters and most importantly all the Motorola Maxtrac, Radius and GM 300 mobiles and Kenwood 830 radios we use for link radios.

- 1) Off brand Motorola RIB (Radio Interface Box) \$25 on Ebay
- 1) Off brand Motorola Programming Cable - Rib to Maxtrac/Radius/GM300 programming cable (please don't buy the cables for USB or ribless) They run \$15.00 each on Ebay
- 1) Off brand Motorola MSF-5000 Programming Cable (Rib to RJ-45 style) different from Maxtrac. Off brand on Ebay \$20
- 1) Motorola MICOR Test Set, alignment meter/cables
- 1) Motorola MSF-5000 Test Set/meter and cables

Recommended Test Equipment/Tools for ARRG Repeater Technical Team Member			
Test Gear or Item	Required Options	Required Options	Price Range
<p>Bird 43 N Watt Meter and a minimum of four slugs</p>  <p>ARRG does own a BIRD with multiple Slugs that can be checked out from the Technical Lead</p>	<p>The following VHF slugs should be carried to the site</p> <p>BIRD25C Bird Wattmeter Element, 100-250 MHz, 25 Watt, Bird</p> <p>and BIRD100B or C Bird Wattmeter Element, 100-250 MHz, 100 Watt, Bird</p> <p>Two N male to N Male 36" to 72" jumper cables RG-213</p>	<p>The following UHF slugs should be carried to the site</p> <p>BIRD25D Bird Wattmeter Element, 200-500 MHz, 25 Watt, Bird</p> <p>and BIRD100D Bird Wattmeter Element, 200-500 MHz, 100 Watt, Bird</p>	<p>On Ebay, used Bird 43N wattmeter's run \$125 to \$300 depending on Condition. Individual slugs run between \$25 and \$100 each. We use only N connectors on our Birds, no UHF.</p>
 <p>100 W (Left) 25 W (Right) Dummy Load</p>	<p>150 W Max Usually get a 100 W</p>	<p>Optional 25 Watt smaller load</p>	<p>N male connector</p>

 <p>Coax Jumpers for Wattmeter/Service Monitor and bench testing</p>	<p>36" N to N male Coax Jumper, RG-213 or better</p>	<p>And 72"</p>	<p>Good LMR240 or double shielded silver plated coax. RB-8, RG-213 and LMR-400 is too large and stiff for use with most service monitors. From \$10 to \$20 or make your own.</p>
	<p>Plastic RF Tuning (TV Radio) Alignment Tools And screwdrivers</p>	<p>Needed for tuning every receiver and transmitter used in our system. They are also used for adjusting coils, slugs, pots and controls.</p>	<p>EBAY from \$10 to \$50 You will also need thin – long Screwdrivers of all types for screws, rf metal pots that are in tight places</p>

Equipment Section: Hands On Experience**Recommendations**

- Repeaters (stations and duplexed mobile radios)
- Linking/remote base radios
- Antennas, Omni, Directional, Offset designs.
Antenna down tilt, Beamwidth, Bandwidth.
- Duplexers
- Filtering products (cavity filters, isolators, etc.)
- Voting comparators
- Voting receivers (remote or satellite receiver sites)
- Controllers
- Crystals
- Power supplies
- Surge/lightning arrestors
- Transmission lines and connectors
- Preamplifiers
- Power Amplifiers
- Crossband couplers
- Audio Processing
- Tone signaling (PL, Channel Guard, Call Guard, CTCSS)
- Testing and servicing equipment, Communication Analyzers, Service Monitor experience

Model-Specific Questions (specifications, troubleshooting, tune-up, modifications, etc.)

- GE
- Motorola
- Kenwood
- Yaesu/Vertex
- ICOM
- Home Brew

Repeater Controllers

- SCOM
- Link Comm
- ACC
- MCC
- CAT
- NHRC
- CSI
- Pacific Research
- Zetron

Theory and Engineering Questions

- Filtering/duplexing/isolation
- Troubleshooting techniques
- Analog circuit design
- RF circuit design
- Digital circuit design
- Transmission line theory
- Coverage modeling/path analysis
- Antenna design/theory
- Intermod analysis
- Isolation analysis - System troubleshooting (desense, noise, intermodulation, etc.) - Performance/optimization (audio quality, antenna patterns, etc.)

Implementation Concepts

- Linking schemes
- Installation techniques and materials
- Tower/rigging techniques and materials
- Interfacing/Third-Party Equipment

Another Help Guide
Tools, Test Equipment and Shack Accessories
For the New Ham Radio Operator
By N4UJW

This article is tailored for the **new ham radio operator** so if you have been a ham for many years, you already know that there are a few required tools and test equipment you need to be able to maintain your station, it's accessories and your antenna setup.

And if you are married, your wife may suddenly realize you are smarter than you look and she may think that since you are a ham radio operator, you have suddenly gained the knowledge to repair ANYTHING "electrical" around the house!

This depends on your wife! If you want more operating time on the air, my advice is to reply to a "Can you fix this?" from her....is to just say a polite...."Sorry honey, I don't know anything about it!", and carry on with ham radio or there might be a better option to keep the peace....you would just say "I will take a look at it soon".

And as an added thought, depending on how you handle it, a "fix it" opportunity for her may be to your advantage if every time you needed a new tool or piece of test equipment for ham radio, you could justify the expense of it with her now that you are a ham! Now, maybe you "can" if she thinks you're now "authorized" and have become much "smarter" in household repairs because you are a ham! (insert laugh here!)Read on.....

Many new hams realize that during the initial setup of a ham station that they have to cut wire, coaxial cable, tighten nuts, solder, need a screwdriver, or a wrench or two and test their final antenna installation.

They also realize that in the instructions that came with that new whiz bang antenna they just bought or are trying to build that they need a way to adjust their antenna for lowest swr and then it "dawns" on them, that it has to be mounted on a support of some sort up high! Do you have a means to install it such as a ladder?

All of this requires a minimum of hand tools and accessories to get the job done just to get on the air in most cases!

So... here is a suggested list of some items you WILL need if you don't already have them. The list is NOT all inclusive. Add to the list if and when you see the need.

You will notice that individual sizes usually are not mentioned. The choice will be yours and depends on the application. **Note of wisdom...don't buy the cheap stuff...**you will pay for them over and over by having to replace them many times during your ham radio lifetime if you use tools a lot! You will lose one or two along the way. They have a habit of becoming invisible especially if kids are in the family! I lost many of my Dad's tools over my childhood, now it is coming back to me with my family!

Hand Tools: You can't have too many!
(not listed in any particular priority)



- 1. A good set of screw drivers.** Look for a phillips head type and a flat blade type. There are many different sizes of screw drivers out there. Pick an assortment of the sizes you think you may need. Multi-use screw drivers are very handy and they have usually 4 different blades that can be interchanged in the handle and one tool will do the job of 4 saving you space in your tool box. A good set of [Jewelers Screw Drivers](#) is needed when it comes to those tiny screws on knobs and controls and also putting on mic connectors, etc. Remember those tiny screws in the hinges of your glasses.....that just justified the purchase of them with your wife. They will come loose eventually and you just saved yourself or her a trip in the car to the eye glasses store.
- 2. Tool Box...**as mentioned in #1 above. The size and type depends on the amount of tools you may want to add in the future.
- 3. Wire cutters.** These vary in size according to the wire size that you will be cutting. As a general rule of thumb, many wire type antennas that you may build, require #12 or #14 gauge wire, so the wire cutters should be of appropriate size. Wire crimpers would be a good tool to have latter on. These aid in the connection of various connectors to wire ends and splices. Some even have small bolt cutters built in....very handy when you need them.
- 4. Wrenches and socket sets.** Adjustable wrenches are recommended as they are multipurpose and fit many different size nuts or you can get the open-end types or closed end types to suit your taste. Many choices are yours in socket and wrench sets that come in handy carrying cases for good prices with a wide assortment of sizes to fit "all". Wrenches are usually needed when mounting many antennas on supports depending on their construction and the mfg's recommendations and many other variables. "Allen" and hex head wrenches also come under this category...available in various assorted sizes. Very handy for removing knobs.
- 5. Pliers.** These come in many different sizes and shapes according to their intended use. A couple of different sizes of "Channel Lock" types are very handy along with regular hand sizes. Some come with wire cutter ends. "Needle nose" types are very handy also and come in many sizes. "Ignition pliers" are very handy for small jobs and fit in your pocket. A pair of "Vice Grips" is a great help.
- 6. Tape measure.** 12 feet or longer depending on your needs. Great aid for antenna work! A 50 foot tape measure is very helpful with building hf antennas.
- 7. Electrical Tape.** Not really considered a hand tool, but you will certainly use it. Again, don't buy the cheap stuff, especially if it will be used outdoors. [Scotch Super 33+ Vinyl Electrical Tape](#) brand is excellent. Many hams swear by it. Your choice should be flexible in cold weather and seal well. Don't buy the cheap stuff.
- 8. A good sharp pocket knife or utility knife.** Used for trimming insulation from wire, coax, etc. Use as needed and be careful.
- 9. Soldering iron and/or gun.** This will depend on your ability to solder. Many times in your ham radio lifetime, you will need to be able to solder and [Soldering Irons](#) will be needed, so if you don't know

how....just get a ham friend who knows how to help you learn or search the internet. There are many good "How to Solder" web sites out there. When soldering, practice, practice and lots more practice for the inexperienced! [Soldering Guns](#) are used for larger soldering jobs, like soldering coax connectors, small copper tubing, putting on PL-259 connectors, and the like.

10. **All of those tools I left off of this list** that will come as time passes and you get more acquainted with exactly what you may need depending on how far you want to go with your station and your ability.....don't forget a good ladder that will **safely** reach your job. **Do not use metal ladders near power lines!**

11. A good bench [Vice](#) either temporary mounted or permanent. Very handy as a "third" hand, especially when putting on rf connectors, plugs, etc

12. A large supply of....**SAFETY FIRST!** Hand tools, ladders, test equipment, other ham equipment, etc, can get you hurt, or worse. **Metal ladders should NEVER be used when working on ANY electrical job.** Get help if you don't know what you are doing or are not mechanically inclined...be safe, not sorry! Remember [Antenna Safety](#) and the lethal levels of electricity you may be working with in or around your ham station!

Search Amazon.com for Hand Tools!

Suggested Test Equipment for the New Ham:

(Again, not presented in any particular order of importance)



1. SWR/POWER METER.

I refer to an external swr/power meter. Yes, you may have a built in unit in your radio, but how do you know it is accurate? An external meter is invaluable in trouble shooting station problems!

This will strictly be an individual choice. It must cover the frequency range and potential rf power level that your station will be operating on. Some are built into different radios, some are external. As a

general rule, most external swr/power meters are more accurate than the little ones built into the face of many radios. The external types come in many sizes, frequency ranges and power levels.

2. An swr/power meter that covers up to 30mhz...will usually not work on 6 meters and higher frequencies with any sort of accuracy. Assure yourself your meter is the right one for your station by reading the specifications of it. You need accuracy....not guess work!

[Here are some suggested Watt and Swr Meters!](#)



2. A good multimeter.

[Digital Multimeters](#) [Click link to see a wide selection.](#)

Again, your choice. It can be either digital or analog. It needs to be able to measure at least continuity, voltage (AC and DC), current, (preferably AC and DC), and resistance (ohms), up to the expected levels you may need to measure with a safety margin to spare.

3. It is also assumed you know how to use one.... if you don't, read the instructions and then get a good ham friend who knows how to help you learn more about how to use it. **DANGER....you COULD BE ELECTROCUTED** if you don't know what you are doing. You can also destroy your meter if it is not used properly. The voltage, current and resistance range must be set higher than your "expected" working ranges!



3. Dummy load.

Used for a substitute "perfect" or near perfect antenna load. Very helpful in determining if your transmitter has output without connecting the transmitter to the antenna and the resulting harmful interference this causes. When used in conjunction with a power (rf watt meter) it will tell you if your radio is up to specifications on its output. It must also be designed for the frequency range you will be

using it for.

Many hams have one for the hf frequencies and then another for VHF/UHF use. They come in "dry" or "wet" types. The wet types usually are submerged in a container containing some type of oil that helps to cool the "load" under very high rf output conditions. Dry types contain the "load" inside a metal container, air cooled, and usually don't handle high power or many hundreds of watts very well. Your choice depends on your station and your future plans for operating.



4. Optional. Antenna analyzer.

(The MFJ-259b shown)

Very helpful and **time saving** when working with antennas and their design and tuning. **The MFJ-259B gives you a complete picture of your antenna's performance anywhere between 1.8~170MHz, even outside the HAM bands! A must have for antenna experimenting!**
[Get More Info From MCM Electronics!](#)

5. A good standby receiver/s.....It can be either portable or desk top type and should cover the bands and frequencies that you use....It can be used for monitoring your station transmissions. A handheld "police" type scanner radio that has the aircraft

band can be used for tracking down noise related problems. The aircraft band uses AM rather than FM and will pick up the noise much better.

If the antenna is detachable, then you can build a simple 2 or 3 element Yagi antenna to attach to it for almost pinpoint accuracy for power line noise location. Having a good [shortwave receiver](#), either desktop or portable, can be a great help when monitoring your station's audio or as a simple backup receiver.

6. Other items of test equipment not on the list will come as you progress.

Assorted items you may want to keep on hand:

Sealer for weather proofing outside connectors and joints, splices, etc.

"Coax Seal" in the ad below is very popular with many hams! Works much better than tape to seal those connectors outdoors and is not a liquid which takes forever to dry.

Click the ad to check out "Coax Seal"

Extra connectors for coax ends. Always good to have on hand. PL-259 types are used often and many other types of connectors. A good source and at some great prices can be found by clicking on the banner below.



Wired Communications has some great pricing on all types of rf connectors!

Extra solder if you are into soldering and extra tips for the soldering equipment.

Extra plugs for various connections in your shack. Don't forget an extra mic plug!

Fuses. Have spares for your radio, power supply and other devices that require them. Consult your operators manuals.

Emergency roll of electrical tape. Hide it from the family or it won't be there when you need it! Same goes for your important tools!

Pencil and pad for taking notes.

Assorted nuts, bolts, screws, lock washers and other hardware as needed. Storage containers....Some way to store them separated by size if possible. Old coffee cans, baby food jars, etc make great "catch all" containers but takes a while to find that one screw you need! Many hams that are into repair and kit building use parts bins with many separate slide out container sections. Your containers are your choice.

Magnifying Glass....(or a pair of good eyes)

Accessories for the Shack!



Bench Lamps!

Bench lamps are a must for the shack when it comes to good lighting for those closeup soldering jobs, kit and construction projects and good "spot" lighting in the shack. They will help to reduce eye strain and fatigue. Many come with adjustable arms and give you a choice of lamp types and magnifying lenses suitable for your specific "bench" needs. Many hams also use the less expensive types for attaching microphones to the end by removing the light head! [Recommended Bench Lamps at Amazon.com](#)

How to save money being a true "ham".



Be a scrounger.....many items of no interest to others can be used in ham radio applications. Although I don't recommend "dumpster diving", sometimes hundreds of feet of wire can be found...antenna paradise! Aluminum and copper tubing, assorted "insulator material" and just too much of other people's "junk" to mention.

Construction sites can be loaded....the throw away stuff, I'm talking about....**get permission first**. Yard and garage sales can be a treasure trove to the ham with a "wise eye". If you decide you're going to upgrade that old VCR....it may be loaded with components you may use in the future. Same goes for that old TV, stereo system, and on and on. Don't pass up on that old CB...loaded with parts.

More advanced hams can convert many of these older CB's to 10 meter beacons or 10 meter mono banders also! Now you can see how that one man's junk can be another man's treasure!
Many consumer devices contain very small speakers that can be removed and used for many applications around the ham shack.

I have several! Old TV antennas can be used for many ham antenna projects especially on 2 meters and up! Think about all of that free aluminum tubing! All of those small screws, nuts and bolts, mounting brackets, insulators, etc, can be removed and save you much money when you need one...think about not having to crank the car to run to the hardware store for 1 screw or a mast mounting bracket!
Don't forget about ham fests....loaded with all the "good stuff" that other hams are trying to unload on you! Let the buyer beware!

Here are a couple of examples of scrounging that happened while I was writing this article.....My wife was taking apart an old table lamp she no longer wanted....most of it was not usable, even by me with all my scrounging experience....but.....wait....there inside the glass globe (which contained artificial flowers that she **did** want) was a very loooooong threaded brass rod with nuts!
I disposed of it for her.....straight to my junk box! Lucky me!

Another opportunity happened the day after that with her....my son had a novelty glass that had a blinking led array in the bottom. It stopped working and she wanted me to take a look, batteries had become corroded due to water leakage, not worth the cost and effort to replace in her opinion.....she said, just throw away the led "stuff" on the bottom and leave the glass, which was OK....I did....now I have several **no cost** leds in my junk box!

One man's (woman's) junk, another man's treasure!
See the cable guy making an installation next door or down the street? Ask him if he has any roll ends of coax you can dispose of for him. Yes CATV coax can be used in a pinch as a substitute for 50 ohm coax using 100 watts or less and it is very low loss! Many hams use it instead of the regular 50 ohm coax in building antennas. Sure, there may be a difference in the match between the antenna and the coax, but who is to know?

This "Scrounger" list could go on forever, but the **point is to keep your eyes and ears open**. You may see or hear about a "windfall" for your station. You have to determine your own needs and compare them with what is in your bank roll!

This list of suggested tools, test equipment and accessories for the new ham is in no way "all inclusive", but should help you in the beginning stages of setting up your new ham station and hopefully help you to prepare it for your future adventures in ham radio. What's that.....The wife is calling me.....Now it's time to throw out the trash.....after I look thru it! She throws away trash, I find treasure! (Sometimes)

73,

Don - N4UJW at Hamuniverse.com