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Amateur Radio Guide to Digital Mobile Radio

2nd Edition

By

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Winner of the 2016 Hamvention®
Technical Achievement Award

May 2019

Previous edition included a list of Talk Groups, because of the confusion caused by different networks offering different Talk Groups I have removed them from this edition.

Contact your local repeater or network operators for what Talk Groups are available on their repeaters.

Amateur Radio Guide to Digital Mobile Radio
2nd Edition

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Forward to the Second Addition

It has been over six years since I was first introduced to DMR by DMR-MARC at the Dayton Hamvention in 2012. Back in those days there were two choices for DMR radios; single band Motorola and Hytera. Today I have lost count of the number of different brands of DMR radios including dual band (VHF/UHF) that are available from over a dozen manufacturers.

The radio ID database was less than 1,000 a few years ago, today it has grown to over 130,000. The cBridge based networks are still limited to Motorola Mototrbo repeaters and analog interfaces, DMRplus, Brandmeister, QualNET, TGIF and others supports just about everything including homebrew repeater and Hot Spots.

The growth of DMR is because of the availability of low-cost radios, some selling for under $100 including dual-band units. Besides the commercial repeaters there are an increasing number analog repeaters being converted to digital with the use of add-in boards such as the MMDVM that support multiple digital technologies.

Both D-Star (Icom and Kenwood), Fusion (Yaesu), NXDN (Kenwood and Icom), and P25 (Motorola and many others) support they own digital protocols. D-Star is the granddaddy in amateur radio only preceded by Alinco's Digital Voice. Yaesu has been pushing Fusion into the amateur market with super low-price specials on their repeaters, Icom has also been offering specials on their repeater and controller. But neither D-Star, Fusion, NXDN nor P25 manufactures have come close to the $100 range for handhelds available for DMR.

Interconnects between the different digital technologies is with us along with VoIP voice technologies also offering interconnects.

The future for all the linked digital repeater technologies is to move off the Internet as much as possible and build out an Amateur Radio wireless backbone. This is especially important for supporting emergency communications. No one can depend on the Internet in an emergency!

Forward

I was first licensed as WB8GZR when I was a college freshman, and later as WB9GQM, WB8PUF, and currently as W2XAB. I built my first analog FM repeater (GE Progress Line) in college and I have been active over the last 49 years in many aspects of amateur radio including FM, Packet, D-Star™ and now DMR, Fusion, and P25. I worked in the Aerospace industry and spent a short time at Motorola before embarking on a career teaching computer technology spanning the last 18 years before retirement.

I strongly believe in supporting local and national amateur radio organizations, including membership in the ARRL, AMSAT, and QCWA. To keep our hobby active and growing, it is important that users support our clubs and individual repeater operators. Every ham needs to recruit one new ham every year!

We need to bring more youth and young adults into our hobby; the reality is that we are all getting older and many of us are closer to being silent keys than we wish to think about. I have passed my genes on to my harmonic (W2JEN), my knowledge on to my students, and I hope I will leave Amateur Radio better off than when I first arrived on the scene.

Amateur Radio is made up of many special interest groups (SIGs), CW, AM, SSB, FM, HF, VHF, UHF, microwave, contesting, DXing, public service, ARES, RACES, repeaters, education, clubs, fox hunting, RTTY, Packet, APRS, Satellite, SDR, D-Star™, P25, DMR, NXDN, kit building, and Elmering, just to name a few. There will always be something new that generates interest in our hobby.

There are three levels of involvement in DMR. The first is as a **user**, where you begin with a single radio, and later, possibly you'll add a second or third; when you get to 20+ radios you are really addicted and may need an intervention. The next level is as a **repeater operator**. You generally undertake this because there are no repeaters in your area or because you want better coverage. The third level of DMR participation is as a **network operator**. As a network operator, you purchase and manage your own bridge (such as the cBridge™, DMR+, or Brandmeister) and build networks that interconnect to the other DMR networks.

Amateur Radio is a hobby; Webster defines a hobby as *a pursuit outside one's regular occupation engaged in especially for relaxation.* I consider *relaxation* the most important part of a hobby. A second important part of

any hobby is the friendships that are developed through participation in the hobby.

Dedication

I dedicate this book to all my ham buddies, but especially WA9TKK (my Elmer), W9JW (ex WB8KLO), and silent keys: W8HQQ (Tom), K8QOE (Joe), and W8JGP (Donn).

I need to also mention my thanks to all my wives for tolerating my hobby both at home and in the car. I especially thank my late father for sparking my interest in technology and for buying me my first computer kit, the IMASI 8080.

Thanks to the Following

I would like to thank KC6OVD for being my local and first DMR mentor and for his help getting my first Mototrbo™ repeater working and online. Thanks to AA9VI and the DMR-MARC group for sparking my interest in amateur DMR at the Dayton Hamvention® in 2012, and lastly, special thanks to W1NGS and NO7RF for their assistance in learning to configure Super Groups on my cBridge™. Thanks to AA9VI, NE1B, NO7RF, K6BIV, W1NGS, WB8SCT and W9JW for reviewing the first edition. A special thanks to the Dayton Amateur Radio Association (DARA) and all those involved with giving the rest of us the annual Mecca of Amateur Radio (aka The Dayton Hamvention®); I miss the old Hara Arena, but Xenia is going to be much better in the long run.

To the ARRL all I can say is good luck in your second hundred years. Thanks to AMSAT for getting the hobby off the planet, and the QCWA for reminding me I am not as old as some hams.

I hope I live long enough to make an interplanetary contact with humans who have migrated to Mars or hams from other planets in our vast universe.

What is DMR?

Digital Mobile Radio (DMR) was developed by the European Telecommunications Standards Institute (ETSI) and is used worldwide by professional mobile radio users. [http://www.dmrassociation.org]

DMR is divided into three tiers. Tier I is a single channel specification originally for the European unlicensed dPMR446 service. It is a single channel FDMA 6.25 kHz bandwidth; the standard supports peer-to-peer (mode 1), repeater (mode 2) and linked repeater (mode 3) configurations. The use of the Tier I standard has been expanded into radios for use in other than the unlicensed dPMR446 service. [http://www.dpmr-mou.org]

Tier II is 2-slot TDMA 12.5 kHz wide peer-to-peer and repeater mode specification, resulting in a spectrum efficiency of 6.25 kHz per channel. Each time slot can be either voice and/or data depending upon system needs. IP Site Connect (IPSC) for interconnecting repeaters over the Internet is vendor specific and is not part of the ETSI standards at this time. Most amateur radio implementations of DMR are using voice on both time slots.

Tier III builds upon Tier II, adding trunking operation involving multiple repeaters at a single or multiple site system. Not all manufacturers' trunking implementation is Tier III compatible.

It is Tier II that amateurs are implementing in their Mototrbo™ [http://www.motorolasolutions.com] and Hytera [http://www.hytera.us] infrastructure networks and the focus of this booklet. The IPSC protocols used by the different brand repeaters are not compatible; it is doubtful the equipment manufacturers will ever standardize for business reasons. Any brand DMR (Tier II) user radio will work on any Tier II system, although some manufacturers offer proprietary features.

The current implementation of DMR utilizes the DSVI AMBE+2™ vocoder by agreement of the manufactures; it is not specified in the ESTI standard. Most of the radio manufacturers have implemented the vocoder in licensed software. The forward error correction in the AMBE+2™ is an improvement of the voice quality of older vocoders such as used by D-Star™.

Amateur DMR networks can be broken down into four main type of bridges, cBridge/TLNet, DMR+, SmartPTT, and Brandmeister, The cBridge/TLNet is a commercial product (RavenNet) supporting only Mototrbo™ repeaters and analog systems. DMP+ supports both Mototrbo™ and Hytera repeaters. Brandmeister supports multiple brands

of DMR repeaters along with a variety of low power Hot Spots and even direct VoIP connects from some radios.

From a user perspective Brandmeister has a much large selection of TGs than DMR+ and cBridge/TLNet, although the typical users only use a small few on a regular basis. From the repeater operator perspective Brandmeister allows them to manage their own selection of full-time TGs whereas the cBridge/TLNet and DMR+ requires administrators to manage the TGs (both full-time and PTT) available on the repeater.

Most of the DMR networks are interconnected to other networks to share TGs. Each TALK GROUP has a hosting bridge, the main ones are DMR-MARC, DMRX, DMR+, and Brandmeister for national and worldwide TGs. For political reasons some of the amateur network fiefdoms refuse to peer with some other networks, maybe someday they will all be able to get along.

The K4USD Network which I administer has interconnections with DMR-MARC, DMRX, DMR+, Brandmeister, QuadNET, TGIF and about 25 other networks as an example. The K4USD Network makes available over 80 TGs to connected repeaters.

These bridges are technically Layer 7 Bridges (ISO Model), they make forwarding decisions based upon the application address mapping.

All the networked digital radio technologies utilize conference bridges for interconnects groups of users. D-Star calls their conference bridges *Reflectors*, Fusion uses the term *Rooms*, DMR and P25 use the term *Talk Group*.

There is a general misunderstanding about the cBridge/TLNet based networks; many hams refer to them as DMR-MARC which is totally incorrect. The are at least 40+ different cBridge/TLNet based networks, DMR-MARC is but one of them. DMR-MARC (Motorola Amateur Radio Club) was the first worldwide Amateur Radio DMR network.

Some hams have installed DMR repeaters and Hot Spots in their vehicle, using 3G/4G (and soon 5G) cellular wireless services for Internet access. Others have implemented remote bases to interconnect to other networks or radios; it is important to remember that the wide area networks typically have policies prohibiting interconnected traffic, but what is implemented locally and stays local is acceptable. While some may consider network policies prohibiting interconnection to different types of networks political, these policies are really about keeping large networks functioning. Users sometimes don't realize the hours put in by network operators or the extent of their efforts that are required to keep a linked

system running smoothly. There are sometimes issues of poor quality from interconnected technologies because of the vocoding process that would degrade the quality of the network and connectivity issues.

Back during the early era of amateur analog repeaters, most everyone used surplus commercial radios. Over time, equipment designed for and targeted to the radio amateur reached the amateur radio marketplace. Today in the DMR marketplace you can find used commercial gear, but new DMR radios are now available with street prices within the range of a typical ham budget, being less expensive than both D-Star and Fusion. Some amateur DMR users are just using their commercial radios from work with a few extra channels programmed.

Most manufacturers are marketing DMR radios for the broader world market, they just happen in most cases to include amateur frequencies. A few models such as the Hytera AR482G only cover the 420-450MHz ham band. Because of FCC Rules & Regulations for commercial users, DMR radios certified for Part 90 do not offer FPP (Front Panel Programming) as is the norm for other amateur radios. Many of the current DMR radios marketed to hams offer some level of FPP. Most of the DMR radios require a programming cable to program the radio using manufacturer software, while some radios support programming using BlueTooth, WiFi and even over-the-air programming.

WARNING – It is illegal to transmit on frequencies you are not licensed for, even programming your radio so it can transmit on an unauthorized frequency can result in fines and prosecution.

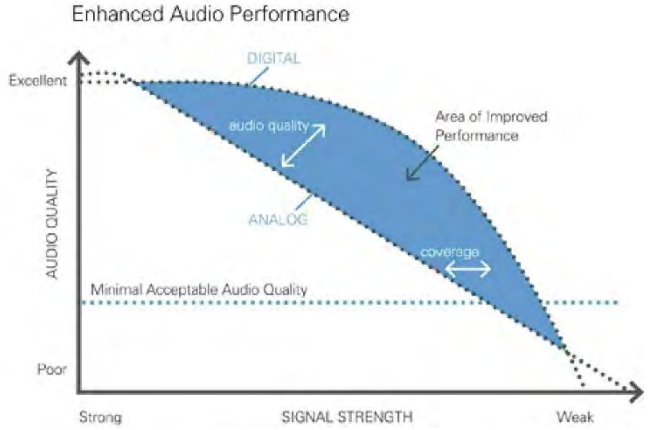
There are police and fire departments, local/state governments and many businesses using DMR Tier II and Tier III; any Tier III capable radio will also work on Tier II systems but neither will work on Tier I. If you have a DMR radio for work, you may be able to program it to also work on amateur repeaters (make sure you have permission) and you will need to contact https://www.radioid.net if you are in North/South America, Asia, or Oceania about a usable subscriber ID that will work on both networks. If you are in Europe or Africa, you need to contact https://register.ham-digital.org.

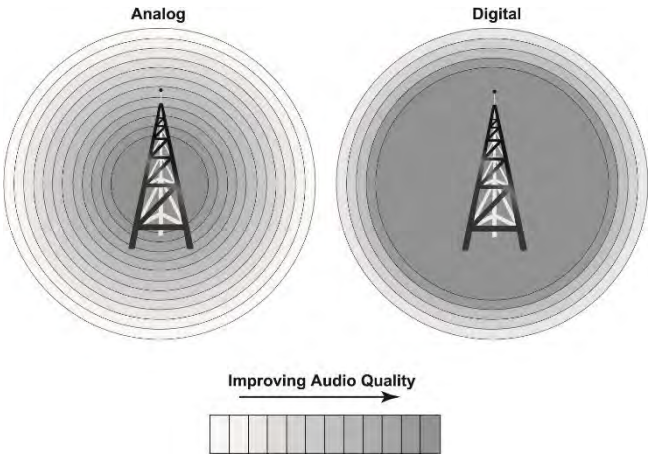
Digital vs. Analog

If you have experience operating on analog FM repeaters, you will have noticed that the audio quality degrades as a station's signal into the repeater (uplink) gets weaker; you start hearing an increase in noise bursts intermixed with the audio until the signal gets so weak that the station can no long access the repeater or you can not understand the audio because

of noise. As you move further from the repeater you will start hearing the same noise bursts into your receiver as the repeater's signal gets weaker (downlink) until you can no longer hear the repeater. A combination of a station's weak signal into a repeater and a repeater's weak signal to the listener can make the usability degrade faster.

The basic difference with digital repeaters is that the audio quality remains the same on the uplink and downlink until the very end of the coverage range; then the audio starts sounding broken (missing portions of the speech) on DMR systems caused by lost packets. The Internet can also drop the UDP packets used for moving traffic between repeaters and bridges, and between bridges, causing the same broken audio affect. Analog static is a thing of the past using DMR unless the TALK GROUP is interconnected to analog audio source.



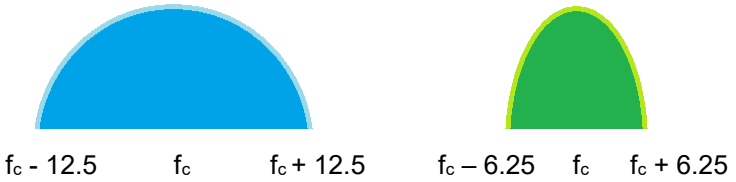


DMR has Forward Error Correction (FEC) which can correct small bit errors, slightly extending the usable range and improving communication quality.

Better quality receivers can operate at a lower noise floor, higher power transmitters, and higher gain antenna systems will also extend coverage of both analog and digital systems.

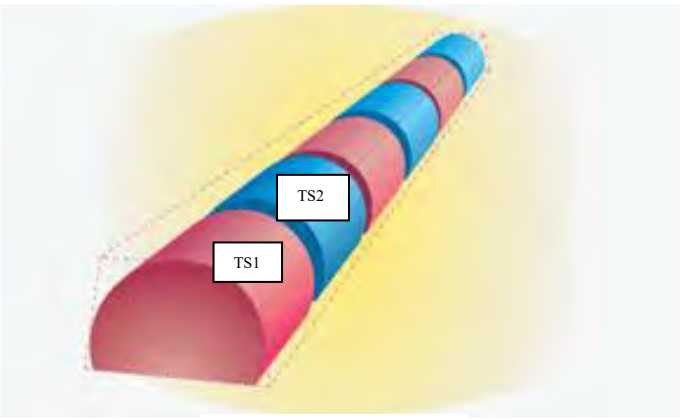
Two-Slot TDMA

DMR Tier II/Tier III occupies a 12.5 kHz bandwidth that two channels share using Time-Division Multiple Access (TDMA). This results in spectrum efficiency of 6.25 kHz per channel. Comparing the spectrum efficiency of DMR to a wideband analog FM, DMR only uses 25% of the bandwidth per talk channel. Each channel can carry either voice and/or data depending on system design. The two time slots are called Time Slot 1 (TS1) and Time Slot 2 (TS2).



Wideband Analog FM
25 kHz Channel
Bandwidth
(25 kHz per Channel)

DMR
12.5 kHz Channel
Bandwidth
(6.25 kHz per Channel)



Two-Slot TDMA

For the amateur, this means one repeater allows two separate channels (TSs) at the same time. Currently most amateur DMR repeater system implementations utilize both channels for voice and some limited text messaging. Talk Group/Time Slot allocation is dependent on the repeater, unluckily there is no real standard anymore and you need to check with repeater operators or online databases.

For DMR repeater operators, a single two-slot TDMA repeater offers a significant savings over two stand-alone repeaters to obtain two separate communication channels as only one repeater, one duplexer, and one antenna system is required.

The utilization of TDMA offers about a 40% battery savings on transmit for a portable, extending talking time over non-TDMA and analog transmissions for portable users.

The two-slot TDMA implemented in DMR uplinks (portable/mobile to repeater) uses a 30-ms window for each time slot, the 30-ms is further divided into a 27.5-ms frame and a 2.5-ms gap. This means when transmitting, your transmitter is only turned on for 27.5ms every 60ms, resulting in extended battery life for portables. Note that you will not be able to measure power output in TDMA with most power meters, use an analog channel to measure power output.

The DMR repeater (downlink) transmits a continuous data stream even if only one timeslot is being used; the 2.5-ms uplink gap is replaced with a CACH burst (Common Announcement Channel) that is used for channel management and low speed signaling.

The 27.5-ms frame consists of a total of 264-bits; 108-bit payload, 48-bit SYNC or embedded signaling, and a second 108-bit payload for a total of 216-bits of payload per frame. The vocoder must compress 60-ms of audio with FEC (forward error correction) into 216-bits of data for transmission. The 2.5ms-gap is used for guard time to allow PA ramping and propagation delay. Because of propagation delay and synchronization there is a limit to the usable range of DMR Tier II/III.

Talk Groups

Talk Groups are a way for groups of users to share a time slot (one-to-many) without distracting and disrupting other users of the time slot. It should be noted that only one Talk Group can be using a time slot at a time. If your radio is not programmed to listen to a Talk Group, you will not hear that group's traffic. There are over 16-million TGs available in DMR, most use only a very few.

Check with your local repeater operator to find out what TGs/TSs are available on a repeater.

The DMR standard also supports private calls (one-to-one), encryption, and data. Private calls are not allowed by most of the amateur networks and many consider private calls not amateur friendly; private calls can tie up a large number of repeater time slots across the network. Note that private calls are not TGs, although they both can use the same numbers. Text messaging and GPS are supported on some networks. The GPS is not directly compatible with amateur APRS and requires translation by a gateway.

For simplex traffic, the accepted standard in the amateur community is to use Talk Group 99 on TS1 with CC1. Many DMR radios do not support simplex on TS2.

When programming your DMR radio, you may find it easier to program multiple TGs for receive, this allows your radio to listen to multiple groups used on a time slot when you have you radio set to any specific channel.

There are TGs implemented for individual states and regionals on many networks. Some TGs are available all the time, while others only at preprogrammed times or PTT which requires a local user to PTT on the Talk Group to activate it for a period of time or until another Talk Group is keyed to turn it off; this is dependent on the bridge the repeater is connected with. Remember you must ID your callsign per FCC Rules. Since only one Talk Group can be active at a time on a time slot, many systems will disable other Talk Groups when a local user is active on a different Talk Group on the time slot. Be ham friendly and try to use TGs that tie up the fewest number of repeaters if you are going to have a long QSO. Further information about specific TGs can be found on the repeater or network websites.

Zones

User DMR radios support Zones. A Zone is just a grouping of individual channels. Some model radios may limit the number of channels per Zone and the number of Zones allowed.

You could program Zones for local channels (DMR or analog), another Zone for a neighboring state, and a Zone for business and government channels. If you do program non-amateur channels in your radio, make sure they are RX only unless you are licensed or authorized to use them as per FCC 90.427(b) ***Except for frequencies used in accordance with §90.417, no person shall program into a transmitter frequencies for which the licensee using the transmitter is not authorized.***; otherwise you will be

in violation of FCC R&Rs and enforcement action could be taken against you. If you have a VHF model, you could program a Zone for all the possible NWS Weather Channels (again, make sure you program the channels as receive only). Zones are just a way to manage large number of channels, much like file folders or directories on your computer.

Color Codes

DMR repeaters use Color Codes (CC) much like analog repeaters use CTCSS (PL) or DCS. To access a repeater, you must program your radio to use the same CC as the repeater. There are 16 different CCs (CC0-CC15), CC1 default and most common. The use of Color Codes is not optional on DMR systems. If your Color Code is not set correctly, you will not be able to access the repeater. The only real purpose of different Color Codes is when multiple repeaters operating on the same frequency have overlapping coverage areas.

Code Plugs

A code plug is simply a radio's configuration file. Using a manufacturer's programming software you configure the channels and operating parameters of a radio. This file is uploaded to the radio and typically should also be saved on you computer as a backup. You can also download the code plug from a radio to modify it. Building a code plug can take many hours, especially if you want to program hundreds of channels. The code plug can also contain a Contact List of Radio IDs, call signs, and names to be displayed. You can find copies of preconfigured code plugs on the web for different models of radio; check with your local repeater or club for availability. All DMR radios support a limited number of entries in the Contact List.

If you want to better understand the DMR repeaters/networks, learn to write your own code plugs. There are many good YouTube videos available to teach you how to write your own Code Plug.

Scanning

All DMR radios allow you to configure scanning of channels. Remember, you will only hear traffic on the frequency, time slot, and groups you have programmed on a channel. I typically scan both time slots on my local repeater and a simplex channel I use; you can also scan analog channels mixed with the digital channels. Scanning will decrease the battery life on your radio. On dual-band radios, you can typically mix VHF and UHF channels.

Roaming

Roaming is not supported on all DMR radios. Check your owner's manual or manufacturer website to see if roaming is supported. In some radios it may be an additional cost option.

Roaming is NOT scanning. Roaming is similar but different. Roaming is designed to have your radio automatically select the best channel if your current channel's Receive Signal Strength Indicator (RSSI) falls below a defined level as you move throughout the coverage area of a group of homogeneous repeaters that carry the same TALK GROUPs on the same time slots at the same time. You should select channels that have the same time slot and receive groups configured; if you do not, roaming may not work correctly. Repeaters must be configured to transmit beacons at predefined intervals of inactivity so roamers will be on the correct channel. Without the repeater beaconing, roaming will still work, but the radio will only change channels if it hears a repeater on the air.

Roaming would be really great if all the DMR repeaters were on the same set of repeater pairs across the country, but it is too much to expect the Repeater Councils to work together for a unified rebanding of existing coordinations. It would also help if the different DMR networks could agree on which time slots were used by which TALK GROUPs. Wouldn't it be really nice to be able to program a dozen different frequencies, with a variety of common TALK GROUPs on the same time slots in your radio and be able to travel across North America and be able to access all DMR repeaters?

Simplex

On the professional side of DMR, *Talk-Around* refers to operating simplex on a repeater output channel. This allows a direct communication while still being able to hear the repeater. This allows users to directly contact other users listening on the repeater output frequency. Amateurs typically use dedicated simplex channels so as not to interfere with repeaters. The amateur DMR community has published a list of recommended simplex frequencies to be used instead of operating simplex on repeater outputs:

> UHF 1) 441.000 2) 446.500 3) 446.050 4) 446.075 5) 433.450
> VHF 1) 145.790 2) 145.510
> [Use TALK GROUP99 / CC1 / TS1 /Admit Criteria: Always / In Call Criteria: TX or Always]

Do not use 146.520 or 446.000; they are the national analog simplex channels and operating DMR on these common analog use frequencies will just cause disharmony within the amateur community. Also, avoid

repeater inputs and outputs, locally used non-DMR simplex channels, satellite sub-bands, and any other frequencies that could disrupt other amateur communications.

Admit Criteria

The Admit Criteria determines when your radio is allowed to transmit. The recommended setting for repeater channels is ***Color Code Free***; this configures your radio to be polite to your own digital system. You should configure your In Call Criteria to ***Follow Admit Criteria***. Simplex channels should be configured as ***Always*** for both Admit Criteria and ***Always*** or ***Follow TX*** for In Call Criteria.

Accessing a DMR Repeater

When you want to access a DMR repeater, you must have the frequency, Color Code, and Talk Group set correctly. When you key your transceiver, you send a signal to the repeater and the repeater responds back to you to acknowledge you can transmit your message. If you do not receive the repeater's acknowledgement, your radio will stop transmitting and you will hear a negative confirmation tone. This is one of the advantages of TDMA: allowing bidirectional communications between user and the repeater when transmitting. The repeater can also signal your radio to stop transmitting if there is contention on the network because more than one station is transmitting at a time.

Not all DMR repeaters are interconnected on the Internet. Internet connectivity may not be available at the repeater site, or not available at a reasonable cost. Some repeater operators may just prefer to keep their repeater for local usage only, or maybe only want it connected to a small local/regional network, without connecting to the larger world wide networks. Some repeater operators may also only connect one time slot to the network, leaving the other only for local communications. If the repeaters loses network connectivity, both time slots will be available for local usage.

IPSC and Bridges

Motorola Solutions IP Site Connect (IPSC) is a vendor specific repeater feature. Note that Mototrbo™ repeaters will only interconnect over the Internet with other Mototrbo™ repeaters because it is not part of the ETSI specifications and the manufacturers don't want to interconnect their infrastructures. Other repeater manufactures have their own protocol for connecting over the IP network.

Motorola Solutions Mototrbo™ IPSC implementation allows up to 15 Mototrbo™ repeaters operating in DMR mode to be connected on a fully meshed IP network, with one of the repeaters (or bridge) serving as a Master and all of the others are Peers. Any traffic originating on one of the interconnected repeaters is relayed over the IP network to each of the other repeaters. The Peers will first establish a connection with the Master and obtain the database of the other Peers along with their IP and port addresses.

The more repeaters in this fully meshed IPSC network, the more IP network bandwidth required for each repeater. A single Peer connected to a Master requires 15 kbps for each time slot participating in the Motorola IPSC network, 6 kbps for link management, and 55 kbps for RDAC (Remote Diagnostics and Control) traffic; if both time slots are participating in IPSC, 91 kbps bandwidth is required; each additional Peer requires 36 kbps bandwidth. The Master requires an additional 3 kbps bandwidth for each Peer in the network. The ***Mototrbo™ System Planner*** has full details about calculating necessary bandwidth for repeater operators.

To expand beyond the limits of basic IPSC network requires the utilization of a bridge to interconnect the different IPSC networks. Rayfield Communications cBridge™ [http://rayfield.net], BridgeCom Systems MV-IPSC™ [http://www.bridgecomsystems.com] are both interoperable as they are the same product sold under different names and licensed/manufactured by RavenNet.

The cBridge™ supports individual managers for each repeater (micro-segmentation), which is an improvement over having the cBridge™ manager connected to a network of multiple repeaters; this gives the ability to reduce bandwidth requirements and customize Talk Group availability for individual repeaters. The cBridge™ manager can serve as either a Master or Peer on an IPSC network for either a single repeater or group of homogeneous repeaters sharing one manager. Allowing a Mototrbo repeater to be a Master is important if the repeater wants to utilize RAS (Remote Access and Security), remote programming, or to have remote receivers.

The cBridge™ allows for network connections to other IPSC networks, and other cBridges™ utilizing Control Center (CC) connections. The c-Bridge™ allows for the management of TGs on an always-on, scheduled, or on-demand (PTT) basis (both timed out and until turned off). Models (upgradeable) are available to support 5, 15, 30, and 50 repeaters and they also support 100+ CC connections between c-Bridges™.

The cBridge™ also supports the interconnection of non-DMR audio sources utilizing an optional URI USB analog dongle [http://dmkeng.com/Products.htm] and vocoder module which can be connected to radios or repeater controllers.

Brandmeister (http://brandmeister.network) is another bridging product that support a number of different commercial DMR repeaters along with home brew systems and Hot Spots. The Brandmeister Network included 44+ servers located around the globe configured in a fully meshed IP network. They offer the ability of repeater/Hot Spot users to configure TGs on full-time with the remaining on a PTT basis time-out basis.

DMR+ is another choice for a bridging solution that supports Motorola and Hytera repeaters, and Hot Spots.

SmartPTT [https://smartptt.com/] is a commercial product that supports bridging Mototrbo™ repeaters. They offer very high end commercial options.

Remember, someone is paying for all of the infrastructure and monthly operating costs. If a club is operating your local DMR repeater, join and support the operation. If an individual is operating the local repeater, donate to support their ongoing expenses. Repeater operators and Hot Spots should also be supporting their bridge operators. Besides the cost of the infrastructure equipment, there are also recurring monthly expenses for rent, utilities (power and Internet), insurance, and maintenance. Don't be a Freeloader!

User Radios

There are many sources of new and used DMR radios. A number of ham radio stores now carry DMR radios. If you want to purchase a new commercial DMR radio or repeater for ham use, you can easily find a dealer, and some dealers are "ham friendly" and will offer reasonable discounts to hams. Check with other DMR users or on DMR related websites for further information.

You can also search on eBay™ and other online flea markets for both new and used radios. Many hamfests also have DMR dealers or sellers in their flea markets. Here are a few things you need to know before buying a DMR radio:

New or Used. For used DMR radios, it is buyer beware! Just remember that you will not be able to repair a non-working DMR radio unless you have the technical skills and necessary test equipment, and that test equipment can cost hundreds of times the cost of the radio. The street

price for new DMR radios is typically $100-$800 although under $100 is possible to find. Arguably higher quality, name brand radios, such as those bearing the name Motorola, Kenwood or Hytera, typically sell for more used than brand new radios cost from newer entrants into the DMR market. You typically get what you pay for; higher priced radios usually have more features, are better constructed and can handle more abuse than less expensive radios. Kenwood offers a commercial line of radios that can support DMR, NXDN, P25, and analog.

VHF, UHF, or 900MHz. UHF is the most commonly used DMR band in the US and world wide, but because of military radar in some US areas, as well as different UHF public service frequency allocations in Canada, only VHF repeaters may be used in certain areas. In most areas, however, DMR activity may be found on VHF and UHF bands. There are also amateur 902-928MHz DMR repeaters in the US, note that only Motorola manufactures certain model user radios that can be hacked to work in this band. If you are purchasing UHF equipment, make sure it covers the amateur band (420-450 MHz) from the factory. Dual-band (VHF/UHF) DMR radios are now available from a number of manufactures.

Programming Software. Some manufactures supply Programming software free. Motorola Solutions charges about $150 in the US for a three year subscription (which covers all their models within a region) to their software and updates. DMR radios, because they are professional radios, typically do not allow keyboard programming. If a vendor charges for the programming software, do not ask another ham to bootleg a copy for you. If you have a legal copy, you may program radios for others, but you cannot legally distribute the software. Software piracy is illegal, and if caught, it could cost you greatly in the end.

Programming Cable. Some radios use standard USB cables for programming, and some use cables that can cost upward of $80.

Front Panel Programming (FPP). Some radios offer FPP, allowing the user to program the radio from the keypad; not all FPP capable radios allows you to save the FPP programmed channel to the code plug.

Number of Channels. Some radios have as few as two channels while others have 16 or 4,000+ channels. You will need a channel for each frequency, Color Code and Talk Group combination. You can easily use 3 to10 memory channels for each DMR repeater you program into your radio.

Display or Non-Display. Some radios have only a channel selector knob, while others have displays (monochrome or color) that will show Talk Group and ID information. Some displays only show channel number.

Visually Impaired Operators. Consideration must be given to the channel selection knob on the radios. Some models have channel selection knobs that have fixed stops instead of 360° degree continuous rotation to allow the operator to find channel one; these radios typically limit zones to 16 channels and the channel selector has 16 positions. Some models offer programmable voice announcements.

DTMF Keypad. Some radios have a 12-button DTMF keypad while others do not. Mototrbo™ repeaters support a proprietary autopatch feature (Digital Telephone Interconnect, requiring an entitlement key costing ~$550 for the repeater). This feature may not work with non-Mototrbo™ radios.

GPS. GPS is available on some models. On professional networks, one of the time slots is typically allocated for location reporting and is interconnected to server based dispatch applications. GPS will shorten battery life if it is enabled. If you are using GPS make sure your GPS transmissions meet the FCC requirements for identification.

Bluetooth. Some higher end radios have Bluetooth built in for wireless headsets. I find this a great feature at work and home so I can listen without bothering others. Some radios with Bluetooth support data and programming via the Bluetooth wireless connection to the radio. Some models have Bluetooth adapters optionally available. Bluetooth will shorten battery life if enabled.

WiFi, 3G, 4G, LTE. Some models support different wireless protocols for programming and/or internet connection. There are even models that support cellular phones combined with DMR radios.

Analog. The Mototrbo™ SL75xx models don't support analog FM, all others support analog. If analog FM is supported, it needs to be wideband FM because wideband FM is used on most legacy amateur repeaters. Current FCC rules require narrowband for most commercial/government services. For DMR radios from some manufacturers, this requires a programming entitlement key or a different version of the programming software.

Warning. Some commercial DMR capable radios are available as analog only in their base configuration. The user may later add DMR for an additional license fee. This is because some manufacturers are discontinuing their analog non-DMR radios, while offering the DMR radios at a reduced MSRP if the digital mode is not enabled. On these radios, the customer later can upgrade the radio to operate DMR if their needs change, for an additional fee.

External Antenna on Portable. Not all portable radios support the connection of an external antenna, except for testing and alignment purposes. Using an adapter to connect an external antenna can place undue stress on the portable antenna connector which may result in premature equipment failure and expensive repair. If you are going to use an external antenna adapter, I recommend an adapter cable that uses RG-174 size cable to reduce stress on the radio's connector. Some Mototrbo™ models, such as the XPR6000 series, support an external microphone with an antenna mounted on the top.

Portable or Mobile. Portables are available in the 1-10 watt range; mobiles are available with a maximum of 10-45 watts. I recommend that your first DMR radio be a handheld type unless you live beyond the handheld coverage of your local DMR repeater. If you spend significant time in your vehicle commuting, you will find a mobile a good investment. Mobiles can also be used as a base station with the addition of an external power supply.

External Amplifier. Many external amplifiers will not work with DMR radios unless they are specifically designed to meet the fast switching requirements of TDMA on DMR. If you need more output power than a handheld DMR radio provides, purchase a mobile DMR radio. I do NOT recommend using an external amplifier on a DMR radio, instead get a higher gain antenna mounted on your vehicle.

Suppliers of DMR Radios

The following brands of user radios are currently available or will hopefully soon be available in the US. There are a number of other manufacturers making DMR radios overseas that do not have distribution channels in the US. Motorola Solutions, Kenwood and Hytera also offer repeaters with their respective proprietary IPSCs. Vertex Standard repeaters do not support Internet connectivity. Many manufacturers offer a variety of DMR radio models, including portables and mobiles. Currently there are no fixed base DMR radios available; a mobile can be used with an AC power supply in fixed base configurations. Some manufacturers of DMR radios may never make them available in the US market because of the cost of obtaining FCC approval.

There are combinations of cellphones and DMR radios available from some manufacturers, including support for LTE for Internet access.

Here is a partial list of manufactures:

Motorola Solutions $$-$$$$
https://www.motorolasolutions.com/en_us.html

Vertex Standard $$-$$$ (Part of Motorola Solutions)
https://www.motorolasolutions.com/en_us/products/vertex-standard.html

Hytera $$-$$$$
https://www.hytera.us/

Kenwood $$$-$$$$ (the NX-5000 series supports analog/NXDN/DMR/P25)
http://www.kenwood.com/usa/com/lmr/nx-5200_5300_5400/

Connect Systems $-$$
http://www.connectsystems.com/

BaoFeng Telecom Technologies (BFDX) $-$$$
http://www.bfdx.com/en/ (Helps if you read Chinese)

Kirisun $$-$$$
http://en.kirisun.com/

Lisheng $$-$$$
http://www.cnlisheng.com/aspx/EN/index.aspx

TYT $-$$$
http://www.tyt888.com/

Batteries and Chargers. Battery operated radios need a charger. Most radios come with at least a wall type charger. Some have desk chargers included or available for optional purchase. Some models have gang chargers available. You may want to consider a mobile charger or 12v battery adapter. Some models can be charged using a USB cable, just like many cell phones. I always recommend having at least one spare battery and rotating them (I always mark my batteries with the date I purchased them MMYY). You should follow manufacturer instructions for initial charging for maximum battery life. Remember to properly dispose of old batteries. Lithium ion batteries should not be thrown into the trash!

Air Transport of Lithium Batteries. Because of the dangers from lithium batteries there are specific shipping limitations, check with your airline and the following website has more detailed information: [https://www.iata.org/whatwedo/cargo/dgr/Pages/lithium-batteries.aspx]

I also strongly recommend that you carry any spare batteries in a non-conductive bag or at least put electrical tape over the contacts if you are carrying in your pockets so they do not get shorted and overheat which can result in a “hot pocket”.

Warranty and Service Contracts. If you buy an expensive new radio, you may want to consider the warranty and possibly purchase an extended service contact. Few amateurs have the technology or skills to work on these radios.

Programming your Radio

When you get your new radio, it must be programmed before first use. Check the DMR-MARC website for basic parameters that need to be configured to get your radio working correctly on the network.

First you need a subscriber ID for your radio, you can get one at [https://www.radioid.net], they issue of all subscriber IDs for amateur users and repeaters except in Europe and Africa. IDs are assigned based upon your geographic location (Country). You should have your subscriber ID within a few hours of requesting it. If you have ordered your radio, request your subscriber ID and have it ready when your new DMR radio arrives. If you use an unauthorized subscriber ID, you may find that you can't access repeaters or the wide area network.

If you have multiple radios that will be on the air at the same time, you will need a subscriber ID for each. If you have a mobile and portable and are going to be only transmitting on one at a time, they can share subscriber IDs. Some brands of radios (including Mototrbo™) will mute traffic from another radio with the same subscriber ID. It can be an advantage if both your mobile and handheld both use the same subscriber ID, as it eliminates issues of audio feedback.

DMR radios have a code plug which contains configuration parameters, including channel information and a contact list with a limited number of subscriber IDs and call signs/names. Your radio only transmits your subscriber ID and not your call sign or name. You can download code plugs populated with some subscriber IDs already in the database. The complete database is many times larger than many of the radios will support, so you want to limit your code plug to regional users and others you may commonly communicate with.

In the DMR world, repeaters are identified by frequency and by a parameter called a Color Code. There are 16 possible Color Codes (CC0-CC15). You need to have the correct Color Code programmed in order to access a repeater. The repeater database available at the DMR-MARC website lists the frequencies, offsets, and Color Codes for DMR repeaters. You will need to contact another local user or repeater operator to find out which TGs are available on a repeater.

When you press your PTT button, your radio sends a data packet to the repeater, and if it is successfully received by an available repeater, the repeater will send back an acknowledgement signal to your radio, and your radio will generate an audible signal telling you to continue to transmit. If you do not receive an acknowledgement back from the repeater, your radio will signal you that your request was not successful. The use of this hand shaking between your radio and the repeater will give you confirmation that you are making it into the repeater, although you could still be in a fringe coverage area and have too high of packet lost to be understandable. If you are communicating across the IPSC network, wait a second or two for your first transmission to signal all the receiving radios to wake up, as they may be scanning or in a power saving mode.

Your radio may stop transmitting while you are talking because of contention on the network or because you have travelled beyond the repeater's range. Your radio is receiving control information from the repeater when you are talking. Network contention occurs when more than one station is transmitting at the same time on the same Talk Group.

Operating on DMR

When you make an initial transmission to announce your availability, to place a call to another station, or to make a general call, you should also announce what Talk Group you are on because some users may be scanning or have radios without a display. Even if you are keying to activate a PTT Talk Group you need to IDENTIFY. Please avoid calling CQ; DMR is not HF and operating DMR over the network is not DXing.

When you are talking on one of the wide area Talk Groups, hundreds of repeaters could be tied up. If you are unable to move to a more localized Talk Group, be considerate of the other users on the network. Talk Groups share time slots. When one Talk Group is active; other Talk Groups on the same time slot will be blocked on your repeater. Leave space between transmissions so others can break in. Remember that emergency traffic always has priority over all other traffic followed by scheduled nets.

On PTT TGs, you may not hear an ongoing conversation until the next user talks on some systems. Listen before you talk!

Examples of good operating practice for initial calls on the DMR networks include:

"This is W2XAB monitoring Tennessee State."
"N5ITU this is W9JW on North America."
"This is WB8VYS for a radio check on Local2."
"WB8FXJ this is WB8SCT on Ohio State."

A quick reminder of the Amateur's Code by Paul M. Segal, W9EEA (1928) may be helpful to remember.

> ***The Radio Amateur is:***
>
> ***<u>Considerate</u> – never knowingly operating in such a way as to lessen the pleasure of others.***
>
> ***<u>Loyal</u> – offering loyalty, encouragement and support to other amateurs, local clubs and the American Radio Relay League, through which Amateur Radio in the United States is represented nationally and internationally.***
>
> ***<u>Progressive</u> – with knowledge abreast of science, a well built and efficient station, and operation beyond reproach.***
>
> ***<u>Friendly</u> – with slow and patient operation when requested, friendly advice and counsel to the beginner, kindly assistance, co-operation and consideration for the interest of others. These are the hallmarks of the amateur spirit.***
>
> ***<u>Balanced</u> – radio is an avocation, never interfering with duties owed to family, job, school or community.***
>
> ***<u>Patriotic</u> – with station and skills always ready for service to country and community.***

Spend most of your time listening, not talking. Be a good neighbor and don't hog the network. Don't over ID! Help new users develop good operating practices. Be polite when informing other users about their poor operating practices or audio levels. There are a number of TGs such as TAC310-319 you should use for long winded conversations, not all bridges and repeaters carry all the TAC channels with TAC310 seeming to be the most populated.

You must identify your transmissions in accordance with the governmental rules and regulations of your country. In the United States, you need to be sure you are in compliance with the FCC Rules & Regulations. If you are a foreign licensed station other than Canadian operating within the jurisdiction of the FCC under Part 97.107, you must comply with Part 97.119g and append a radio district prefix before the call sign such as W8/DH6KQ and identify your location (city/state) at least once during each communication. If you are going to use a phonetic alphabet when you ID, make sure you use standard ITU phonetics.

Canadian licensees operating in the US should append the radio district prefix after their call sign, such as VE3BNI/W2. DMR does not automatically identify for you. US licensees operating in Canada should

append the Canadian call district after their US call sign, such as W2XAB/VE3.

Further information about foreign licensees operating in the US and US licensees operating in foreign countries, on the high seas aboard ships and in aircraft can be found on the American Radio Relay League's website [http://www.arrl.org].

Note that Mototrbo™ DMR repeaters identify in analog mode, during which time the repeater will not accept DMR input. If you have an RSSI (signal strength) indicator on your radio, it will tell you if the repeater is transmitting, but not whether a Time Slot is being used, nor if the repeater is IDing in analog mode.

Buying a Repeater

While DMR is an international standard, the networking capability of repeaters is vendor specific. If you want to be able to connect your repeater to a Mototrbo™ network that uses a cBridge or SmartPTT such as the K4USD Network, you must use a Motorola Solutions Mototrbo™ brand repeater. Talk to other repeater owner/operators before purchasing any repeater equipment. Some DMR repeaters require an additional cost option to be able to connect over the Internet.

If you want better DMR coverage, consider becoming a repeater owner/operator or talking your local club into converting an under utilized analog repeater into DMR. If you have an existing repeater, just purchase a DMR repeater to replace it and keep your duplexers and antenna system. You can operate the repeater in analog mode, digital (DMR) mode, or dynamic mixed mode (DMM). Mototrbo™ repeaters require an entitlement key for DMM mode; DMM and analog will not work with Mototrbo™ IPSC. Hytera repeaters can connect to the Internet when operating in a dual mode, but only DMR traffic is forwarded. Dual mode repeaters are not really a good choice for amateurs, there are designed for commercial system migrating from analog to DMR over a period of time required to get all users converted.

To use the IP connection on a repeater, you will need a connection to an IP network, typically an ISP (Internet Service Provider) or a local IP network. A static IPv4 address is preferred, but only required if the repeater is a Master on the IPSC network. DSL and cable modems will work. WiFi, (802.11) Wireless 3G, 4G, 5G and WiMax (802.16) broadband connections are usable, especially if you want to operate the repeater mobile or portable. VSAT is a possibility but delay (latency) times can be an issue.

In a metro area, it may even be a good idea to have a DMR repeater that is not connected to a network for local usage only. Wide coverage area, high profile repeater sites can be difficult to obtain. A network of interconnected lower profile DMR repeaters can provide equivalent coverage as a high profile mega site. As the number of users on a repeater increases, it may be necessary to add an additional DMR repeater at the site.

Used DMR repeaters can sometimes be found on eBay™ or other websites. Some "ham friendly" dealers offer good prices for Motorola radios and repeaters include [https://northgeorgiacommunications.com] and [http://www.sandyscomm.com]; Hytera radios and repeaters [http://www.ttgcommunications.com/]. There is not a great difference between used and new street prices, especially when you consider the warranty with the new equipment.

If this is your first endeavor into owning or operating a repeater, be aware that there are many steps needed beyond buying the repeater. To make your new repeater fully operational, you will need to purchase duplexers (Band Pass-Band Reject preferred), possibly band-pass filters, lightening protection, feedline, antennas, antenna mounts, mounting rack, battery backup, site (tower or commercial site), insurance (most commercial sights require it), antenna/feedline installation, electricity, internet connection (at commercial or remote sites residential service may not be available), and repeater coordination. Before you take the plunge into repeater ownership, talk to other amateur repeater owners/operators. Repeaters can also be installed in vehicles, I use a Motorola SLR1000 and a Cradlepoint 1200B router with a Verizon USB 3G dongle.

Motortrbo™ repeaters also support remote receivers (max of 15) and digital voting, digital telephone interconnect (autopatch), DMM (Dynamic Mix Mode), RAS (Remote Access and Security) and remote programming; some options require additional licenses.

If your repeater is installed at a remote side and operated under 47CFR97.205(d) automatically controlled, you will need remote control capability to disable it if necessary, to comply with FC R&Rs.; you should review licensee and control operator requirements. Mototrbo repeaters offer RDAC (Remote Diagnostics and Control) which allows the repeater operator to remotely control their repeater and read diagnostic data from the repeater.

Motorola Solutions makes a series of DMR capable repeaters available, including the XPR8300 (discontinued), XPR8400 (discontinued). XPR8380 (900 MHz), MTR3000 and new SLR5700, SLR1000, and

SLR8000 models that cover either the amateur 144-148 MHz or the 420-450 MHz bands. Hytera has RD62x, RD96x, and RD98x repeaters; these will not inter-connect directly with the cBridge based Mototrbo™ networks. Vertex-Standard has a discontinued EVX-R70 (they look exactly like the XPR8300) but they do not support IPSC, so I would not recommend them if you want to connect to the Internet. Kenwood their TKR-D710/TKR-D810 analog/DMR repeaters, connecting them to the Internet requires an additional KTI-5 interface box and are not compatible with any of the existing amateur DMR networks.

You can build your own DMR repeater if you have the skills and necessary test equipment, there is information on the web and Brandmeister and other networks support their connection. You should note that many commercial repeater sites will not let you use anything except commercial equipment (Motorola, Hytera, Kenwood, etc.).

The number one thing you need is time and really deep pockets or a very supportive club structure!

Bridge Providers

Assuming you want your repeater to be interconnected with the wider DMR networks, you will need to establish an association with one of the bridge providers. Some bridge providers have limited offerings of TGs, others will have a wider variety of TGs to offer you. If you are not happy with your bridge provider you can always switch your connection to another bridge provider that supports your repeater.

Most of the repeater activity will be local or state wide. Being selective and offering a limited buffet of TGs may be preferred if you have a large number of local users or offering a wider variety can make your repeater more useful for your users. Some bridge providers such as Brandmeister do not currently allowed limiting the selection of TGs available on a repeater.

The bridge providers typically have peering arraignments with a number of other bridge providers to exchange TG traffic between different networks.

If you build your own state or area network of multiple repeaters, you may want to consider operating your own bridge and establishing peering arraignments with other networks.

The K4USD Network (http://www.k4usd.org) operates multiple cBridges and serves repeaters in 17 states, with interconnects to DMR-MARC, DMRX, DMR+, TGIF, QuadNET, and 25 other networks.

Hot Spots

Hot Spot manufacturers seem to come and go, I am not sure about how long term support will be addressed. I own a DV4mini and an openSPOT, I strongly prefer the openSPOT design which does not require the use of a computer; it can be directly connected via an ethernet cable to your home router. Unluckily both the openSPOT and DV4mini are no longer sold by their manufactures. The DVMEGA is another option for users but requires connection to a small single board computer and is not a plug-and-play type device.

Most of the Hot Spots support other protocols than just DMR, including P25, D-Star, NXDN and Fusion. These are great for experimenters, but their quality is not up to the commercial repeaters and have been known to cause many problems across the network, much because of "Layer Zero" (the human operator).

Hot Spots can cause looping on the network, which ruins a TG for other uses, especially troublesome during nets. The "Ping-Pong" problem is caused by two Hot Spots operating on the same frequency within range of each other on the same TG resulting in a short traffic bouncing back and forth between them. If the Hot Spots are on the same frequency and different TGs they can link the two TGs together,

WARNING – If you are using a simplex Hot Spot do NOT use the default frequency, I would recommend selecting a frequency in the 420.1-431.0 MHz, 433.0-435.0 MHz, and 438.0-440.0 MHz ranges. (Depending on your location in the US you may not be able to use the 420.0-430.0 band segment.) In the two meter band 144.1-144.49 MHz (excluding the APRS 144.39 frequency) and 145.8-146.00 MHz. Do not use frequencies in the 431-433 MHz and 435-438 MHz Space Station (satellite) subband nor repeater subbands; you do not want to cause interference. If your Hot Spot is operating as an Auxiliary Station you should review 47CFR97.201 for additional restrictions. Hot Spots also need to identify

Building an Emergency Repeater Network

One of the purposes of the Amateur Radio Service as defined in 47CFR97.1(a) is ***a voluntary noncommercial communication service, particularly with respect to providing emergency communications.***

The use of repeaters is an accepted component of most amateur emergency plans. Repeater must have non-commercial power available for emergencies; this will typically include battery backup at a minimum for short term power failures and a combination of solar,

wind, and generators to support longer periods of operation. In case of repeater failure plans should include the use of simplex VHF/UHF frequencies; I would suggest using the repeater output frequency so if the repeater fails during an emergency net the stations on the net will know of the repeater failure and also be able to use dedicated simplex frequencies in addition. It would be convient if all the ARES, RACES, and other emergency response groups would agree on a common emergency VHF frequency.

Most digital repeaters, DMR, D-Star, and Fusion, are connected to the Internet and can function as a standalone repeater if their connectivity fails. The Internet is not a reliable option for emergency communications within an emergency area.

Even if the repeater has a secondary Internet connection via a different commercial supplier the possibility of total failure is possible for number of reasons that are well documented, including solar flares, EMP, terrorism, DOS attacks, communication circuit failures, power failures etc. As hams we need to be prepared for any type of emergency to offer our services as communicators when needed. This requires preplanning! Repeaters are but one tool and HF should not be overlooked for long distance communicatons.

Amateurs need to build a wireless data network to bypass the Internet for regional if not nationwide connectivity. The technology exists at a reasonable cost to interconnect repeater sites. The secondary benefit of building our own data backbone is the saving of monthly Internet connection fees.

Hams are already building wireless data networks, groups such as AREDN (https://www.arednmesh.org/) and HamNET (http://www.broadband-hamnet.org/) are examples of two that utilize commercial hardware to build TCP/IP networking in the UHF and microware amateur bands..

This is going to take money and resources; users must help support the costs and not just be freeloaders. This is not something we can put off until needed, it must be in place to prepare for future emergencies.

The End of the Beginning

The most important thing about the hobby of Amateur Radio is to enjoy learning new technologies, experimentation, meeting new friends, public service, and to leave the hobby better than when you entered.

The spark gap transmitter gave way to frequency selective transmitters and receivers using CW; CW gave way to AM; AM was largely pushed aside by SSB; FM became the mode of choice for most on the VHF and shorter wavelengths. The digital ham started at the same humble beginning, CW over spark gap. Over the years, the digital ham's interests may have included CW, RTTY, then Packet (AX.25), and a whole host of mainstream and experimental digital modes, and even WiFi (802.11). With the advent of faster computer processors and vocoder technology, analog voice moved into the digital age, both on the HF bands and on VHF and higher bands. Vocoder technology merged with packet technology and D-Star™ took the VHF and UHF bands by storm with the help of a single vendor and the JARL (Japan Amateur Radio League). Yaesu has enter the arena with their proprietary System Fusion™.

Traditional professional analog FM two-way users are all migrating to digital formats, including TETRA, P25 (Phase 1 and Phase 2), NXDN, and DMR (Tier II and Tier III). Hams have already adopted the professional P25 (Phase 1), NXDN, and DMR (Tier II) technologies. DMR is the clear winner based upon number of amateur systems and users currently using the technology.

D-Star™ is not going away overnight; it has an existing strong base. P25 and NXDN are very small groups in amateur radio community and I doubt they will have much growth. With the new support of interconnecting Fusion repeaters by Brandmeister (and possibly others to follow) and the special offers by Yaesu Fusion all these digital technologies will be around for a while. With the expansion of DMR and the entry of low cost DMR radios into the marketplace from multiple vendors, lower cost per channel repeater systems, better audio quality, and international standards, DMR is going to be the technology of choice for digital repeaters systems for the foreseeable future. DMR is not driven by the amateur market, it is driven by the millions of government and commercial users around the world. DMR is not the final answer; it is only one small step along the path to the future of our hobby. Someday DMR will be replaced by something better. When that happens, hams as early adopters of emerging technology will be in the forefront of the technology change.

The Beginning of the Middle

The DMR networks along with other technologies have become commonplace across the nation and world. We still need to build out the repeater networks to cover more of the country and at the same time make the repeater networks resilient for emergencies.

Repeater councils need to become unified and implement spectrum re-farming in a more manageable way with a focus on the different technologies. We need one repeater council for the whole nation, possibly with subgroups managing frequency pairs dedicated for use by specific technologies.

Wouldn't be nice if all digital technologies had specific coordinated frequencies so travelers could easily roam from one area to another.

Maybe someday you will be able to purchase a radio that will handle all the digital technologies in one unit.

If you build it, hams will use it!

But getting them to support it is difficult!

For Further Information about DMR

DMR-MARC (Motorola Amateur Radio Club)
http://www.dmr-marc.net

DMR-MARC Canada
http://www.va3xpr.net/dmr-marc-canada/

DMR-UK.net (United Kingdom)
http://www.dmr-uk.net

Digital Communications Interconnect Group (DCI)
http://www.trbo.org

Pacific Northwest DMR
http://pnwdigital.net/

DMRX
http://www.dmrx.net

Digital Mobile Radio Association (Professional DMRA)
http://www.dmrassociation.org

US Digital Amateur Repeater Club
http://www.k4usd.org

Brandmeister
http://brandmeister.network

Central Michigan Emergency Network (CMEN MI5)
http://w8cmn.net

K0USY Group (Kansas)
http://k0usy.strikingly.com

NC-PRN (VA/NC/SC/TN)
http://www.ncprn.net

New England Digital Emergency Communication Network (NEDECN)
http://nedecn.org

NJ-TRBO Network (NJ/NY)
http://www.n2jti.net

NOCO DMR Group (CO/UT)
http://www.w0dmr.net

MDARC (California)
http://www.mdarc.org/

NOCAL (Northern California)
https://norcal-brandmeister.org

Rocky Mountain Ham Radio
http://www.rmham.org

For Further Information about Amateur Radio

American Radio Relay League (ARRL)
http://www.arrl.org

Quarter Century Wireless Association (QCWA)
http://www.qcwa.org

Radio Amateur Satellite Corporation (AMSAT)
http://www.amsat.org

Tucson Amateur Packet Radio Association (TAPR)
http://www.tapr.org

Radio Amateurs of Canada (RAC)
http://www.rac.ca

Radio Society of Great Britain (RSGB)
http://www.rsgb.org

Ham On DMR!

Make Amateur Radio Great Again!