Digital Mobile Radio (DMR) For The Challenged *

by Doug Sharp - K2AD

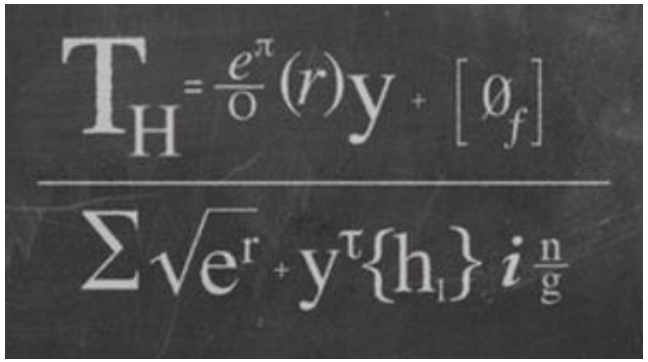
* And don't give me grief about the title. Joe KD0TYU picked it.

DMR For The Challenged

- I'm glad you are here today
- Are you DMR challenged?
- Most hams are challenged in some way with DMR
- Including me!

The K2AD Seal of Approval

- DMR is a complicated protocol
- "If it's too complicated, it's not going to work" says Scott, W0KU
- I don't think that DMR is too complicated



- I am challenged every day
- I learn new things every day
- DMR is good

Let's learn something new together

To understand DMR we start with Maxwell's Equations

Maxwell's Equations	Maxwell's Equations
Differential form	Integral form
$\nabla \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$	$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{enc}}{\varepsilon_0}$
$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$	$\oint \vec{E} \cdot d\vec{l} = -\int \frac{\partial \vec{B}}{\partial t} \cdot d\vec{a}$
$\nabla \cdot \vec{B} = 0$	$\oint \vec{B} \cdot d\vec{a} = 0$
$\nabla \times \vec{B} = \mu_0 \vec{J} + \mu_0 \varepsilon_0 \frac{\partial \vec{E}}{\partial t}$	$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc} + \mu_0 \varepsilon_0 \int \frac{\partial \vec{E}}{\partial t}$

Basics

- Often associated with Motorola Solutions (Motorola TRBO)
- But many vendors with product in the ecosystem

- Typically used on VHF (144 MHz) and UHF (440 MHz) bands
- Originated as a commercial protocol
- Three Tiers of DMR
  - Tier I: Simplex (and places the same information in both time slots)
  - Tier II: Repeater and two-slot TDMA
  - Tier III: Trunking

DMR Standard – ETSI TS 102 361

- Tier 1 (Unlicensed)
  - FDMA, Consumer applications, .5 watt
  - dPMR (446 MHz European unlicensed service)
- Tier 2 (Conventional)
  - 2-slot TDMA
  - IP Site Connect (Vendor specific)
- Tier 3 (Trunked)
  - 2-slot TDMA
  - Multi-channel, Multi-Site

Amateur Radio Use

Things That Aren't DMR

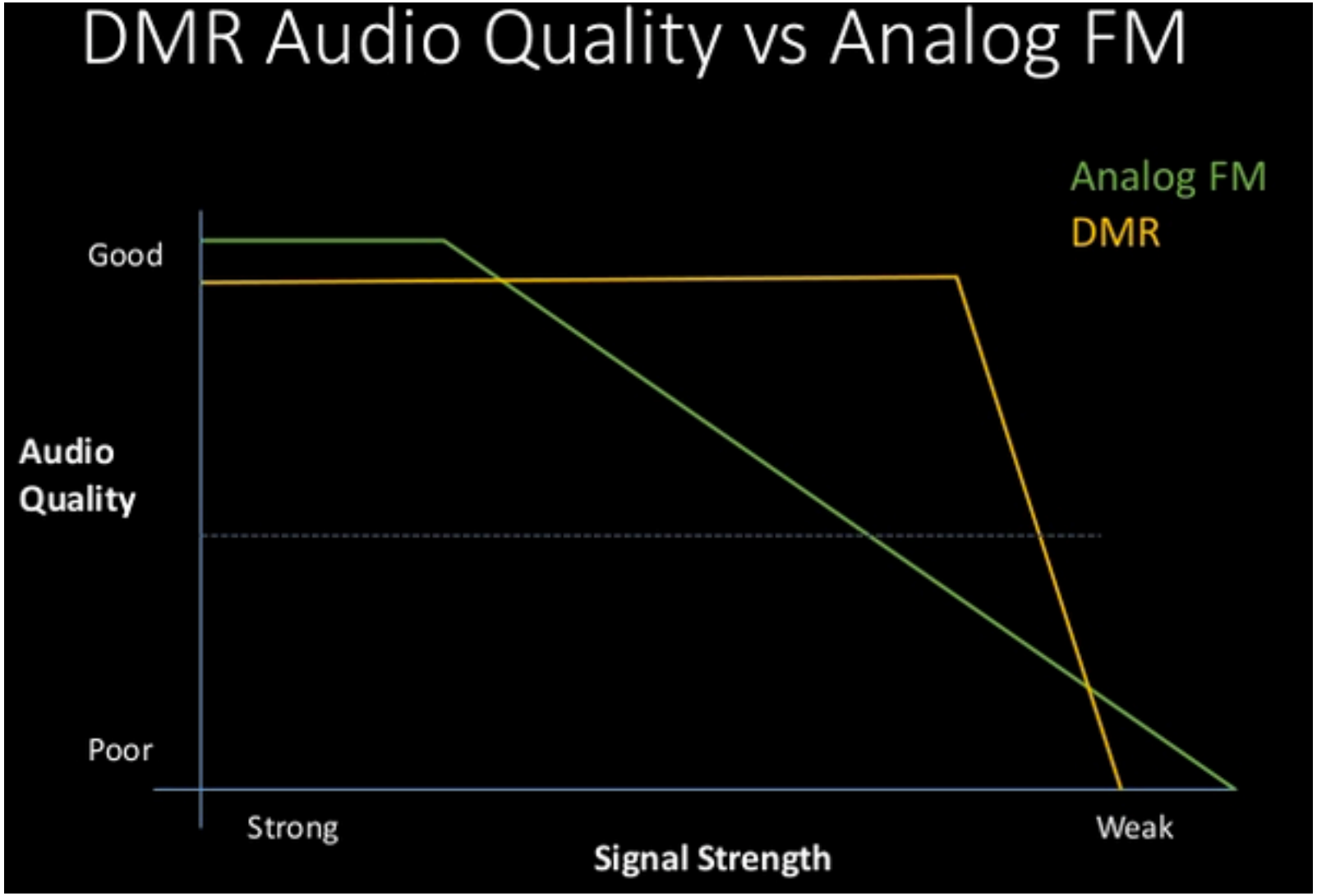
- DStar
- C4FM (Fusion) + WIRES-X
- P.25 (Project 25)
- NXDN
- dPMR

Disclaimer: Slide stolen from Bob Witte, K0NR (without his permission, but being he is a friend, I'm sure he won't mind.)

Please don't feel that "things that are not DMR" are bad.
It is NOT a war of the digital protocols. They are just not the subject of this presentation.

Digital Voice versus Analog FM Voice

- Digital Voice sounds weird until you adjust your brain
- Analog FM is better when the signal is strong
- Digital Voice / DMR is better when the signal is weak

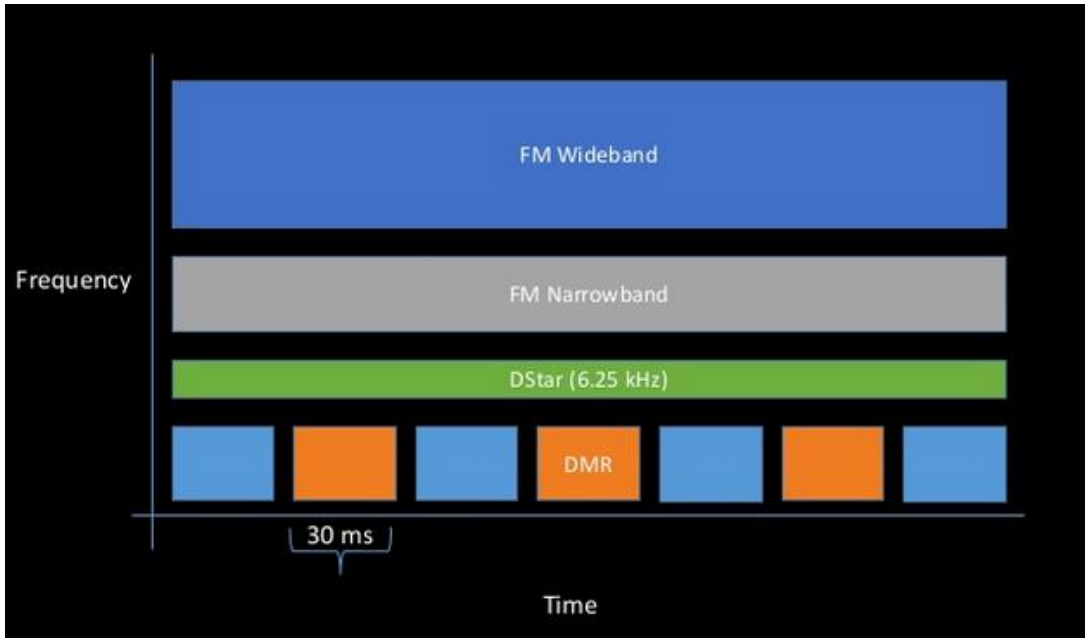


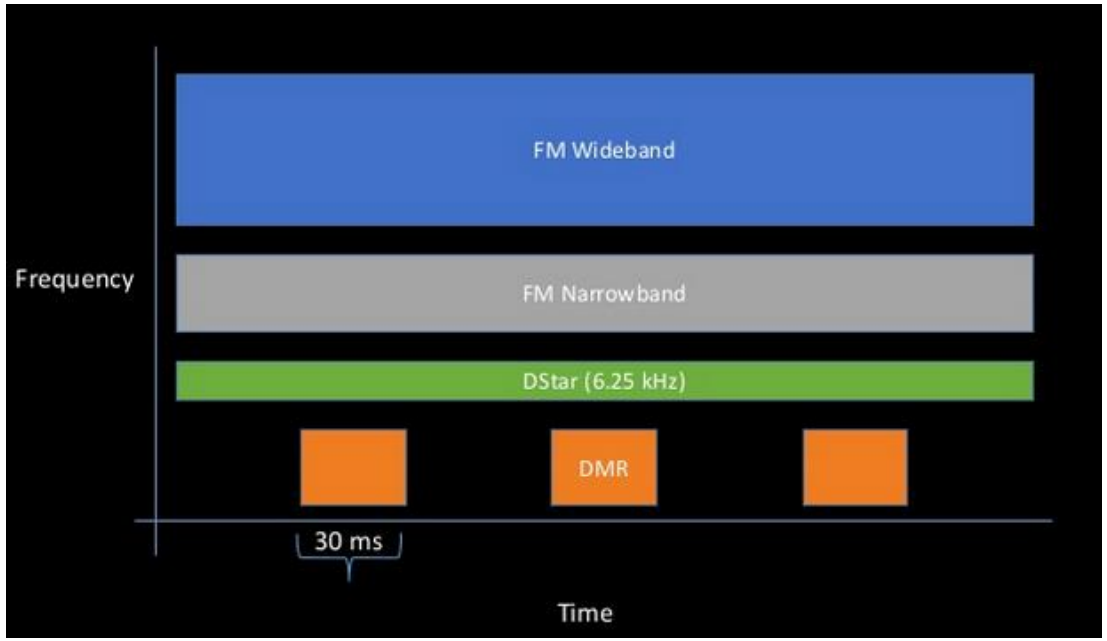
TDMA and Spectrum Efficiency (A lot of words)

- A “traditional” Analog FM signal
  - Occupied Bandwidth is 16 kHz (Emission Designator 16K0F3D)
  - Channels spaced at 15 or 20 kHz (VHF) or 25 kHz (UHF)
- A DMR Narrowband Digital Voice (NBDV) Signal
  - Occupied Bandwidth is 12.5 kHz (Emission Designator 7K60FXE)
  - Channels spaced at 12.5 kHz (UHF) or 15 kHz (VHF) depending upon band
- TDMA – Time Division Multiple Access
  - DMR utilizes two-slot TDMA
  - Time slots are thirty milliseconds each (30 ms)

4X Efficiency - DMR occupies half the bandwidth of analog FM and delivers two conversations at the same time!

TDMA and Spectrum Efficiency (1000 word equivalent)





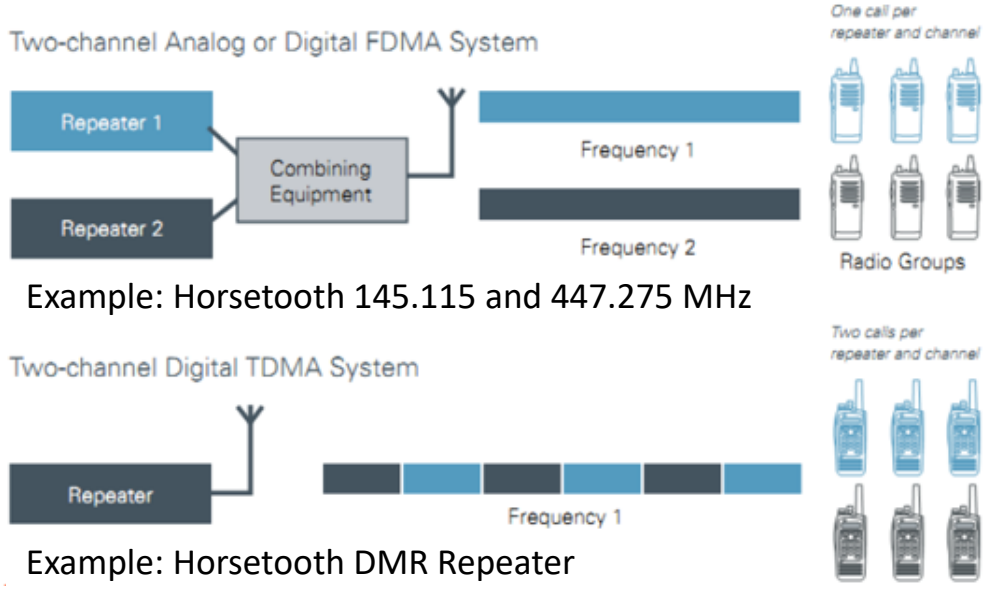
4X Efficiency – Can you see the efficiency?

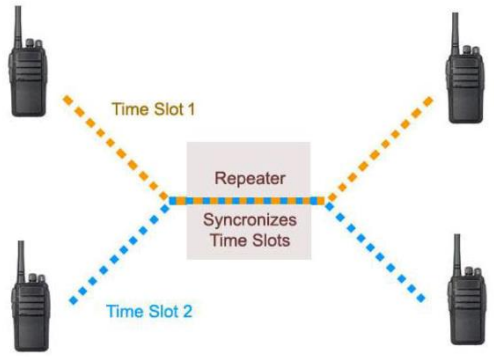
TDMA Time Slots

- TDMA allows two conversations on the same repeater

- One conversation on Time Slot 1 (orange)
- Second conversation on Time Slot 2 (blue)

- If properly implemented, neither knows the other is there!





Perhaps a traffic circle that actually works?

DMR Identifiers

- Yes, you need one
- You can, but you should not, create your own
- The Radio ID is NOT accepted by the FCC as legal identification
- You can use the same Radio ID in multiple radios …
  - but you can not talk between radios with the same Radio ID
- Radio ID is used to route calls within the DMR network
- You can program your radio to display the callsign of the other station ...
  - But this is a function of your radio
  - Callsigns are NOT sent over the DMR radio. Only the Radio ID.
- Radio ID is free. Just do it.

Go to RADIOID.NET to obtain a DMR ID

Talk Groups

- DMR transmissions use Talk Groups

  Example: TG 1, TG700 or TG 3108

- In amateur use, usually organized by geography, language or content

  Example: TG700 is Rocky Mountain, TG721 is Northern CO

- Talk Groups can be static (always connected) or Dynamic (PTT connected)
- RMHAM DMR generally uses Static Talk Groups
- Brandmeister DMR uses both Static and Dynamic
- A DMR bridge (like a cBridge or the Brandmeister Network) can ”route” a Talk Group from one repeater to another

What do I need to program my radio

Analog FM:
- Frequency
- Offset (for repeaters)
- CTCSS or DTCSS tone

DMR:
- Frequency
- Offset (for repeaters)
- Color Code
- Time Slot (TS1 or TS2)
- Talk Group (example: TG700)
- Your radio ID
- Other radio parameters specific to your radio

I can hear W0KU saying it now, "It's too complicated …"

Where do I find programming information

Try the web site for your local DMR repeater

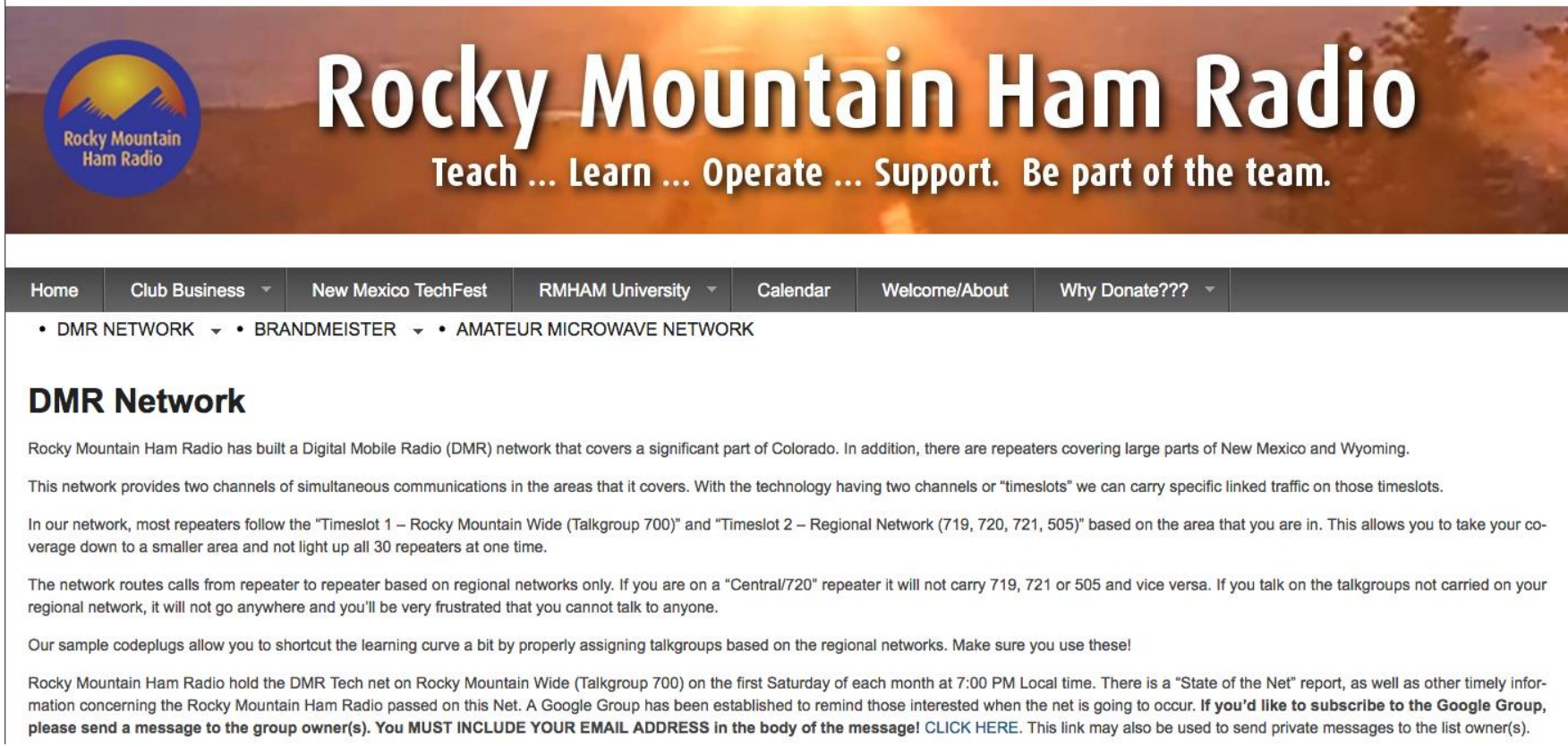
www.rmham.org

www.ncarc.net

Two clubs …

one group …

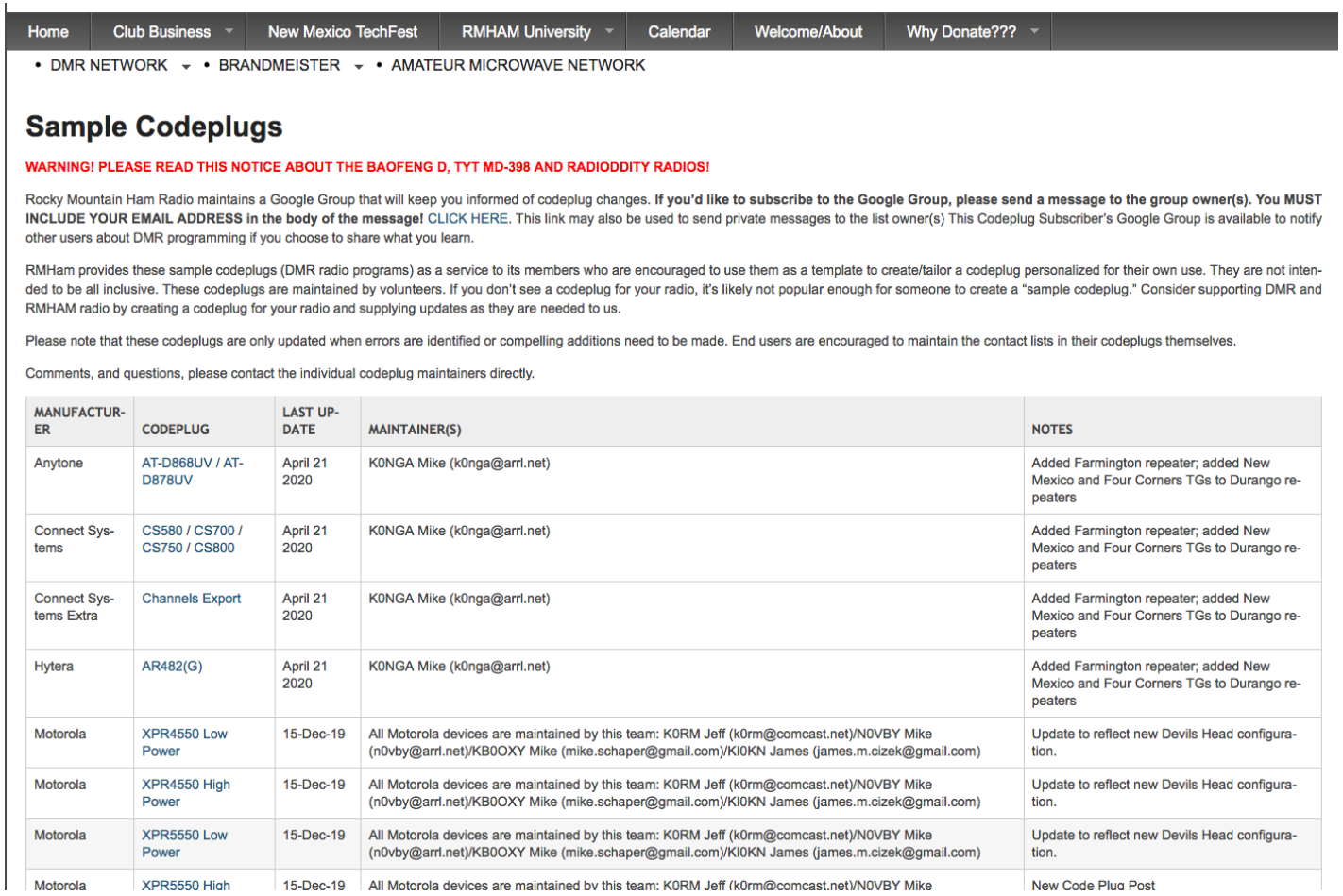
working together.



Best to start with a sample code plug from the web site

Sample Code Plugs

- The sample code plugs are a great place to start
- Add your favorites or new repeaters in a new zone
- I have a “home zone” for my favorites with a mix of analog and DMR repeaters



Home | Club Business | New Mexico TechFest | RMHAM University | Calendar | Welcome/About | Why Donate???

• DMR NETWORK • BRANDMEISTER • AMATEUR MICROWAVE NETWORK

Sample Codeplugs

WARNING! PLEASE READ THIS NOTICE ABOUT THE BAOFENG D, TYT MD-398 AND RADIODDITY RADIOS!

Rocky Mountain Ham Radio maintains a Google Group that will keep you informed of codeplug changes. **If you'd like to subscribe to the Google Group, please send a message to the group owner(s). You MUST INCLUDE YOUR EMAIL ADDRESS in the body of the message!** CLICK HERE. This link may also be used to send private messages to the list owner(s) This Codeplug Subscriber's Google Group is available to notify other users about DMR programming if you choose to share what you learn.

RMHam provides these sample codeplugs (DMR radio programs) as a service to its members who are encouraged to use them as a template to create/tailor a codeplug personalized for their own use. They are not intended to be all inclusive. These codeplugs are maintained by volunteers. If you don't see a codeplug for your radio, it's likely not popular enough for someone to create a "sample codeplug." Consider supporting DMR and RMHAM radio by creating a codeplug for your radio and supplying updates as they are needed to us.

Please note that these codeplugs are only updated when errors are identified or compelling additions need to be made. End users are encouraged to maintain the contact lists in their codeplugs themselves.

Comments, and questions, please contact the individual codeplug maintainers directly.

MANUFACTURER	CODEPLUG	LAST UPDATE	MAINTAINER(S)	NOTES
Anytone	AT-D868UV / AT-D878UV	April 21 2020	K0NGA Mike (k0nga@arrl.net)	Added Farmington repeater; added New Mexico and Four Corners TGs to Durango repeaters
Connect Systems	CS580 / CS700 / CS750 / CS800	April 21 2020	K0NGA Mike (k0nga@arrl.net)	Added Farmington repeater; added New Mexico and Four Corners TGs to Durango repeaters
Connect Systems Extra	Channels Export	April 21 2020	K0NGA Mike (k0nga@arrl.net)	Added Farmington repeater; added New Mexico and Four Corners TGs to Durango repeaters
Hytera	AR482(G)	April 21 2020	K0NGA Mike (k0nga@arrl.net)	Added Farmington repeater; added New Mexico and Four Corners TGs to Durango repeaters
Motorola	XPR4550 Low Power	15-Dec-19	All Motorola devices are maintained by this team: K0RM Jeff (k0rm@comcast.net)/N0VBY Mike (n0vby@arrl.net)/KB0OXY Mike (mike.schaper@gmail.com)/KI0KN James (james.m.cizek@gmail.com)	Update to reflect new Devils Head configuration.
Motorola	XPR4550 High Power	15-Dec-19	All Motorola devices are maintained by this team: K0RM Jeff (k0rm@comcast.net)/N0VBY Mike (n0vby@arrl.net)/KB0OXY Mike (mike.schaper@gmail.com)/KI0KN James (james.m.cizek@gmail.com)	Update to reflect new Devils Head configuration.
Motorola	XPR5550 Low Power	15-Dec-19	All Motorola devices are maintained by this team: K0RM Jeff (k0rm@comcast.net)/N0VBY Mike (n0vby@arrl.net)/KB0OXY Mike (mike.schaper@gmail.com)/KI0KN James (james.m.cizek@gmail.com)	Update to reflect new Devils Head configuration.
Motorola	XPR5550 High	15-Dec-19	All Motorola devices are maintained by this team: K0RM Jeff (k0rm@comcast.net)/N0VBY Mike	New Code Plug Post

Repeaters in the area

from www.rmham.org

Listed for each repeater

- Site name
- Sponsor
- Frequency
- Color Code
- Status
- IP Link status

- And don't forget the Brandmeister Repeaters

DMR Site Information

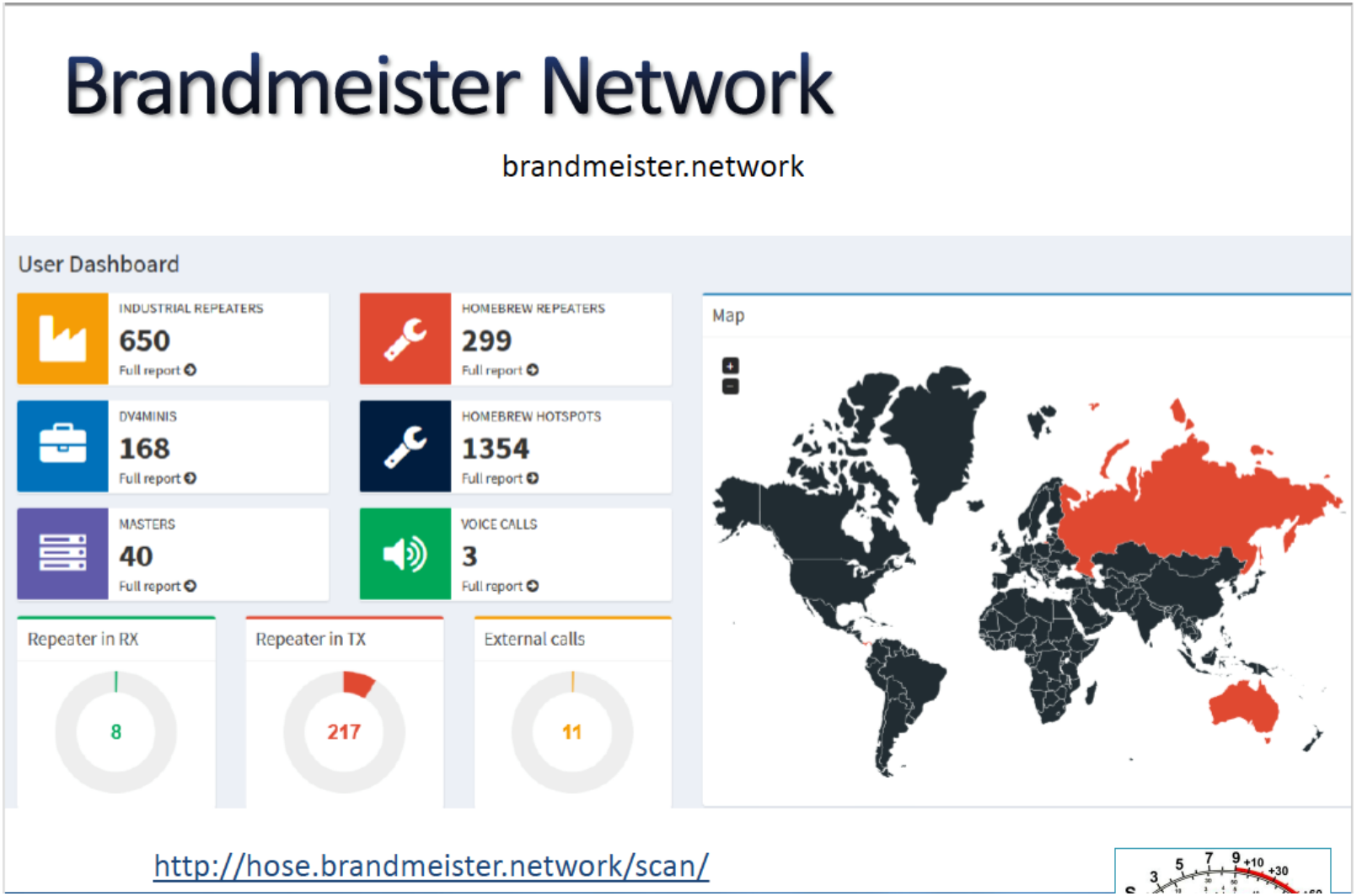
Rocky Mountain Ham Radio's DMR Network Information as of 5/9/2020

> *SPECIAL NOTE: Private calling, texting, DPRS/APRS/GPS Location Services should never be used on the RMHAM network. Only our Brandmeister repeaters on talkgroups specifically allocated for APRS/DPRS/GPS activity should be used for this. Please note that autonomous (GPS/Text or data) transmissions must be identified with your FCC callsign. An ID number isn't a legal identification.*
>
> *Sample Codeplugs for several radios are available in the menu above under DMR Network.*

Full Time DMR Sites in the RMHAM Network

NAME	SITE	SPONSOR	REPEATER INPUT	REPEATER OUTPUT	COLOR	REPEATER STATUS	IP LINK STATUS
Akron	Akron	NEAHR	443.1750 MHz	448.1750 MHz	7	Operational	Operational
Albuquerque NM	Sandia Crest	RMHAM-KA8JMW	447.9000* MHz	442.9000* MHz	7	Operational	Operational
Fairplay	Badger Mountain	RMHAM-N0SZ	441.7625 MHz	446.7625 MHz	7	Operational	Operational
Boulder 1	Boulder South (RMHAM network)	RMHAM-N0SZ	441.9875 MHz	446.9875 MHz	7	Operational	Operational
Boulder 2 BM	Lee Hill (Brandmeister.network)	RMHAM-N0SZ	440.0500 MHz	445.0500 MHz	1	Operational	Operational
Breckenridge/Summit Co	Baldy	RMHAM-N0SZ	440.0875 MHz	445.0875 MHz	7	Operational	Operational
Canon City	Fremont Peak	RMHAM-K0JSC	441.7375 MHz	446.7375 MHz	7	Operational	Operational
Cheyenne WY RMHR	Cheyenne WY	RMHAM-K7PFJ	444.9375 MHz	449.9375 MHz	7	Operational	Operational
Colorado Springs VHF	Almagre Mountain	RMHAM-N0SZ	144.6350 MHz	145.2350 MHz	7	Operational	Operational
Colorado Springs BM	Cheyenne Mtn(Brandmeister.network)	COLCON	440.0625 MHz	445.0625 MHz	1	Operational	Operational
Colorado Springs	Almagre Mountain	RMHAM-K7PFJ	441.9500 MHz	446.9500 MHz	7	Operational	Operational
Conifer-Bailey	Conifer Mtn	RMHAM-N9GDM	147.8550 MHz	147.2550 MHz	1	Operational	Operational
Denver-West UHF	Squaw Mountain	RMHAM-N0SZ	441.9375 MHz	446.9375 MHz	7	Operational	Operational
Denver-North UHF	Thorodin Mountain	RMHAM-N0SZ	441.8000 MHz	446.8000 MHz	7	Operational	Operational
Denver-Central UHF	Lookout Mountain UHF	RMHAM-WA2YZT	441.8375 MHz	446.8375 MHz	7	Operational	Operational
Denver-Central VHF	Lookout Mountain VHF	RMHAM-N0SZ	144.7700 MHz	145.3700 MHz	7	Operational (receiver impared)	Operational
Denver-VHF	Lower Squaw Mt	RMHAM-N0SZ	144.5750 MHz	145.1750 MHz	7	Operational	Operational
Douglas County	Devils Head	Colo Emcomm	441.9250 MHz	446.9250 MHz	8 See Below	Operational	Operational
Durango/Missionary	Missionary Ridge	RMHAM-N5UBJ	440.1375 MHz	445.1375 MHz	7	Operational	Operational
Durango/Mancos	Caviness Mtn	RMHAM-N5UBJ	441.7375 MHz	446.7375 MHz	6	Operational	Operational
Farmington NM NEW!	FAA Hill	RMHAM-N5UBJ	445.3000* MHz	440.3000* MHz	6	Operational	Operational
Fort Collins	Buckhorn	RMHAM	440.2000 MHz	445.2000 MHz	7	Operational	Operational
Fort Collins	CSU	CSUARC/W0QEY	441.7625 MHz	446.7625 MHz	8	Operational	Operational
Fort Collins	Horsetooth Mountain	RMHAM-K7PFJ	441.7500 MHz	446.7500 MHz	7	Operational	Operational
Fort Morgan	Fort Morgan EOC (mixed mode)	NEAHR	443.2000 MHz	448.2000 MHz	7	Operational	Operational
Genoa	Genoa	K0RTS	441.7375 MHz	446.7375 MHz	8	Offline Moving	Offline Moving
Leadville	Mosquito	RMHAM-N0SZ	440.0500 MHz	445.0500 MHz	7	Operational	Operational
Los Alamos NM	Pajarito	RMHAM-NM5BB	447.2250* MHz	442.2250* MHz	7	Operational	Operational

Bransmeister



Talk Groups in the RMHAM / NCARC System

From https://www.rmham.org/dmr-site-information/

Rocky Mountain Ham Radio Talk Groups

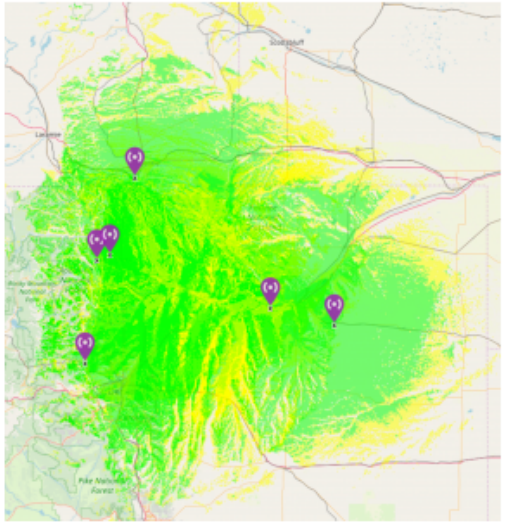
We will be using the following talk groups on the RMHAM Network. Note that we ONLY support these talkgroups on our statewide network. No push to talk talkgroup selection is available on the RMHAM network.

TALK GROUP	TIMESLOT	DESCRIPTION
505	TS2	New Mexico (All New Mexico and Durango/Mancos Repeaters) NEW!
700	TS1	Rocky Mountain Wide
705	TS2	Eastern (Configured for Data and Text Testing – Manual Station Identification is required.)
710	TS1	Denver Local (Lookout Mountain UHF repeater only)
711	TS2	Devilshead Local (Devilshead UHF repeater only)
713	TS2	Sandia Local (Sandia/Albuquerque repeater only) NEW!
714	TS2	Pajarito/Los Alamos Local (Los Alamos repeater only) NEW!
718	TS2	Southeastern Region (future use – not yet implemented)
719	TS2	Southern Colorado Regional
720	TS2	Central Regional
721	TS2	Northern Colorado Regional
722	TS1	Ft Collins Local (Fort Collins CSU Repeater Only)
745	TS2	Four Corners Regional (Farmington Caviness and Durango repeaters only) NEW!

What Talk Groups are used on each Repeater?

From https://www.rmham.org/dmr-site-information/

Northern Colorado Regional Network (No CO) – Talk Group 721

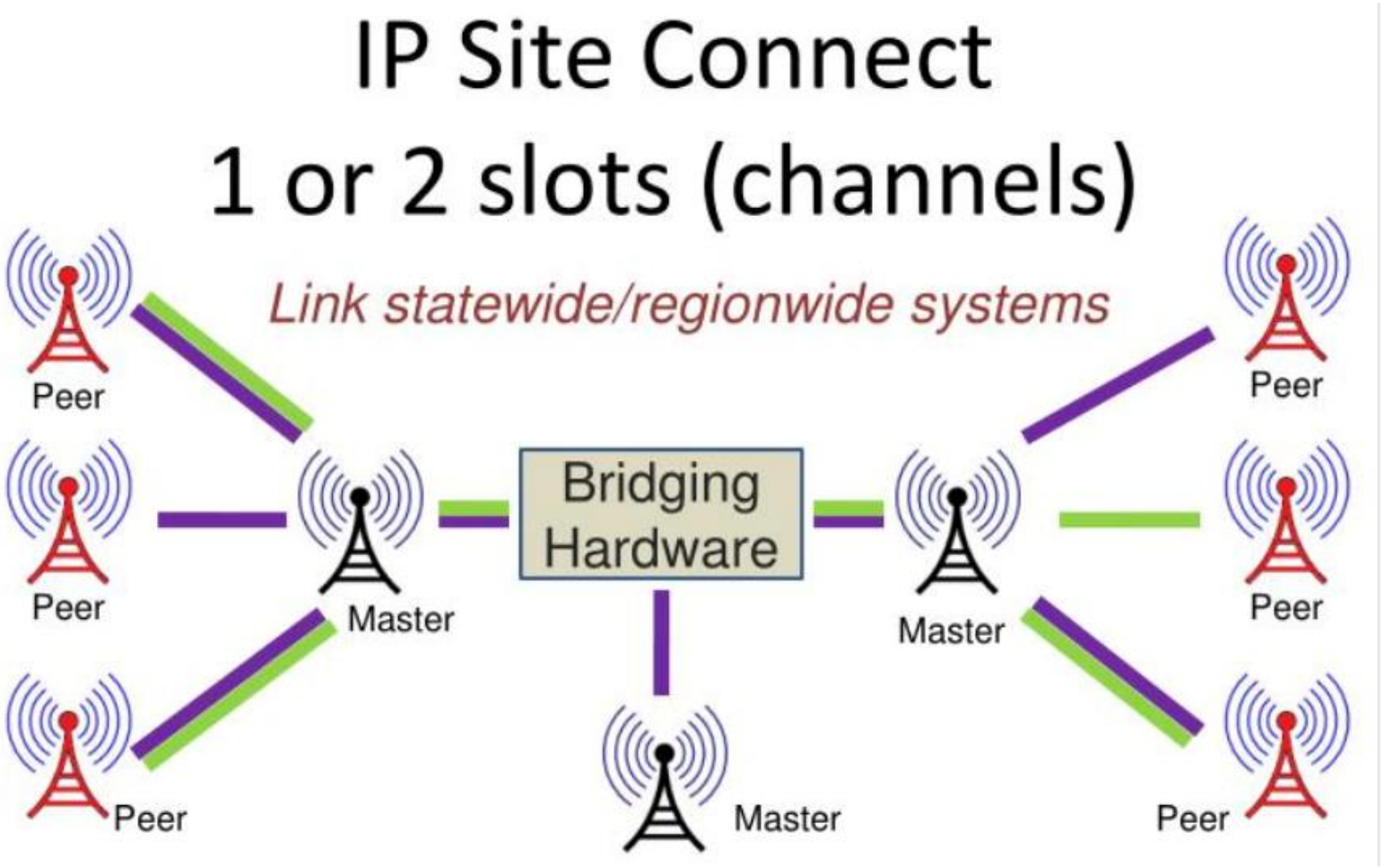


A regional network supporting Northern Colorado is established using Talk Group **721.** No Data, Texting or GPS. Repeaters supporting this talk group are:

NAME	SITE	REPEATER INPUT	REPEATER OUTPUT	COLOR CODE	TIME SLOT	STATUS
Akron	Akron	443.1750 MHz	448.1750 MHz	7	2	Operational-Linked
Boulder	Boulder South (RMHAM network)	441.9875 MHz	446.9875 MHz	7	2	Operational-Linked
ChyWy RMHR	South Cheyenne	444.9375 MHz	449.9375 MHz	7	2	Operational-Linked
Fort Collins	CSU	441.7625 MHz	446.7625 MHz	8	2	Operational-Linked
Fort Collins	Horsetooth Mountain	441.7500 MHz	446.7500 MHz	7	2	Operational-Linked
Fort Morgan	Fort Morgan EOC (mixed mode)	443.2000 MHz	448.2000 MHz	7	2	Operational-Linked

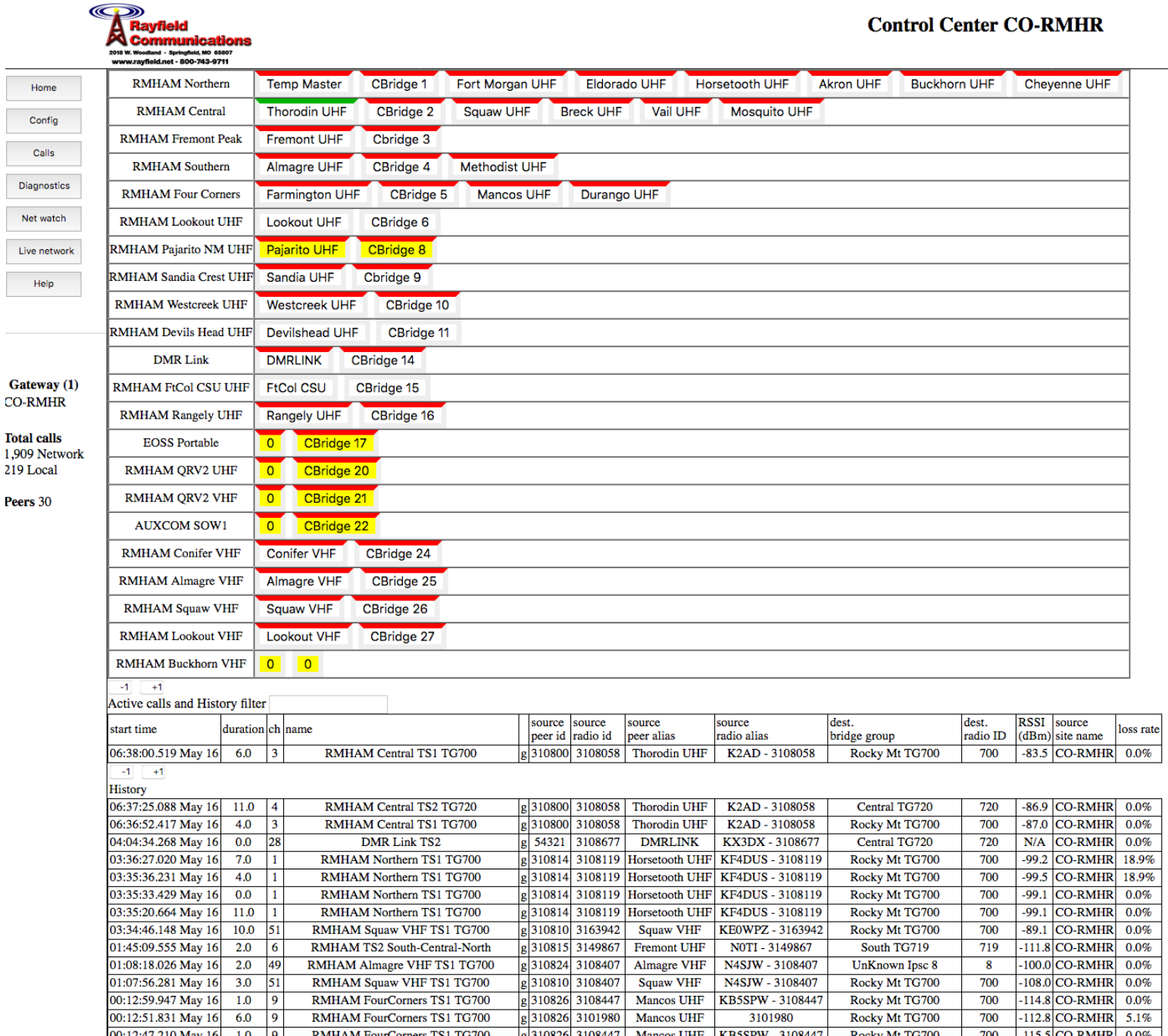
Do I need to know about IP Site Connect?

- The short answer is not really
- The repeater operator uses IPSC (a Motorola Solutions protocol) to link our DMR repeaters
- Each network has a Master and one or more Peers
- Multiple IPSC networks are connected by bridging hardware (a cBridge)



What is a cBridge?

- cBridge is a DMR “Connection Bridge”
- The cBridge connects multiple IP Site Connect repeaters
- Talk Groups are bridged between networks



Rayfield Communications
2018 W. Woodland - Springfield, MO 65807
www.rayfield.net - 800-743-9711

Control Center CO-RMHR

Home | Config | Calls | Diagnostics | Net watch | Live network | Help

RMHAM Northern	Temp Master	CBridge 1	Fort Morgan UHF	Eldorado UHF	Horsetooth UHF	Akron UHF	Buckhorn UHF	Cheyenne UHF
RMHAM Central	Thorodin UHF	CBridge 2	Squaw UHF	Breck UHF	Vail UHF	Mosquito UHF		
RMHAM Fremont Peak	Fremont UHF	Cbridge 3						
RMHAM Southern	Almagre UHF	CBridge 4	Methodist UHF					
RMHAM Four Corners	Farmington UHF	CBridge 5	Mancos UHF	Durango UHF				
RMHAM Lookout UHF	Lookout UHF	CBridge 6						
RMHAM Pajarito NM UHF	Pajarito UHF	CBridge 8						
RMHAM Sandia Crest UHF	Sandia UHF	Cbridge 9						
RMHAM Westcreek UHF	Westcreek UHF	CBridge 10						
RMHAM Devils Head UHF	Devilshead UHF	CBridge 11						
DMR Link	DMRLINK	CBridge 14						
RMHAM FtCol CSU UHF	FtCol CSU	CBridge 15						
RMHAM Rangely UHF	Rangely UHF	CBridge 16						
EOSS Portable	0	CBridge 17						
RMHAM QRV2 UHF	0	CBridge 20						
RMHAM QRV2 VHF	0	CBridge 21						
AUXCOM SOW1	0	CBridge 22						
RMHAM Conifer VHF	Conifer VHF	CBridge 24						
RMHAM Almagre VHF	Almagre VHF	CBridge 25						
RMHAM Squaw VHF	Squaw VHF	CBridge 26						
RMHAM Lookout VHF	Lookout VHF	CBridge 27						
RMHAM Buckhorn VHF	0	0						

Gateway (1)
CO-RMHR

Total calls
1,909 Network
219 Local

Peers 30

-1 +1

Active calls and History filter

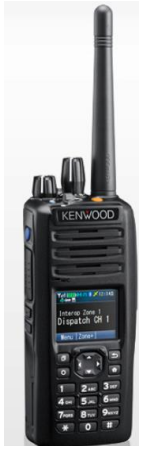
start time	duration	ch	name		source peer id	source radio id	source peer alias	source radio alias	dest. bridge group	dest. radio ID	RSSI (dBm)	source site name	loss rate
06:38:00.519 May 16	6.0	3	RMHAM Central TS1 TG700	g	310800	3108058	Thorodin UHF	K2AD - 3108058	Rocky Mt TG700	700	-83.5	CO-RMHR	0.0%

-1 +1

History

06:37:25.088 May 16	11.0	4	RMHAM Central TS2 TG720	g	310800	3108058	Thorodin UHF	K2AD - 3108058	Central TG720	720	-86.9	CO-RMHR	0.0%
06:36:52.417 May 16	4.0	3	RMHAM Central TS1 TG700	g	310800	3108058	Thorodin UHF	K2AD - 3108058	Rocky Mt TG700	700	-87.0	CO-RMHR	0.0%
04:04:34.268 May 16	0.0	28	DMR Link TS2	g	54321	3108677	DMRLINK	KX3DX - 3108677	Central TG720	720	N/A	CO-RMHR	0.0%
03:36:27.020 May 16	7.0	1	RMHAM Northern TS1 TG700	g	310814	3108119	Horsetooth UHF	KF4DUS - 3108119	Rocky Mt TG700	700	-99.2	CO-RMHR	18.9%
03:35:36.231 May 16	4.0	1	RMHAM Northern TS1 TG700	g	310814	3108119	Horsetooth UHF	KF4DUS - 3108119	Rocky Mt TG700	700	-99.5	CO-RMHR	18.9%
03:35:33.429 May 16	0.0	1	RMHAM Northern TS1 TG700	g	310814	3108119	Horsetooth UHF	KF4DUS - 3108119	Rocky Mt TG700	700	-99.1	CO-RMHR	0.0%
03:35:20.664 May 16	11.0	1	RMHAM Northern TS1 TG700	g	310814	3108119	Horsetooth UHF	KF4DUS - 3108119	Rocky Mt TG700	700	-99.1	CO-RMHR	0.0%
03:34:46.148 May 16	10.0	51	RMHAM Squaw VHF TS1 TG700	g	310810	3163942	Squaw VHF	KE0WPZ - 3163942	Rocky Mt TG700	700	-89.1	CO-RMHR	0.0%
01:45:09.555 May 16	2.0	6	RMHAM TS2 South-Central-North	g	310815	3149867	Fremont UHF	N0TI - 3149867	South TG719	719	-111.8	CO-RMHR	0.0%
01:08:18.026 May 16	2.0	49	RMHAM Almagre VHF TS1 TG700	g	310824	3108407	Almagre VHF	N4SJW - 3108407	UnKnown Ipsc 8	8	-100.0	CO-RMHR	0.0%
01:07:56.281 May 16	3.0	51	RMHAM Squaw VHF TS1 TG700	g	310810	3108407	Squaw VHF	N4SJW - 3108407	Rocky Mt TG700	700	-108.0	CO-RMHR	0.0%
00:12:59.947 May 16	1.0	9	RMHAM FourCorners TS1 TG700	g	310826	3108447	Mancos UHF	KB5SPW - 3108447	Rocky Mt TG700	700	-114.8	CO-RMHR	0.0%
00:12:51.831 May 16	6.0	9	RMHAM FourCorners TS1 TG700	g	310826	3101980	Mancos UHF	3101980	Rocky Mt TG700	700	-112.8	CO-RMHR	5.1%
00:12:47.210 May 16	1.0	9	RMHAM FourCorners TS1 TG700	g	310826	3108447	Mancos UHF	KB5SPW - 3108447	Rocky Mt TG700	700	-115.5	CO-RMHR	0.0%

What happened when I press PTT ?



Request with User ID, TG, CC and TS

Responds “go ahead” or “denied”

PTT established

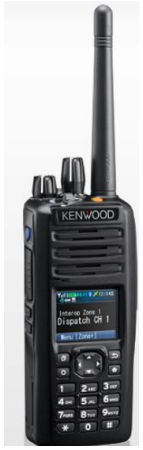
Repeater starts repeating

A little while later …
maybe a lot later.

PTT released. Call complete

Repeater release

What happened when I press PTT with IPSC ?



Request with User ID, TG, CC and TS

Responds “go ahead” or “denied”

Repeater: Incoming call

PTT established

PTT established

Repeater starts repeating

Repeaters start repeating

A little while later …
maybe a lot later.

PTT released. Call complete

PTT released. Call complete

Repeater release

Repeaters release

Some closing thoughts

- Airtime is a resource
  - Some people say, “DMR is too quiet.”
  - Is that a bad thing?
  - Do you value having a wide area coverage linked repeater system?
- TDMA is a bit sensitive
  - Inexpensive radios may not work as well as expensive radios
  - Or maybe vice versa?
  - Audio level can vary greatly based upon radio manufacturer
- Beware of Tier I or “One Slot” radios.
  - We don’t allow them on our network since they “jam” the other time slot
  - Be afraid. Be very afraid.
- DMR is fun
  - Go out there and have some fun!
  - And I have to say it … DMR is Covid-19 free. DMR is social with physical distancing.


QUESTIONS
?