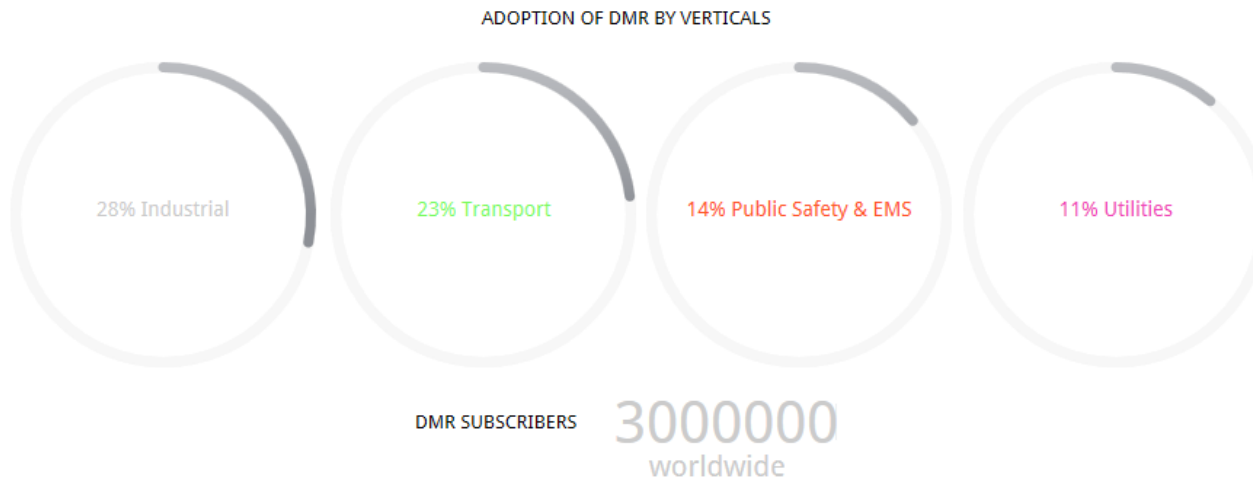




# DMR Overview

## Background

- ETSI (European) standard for Digital Mobile Radio
  - Open Standard
  - Ratified in 2005
- Three (3) Tiers, I, II, III
  - Tier I Unlicensed
  - **Tier II Conventional, direct or repeater, non-trunked**
  - Tier III Trunked



ETSI TS 102 361-2 V2.1.1 (2012-04)



Electromagnetic compatibility  
and Radio spectrum Matters (ERM);  
Digital Mobile Radio (DMR) Systems;

# DMR Overview

## Background

- Not USA public safety grade, but utility grade solution
- Widespread acceptance internationally and in the USA
- Very large market presence by Motorola (MotoTRBO™)
- Very popular in Europe
- Radio and repeater pricing much closer to amateur product levels
  - subscriber units \$400 - \$800
  - Repeaters \$1,500 - \$2,000
- Recent market entry by Chinese manufacturers
  - sub \$200 portable units available
- Adopted internationally for amateur radio use
- Analog & Digital Operation





# DMR Overview

## Call Types and Features

- Group Call
- Individual Call (ack and unack)
- All Call (one way to *all* users of TS)
- Broadcast Call (one way to predefined users of TS)
- Priority and Emergency Call
- Polite/Impolite Channel Access
- IP over DMR
- Short Data Messaging (Status, SMS, defined)
- Radio Check
- Location



# DMR Overview

## What does a DMR user radio look like?

- Three Tiers, similar to P25 and professional grade radios
  - Tier I – no keypad or display (monochrome or color display)
  - Tier II – limited keypad, display
  - Tier III – full keypad, display
  - Cellular Style
- Part 90 Type Acceptance (Freq. Stability, Adj. Chan. Selectivity)
- VHF, UHF L, UHF H, 800 & 900

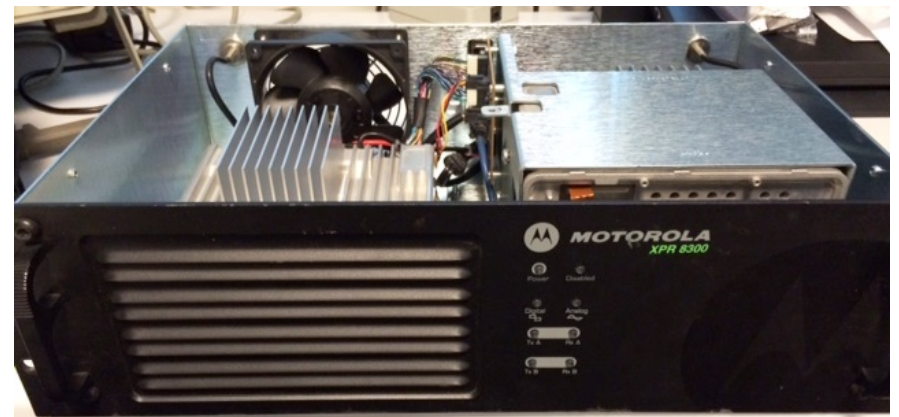




# DMR Overview

## What does a DMR repeater look like ?

- 1st & 2<sup>nd</sup> generation Motorola repeaters effectively 2x mobiles + control logic
- Low infrastructure cost
- 1 racked repeater, 2 voice channels



# DMR Overview

## What does a DMR repeater look like ?

- Some other examples





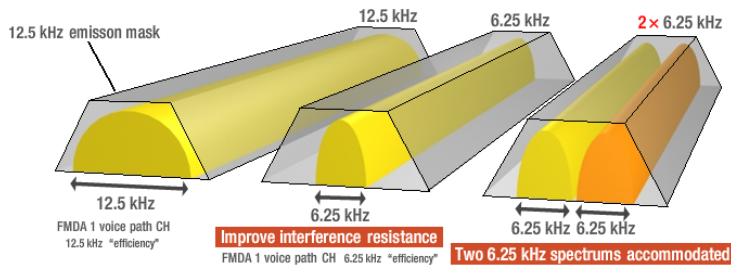
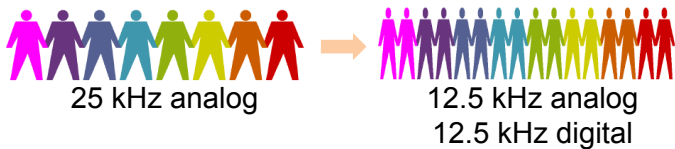
# DMR Tech Overview

## Technical Background

- 12.5 kHz BW (narrowband)
- C4FM (“4FSK”) Modulation  
- same as P25, NXDN, and Yaesu Fusion
- State-of-the Art Forward Error Correction (FEC)

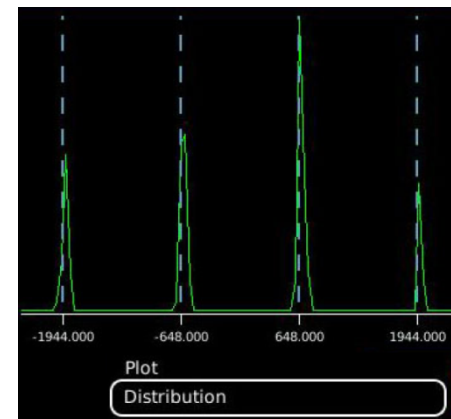


Better Spectral efficiency = More Users



Information bits		Symbol	4FSK deviation
Bit 1	Bit 0		
0	1	+3	+1,944 kHz
0	0	+1	+0,648 kHz
1	0	-1	-0,648 kHz
1	1	-3	-1,944 kHz

Dibit symbol mapping to 4FSK deviation

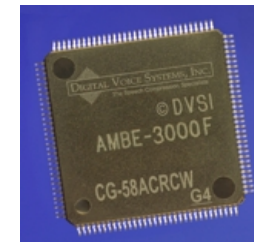
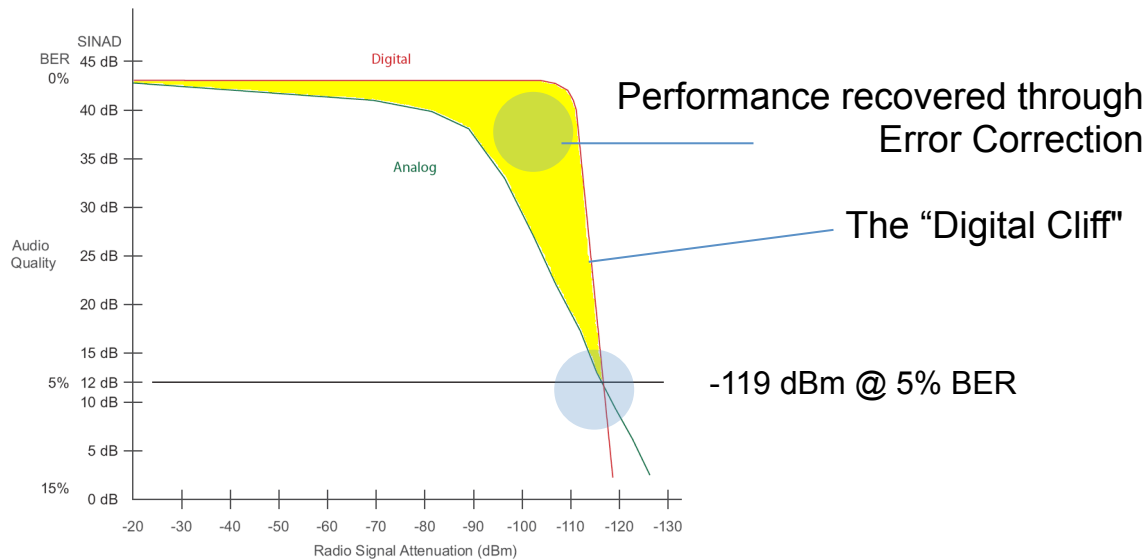




# DMR Tech Overview

## Technical Background

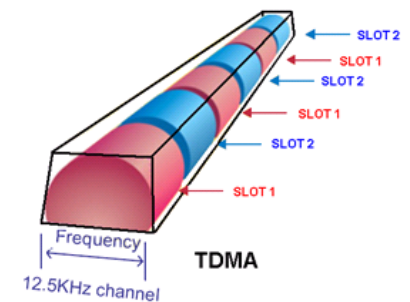
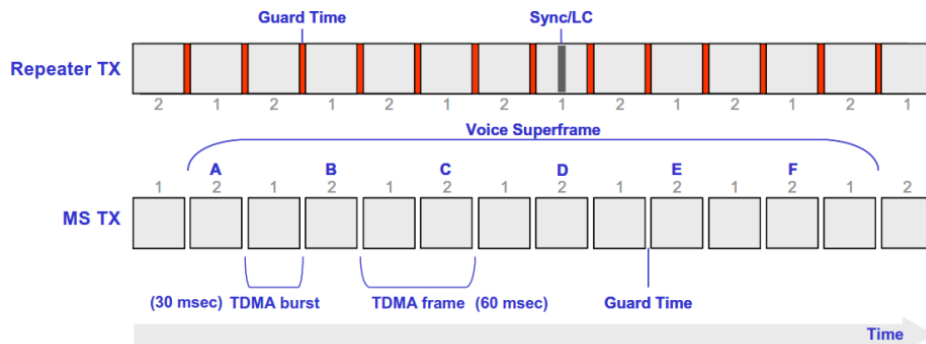
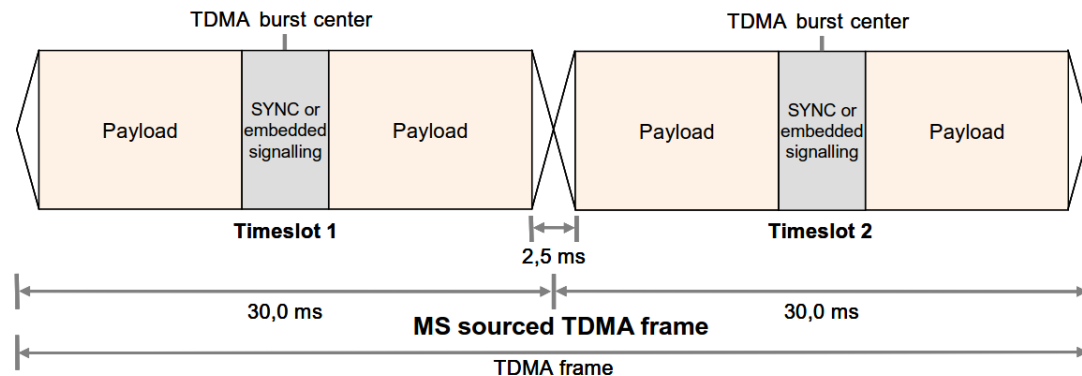
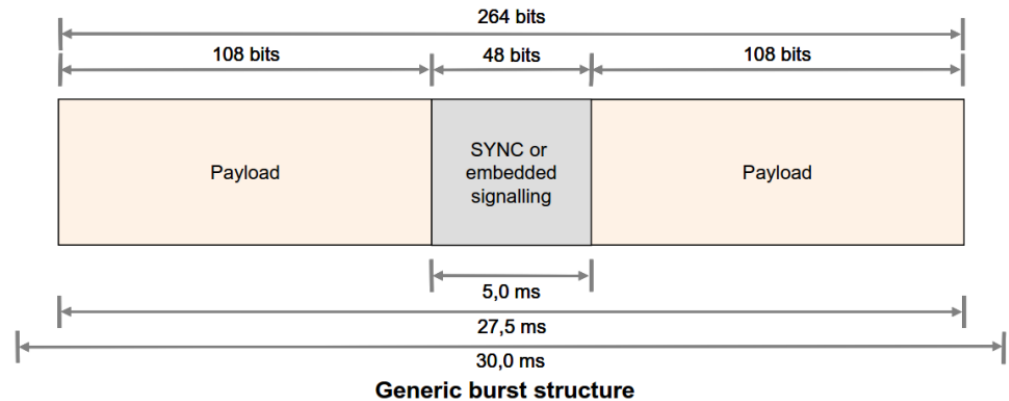
- State-of-the Art Forward Error Correction (FEC)
- DVSI AMBE++ VOCODER (adopted, not specified)
  - synthetic, modeled speech
  - very low bit rate 2450 bps voice + 1150 FEC = 3600 bps
  - very high voice quality
  - robust against strong background noise
  - proven technology MBE family adopted by TIA for APCO P25



# DMR Tech Overview

## Technical Background

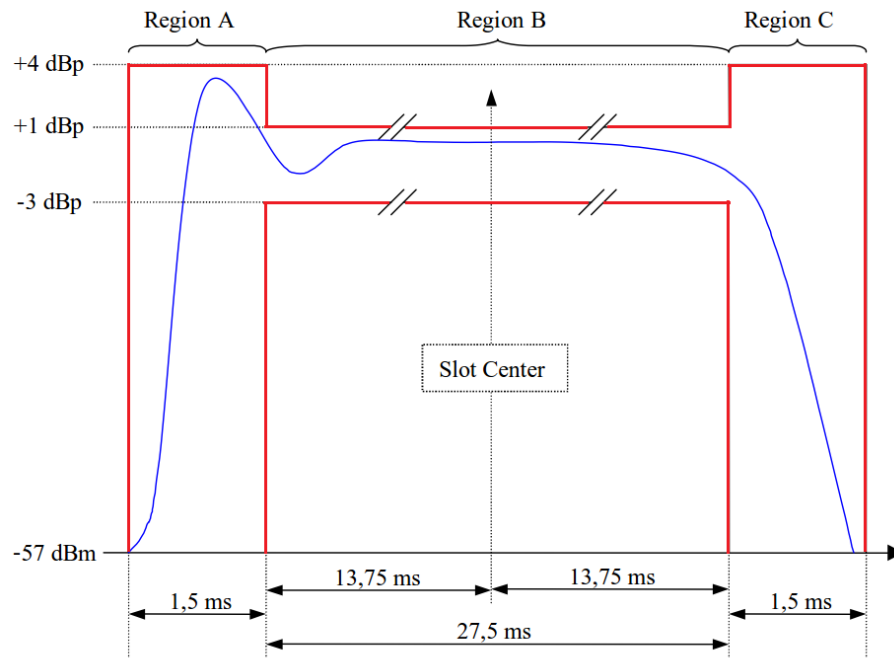
- 2-slot TDMA for 6.25 kHz equivalence
- 30 ms slot, 50% duty cycle
- 216 bit payload (2x 108 bits)
- 2.5 ms guard time needed
  - Tx ramp time
  - propagation delay



# DMR Tech Overview

## Radio Performance

- DMR Radios must have high performance characteristics in several areas:
  - transmitted power transients
  - power ramp time, time for carrier to “rise” and stabilize
  - clock stability and drift
  - frequency stability



## dBp

- Power relative to the average power transmitted over a burst in decibel/



**RF Zone**

Mon Freq  Mon Port

Attenuation

---

Output Lvl  Input Lvl

Freq Error  Deviation

DMR Brand

SYNC Pattern  Count

Source ID   CC

Burst

Symbol Deviation

FSK Error

Magnitude Error

BER Test  Pattern

BER

Marker Mode

**Display Zone** Power Profile

Vertical Maximum  Vertical Scale

Delta (1-2)

Marker 1   Marker 2   Marker Mode

View  Display Mode

**Meter Zone** Constellation

Horz Scale

Squelch Opens @

Monitor  RF D

**RF Zone**

Mon Freq  Mon Port

Attenuation

---

Output Lvl  Input Lvl

Freq Error  Deviation

DMR Brand

SYNC Pattern  Count

Source ID   CC

Burst

Symbol Deviation

FSK Error

Magnitude Error

BER Test  Pattern

BER

**Display Zone** Power Profile

Vertical Maximum  Vertical Scale

Marker Mode

Display Mode

**Meter Zone** Constellation

Horz Scale

Monitor

# Time in TDMA

## Some quirks about time in TDMA

- Data (frame) synchronization is important in DMR
  - repeater generates timing, all mobiles sync to it
  - simplex mode, source Tx becomes synch master
- Power ramp time, time for carrier to “rise” and stabilize
  - 2.5 msec. guard time used to manage this
- Clock stability and drift
- Distance and propagation delay
  - 1 msec “slop” built in to compensate for disparate radio distances
  - different radios with different clock drifts
  - equates to about a 75 km range before the 1 msec “slop” is exceeded
  - = about 45 miles



# DMR Basics

## DMR Basics

- Radios programmed similar to analog
- Each radio has a unique ID that is registered before accessing the networks
- Info on repeater characteristics needed before a DMR call can be made – in either networked or stand-alone operation
  - Color Code
  - Time Slot assignment (1 or 2)
  - ID of called Group/Individual

Contact Name	Call ID
Call1	1
All Call	16777215
Admin	3015555
North America	3163
Comm 1	3777215
Comm 2	3777216
EchoLink 1	3005465
EchoLink 2	3005466
Roundtable 1	3017500
Roundtable 2	3017501
Owners 1	3010999
Owners 2	3011000
TG 1	1
NorCal 3	3
NorCal 4	4
K5EH Paul M2	3106004
K5EH Paul CS1	3106005
K5EH Paul CS2	3106006
N5PCH Steve P	3106626
K5ARO Adam P	3106630

LYN DCI 1

[Top](#) [RX](#) [TX](#)

Scan/Roam List: Scan LYNN SCAN

Auto Scan:

Color Code: 1

Repeater/Time Slot: 1

Allow Talkaround:

RX Only:

---

**RX**

Frequency (MHz): 444.150000

Group List: None

Offset (MHz): 0.000000

Copy

**TX**

Frequency (MHz): 449.150000

Contact Name: DCI 1

Emergency System: None

VOX:

Power Level: High

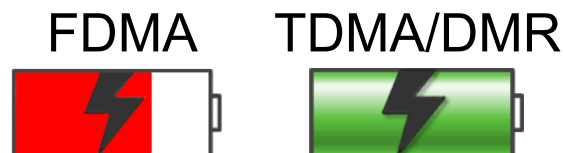
Private Call Confirmed:



# DMR Benefits

## Digital vs. Analog

- Worldwide digital standard
- Over 6 manufacturers of DMR radios
- Superior voice quality over older digital modes
- Longer battery life via TDMA 50% Tx / 50% Rx mode
- Supports multiple talk groups on one channel
- Supports data applications and simultaneous voice & data
- Commercial specs give rugged performance in urban RF environments



“TDMA radios indicate 19%~34% less required battery capacity than FDMA per hour, and “40% improvement in talk time over analog radios“ <http://dmrassociation.org>

# DMR Networking

## Topology

- Motorola implements various levels of site networking
  - conventional, with auto roaming
  - trunked
- All are based on two important aspects of the MotoTRBO™ protocol
  - IP linking of repeater sites
  - Beaconing capability for radios to scan and acquire new sites
- IP addressable radios



# DMR Networking

## Amateur DMR networking

- DMR intersite linking/networking protocol *not defined by ETSI*
- MotoTRBO™ has a proprietary networking scheme IP SiteConnect™
- Limited to 15 sites and 100 users

**By the use of a special router, the original IP SiteConnect™ limitations are relieved.**

- Distributed by Rayfield Communications
- “C-Bridge”





# DMR Networks

## Two major wide area DMR based Amateur Networks

- DCI (has a bridge to MARC)
- MARC (has a bridge to DCI)



## Other international, regional or “private” networks

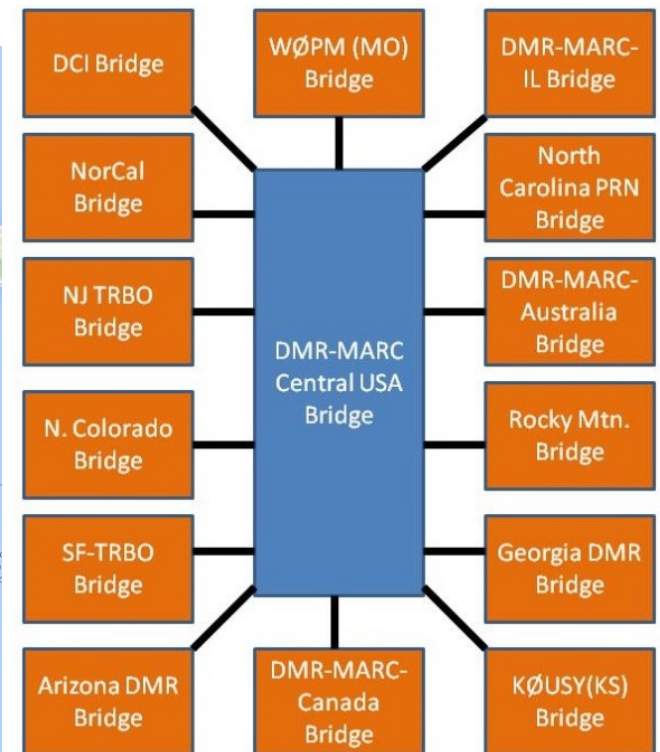
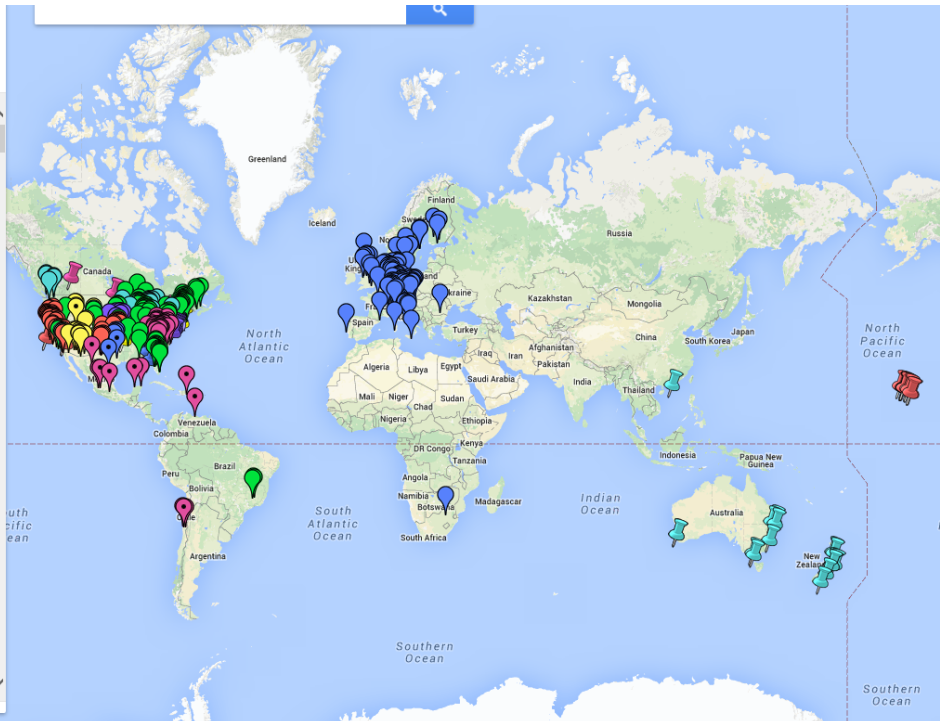
DMR-MARC Networked Repeaters

Digital Mobile Radio



Network and Location

- DMR-MARC - Los Angeles - California
- MIT NET - Galloway, NJ
- DMR-MARC - Schaumburg IL
- DMR-MARC - Crystal Lake IL
- DMR-MARC - Haymarket - Virginia
- DMR-MARC - Hudson NH
- KS DMR - Kansas City - Missouri
- NoCo - Ft. Collins CO
- AZ-TRBO - White Tanks Mtn. - Phoe...
- DMR-MARC - Morris IL
- BC - TRBO - New Westminster BC - ...
- DMR-MARC - Omaha NE
- NJ-TRBO - Orangeburg, NY
- DCI - Waterloo, MI
- NC-PRN - Richmond - Virginia
- DMR-MARC - Plantation - Florida
- WØPM - Springfield MO
- AZ-TRBO Tucson, AZ
- DMR-MARC - Washington DC
- VK-TRBO - Melbourne - Australia
- VK-TRBO - Perth - Australia
- ZL-TRBO - Wellington - New Zealand
- DMR-MARC - Johannesburg - Sout...
- DMR-MARC - Aachen / Stolberg - G...
- DMR-MARC - Berlin / Tegel - Germa...

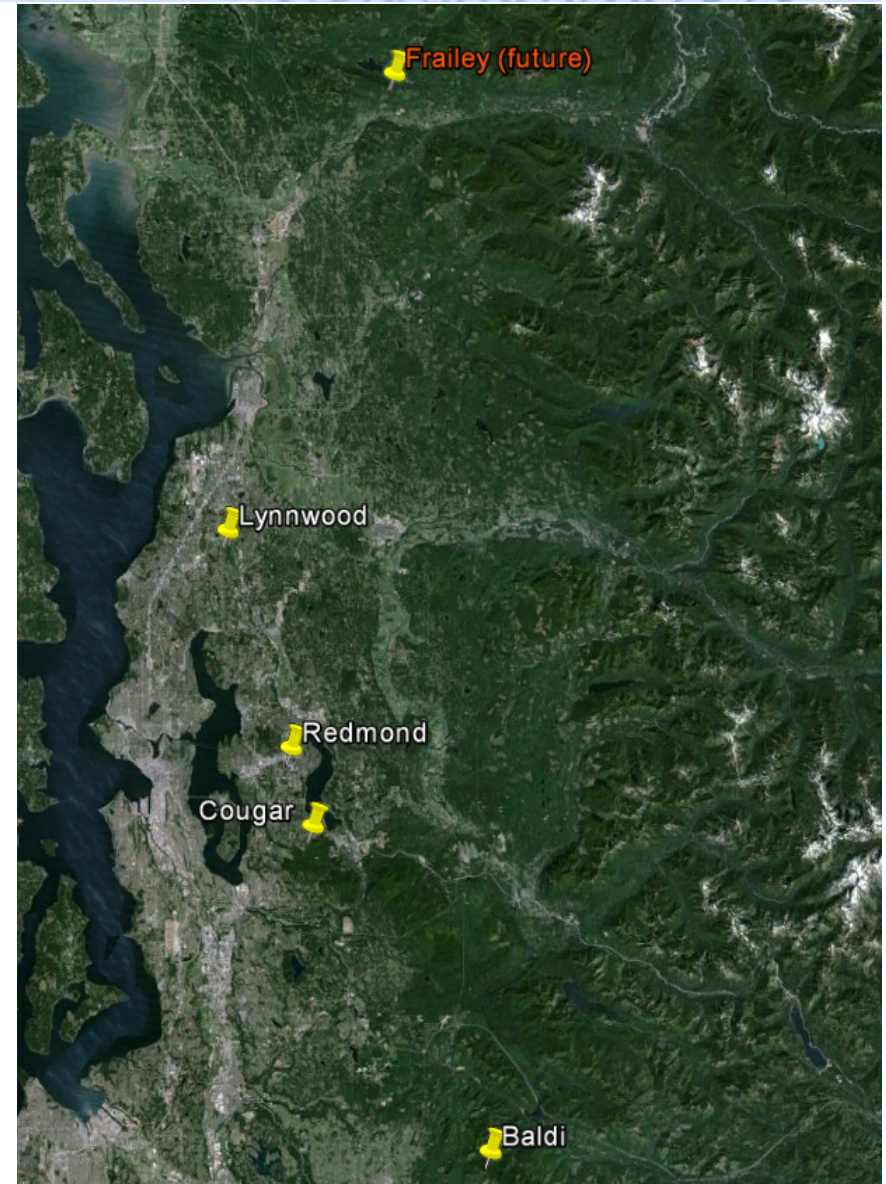




# Local DMR Repeaters

PNW Talkgroups - Full Time		
Bridge 2 (On)	BC 1 (On)	Comm 1 (On)
DCI 1 (On)	DCI 2 (On)	Mountain Reg 2 (On)
Wash 1 (On)	Wash 2 (On)	
Local 1 & Local 2 are full-time on Washington State Repeaters only		
PNW Talkgroups - Part Time		
Alabama 1 (PTT)	California 1 (PTT; 1 hr)	Canada 2 (PTT)
Georgia 1 (PTT)	Illinois 2 (PTT)	I-5 2 (PTT; 1hr)
	Mass 2 (PTT)	North America 2 (PTT; 1hr)
Ontario 2 (Can) (PTT)	Oregon 1 (PTT; 1hr)	PA-525 2 (PTT)
Pennsylvania 1 (PTT)	TAC 310-2 (PTT 15/3)	Worldwide 2 (PTT; 10 min)
WW English 2 (PTT)		
"Hawaii Statewide 1" (PTT) on Washington State Repeaters only		
NOTES: PTT Info -- PTT: On time is 15 minutes Other TG hold-off times are 2 minutes unless otherwise noted Parrot 2 and Audio Test 2 are available on very short PTT timer cycles		

Repeater Location	Frequency / Offset	Color Code
Baldi Mtn, WA	441.3500 +5 Mhz	CC1
Cougar Mtn, WA	441.2875 +5 Mhz	CC1
Frailey Mtn, WA (Oso/Mt Vernon) (soon)	tba	tba
Lynnwood, WA (Gunnysack)	444.1500 +5 Mhz	CC1
Mazama, WA (testing Fusion)	444.8500 +5 Mhz	CC3
Mazama, WA (Edelweiss)	433.1500 +16.5 Mhz	CC3
Spokane, WA (temp low level, Lookout Pt soon)	444.1250 +5 Mhz	CC1
Winthrop (Edelweiss)	145.5100 +2 Mhz	CC3
Mt Seymour, BC, Canada (CAN-TRBO)	443.4000 +5 Mhz	CC1
New Westminster, BC Canada (CAN-TRBO)	444.6000 +5 Mhz	CC1
Lewis County	coming in 2015	



# DMR Feedback

## Wealth of Information for Starters

- **MARC and DCI Websites loaded with info**
  - DMR technology
  - Network Topology
  - Operating protocol
  - How to get started
  - Even radio programming “bootstrap” starter files
- **Incredibly Professional and Knowledgeable People**
  - Many DMR users are “in the LMR industry”
  - Motorola employees (current & retired)
  - LMR shop technicians
  - Most embrace new technology
  - Some transitioning from or adding to D-Star operation



**Websites:**

[www.dmr-marc.net](http://www.dmr-marc.net)

[www.trbo.org](http://www.trbo.org)





**THANK  
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Where do you want to QSO today?

**Andy Ruschak**

**KK7TR**