Digital Mobile Radio (DMR) & PNW System Primer

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DMR Overview

Background

• ETSI (European) standard for Digital Mobile Radio
  - Open Standard
  - Ratified in 2005

• Three (3) Tiers, I, II, III
  - Tier I Unlicensed (PMR 446 in Europe and other countries)
  - Tier II Conventional, direct or repeater, non-trunked (primary use in amateur)
  - Tier III Trunked
Background

• Not USA public safety grade, but utility grade solution
• Widespread acceptance internationally and in the USA
• Very large market presence by Motorola (MotoTRBO™)
• Radio and repeater pricing closer to amateur market
  - subscriber units $100 - $800
  - Repeaters $1,500 - $2,000
• Recent market entry by Chinese manufacturers
  - sub $120 portable units available
• Adopted internationally for amateur radio use
• Analog & Digital Operation
• V/U/700/800/900 MHz, and Dual-Band Models
DMR Overview

Call Types and Features

• Group Call on a “Talkgroup” (typical for amateur radio QSO’s)
• Individual Call (acknowledged and unacknowledged)
• 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 (not used on amateur DMR systems)

• Important Point: With TDMA operation in DMR, 2 time slots on a repeater channel provides 2 independent and simultaneous QSO’s/conversations (1 per time slot)

• Currently, no other amateur digital voice mode (i.e., D-Star, Fusion, etc., can support this capability
What does a DMR user radio look like?

- Three Tiers, similar to P25 and professional grade radios
  - Low Tier – no keypad or display (monochrome or color display)
  - Mid Tier – limited keypad, display
  - High Tier – full keypad, display
- Part 90 (not 97) Type Acceptance (Freq. Stability, Adj. Channel Selectivity)
- Please refer to the PNW DMR website for feedback and recommendations on preferred and non-preferred radios
  - you get what you pay for (let’s just leave it at that)
DMR Overview

What does a DMR repeater look like?

- 1st & 2nd generation Motorola repeaters effectively 2x mobiles + control logic
- Low infrastructure cost, with 1 racked repeater, you get 2 voice channels
Technical Background

- 12.5 kHz BW (narrowband)
- C4FM (“4-level, FSK”) Modulation
  - same as P25, NXDN, Yaesu Fusion, dPMR
  - DStar is different (uses GMSK)
- State-of-the Art Forward Error Correction (FEC)
- 2-slot TDMA for 6.25 kHz equivalence
- 30 ms slot, 50% duty cycle

Better Spectral efficiency = More Users

25 kHz analog  
12.5 kHz analog  
12.5 kHz digital
DMR Tech Overview

Technical Background

- State-of-the Art Forward Error Correction (FEC)
- DVSI AMBE 2+ 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

Performance recovered through Error Correction

The “Digital Cliff"

-119 dBm @ 5% BER
Radio Programming

- Radios programmed similar to analog, most require configuration software & cable
- Each radio has a **unique ID that is registered** before accessing the networks
  - for amateur DMR, ID's issued by DMR-MARC (typically 1 day turnaround)
- Info on repeater characteristics needed before a DMR call can be made – in either networked or stand-alone operation
  - Color Code (similar to CTCSS/DCS)
  - Time Slot assignment (1 or 2)
  - ID of called Group/Individual
- Each talk group (TG) has its own ID number
- TG IDs can be used on multiple repeaters
Callsign Display Information on a DMR Radio

• A unique numerical ID is embedded in a DMR radio transmission, but the user’s FCC callsign (its alphanumeric information) info is not

• Callsigns and descriptors reside in each DMR radio, contained in a “contacts list”
  - must program these if you want to see an alias in lieu of a “plain” ID number
  - must update it as the master list changes (with new hams joining the DMR network)

• This differs from Yaesu Fusion & D-Star where callsign is entered manually and embedded in radio transmission
  - yes, a little inconvenient, but consider the capabilities DMR brings to amateur radio, and that this is professional radio protocol serving amateur radio!

• DMR-MARC issues ID’s and maintains the master ID database

• Fortunately, the PNW website has uploaded “bootstrap” radio data files with contacts lists already created, for your benefit
DMR Benefits

Digital vs. Analog

• Worldwide digital standard
• Many manufacturers of DMR radios
• Economical (price point of analog radios now)
• 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 Network Access

New “Access Point based” Technology

- Multi-waveform radio modem w/IP link & gateway to one or several networks
  - multi-waveform (C4FM, GMSK) for D-Star, DMR, Fusion, P25, DPMR
  - gateways to DMR-MARC, Brandmeister, DCI, PNW and other networks
  - some need external PC, others are dedicated/integrated with Arduino/Raspberry Pi
  - VHF, UHF (some are dual-band)

- Allow talk group selection, *as authorized*, on each network
  - can cross connect protocols (cross-mode operation)

- Advantages
  - access DMR networks even if no local repeater coverage
  - mobile access via cellular data
  - link disparate digital voice modes

- Disadvantages and caveats
  - Range> Tx power (approx. 10 mW)
  - Rx Overload/desense> no Rx front-end selectivity or BPF
  - RF connection> combined antenna port (cannot use duplexer)
  - Audio> VOCODING quality readily apparent (IMHO)
DMR Networking

- DMR inter-site linking/networking protocol *not defined by ETSI*
- MotoTRBO™ has a proprietary networking scheme IP SiteConnect™ (IPSC) but limited to 15 sites and 100 users
- Repeater “Beaconing” allows automated roaming for user radios
- Other manufacturers each support their own network capabilities

**Amateur DMR Networking - by using a special router, original IP SiteConnect™ limitations are relieved**

- Distributed by Rayfield Communications
- “C-Bridge” creates a new network to link repeaters into IPSC network, greatly expanding the capacity and coverage. Allows segmentation of repeaters into their own “managers”, for flexibility to manage talkgroups separately from other repeaters.
## PNW DMR Repeaters

<table>
<thead>
<tr>
<th>St.</th>
<th>Repeater City - Heat Map</th>
<th>Information - Details</th>
<th>PNW Area Map - Heat Maps: OR - WA</th>
<th>Freq / Offset Color Code / Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>New Westminster</td>
<td>BC-TRBO Affiliate, NWARC</td>
<td></td>
<td>444.6000 +5 Mhz CC1</td>
</tr>
<tr>
<td>BC</td>
<td>Vancouver - Mt Seymour</td>
<td>BC-TRBO Affiliate, BCFMCA, Wide area coverage, South to Bellingham</td>
<td></td>
<td>443.4000 +5 Mhz CC1</td>
</tr>
<tr>
<td>ID</td>
<td>Coeur d'Alene - Blossom Mtn</td>
<td>I-90 corridor coverage, about 69 miles from 4th of July Pass ID to Four Lakes WA (Hwy 904).</td>
<td></td>
<td>444.4750 +5 Mhz, CC1 - BP</td>
</tr>
<tr>
<td>OR</td>
<td>Buxton - Green Mtn</td>
<td>Hwy 6, 26 &amp; 47 in Columbia &amp; Washington counties OR</td>
<td></td>
<td>444.0250 +5 Mhz CC9</td>
</tr>
<tr>
<td>OR</td>
<td>Colton - Goat Mtn</td>
<td>Wide area, Clackamas County, I-5, Lebanon to Portland</td>
<td></td>
<td>442.7500 +5 Mhz CC1</td>
</tr>
<tr>
<td>OR</td>
<td>Eugene OR - Prairie Pk</td>
<td>Wide area, I-5: South of Eugene to North of Salem, Coastal; Florence to Newport, online as of 5-10-17</td>
<td></td>
<td>442.9625+5 Mhz CC1</td>
</tr>
<tr>
<td>OR</td>
<td>Hebo - Mt Hebo</td>
<td>North coast. Portions of Central OR (MCT soon)</td>
<td></td>
<td>442.8125 +5 Mhz CC1</td>
</tr>
<tr>
<td>WA</td>
<td>Portland - West Hills</td>
<td>Wide area, I-5: Salem to Longview WA. Site Info</td>
<td></td>
<td>440.6250 +5 Mhz CC1</td>
</tr>
<tr>
<td>OR</td>
<td>Redmond - Gray Butte</td>
<td>Wide area Hwy 97; Crescent to Shaniko possible</td>
<td></td>
<td>442.9500 +5 Mhz CC1</td>
</tr>
<tr>
<td>OR</td>
<td>Timberline - MT Hood - MCT</td>
<td>Wide area, I-5: from Salem to Vancouver, Bend to Maupin</td>
<td></td>
<td>442.9675 +5 Mhz CC1</td>
</tr>
<tr>
<td>OR</td>
<td>Salem OR - Woodburn</td>
<td>Lower level but with wide coverage, was testing low level but not seen on network in many months.</td>
<td></td>
<td>442.8675 +5 Mhz CC1</td>
</tr>
<tr>
<td>WA</td>
<td>Bellingham - Lookout Mtn</td>
<td>Wide area coverage, I-5 corridor; Everett to Vancouver BC</td>
<td></td>
<td>440.9250 +5 Mhz CC1 - BP</td>
</tr>
<tr>
<td>WA</td>
<td>Bellington - BawFaw</td>
<td>Wide area, I-5, Olympia to Portland, as soon as June 2017</td>
<td></td>
<td>440.7375 +5 Mhz CC1 - BP</td>
</tr>
<tr>
<td>WA</td>
<td>Bremerton - Gold Mtn</td>
<td>Wide area I-5, Downtown Seattle; Puget Sound to Lynnwood</td>
<td></td>
<td>440.7000 +5 Mhz CC1 - BP</td>
</tr>
<tr>
<td>WA</td>
<td>Longview/Kelso - Rainier Hill</td>
<td>Wide area, I-5, Portland, OR to Napavine, WA</td>
<td></td>
<td>441.7000 +5 Mhz CC1</td>
</tr>
<tr>
<td>WA</td>
<td>Lynnwood - Gunnsack</td>
<td>Low level, I-5, Seattle to Marysville, Puget Sound</td>
<td></td>
<td>444.1500 +5 Mhz CC1 - BP</td>
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<tr>
<td>WA</td>
<td>Mazama UHF - E-Town</td>
<td>North Methow Valley, North Central WA, low level</td>
<td></td>
<td>433.15 +16.5 Mhz CC3 - BP</td>
</tr>
<tr>
<td>WA</td>
<td>Mazama VHF - E-Town</td>
<td>North Methow Valley, North Central WA, low level</td>
<td></td>
<td>145.5100 +2 Mhz CC3 - BP</td>
</tr>
<tr>
<td>WA</td>
<td>Megler - Megler</td>
<td>Southwest WA &amp; Northwest OR coastal &amp; Inland (OR-N network)</td>
<td></td>
<td>444.2375 +5 Mhz CC9</td>
</tr>
<tr>
<td>WA</td>
<td>Moses Lake - Moses Lake</td>
<td>I-90 corridor coverage for 100 miles, MTR3000 // Project on hold, delayed or cancelled; also considering Mission Ridge, a much better site</td>
<td></td>
<td>440.8250 +5 Mhz; CC1 - BP</td>
</tr>
<tr>
<td>WA</td>
<td>Olympia - Capitol Peak</td>
<td>I-5 corridor coverage, Castle Rock to Seattle plus Coastal</td>
<td></td>
<td>440.7125 +5 Mhz; CC1 - BP</td>
</tr>
<tr>
<td>WA</td>
<td>Seattle - Cougar Mtn</td>
<td>Wide area, I-5 corridor; Tacoma to Everett</td>
<td></td>
<td>441.2875 +5 Mhz CC1</td>
</tr>
<tr>
<td>WA</td>
<td>Spokane - Krell</td>
<td>MTR-3000 to be deployed, 2017?</td>
<td></td>
<td>4xx xxxx +5 Mhz CC1 - BP</td>
</tr>
<tr>
<td>WA</td>
<td>Spokane - Lookout Pt</td>
<td>Wide area, I-90 corridor; Ritzville to Coeur d'Alene</td>
<td></td>
<td>444.1500 +5 Mhz CC1 - BP</td>
</tr>
<tr>
<td>WA</td>
<td>Sultan - Haystack Mtn</td>
<td>HKS Network repeater; wide area, I-5 corridor / More info</td>
<td></td>
<td>444.4000 +5 Mhz CC1</td>
</tr>
<tr>
<td>WA</td>
<td>Tacoma - Baldi Mtn</td>
<td>Wide area, I-5 corridor; Olympia to Seattle</td>
<td></td>
<td>441.3500 +5 Mhz CC1 - BP</td>
</tr>
<tr>
<td>WA</td>
<td>Tacoma North - Ruston</td>
<td>Tacoma / Seattle area fill-in</td>
<td></td>
<td>440.7250 +5 Mhz CC1 - BP</td>
</tr>
<tr>
<td>WA</td>
<td>Vancouver - Larch Mtn (WA)</td>
<td>Wide area; I-5, Southern WA &amp; Northern OR (OR-N network)</td>
<td></td>
<td>442.9850 +5 Mhz CC1</td>
</tr>
</tbody>
</table>
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
www.trbo.org
THANK YOU!

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