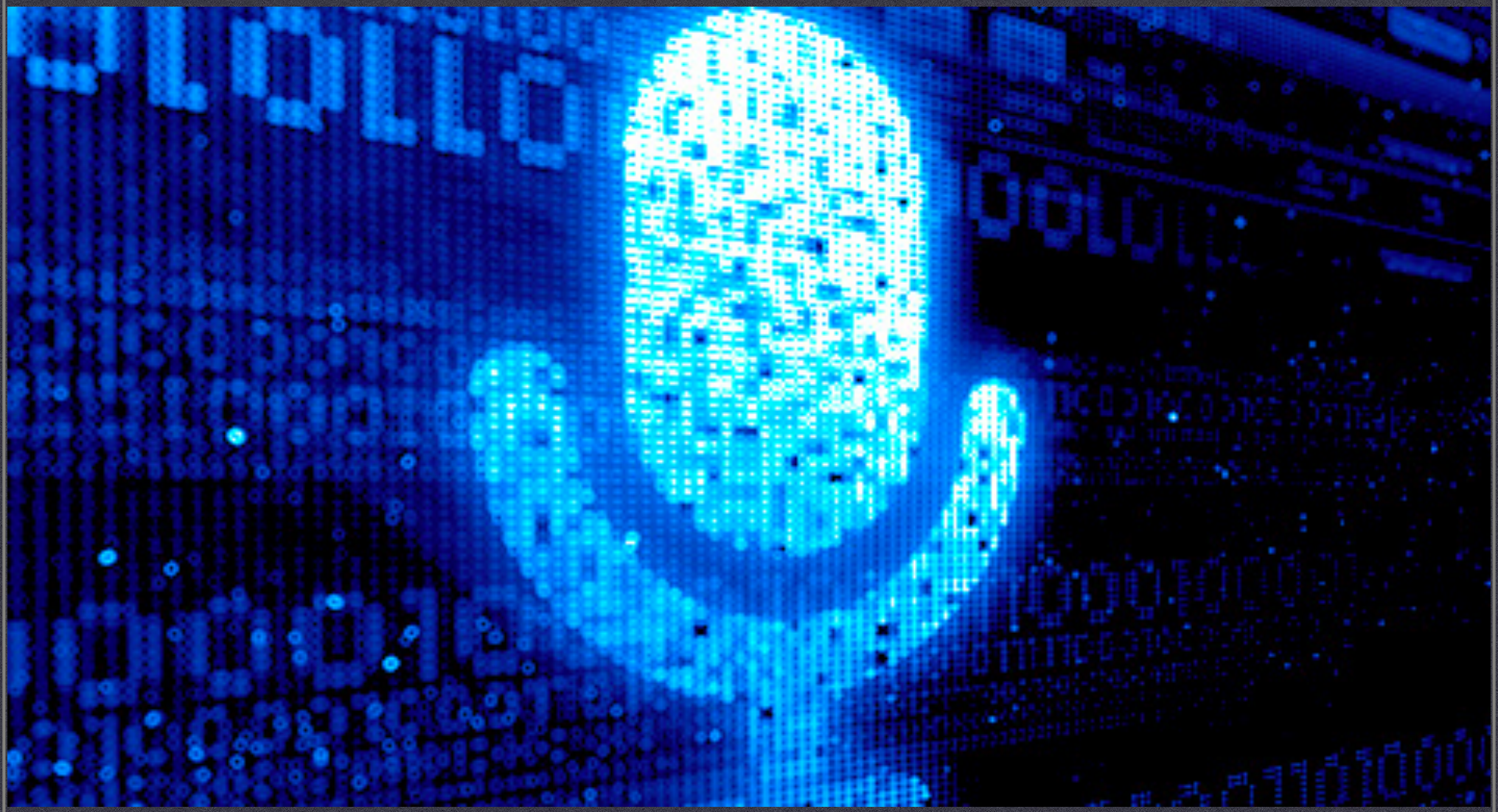


DIGITAL AUDIO MODES

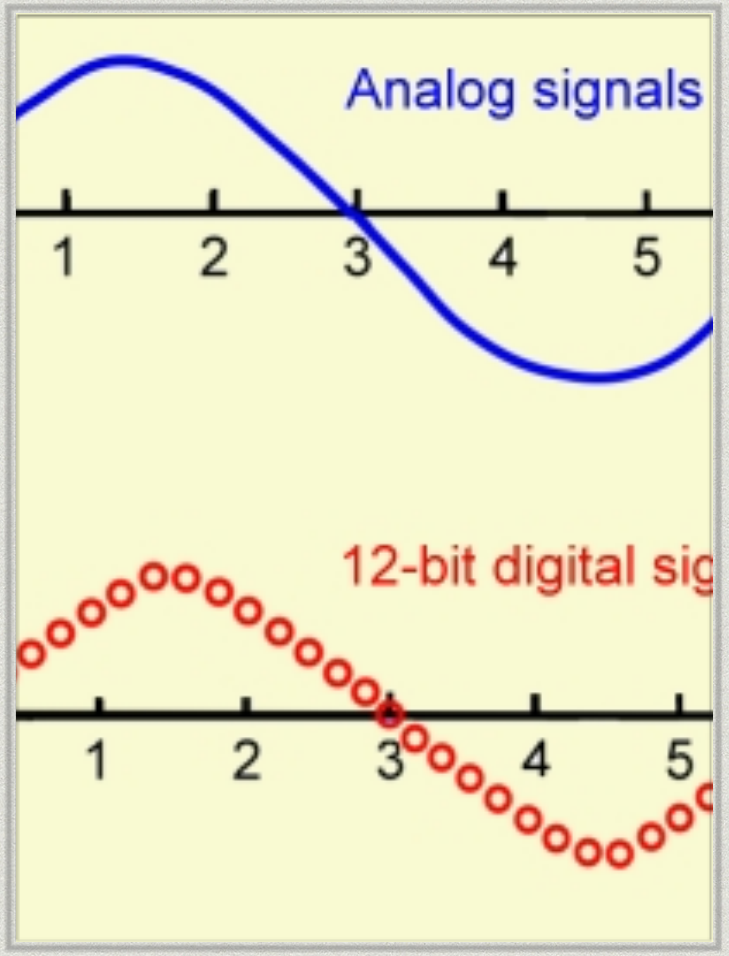
MIKE MYERS

Overview

- Overview of Digital Voice
- One Technology Started it All
- Modes Overview
- Going Beyond your Repeater
- Other Connection devices
- Compare the Digital Modes
- Resources

Overview of Digital Voice

- On the sending side analog voice is converted to digital signals using analog to digital converters.
- On the receiving side the digital signal is converted back to audio using digital to analog converters.
- Assuming all data is received, the audio is delivered noise free.



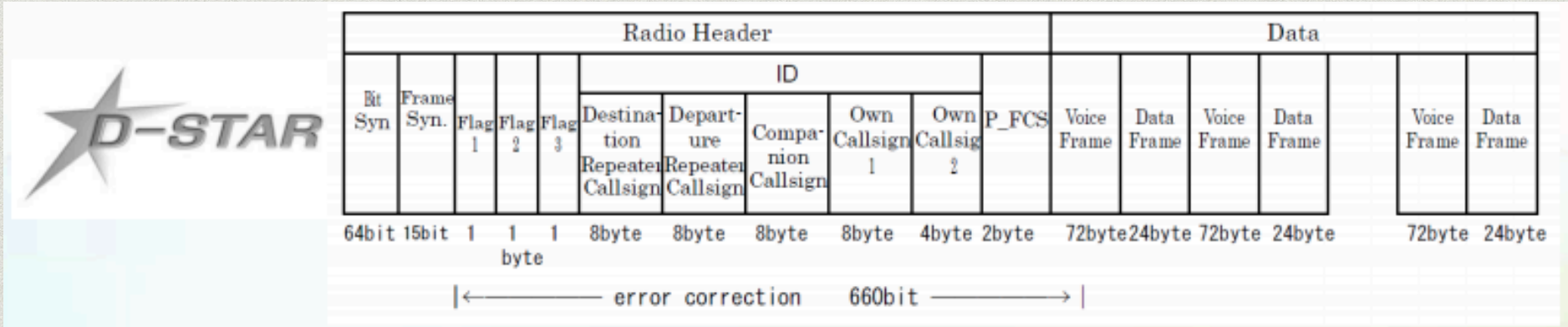
One Technology Started it All

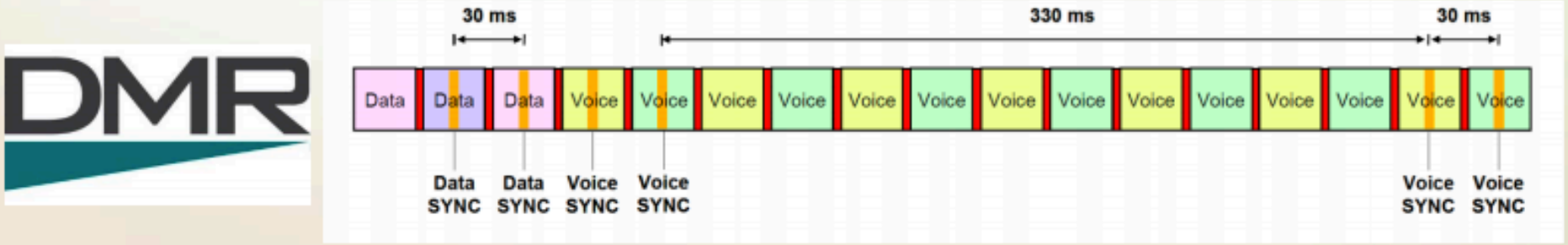
- AMBE+ Vocoder Chip (Digital Voice Systems, Inc)
- Compresses the data from A/D into a smaller data stream that can occupy the available bandwidth of Amateur Radio frequency.
- AMBE is needed on both sides of a conversation. On the transmit side it encodes and on the receive it decodes.

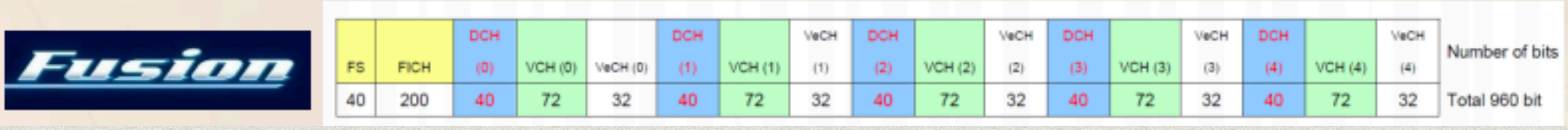
One Technology Started it All

- D-Star was the first to use this technology for amateur radio.
- DMR and C4FM use a new version of this vocoder called an AMBE+2.
- AMBE+2 is backward compatible with the AMBE+ vocoder.

Modes Overview - Data Format

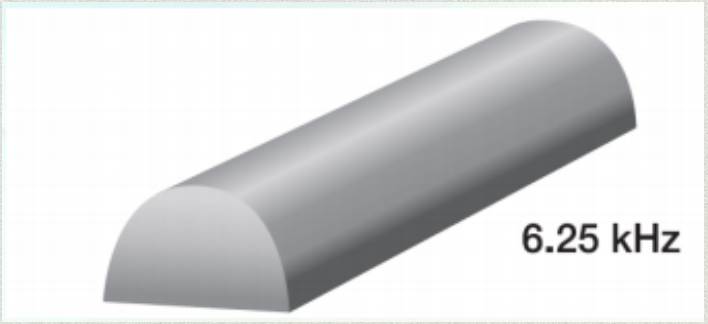




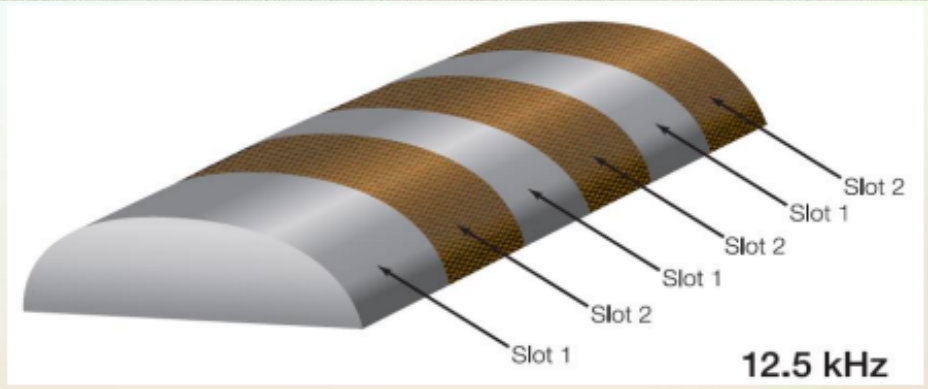


Modes Overview - Bandwidth

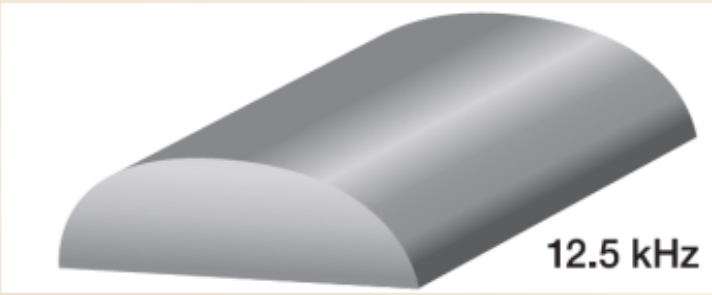
D-STAR



DMR



System Fusion



Modes Overview - D-Star

- Open Standard developed by the Japan Amateur Radio League (JARL).
- D-Star standard was officially published in 2001.
- in 2004 Icom began releasing D-Star optional hardware.
- Until Recently, Icom has been the only radio manufacturer for 2Meters, 70CM and 23CM communication, Kenwood now has a handheld available. Flex Systems supports D-Star on HF.
- Uses the AMBE+ vocoder.
- Voice audio is encoded as 3600 bps data stream, there is a 1200 bps FEC totaling 4800 bps for voice.
- There is an additional 1200 bps that can be used for data transfer.

- Repeaters transfer the data to a gateway to access other repeaters, gateways and reflectors.
- Communication is done between sites via an IP network, typically the internet is used as the transport network.
- Requires registration to access the US Trust network.
- Supports data from external sources and can be used for text communication (D-Rats), sending messages, etc.
- If a GPS receiver is on or attached to radio, the location information is passed in the header.
- Meets FCC ID requirements.

Modes Overview: Fusion

- Developed by Yeasu, also known as C4FM
- Repeaters support both analog and digital modes.
- Uses AMBE+2 Vocoder
- Has multiple digital modes:
  - Digital Narrow (DN) support digital voice and data simultaneously.
  - Digital Wide (DW) uses all the bandwidth for high fidelity voice.
  - Highspeed data (9600 BPS) for transferring images, text messages, etc.
  - Automatic mode select can be activated.
- Supports picture messaging.

System Fusion

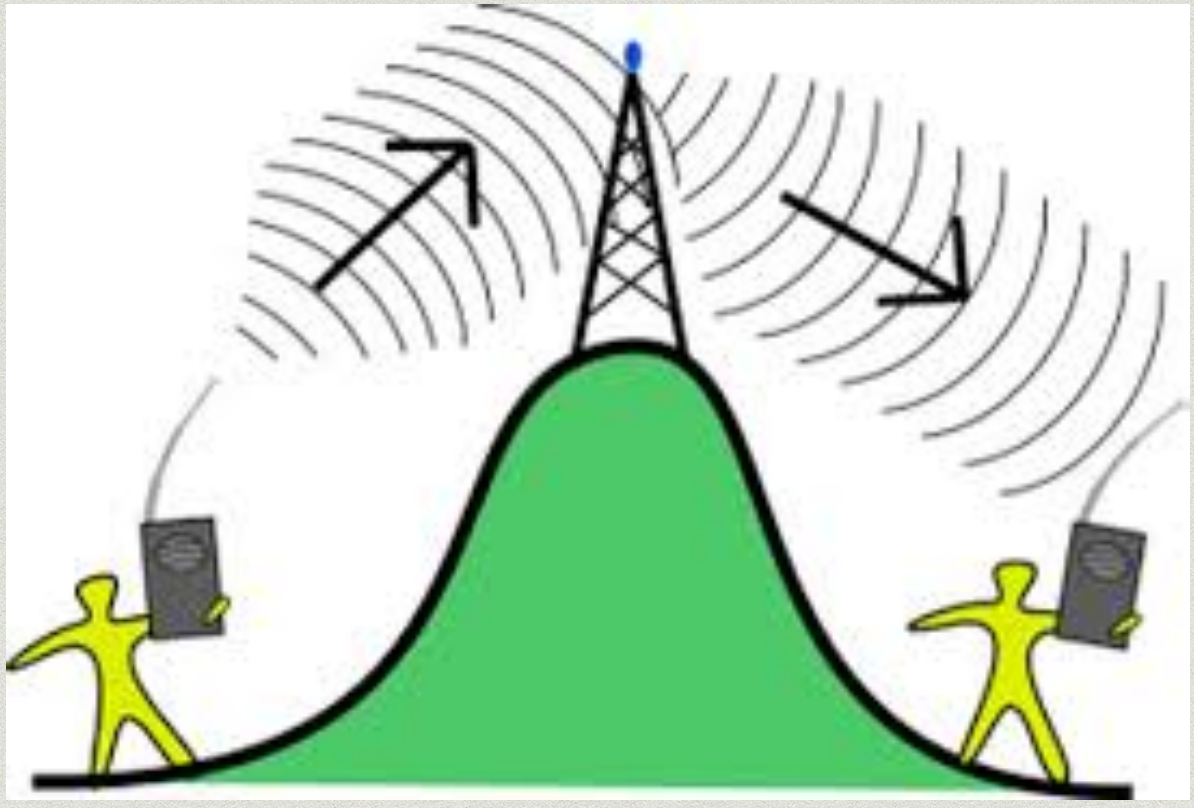
- Yeasu is the only manufacturer of radios for Fusion
- Has a Group Mode function that monitors who is in communication range.
- Radios have built in functions to communicate with a Wires-X Node.
- Easy to navigate Wires-x specific menus for selecting rooms and nodes.
- Field Programmable
- Most radios have built in APRS functions that can report locations using normal APRS methods.
- Meets FCC ID Requirements

Modes Overview: DMR

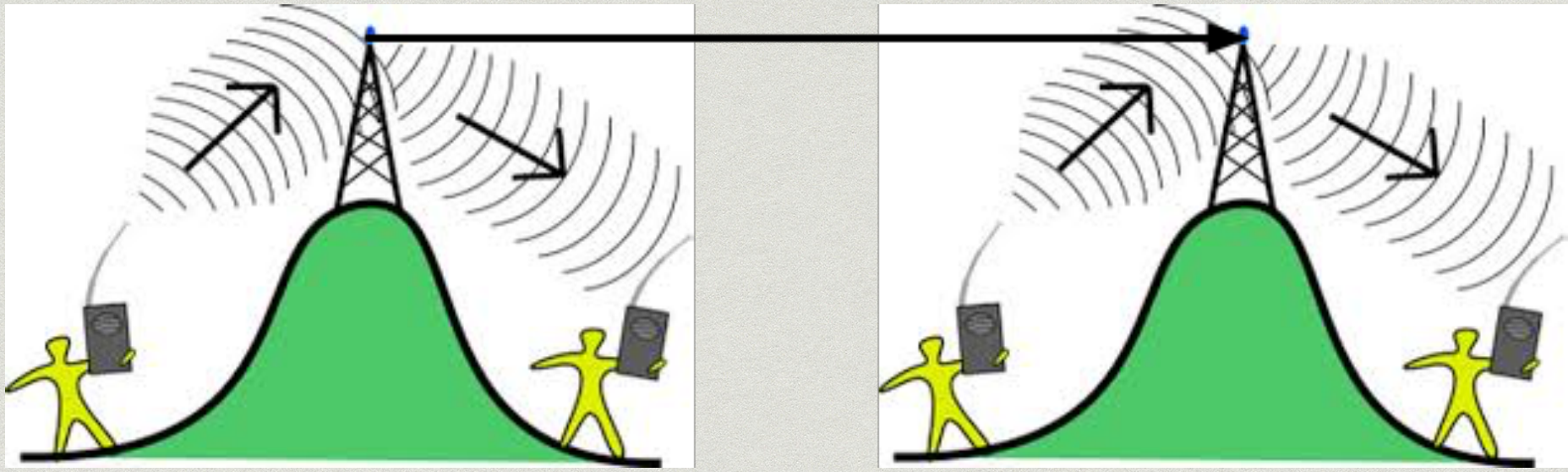
- Developed by the European Telecommunications Standards Institute (ETSI) for commercial communication products around the world.
- Uses the AMBE+2 vocoder
- The conventional DMR was first published in 2005.
- Uses a 2 slot TDMA that is 12.5 Khz to be narrow band compliant.
- Modulation is 4 state FSK (4FSK)
- Many manufacturers of radios
- Radios are not field programmable *
- Radios are single band radios
- Can send text based messages.

- DMR Mode 1 is for simplex operation only *
- DMR Mode 2 is what is used for Amateur Radio.
- DMR Mode 3 is trunking
- Two separate conversations can be going on at one time.
- Requires a CCS7 id.
- Has no understanding of Callsigns.
- Does not meet the FCC requirements for ID.
- Cannot send GPS location data legally because it does not support the FCC requirements for ID.

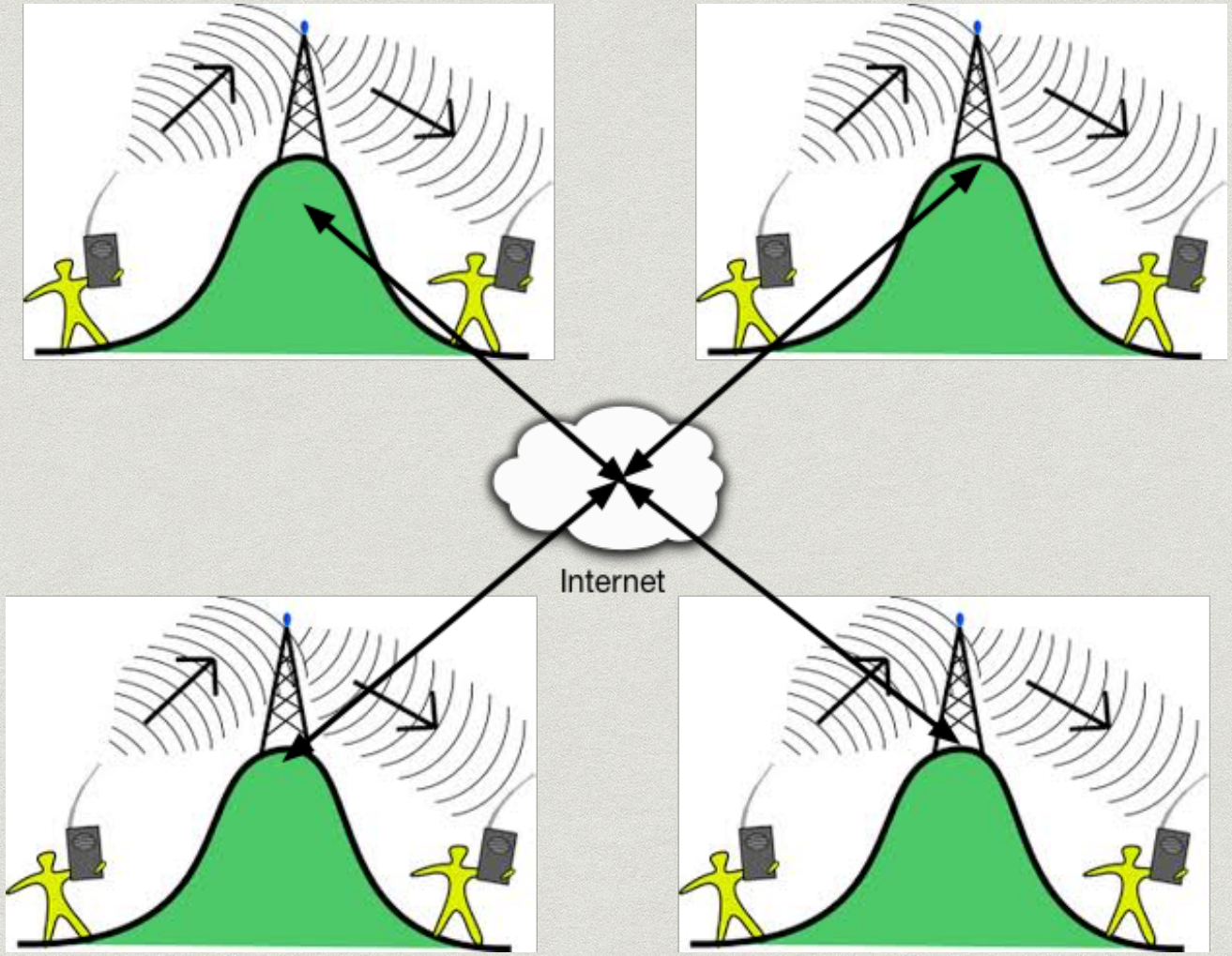
Going Beyond Your Repeater



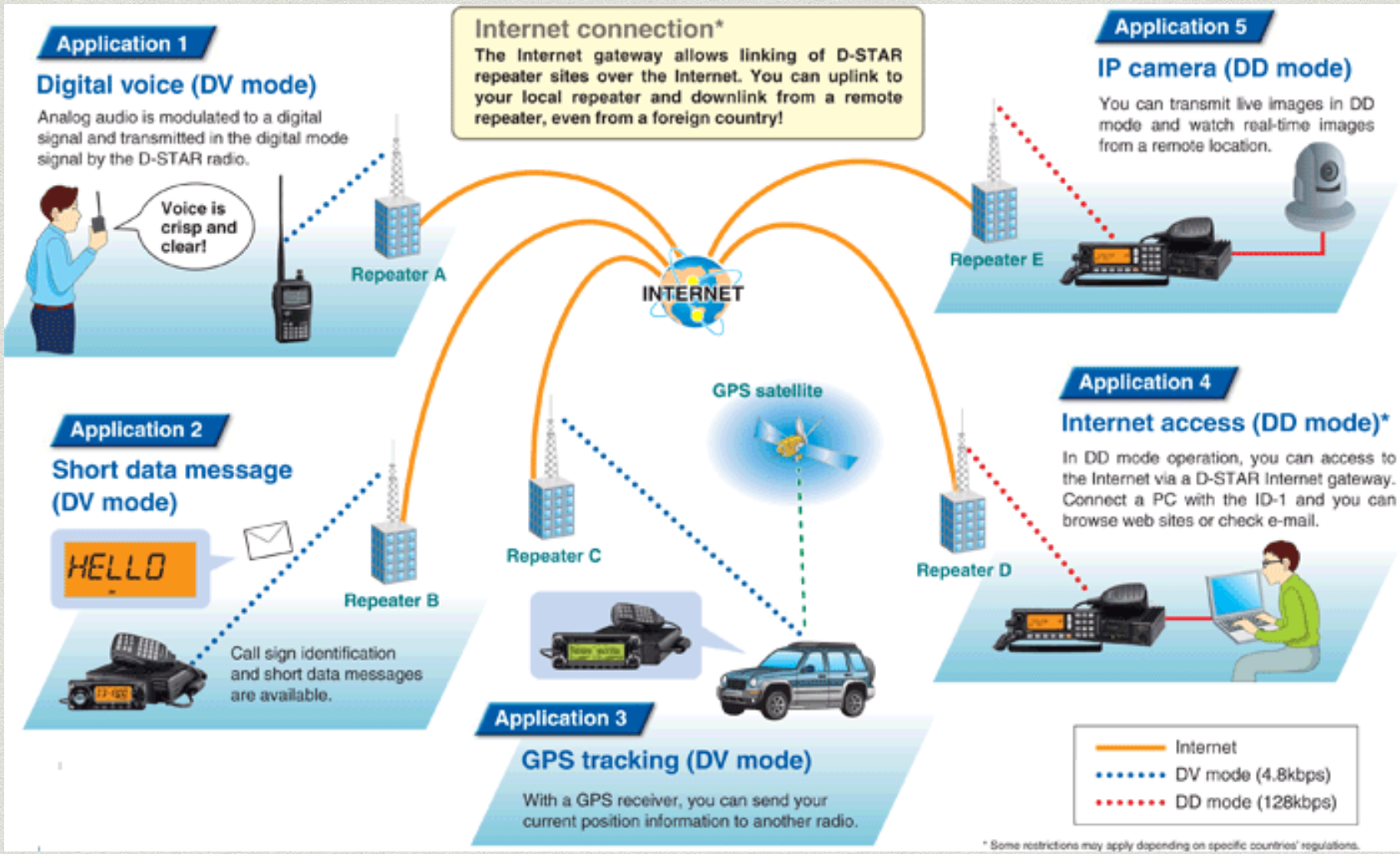
Going Beyond Your Repeater



Going Beyond Your Repeater



Going Beyond Your Repeater



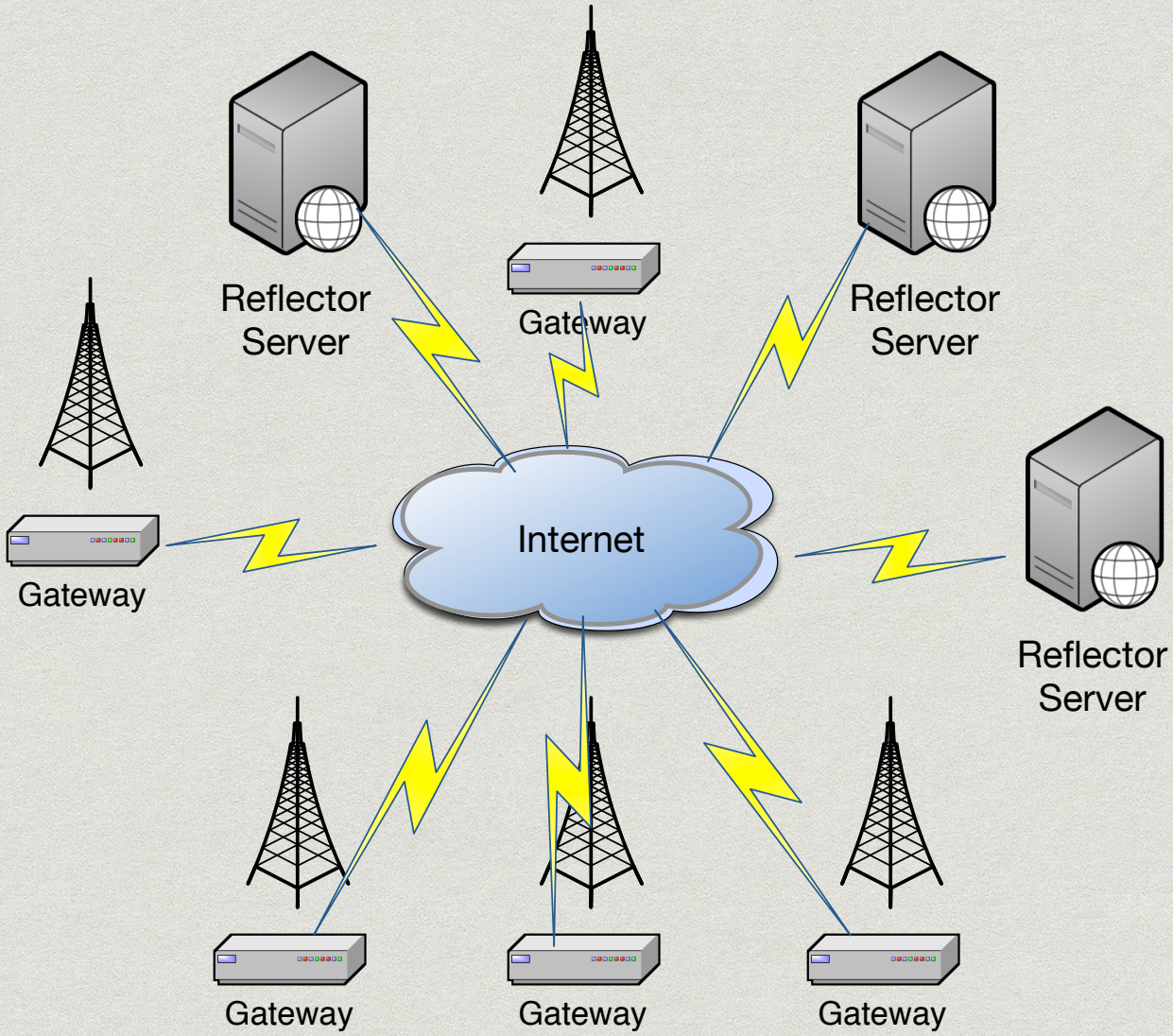
Going Beyond Your Repeater - Dstar

https://kb3ybh.dstargateway.org/

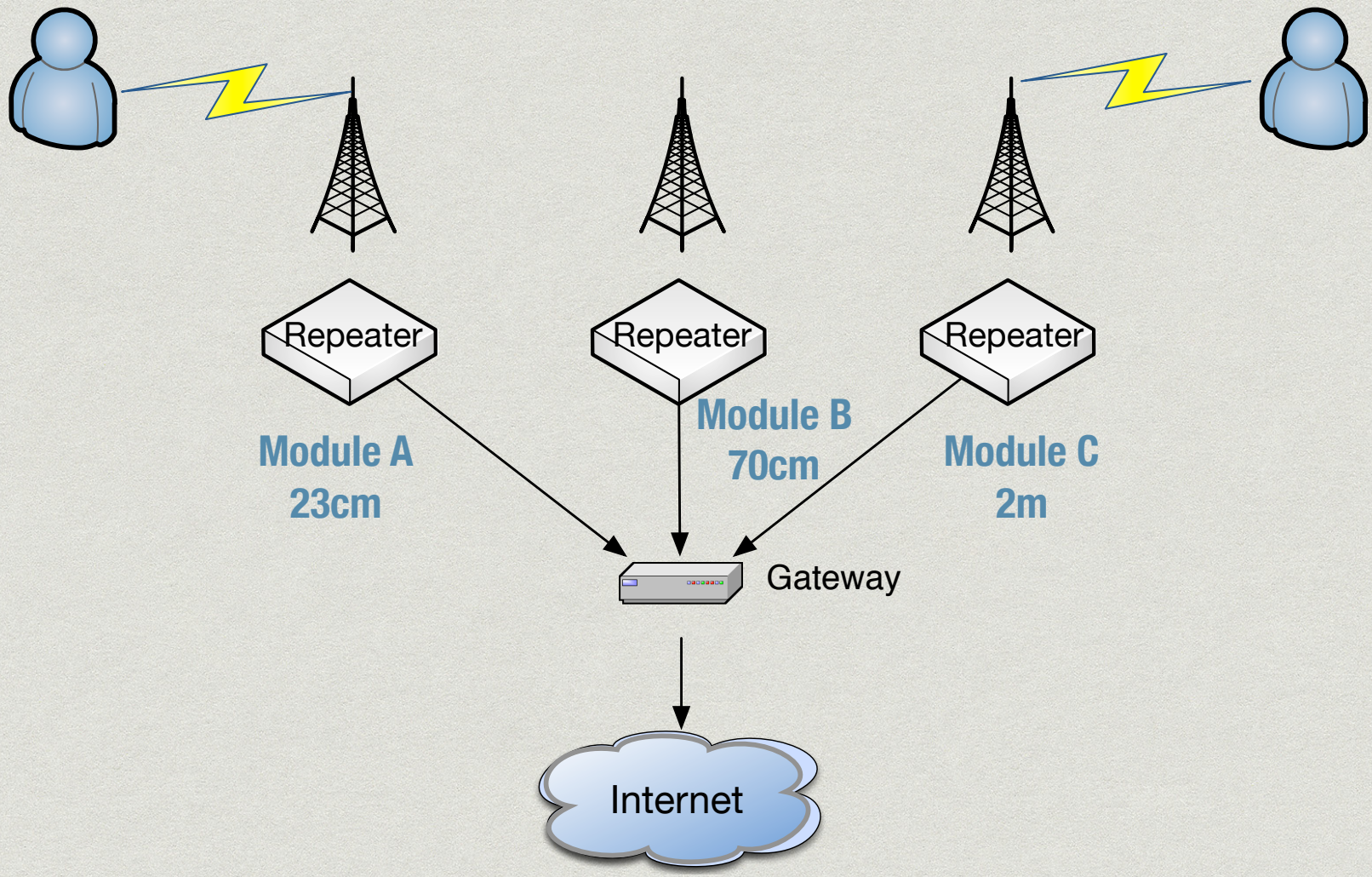
UR: REF025BL

http://ref025.dstargateway.org/

Going Beyond Your Repeater - Dstar



Going Beyond Your Repeater - Dstar



Going Beyond Your Repeater - Dstar

- Original Reflector application written by Robin Cutshall (AA4RC).
- Not open source.
- Reflectors have 5 Modules which are basically separate conference servers that repeaters can connect to. They do not relate to frequencies like the repeater modules.
- Very strict requirements to load the reflector software on.
- Requires registration with US Trust.
- DCS Reflectors are the next generation of reflector.
- Developed by Torsten Schultze (DG1HT)
- Open Source
- Combined the header into the main data stream for voice. This is more efficient in a non RF environment.
- Supports up to 26 Modules (conference rooms).

Going Beyond Your Repeater - Dstar

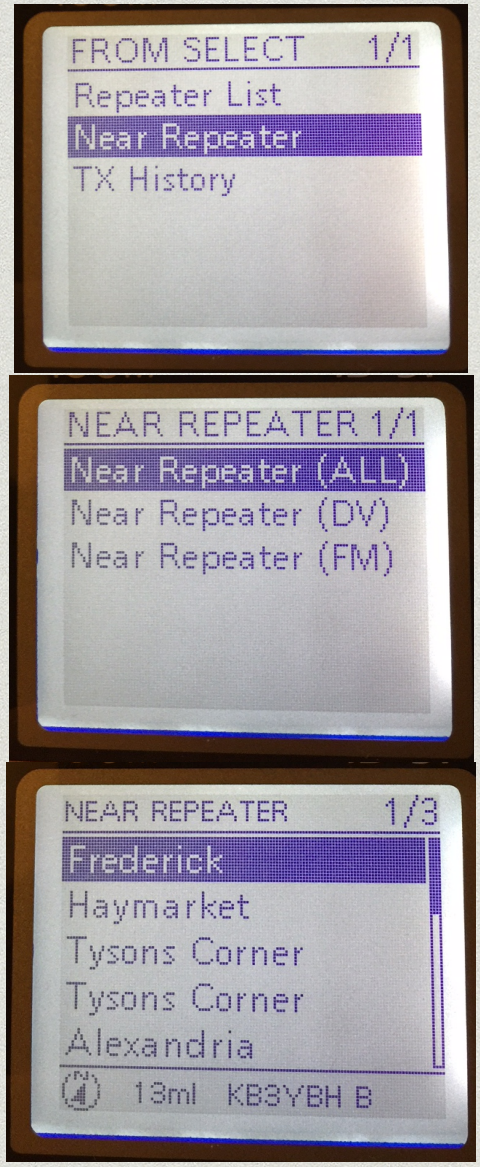
- XRF or commonly called X-Reflectors are the latest generation protocol for D-Star.
- Has better call sign routing.
- Uses IrcDDB for call sign routing.
- Most popular D-Star Protocol.
- Completely Open source and community developed.
- Supports up to 26 modules.
- Latest generation of Reflector software is XLX.
- Emulates all 3 reflector protocols: REF, DCS and X-Reflector.
- Can connect to DMR.
- Multiple Reflector Servers can be linked together in multiple ways to form a large fault tolerant network of reflector servers.

Going Beyond Your Repeater - Dstar

- iCom provided gateway software can only connect to REF reflectors.
- REF reflectors are losing users at an alarming rate.
- An XLX reflector running REF reflector will get blocked once detected.
- IrcDDBGateway can be used instead of the iCom provided software and can access all Reflector types.
- IrcDDBGateway works with IrcDDB for call sign routing and linking to reflectors.
- iCom recently released the generation 3 software for their gateway.
- The G3 software has had some issues with documentation and support.
- Users have to re-register for G3 unless they are on a repeater that is upgraded from G2 to G3.
- G3 allows for new radios to use “terminal mode” which allows for connection to D-Star Repeaters using an iCom radio and an Android Phone.

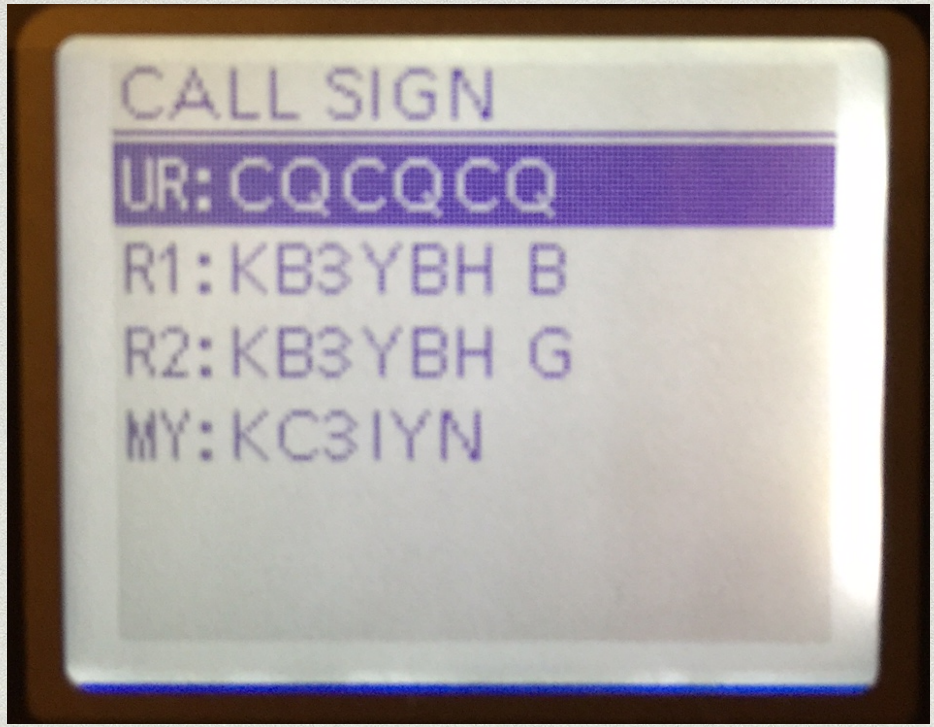
Going Beyond Your Repeater - Dstar

- Some people say d-star to very complicated.
- Once you understand the basics it is not complicated.
- D-Star is very flexible.
- Easy to change reflectors by setting channels.
- New radios have an interface to find repeaters and change reflectors.



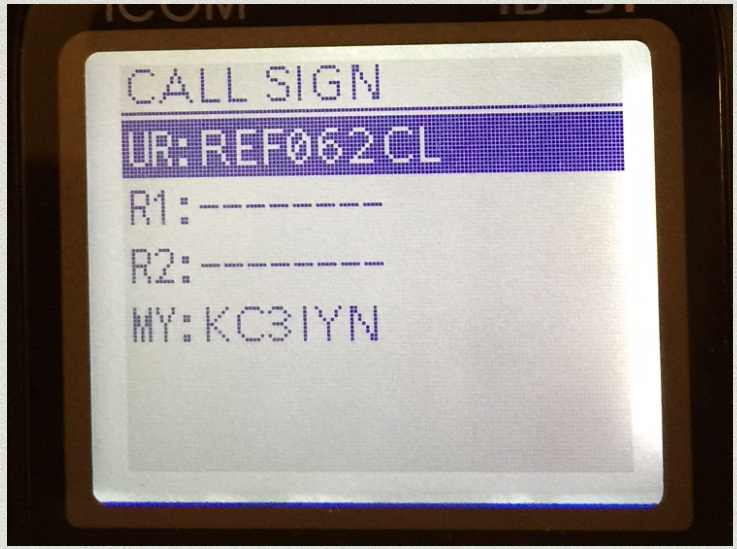
Going Beyond Your Repeater - Dstar

- Settings to talk through a repeater
  - UR: CQCQCQ
  - RPT1: KB3YBH B
  - RPT2: KB3YBH G
  - MY: K3DO



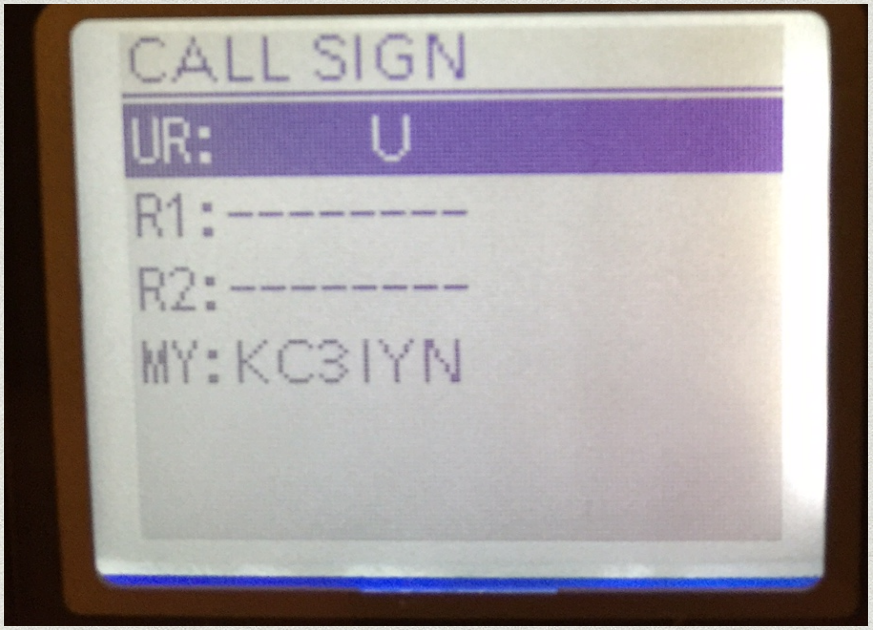
Going Beyond Your Repeater - Dstar

- Connect to Module C on REF062.
  - UR: REF062CL
  - RPT1: KB3YBH B
  - RPT2: KB3YBH G
  - MY: K3DO



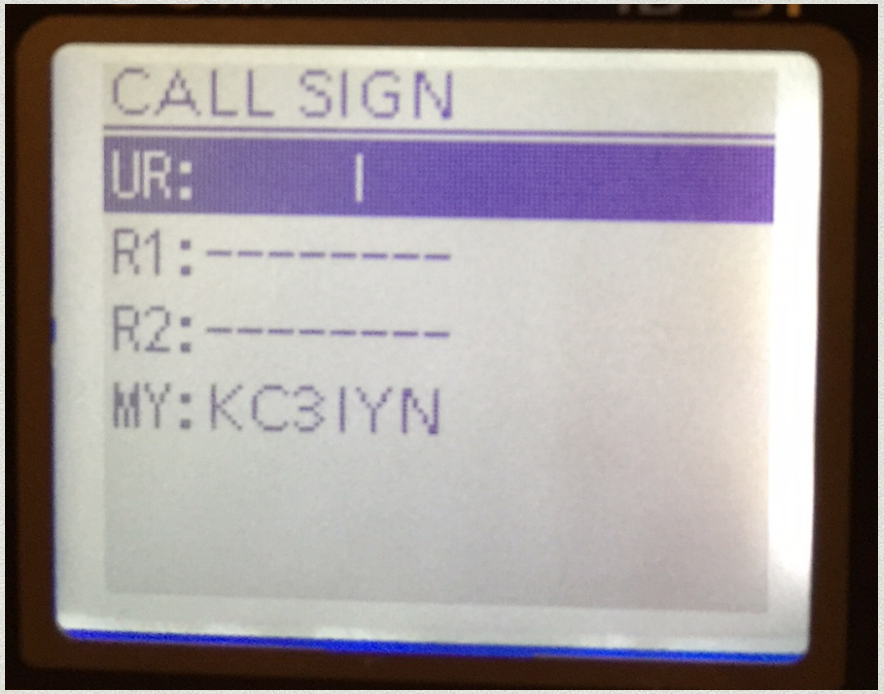
Going Beyond Your Repeater - Dstar

- Unlinking from a Reflector
  - UR: U
  - RPT1: KB3YBH B
  - RPT2: KB3YBH G
  - MY: K3DO



Going Beyond Your Repeater - Dstar

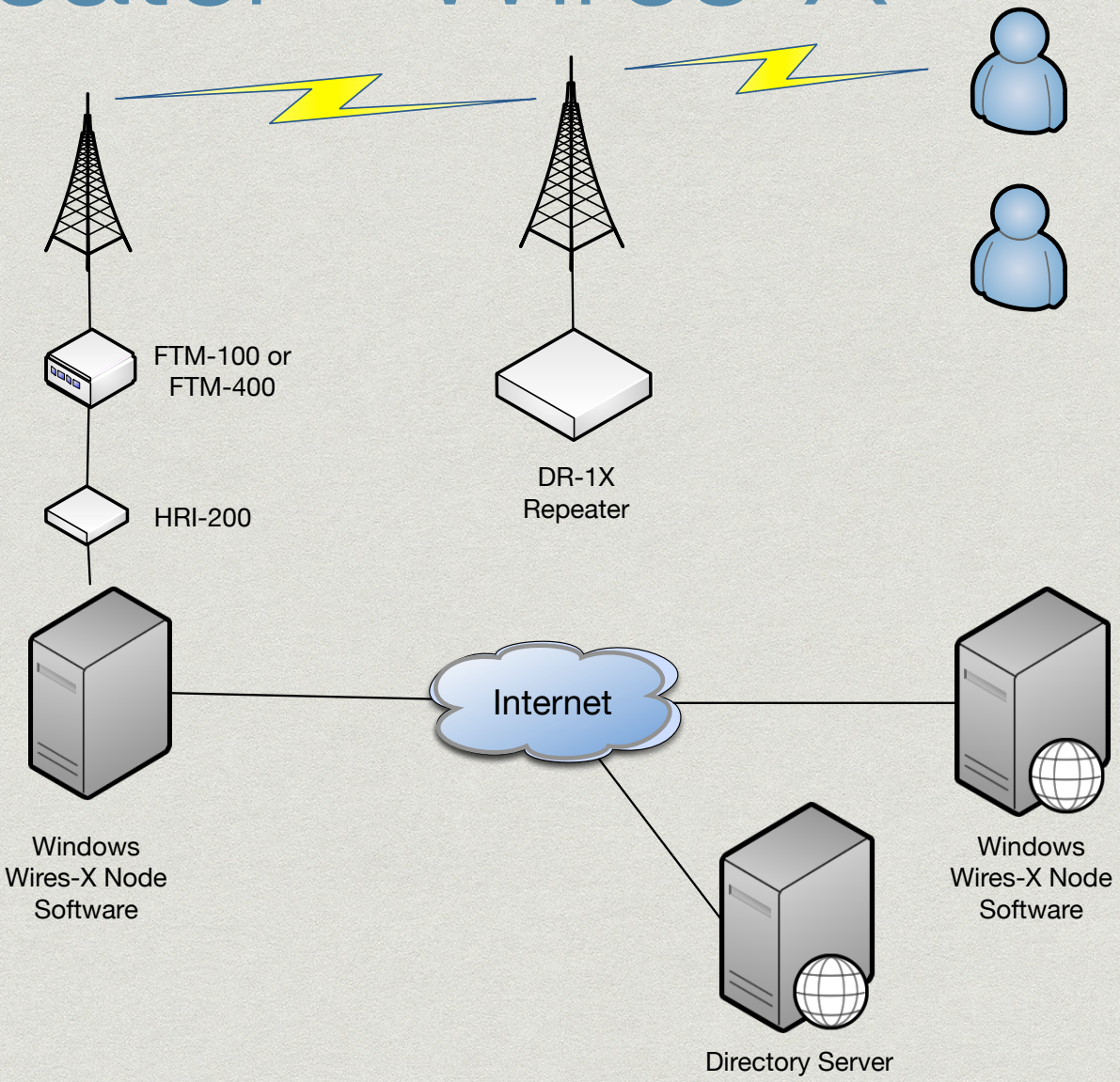
- Getting info like what the repeater is linked to.
  - UR: I
  - RPT1: KB3YBH B
  - RPT2: KB3YBH G
  - MY: K3DO



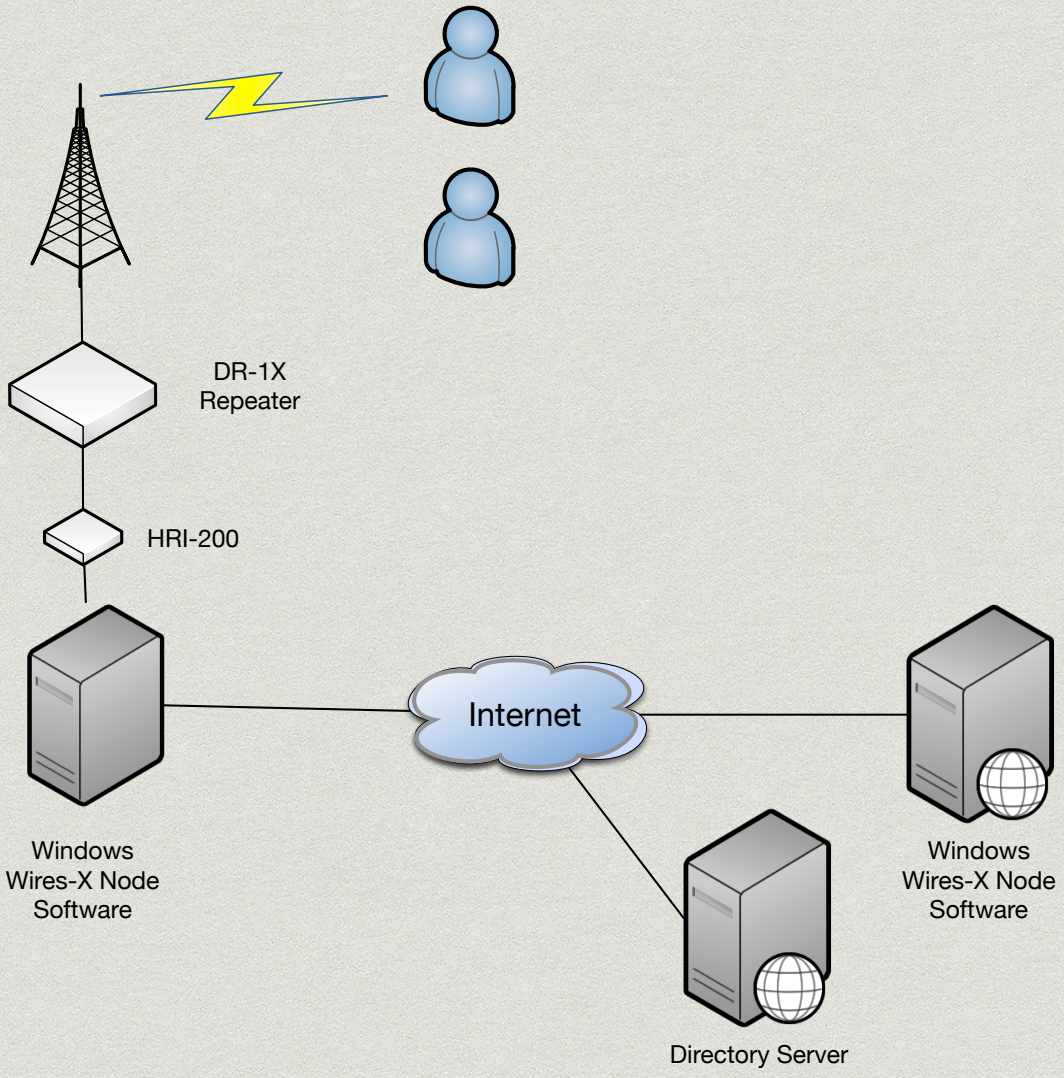
Going Beyond Your Repeater - Dstar

- What Happens Here?
  - UR: CQCQCQ
  - RPT1: KB3YBH B
  - RPT2:
  - MY: K3DO

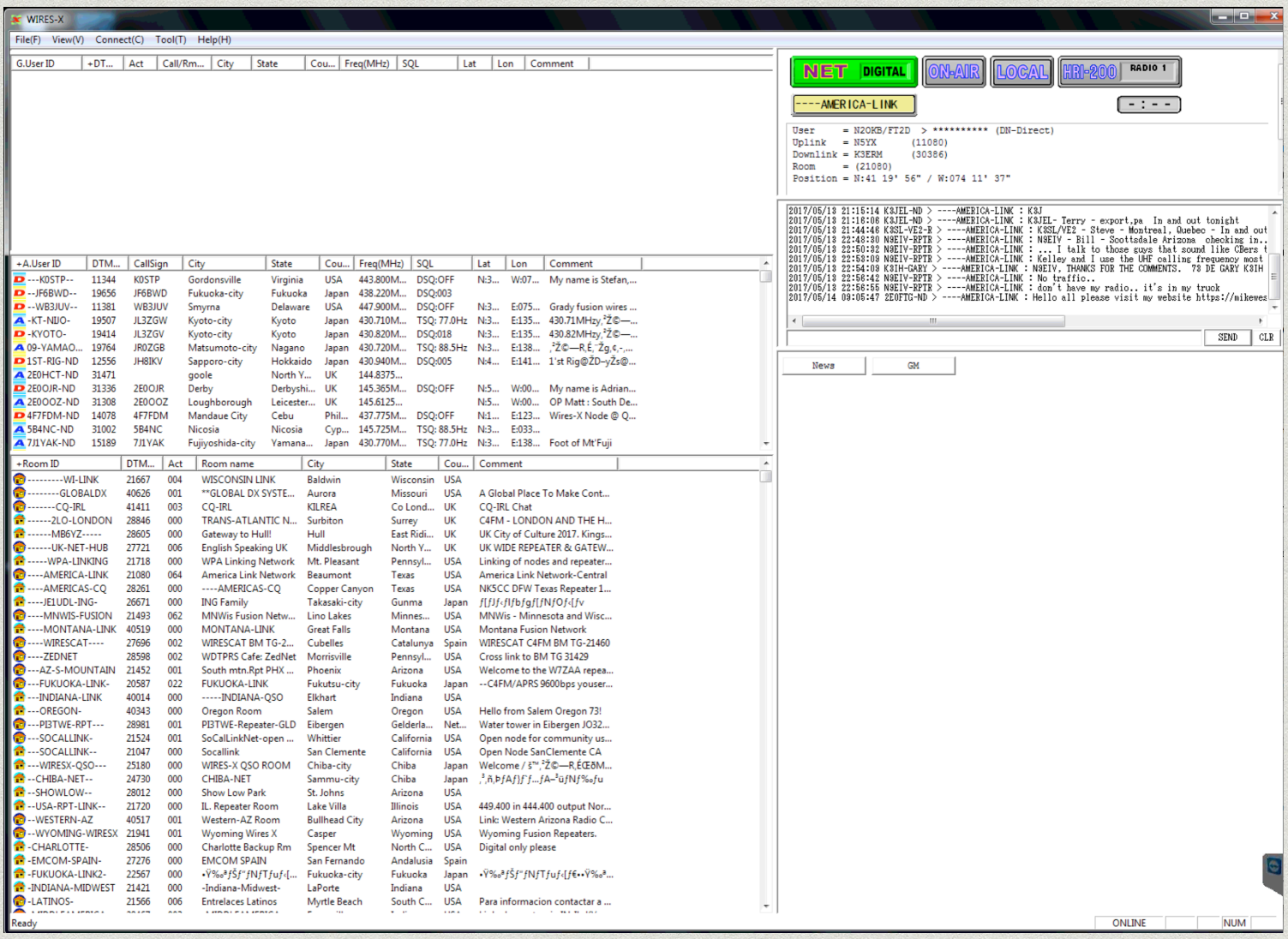
Going Beyond Your Repeater - Wires-X



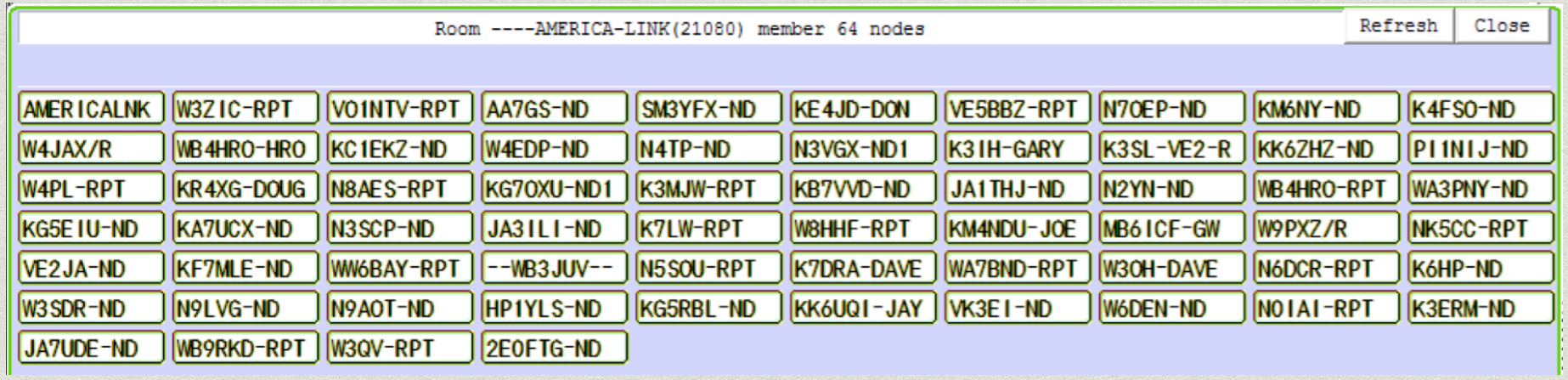
Going Beyond Your Repeater - Wires-X

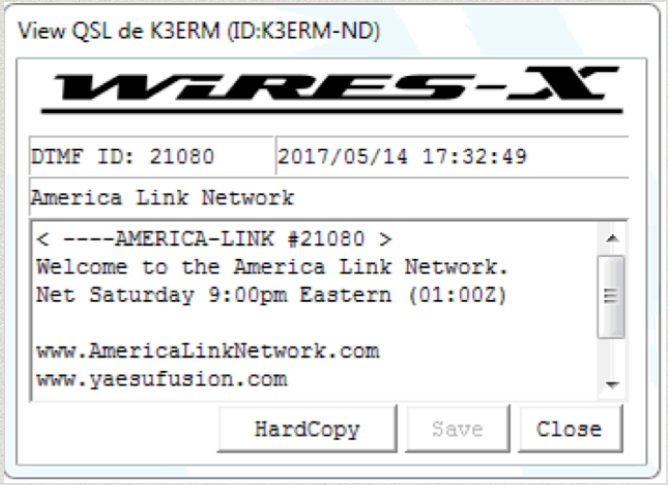


Going Beyond Your Repeater - Wires-X



Going Beyond Your Repeater - Wires-X

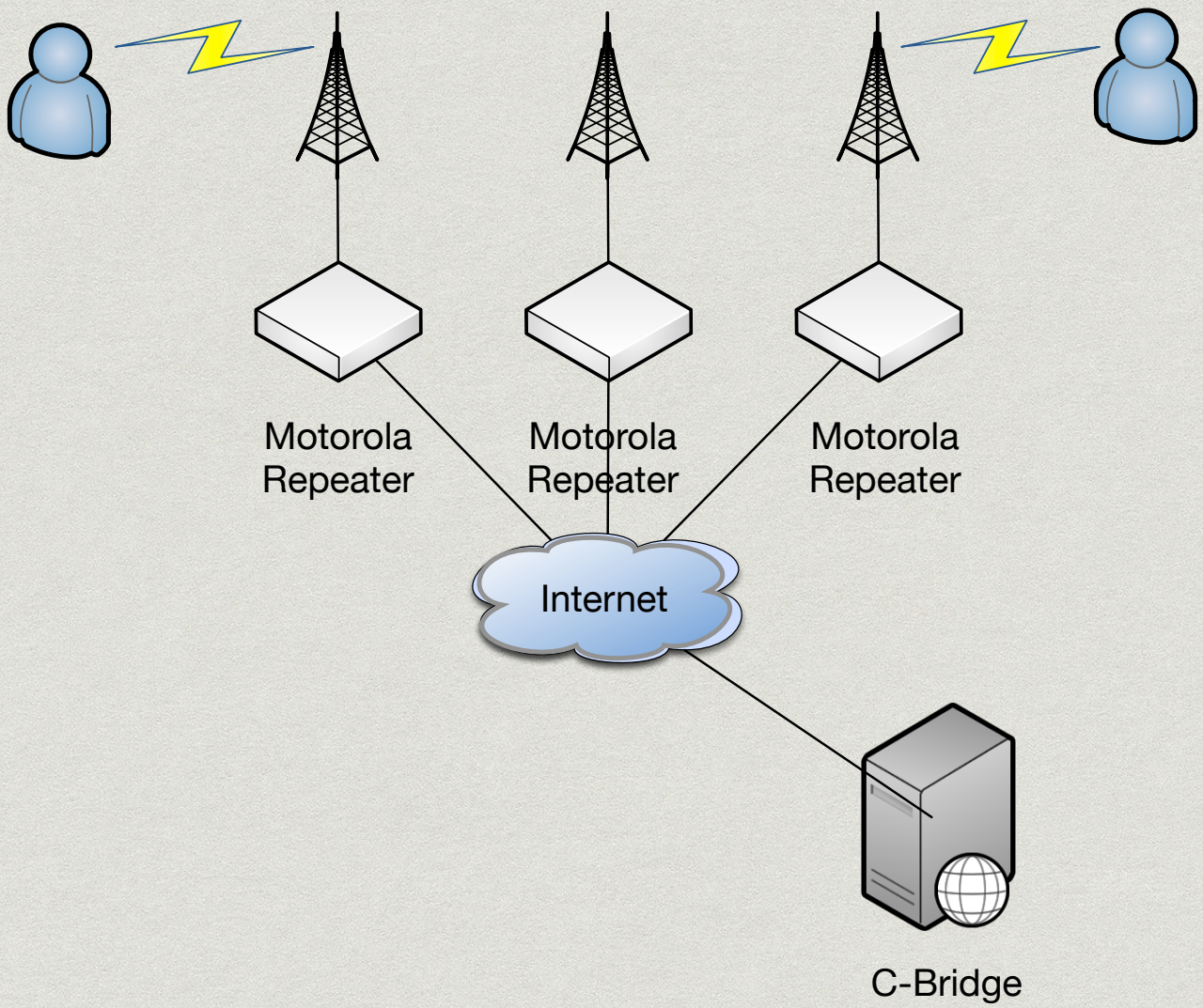




Going Beyond Your Repeater - Wires-X

- WIRES-X is at a layer above the C4FM.
- A Node downloads a list of Rooms and Users from a Directory server.
- There are currently 2 directory servers, one in Japan and one in Florida.
- A Node connects to a room server directly, not through a central server.
- The room server runs in the same software as the node software.
- Every node registration also creates a room that anyone can connect to.
- Nodes have the ability to have messages, news and photos.
- Easy user interface to change and search for rooms.
- Touch screen radios allow for quick searching of rooms, sending messages and if you have a camera equipped microphone you can send pictures.
- Supports analog radios in addition to digital radios.
- Analog radios can change rooms using DTMF keys but cannot search for rooms.

Going Beyond Your Repeater - DMR-Marc



Going Beyond Your Repeater - DMR-Marc

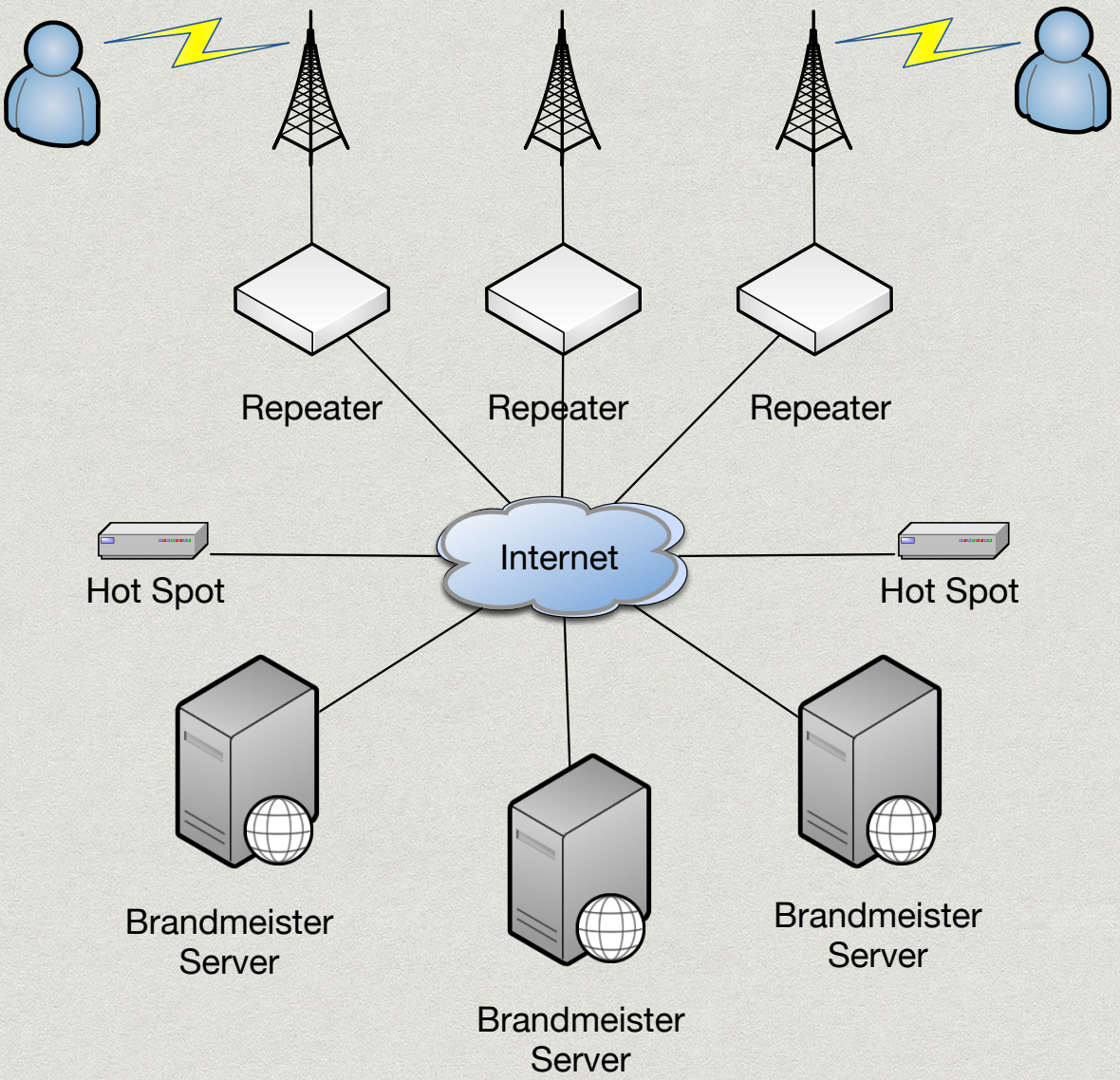
- All repeaters are connected via internet to a C-Bridge.
- C-Bridge is the controller of all the repeaters connected to it.
- The repeater owner tells the C-Bridge owner what talk groups they want to have available on their repeater and on what Timeslot.
- Repeaters are reliant on the C-Bridge, if the C-Bridge goes down, all of the repeaters connected to it stop working.
- Completely closed system.
- Repeater owners specify what talk groups are “pinned” and are active all the time.
- Talk groups that are assigned to a time slot but not pinned are activated by kerchunking when your on that talk group.
- When a new talk group is activated, the other talk groups that were activated are de-activated.
- It is common for people to change a talk group when someone else is using it because they are not aware someone else already is using that repeater in a different talk group.

Going Beyond Your Repeater - DMR-Marc

Assignment	TS	TG	Access
North America	1	3	PTT
WW English	1	13	PTT
MD Statewide	1	3124	Full-Time
PA Statewide	1	3142	Full-Time
Northeast USA	1	3172	Full-Time
Mid-Atlantic USA	1	3173	Full-Time
Local 2	2	2	Full-Time
PENN-MAR	2	8	Full-Time
Local	2	9	Full-Time
UA English 1	2	113	PTT
UA English 2	2	123	PTT
TAC 310	2	310	PTT
TAC 311	2	311	PTT
TAC 312	2	312	PTT
TAC 313	2	313	PTT
TAC 314	2	314	PTT
TAC 315	2	315	PTT
TAC 316	2	316	PTT
TAC 317	2	317	PTT
TAC 318	2	318	PTT
TAC 319	2	319	PTT

DE Statewide	2	3110	PTT
Dist of Columbia	2	3111	PTT
MD Statewide	2	3124	PTT
NY Statewide	2	3136	PTT
OH Statewide	2	3139	PTT
PA Statewide	2	3142	PTT
VA Statewide	2	3151	PTT
Midwest USA	2	3169	PTT
Northeast USA	2	3172	PTT
Mid-Atlantic USA	2	3173	PTT
Southeast USA	2	3174	PTT
TX/OK Regional USA	2	3175	PTT
Southwest USA	2	3176	PTT
Mountain Reg. USA	2	3177	PTT
Crossroads	2	8710	PTT
TAC 1	2	8951	PTT
Parrott	2	9998	PTT

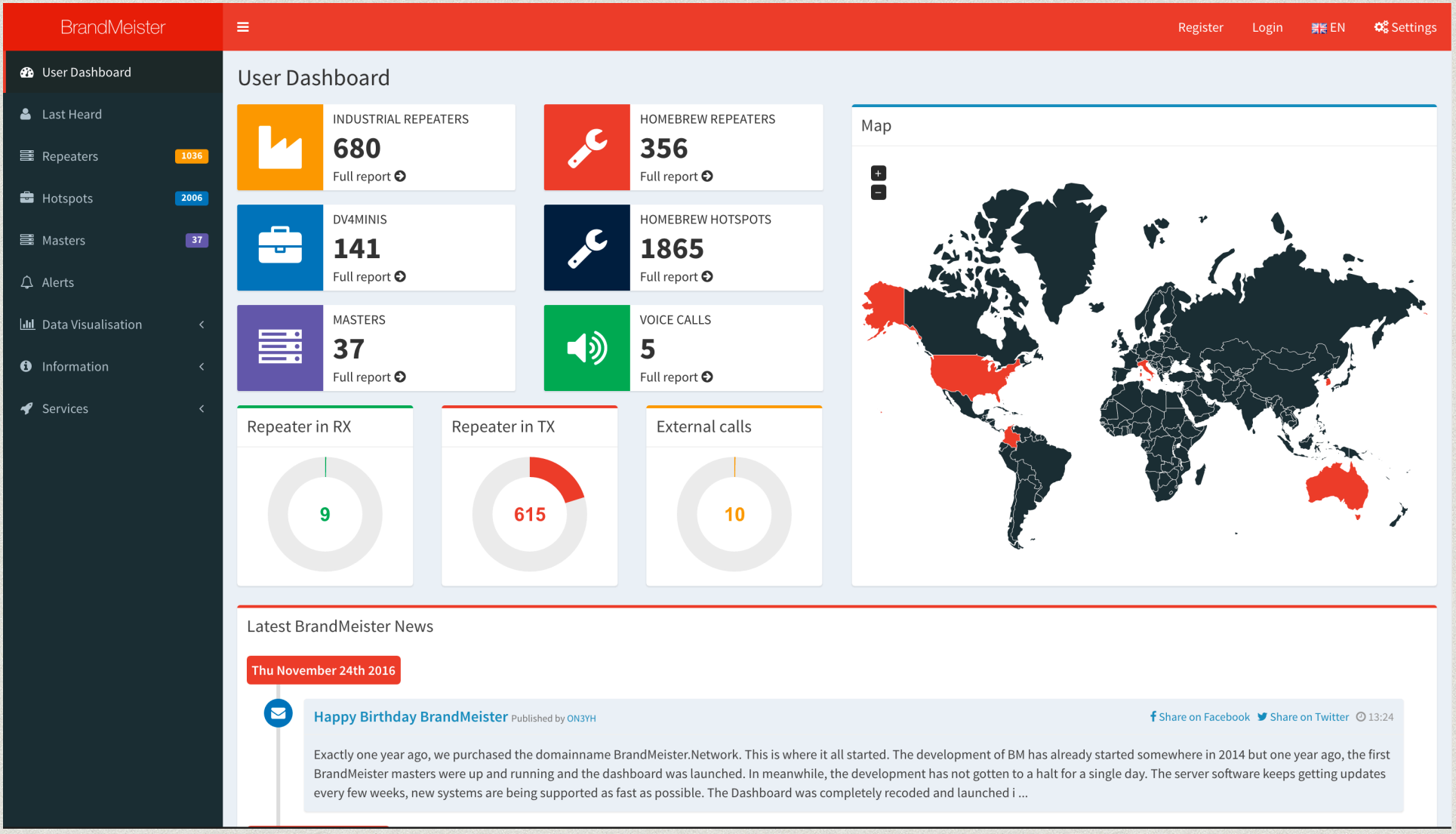
Going Beyond Your Repeater - DMR-Brandmeister



Going Beyond Your Repeater - DMR-Brandmeister

- Open
- Can connect to Motorola, Hytera and home-brew repeaters and hotspots.
- Multiple servers around the world provide failover and redundancy.
- A user can connect to any talk group. The repeater owner can add restrictions but by default all talk groups are available.
- Can connect to D-star and Fusion Reflectors.
- Supports Location Based Services.
- Bridges location data to APRS and D-Star.
- People leaving DMR-Marc for Brandmeister in large groups:
  - DMR Phoenix, DMR-Utah, Mountain West DMR, Norcal DMR, PAPA System and many more.
- Detailed dashboard at: https://brandmeister.network/

Going Beyond Your Repeater - DMR-Brandmeister

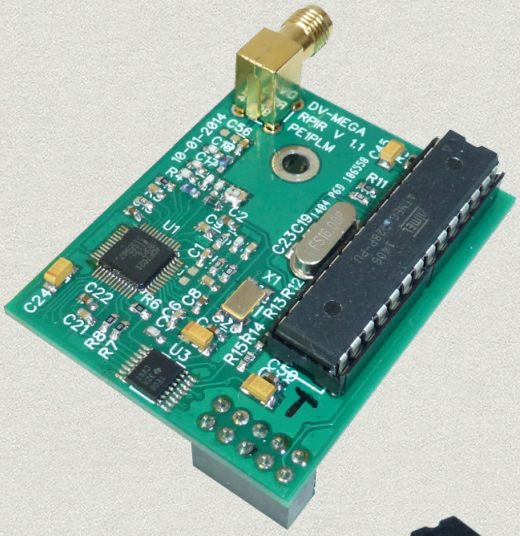


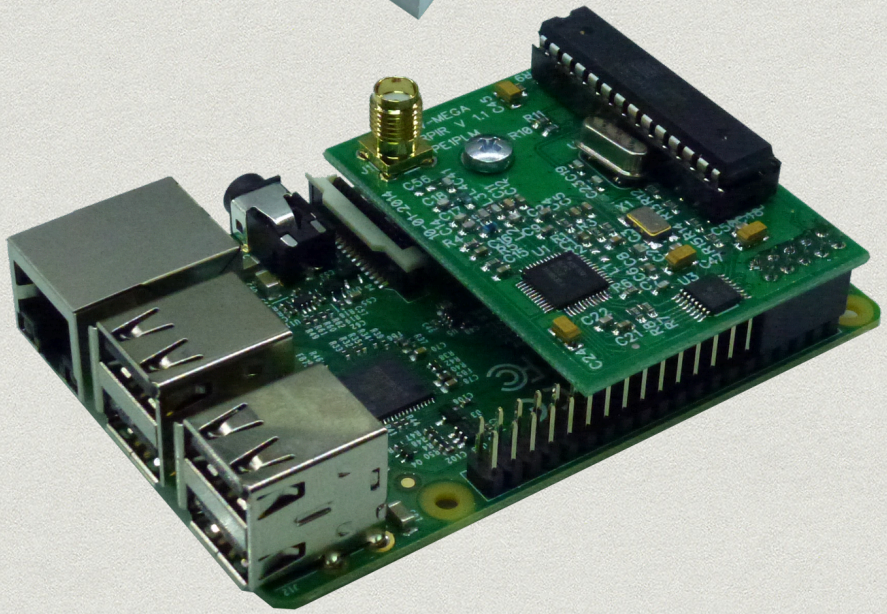
Other Connection Devices OpenSpot

- Supports D-Star (all reflector types), Fusion (Not Wires-x) FCS and YSF Reflectors, DMR Brandmeister and DMRPlus.
- Modem and Connector protocols separate.
- Can use a DMR radio to talk to Fusion and a Fusion radio to talk to DMR.
- D-Star radios can only talk to D-Star networks.
- Easy to use Web Interface.

Other Connection Devices
DV-Mega

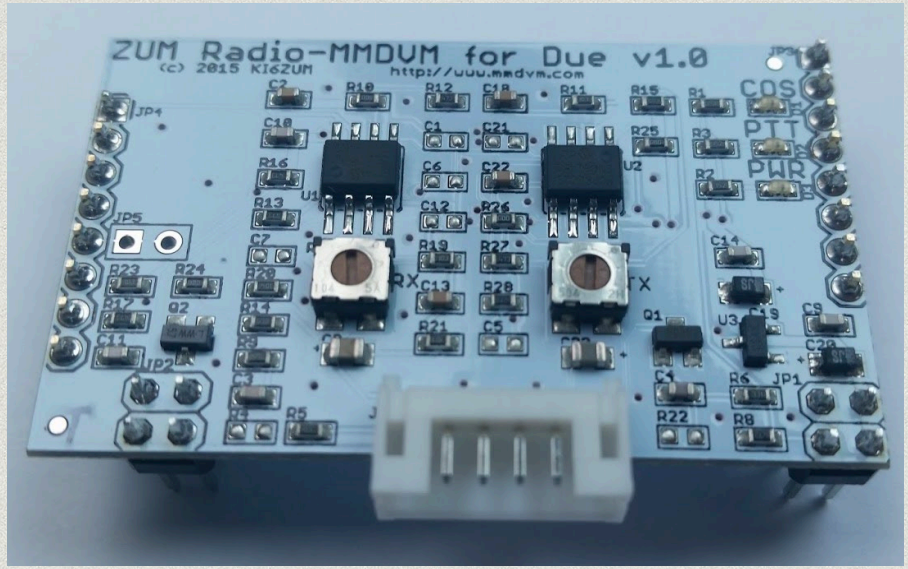
- Can be used on a Raspberry Pi or Bluestack device with Android.
- Works with IrcDDBRepeater like in D-Star commander or Maryland D-Star raspberry pi images.
- With MMDVM software it can simultaneously work D-Star, Fusion or DMR.
- Is available in 70cm version or 2 Meter / 70cm combination.





Other Connection Devices MMDVM

- Mounts onto a Arduino Due.
- Arduino connects to PC or Raspberry pi running linux with the MMDVM software installed.
- Connects to a pair of radios or a repeater like a VXR-7000 to create a repeater.
- Repeater is capable of doing D-Star, Fusion or DMR.
- All 3 modes or any combination of modes can be operated at one time.



Other Connection Devices
DV4Mini

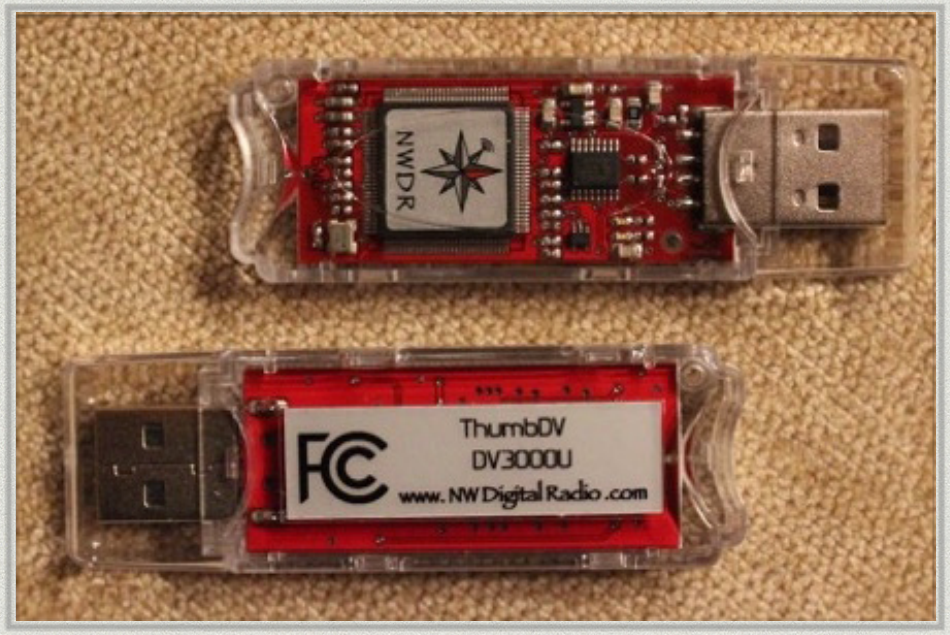
- Works on Windows or Linux.
- Plugs into regular USB drive.
- Supports D-Star, Fusion and DMR (only one at a time).
- Connects to FCS or YSR reflectors for fusion, not Wires-X.
- For DMR, it connects to DMRPlus. There is a version that connects to Brandmeister floating around too.

Other Connection Devices DV4Home

- Internally it uses the DV4Mini.
- No need for a computer to access D-Star, Fusion or DMR.
- Plug a microphone right into the front panel and use it just like a regular radio.

Other Connection Devices ThumbDV

- Works on Windows and Mac.
- Has no built in radio.
- Has a built in AMBE+ chip.
- Only works with D-Star.
- Use headphones or computer mic to talk on D-Star.



Other Connection Devices DVAP

- Works on D-Star.
- Has built in radio and requires a D-star radio to access d-star.
- Works on Windows, Mac and Linux.
- Connect to computer via the USB port.
- Works in the 2 Meter band.

Other Connection Devices DVDongle

- Original DV Dongle.
- Connect to PC via USB cable.
- Works on Windows, Mac and Linux.
- There is no radio, all communication is done from the speakers, microphone or headset on the computer.
- Only works on D-Star.

Compare the Digital Modes

	D-Star	Fusion / C4FM	DMR
Vocoder	AMBE+	AMBE+2	AMBE+2
FEC	Voice Only	Voice Only	Voice Only
Modulation	GMSK	C4FM	4FSK
Multiplex	FDMA	FDMA	TDMA
Transmission Rate	4.8 Kbs	DN 4.8 Kbs / VW 9.6 Kbs	4.8 Kbs x 2
Bandwidth	6.25 KHz	12.5 KHz	12.5 KHz
Simultaneous Voice Channels	1	1	2

Compare the Digital Modes

	D-Star	Fusion / C4FM	DMR
Registration	US Trust for REF reflectors	Not Required	CCS7 ID
User ID Method	Callsign	Callsign	Subscriber ID
Meets FCC ID Requirements	Yes	Yes	No
GPS	Yes	Yes	Not Legally
Potential Sound Quality	Good	Best	Best
Ease of Configuration	Easy *	Easiest	Hardest
Flexibility	Most Flexible	Flexible	DMR-Marc: Not Brandmeister: Better

Compare the Digital Modes

	D-Star	Fusion / C4FM	DMR
Dual Band Radio	Yes	Yes	No
Field Programmable	Yes	Yes	No
Good for Traveling	Yes	Yes	No
Openness	Most	Some	DMR-Marc: Not Brandmeister: Good
Connect to Another Repeater	Yes	Yes Via Node on Repeater	No
Connect to Anywhere	Yes	Yes	DMR-Marc: No Brandmeister: Yes
Connect to Another Ham	Yes	No *	No

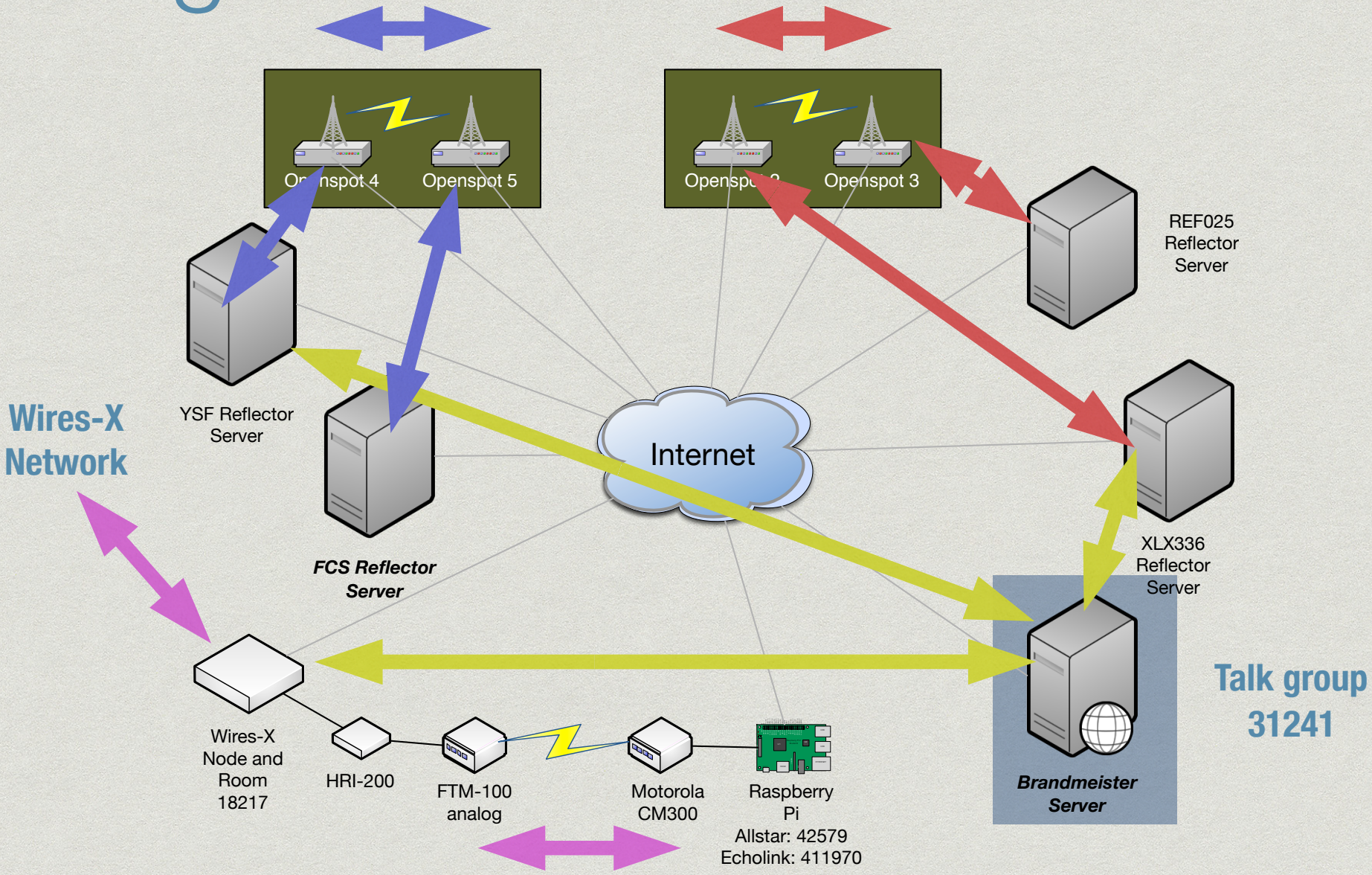
Compare the Digital Modes

	D-Star	Fusion / C4FM	DMR
Data Transfer	Yes	No	No
Messaging	D-Rats	Wires-X / APRS	Text Style Messaging
News / Photos	No	Yes	No
Location to aprs.fi	DPRS on each transmission	Via APRS on radio	No
Echo Test	Yes	No	Yes

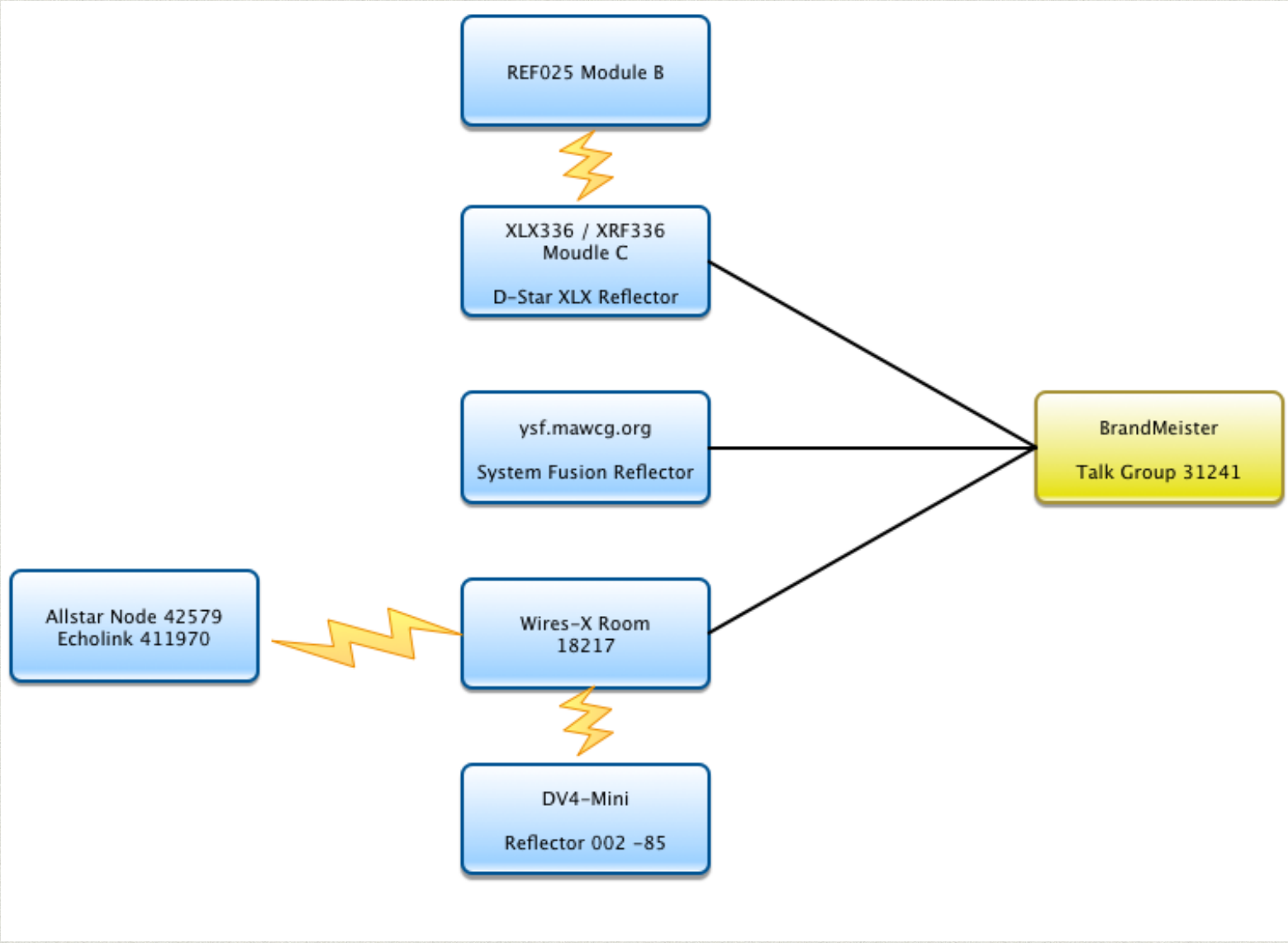
Compare the Digital Modes

	D-Star	Fusion / C4FM	DMR
Method to Connect besides repeaters and radios	Thumb Sticks, DV Dongle, DVAP, DV4Mini, Openspot, MMDVM, DV4Home, DVMega, Bluespot, GMSK Modem	DV4Mini, Openspot, MMDVM, DV4Home Not connected to Wires-X Network directly	DMR-Marc: None Brandmeister: DV4Mini, Openspot, MMDVM, DV4Home, Bluespot
Distance	No personal experience in distance gains	The club C4FM repeater has a larger reach, from Annapolis, MD to past Sidling Hill, Dumfries VA to at least Mechanicsburg, PA	I have no personal experience with distance gain but the claim is DMR adds 20% to the distance.
Observations	Audio gets easily distorted (R2D2)	Overdriven Audio, Rooms do not like over 100 connections	Difficult to program, no dual band radios, not field programmable. Excellent Audio
My Personal Favorites	#1	#3	#2 *

Connecting Everything Together



Connecting Everything Together



Connecting Everything Together

- You can connect via D-star to either XLX336 or XRF336 Module C. They are the same server but different programs have them listed differently.
- You can also connect to the older REF025 Module B.
- On Wires-X you can connect to Room 18217.
- If you connect to a System Fusion Reflector, you can connect to ysf.mawcg.org
- On DMR, if you are on the BrandMeister DMR network, we are talk group 31241.
- On Allstar you can connect to node 42579.
- On Echolink we are node 411970.
- On the DV4-Mini connection to the fusion FCS002 to room 85 (This is still being worked on, it might be working, it might not be).

2 Other digital modes

P25

Frequency	Offset	Tone	Location	County	Call	Use
147.0000	+0.6 MHz		Ashton	Montgomery	K3WX	OPEN
147.1800	+0.6 MHz	156.7	Silver Spring	Montgomery	KA3LAO	OPEN
147.2700	+0.6 MHz	156.7	Germantown	Montgomery	WA3KOK	OPEN
442.8000	+5 MHz	79.7	Frederick	Frederick	N3ITA	OPEN
448.1250	-5 MHz	123.0	Frederick	Frederick	K3MAD	OPEN

NXDN

SEARCH | SPECIAL MODES | VACANCY | NEW REPEATER | MAP RESULTS | EXPORT

NO NXDN capable REPEATERS FOUND

Dashboard Links

- D-Star Repeater Link: https://kb3ybh.dstargateway.org/
- D-Star Reflector Link: http://ref062.dstargateway.org/
- DMR c-bridge: http://cbridge.k4usd.org:42420/MinimalNetwatch & http://cbridge.k4usd.org:42420/PeerWatch
- DMR Brandmeister: https://brandmeister.network/

Hardware / Software Links

- OpenSpot: https://www.sharkrf.com/products/openspot/
- DV Mega: http://www.dvmega.auria.nl/
- DV4Mini / DV4Home: http://wirelesshold.com/
- DV Dongle: http://www.dvdongle.com/DV_Dongle/Home.html
- DVAP: http://dvapdongle.com/DV_Access_Point_Dongle/Home.html
- MMDVM hardware: http://mmdvm.blogspot.com/
- MMDVM software: https://groups.yahoo.com/neo/groups/mmdvm/info
- Maryland D-Star: http://maryland-dstar.org/

Listen Online

- D-Star: http://www.broadcastify.com/listen/feed/21802
- Wires-X: http://www.broadcastify.com/listen/feed/22729

Questions?