DIGITAL AND NETWORK-CONNECTED REPEATERS

Jason McCormick N8EI

John Wagner N8CD

SARA

WAYNE TECHNICAL FANATICS WWBTF

SILVERCREEK AMATEUR RADIO ASSOCIATION

W8WKY.ORG

WHAT'S THE POINT?

Repeater use is dropping everywhere – how many 99% idle repeaters do you know about? Why care about this?

WHAT'S THE POINT?

- Most new hams are Techs and Techs are practically limited to VHF and up which mostly means FM in the US

- Repeaters have been largely replaced by cell phones and the Internet – must design repeaters accordingly

- Many previously-accessible high-profile sites (e.g. TV towers, community public safety, tall buildings) are going away
  - TV towers kicking off repeater owners – new tower load requirements
  - Statewide radio systems are replacing local sites/systems
  - New city and county managers are risk-adverse in today's legal climate
  - Tall buildings want rental income from cell providers – especially with 5G

WHAT'S THE POINT?

- Influx of inexpensive LMR DMR radios that work in the ham bands have re-sparked interest in digital voice

- Many people have D-STAR and YSF radios they've never used digitally because of the cost of Icom repeaters and the many problems with Yaesu AMS repeaters

The Amateur Radio Community needs to shift its thinking on repeaters!

PARADIGM SHIFT

REPEATERS ARE NOT

- Going to win back users that left for mobile/cell – that battle was lost 15 years ago
- Attracting youth and makers with standalone analog FM
- Going to save the world by their mere existence – they are a tool in the box
- Monolithic services that have "the one true way" of use

REPEATERS ARE

- A unique way to deliver real-time comms with RF as the "last mile"
- Connecting virtual communities by topic or interest
- Experimentation playground – and consciously being one
- A labor of love

STRATEGY

- Develop and deploy repeaters which are network-connected and that work well and are stable
- Don't abandon analog FM – enhance it
- Deploy repeater systems that are complementary and interconnect
    - More repeaters at lower profiles to fill coverage gaps
    - Use existing low and mid profile sites effectively
    - Have capability and capacity to support others losing a site
- Consciously provide a space for learning and development
- Lower investment costs – deploy using less-expensive equipment
- Where possible, operate in situations w/o Internet – don't build ourselves into an infrastructure corner

REPEATERS

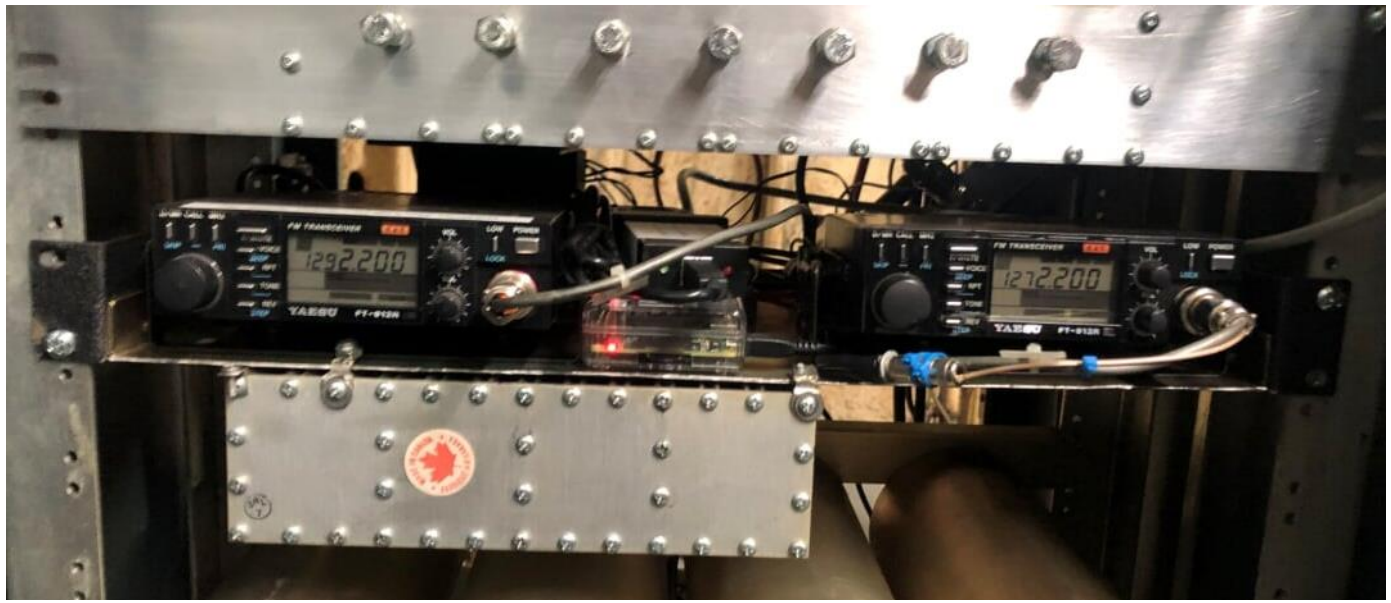
Callsign	Frequency	Location	Equipment
W8WKY	147.390+	Doylestown, OH	Bridgecom BCR-50V Allstar Pi Controller
W8WKY	442.275+	Doylestown, OH	Kenwood TKR-850 Pi-Star + STM32-DVM Multimode Controller
WW8TF	442.375+	Rittman, OH	Motorola Radius Pi-Star + STM32-DVM Multimode Controller
KE8LDH (WW8TF)	442.5125+	Akron, OH	Vertex VXR5000 Pi-Star + STM32-DVM Multimode Controller
KE8LDG (WW8TF)	442.7375+	Rittman, OH	Motorola Radius Pi-Star + STM32-DVM Multimode Controller
W8WOO	443.175+	Wooster, OH	Yaesu DR-1X Pi-Star + STM32-DVM Multimode Controller

REPEATERS

Callsign	Frequency	Location	Equipment
N8XPK	53.17-	Northeast Ohio	GE Mastr II w/ CAT1000 Controller Allstar Pi as remote base
N8XPK	444.200	Akron, OH	Motorola w/ RLC Controller Allstar Pi as remote base
N8XPK	1292.2000	Akron, OH	Yaesu FT-912R x2 Allstar Pi Controller
W8WOO	147.210	Wooster, OH	Yaesu DR-1X in FM mode w/ SCOM Controller Allstar Pi as remote base (COMING SOON)
WW8TF	146.685	Rittman, OH(?)	Yaesu DR-1X with lots of surgery Allstar Pi Controller (SPRING 2020)

REPEATERS

KE8LDH – 442.5125 Pi-Star Multimode Digital
Akron



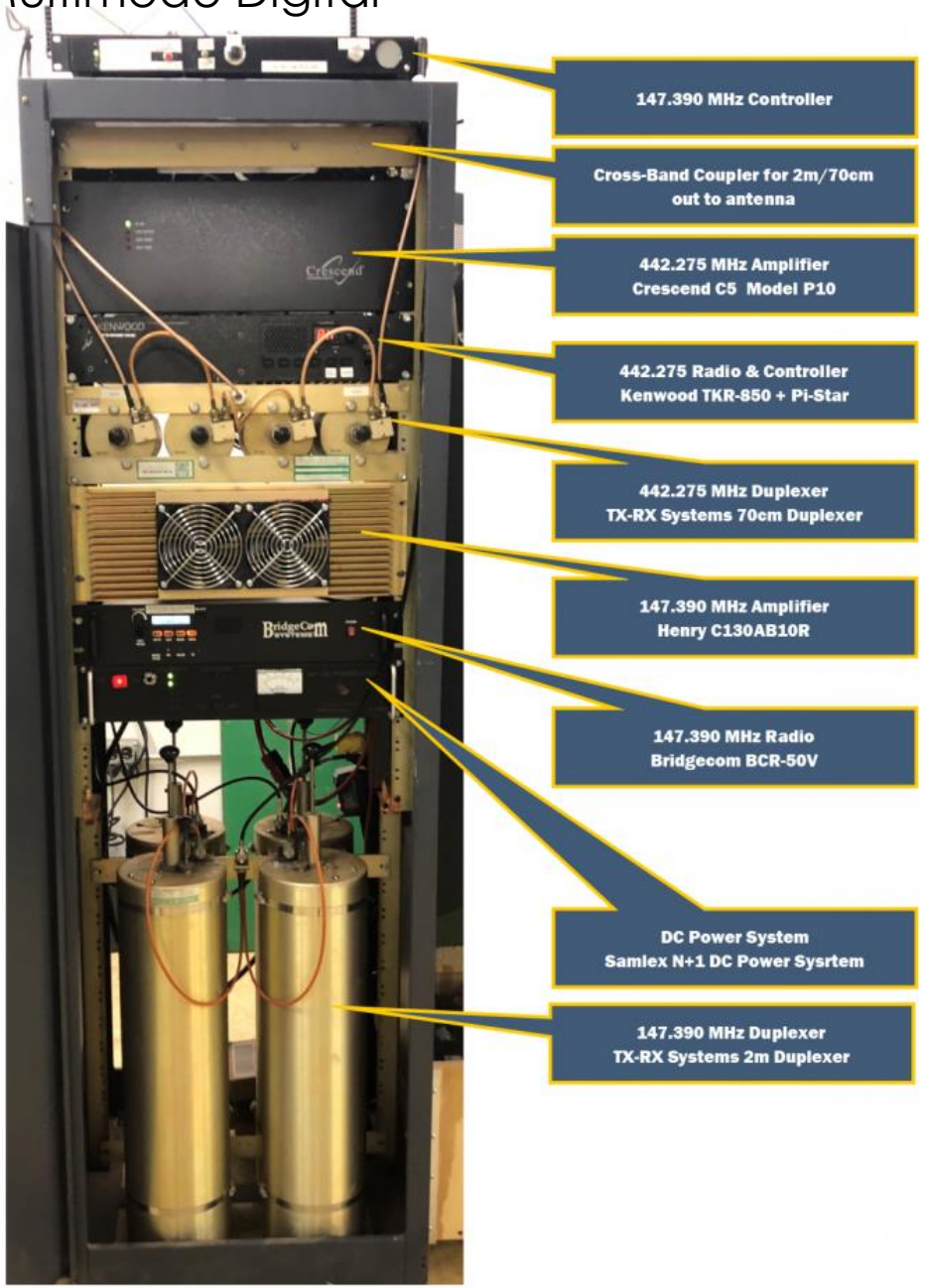
N8XPK – 1292.2 Allstar
Akron

REPEATERS

W8WKY - 442.275 Pi-Star Multimode Digital
W8WKY - 147.390 Allstar
Doylestown

KE8LDG – 442.7375 Rittman Pi-Star Multimode Digital

WW8TF – 442.375 Rittman
Pi-Star Multimode Digital

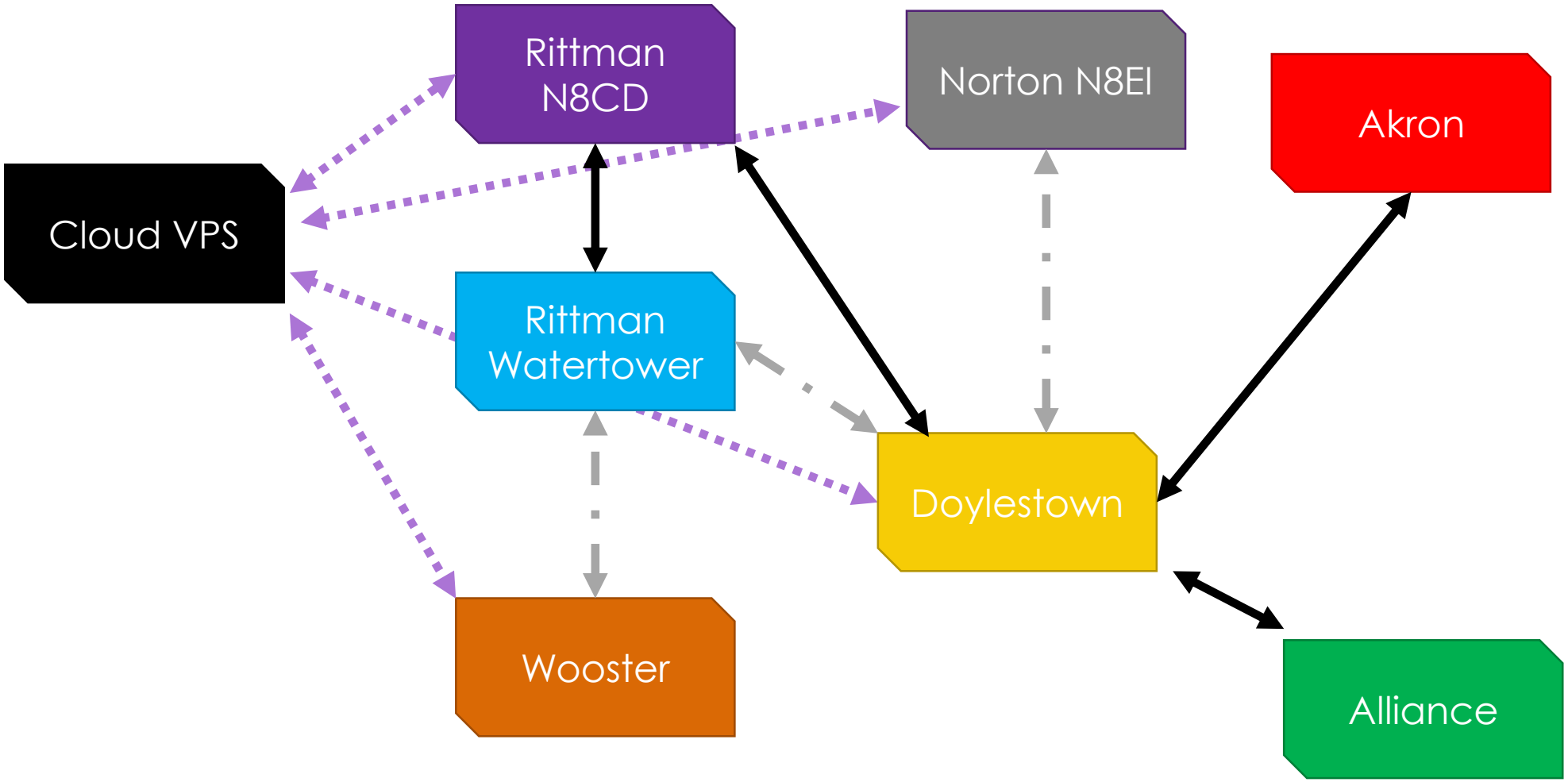


SARA

SITE CONNECTIONS

- All main sites are connected with commercial 5 GHz WiFi
- Why not use Broadband-Hamnet / ARDEN / HSSM-Mesh?
  - Amateur no-encryption and no-commercial restrictions are limiting
  - No real advantage for this use case
- Dual-Stack IP network
  - AMPR 44Net IPv4
  - RIR-Assigned IPv6
- Tunnels to virtual hosts in the cloud for IP connectivity
- Dynamic BGP IP routing for failover
- Most gear at sites with WiFi links can be interlinked without Internet
- Sites without WiFi links have VPN connectivity via broadband

THE MEGALINK SITE DIAGRAM



SARA

INTER-SITE LINKS

Akron

Doylestown

N8CD - East

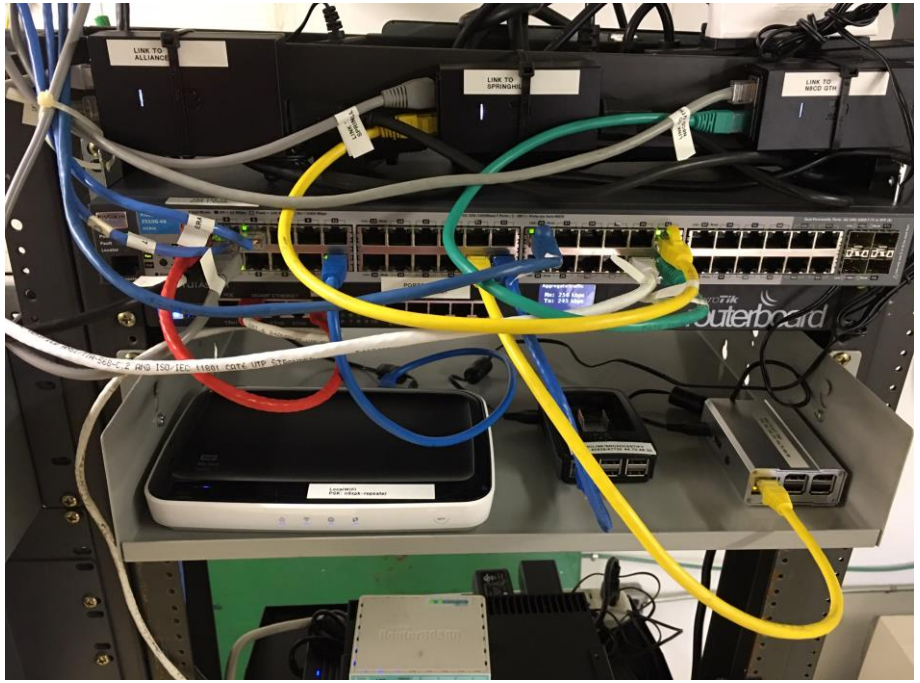
N8CD - West

Rittman

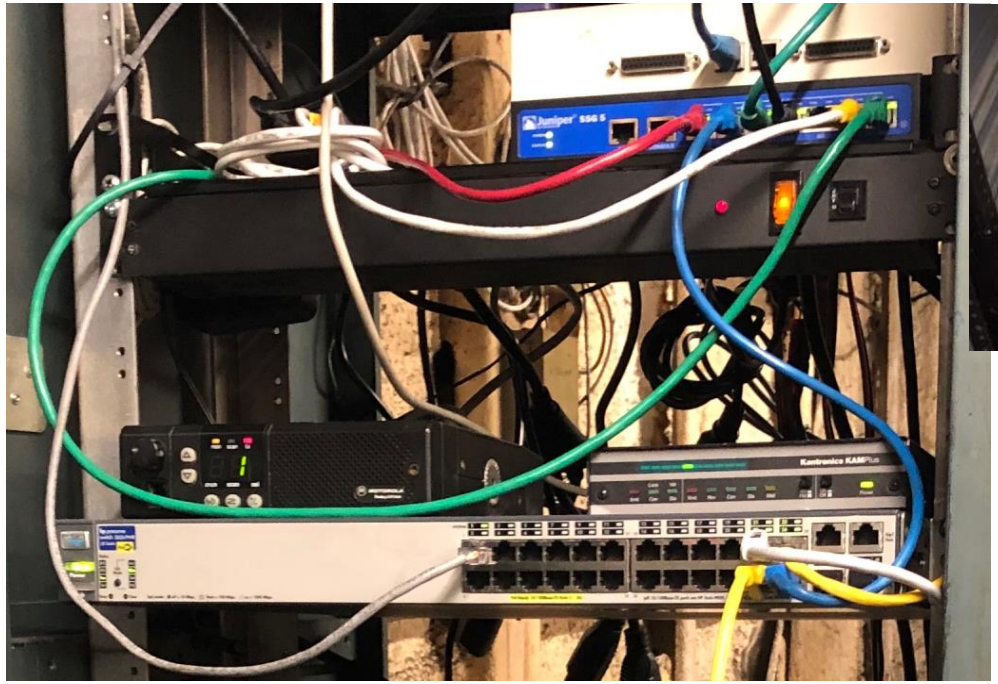
Standardized on
Ubiquiti PowerBeam

SARA

INFRASTRUCTURE



Doylestown



Akron

Rittman Watertower

- Each site has a router (real router, not home router)
- Some sites have switches and Raspberry Pi for infrastructure like XLX reflector, DNS, monitoring

OPERATING DURING EMERGENCIES

ALLSTAR

- Allstar is naturally peer-to-peer
- All repeaters on The Megalink use 44Net IP addresses so “internal” is the same as “external” – no DNS or directory lookups needed (no NAT)
- Trivial to execute DTMF commands on all repeaters to create one large emergency network
- **Allstar supports MT63-2K and other VHF+ data modes**

PI-STAR (D-STAR)

- All repeaters on The Megalink use 44Net IP addresses so “internal” is the same as “external” – no DNS or directory lookups needed
- Megalink Reflector XLX330 operates from the Doylestown site and is always available even without Internet
- Only D-STAR is truly suited for operation during no-Internet situations

ALLSTAR LINK

- Repeater controller based on the Asterisk PBX
- Add-on module to Asterisk adds repeater functionality
- All RF is standard analog FM
- Control by DTMF codes
- Can be grafted onto almost any radio stack
- Create many links – scheduled, ad-hoc
- Supports Echolink on the repeater

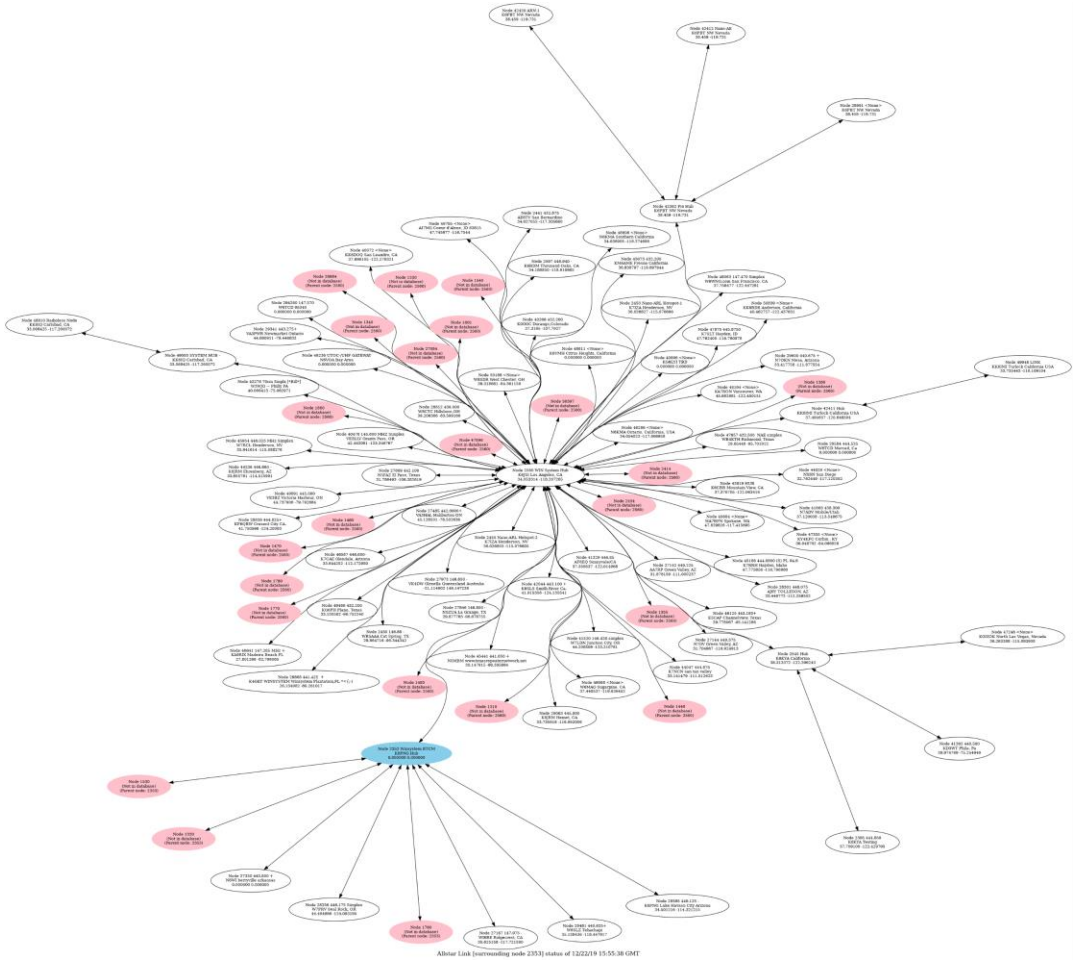
Allstar Link Main Project

https://www.allstarlink.org

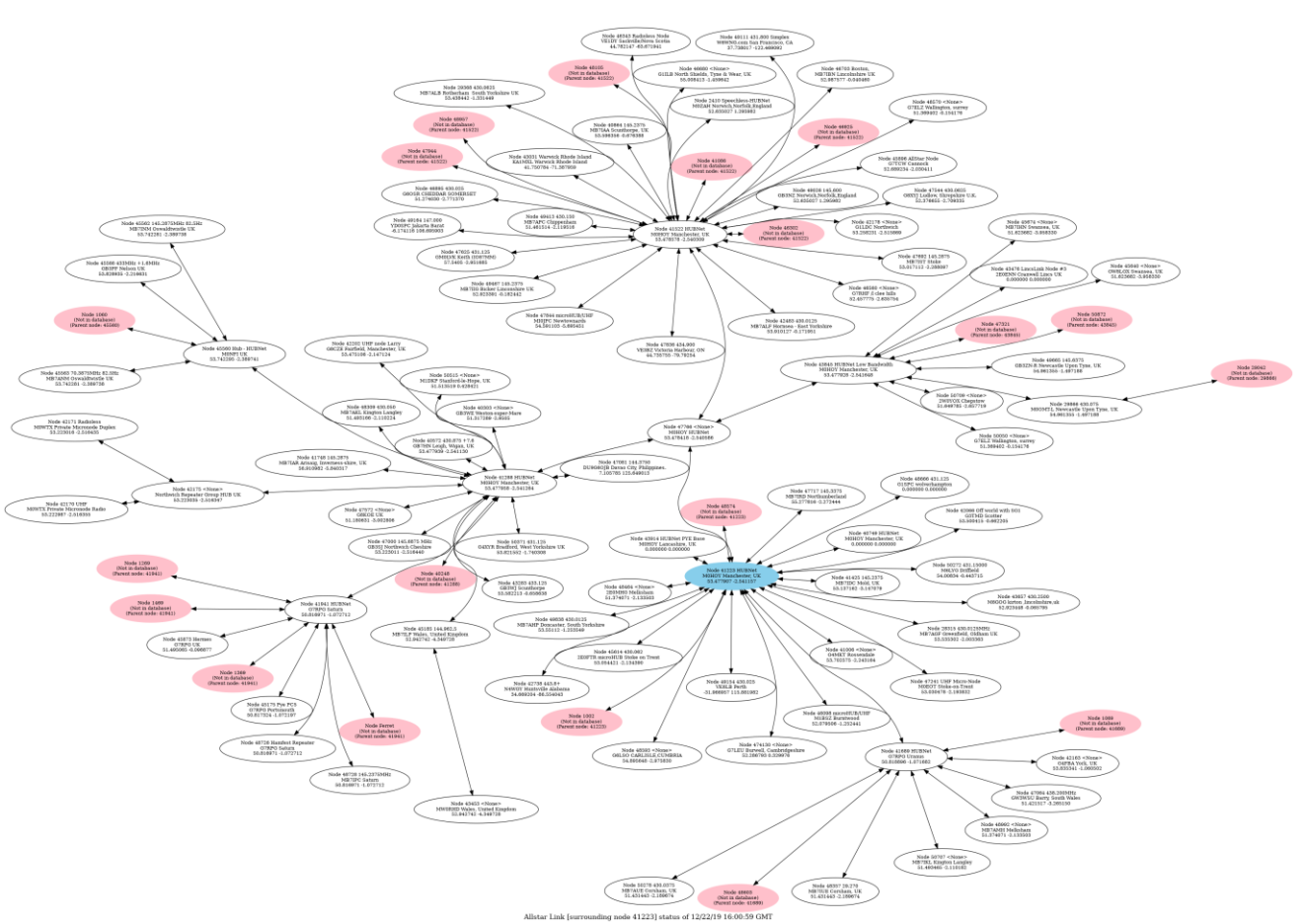
HamVOIP Pi Distribution

https://hamvoip.org

LARGE ALLSTAR MESHES ARE ACHIEVABLE



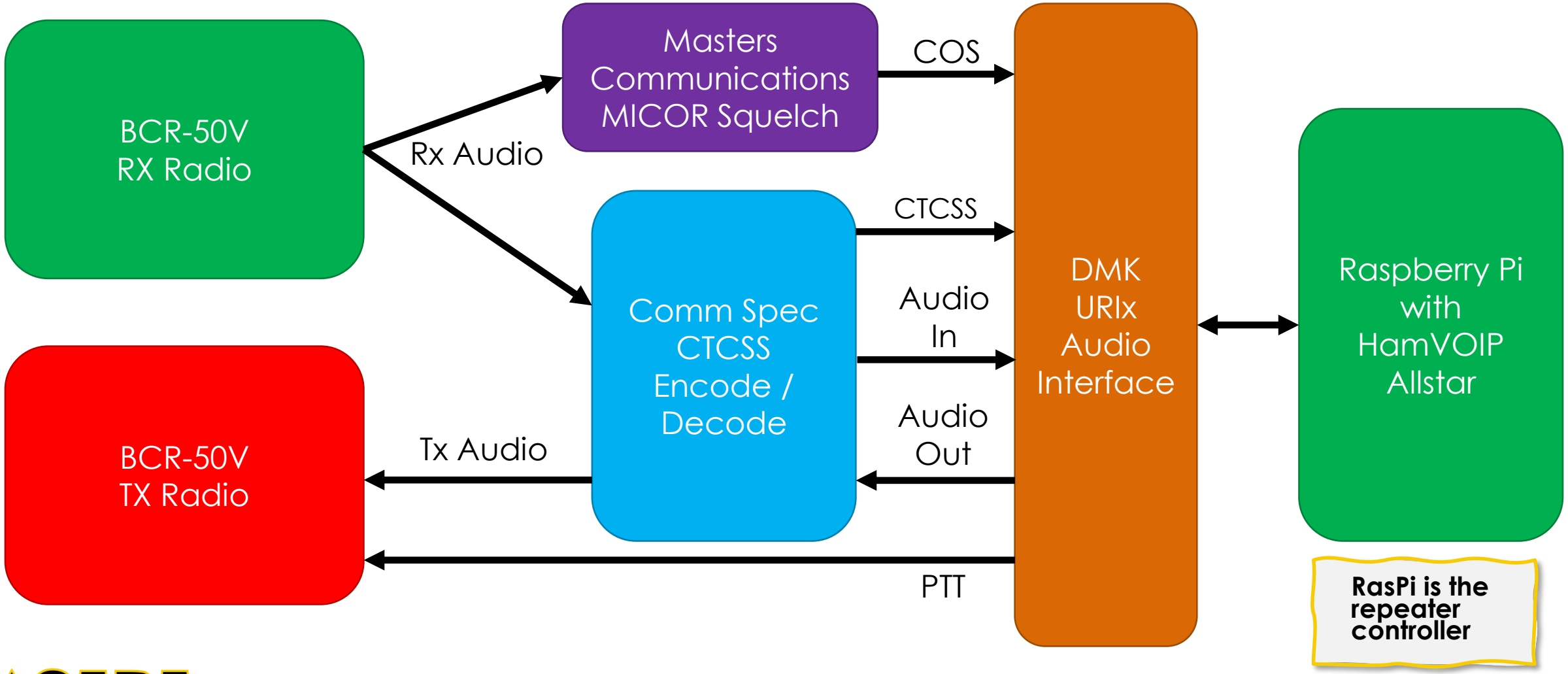
Western Intertie Network System (WINSystem)



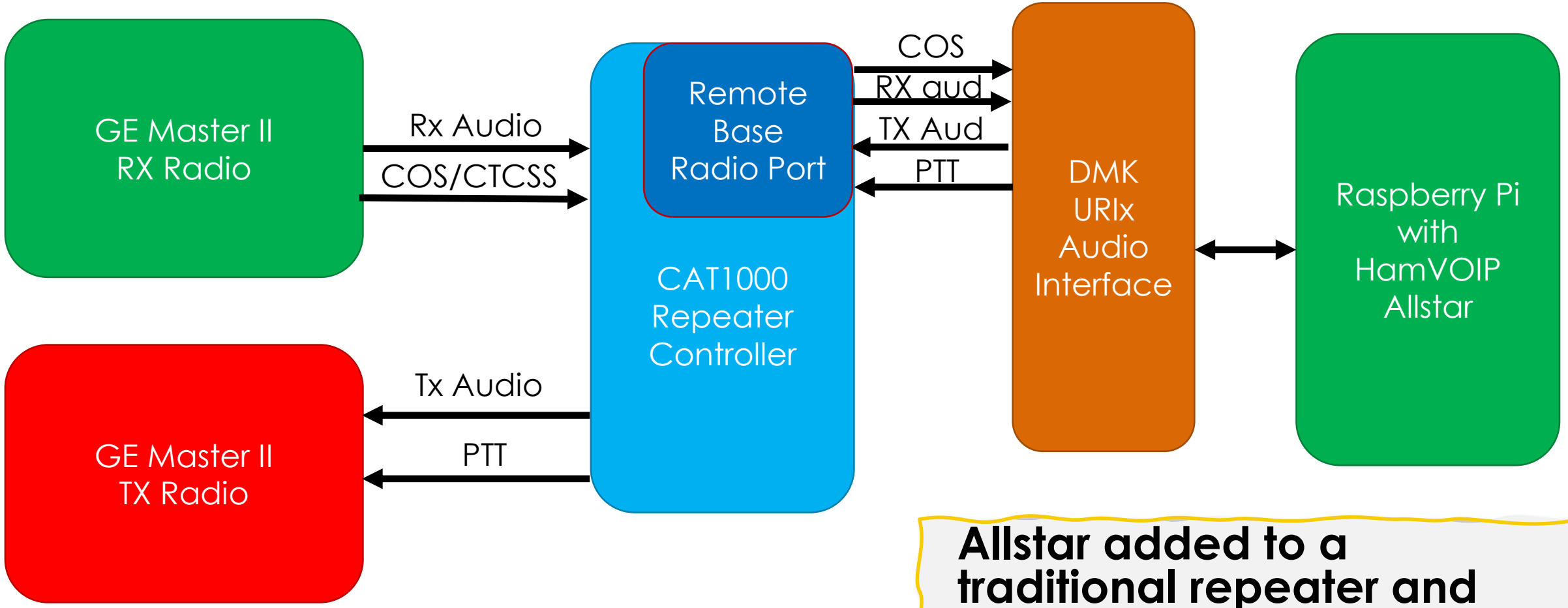
M0HOY HUBNet

SARA

W8WKY 147.390



N8XPK 53.17



Allstar added to a traditional repeater and controller

ALLSTAR PRO/CON

Pros

- Uses standard analog FM so no special radios or skills are needed
- Repeater – repeater linking without the need of a central network or reflector
- Easy to script announcements, clocks, weather alerts, and more
- Echolink is an option
- Supports data modes – e.g. MT63

Cons

- Requires modest skills with Linux to maintain
- Echolink is an option

ALLSTAR RECOMMENDED HARDWARE

Item	Vendor	Cost
Raspberry Pi 3B Kit (Note: Don't use a Pi 4 yet; software is not ready)	Canakit Raspberry Pi 3 w/ case, heatsink, and power supply Amazon Item: B01C6EQNNK	$50
MicroSD Card	Samsung EVO Select 32G Amazon Item: B06XWN9Q99	$6.50 Do not use an old one!
USB Audio Adapter with repeater signaling	Masters Communications RA-40 https://www.masterscommunications.com/products/radio-adapter/ra40.html - or - DMK URIx https://dmkeng.com/Products.htm	$65 (RA-40 + Case + S/H)
	TOTAL (except interface cable)	**$121.50**

SARA

REPEATER INTERFACE

Premade Cables

Many vendors

Example:
http://www.uricables.com/

Custom Cabling

RA-25/40 has a D-Sub DB9 female port; DMK URIx has D-SUB DB-25 female port. Easy to build:

- Audio In
- Audio Out
- PTT
- GND
- COS/COR Detect
- CTCSS Detect

Almost all repeaters and most radios can be lightly modified to connect to this port

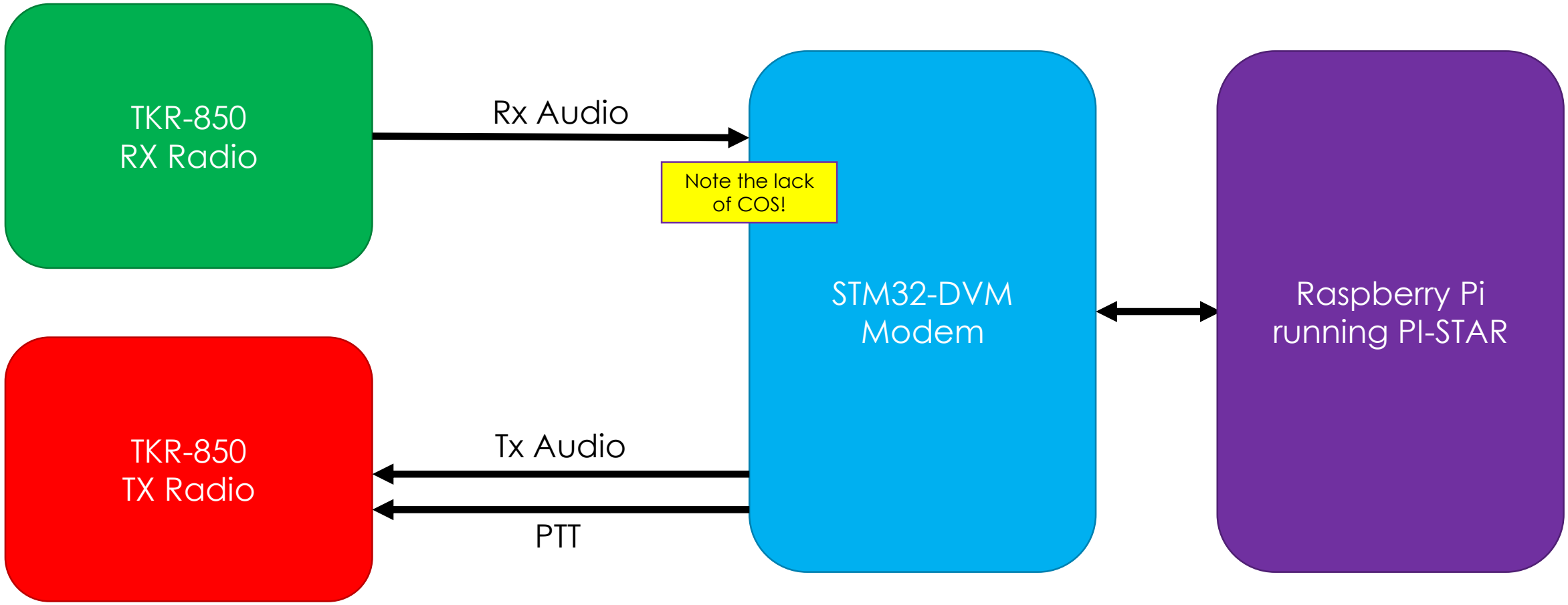
PI-STAR

- Raspberry Pi system
- Multiprotocol decode board based on MMDVM
- Network support for D-STAR, DMR, YSF, P25, and NXDN
- Easy-to-use system that's easy to deploy
- Can transcode between compatible CODECS

PI-STAR

https://pistar.uk

W8WKY 442.275



PI-STAR PRO/CON

Pros

- Very easy to deploy with basic computer skill
- Digital modes don't require COS/COR detection
  - Repeaters with bad/broken squelch can be used well
  - Homebrew isn't limited to radios that expose a COS pin
- Scales from micro simplex hotspots to full repeaters

Cons

- Modes can't talk to each other (without transcoding – whole other presentation)
- Some modes don't function well without their supporting network working (looking at you DMR…)
- Can't do data due to vocoder corruption of the audio (except D-STAR D-RATS)

PI-STAR RECOMMENDED HARDWARE

Item	Vendor	Cost
Raspberry Pi 3B Kit (Note: Don't use a Pi 4 yet; software is not ready)	Canakit Raspberry Pi 3 w/ case, heatsink, and power supply Amazon Item: B01C6EQNNK	$50
MicroSD Card	Samsung EVO Select 32G Amazon Item: B06XWN9Q99	$6.50 Do not use an old one!
MMDVM duplex-capable modem	Repeater Builder STM32-DVM PiHat + Pi Case http://www.repeater-builder.com/products/stm32-dvm.html	$110 (PiHat + Case + S/H)
	TOTAL (except interface cable)	**$166.50**

REPEATER INTERFACE

Premade Cables

Bridgecom BCR-series

Yaesu DR-1X

Kenwood TKR-x50

Motorola MaxTrac/Radius

Custom Cabling

PiHat has a D-Sub DB9 female port

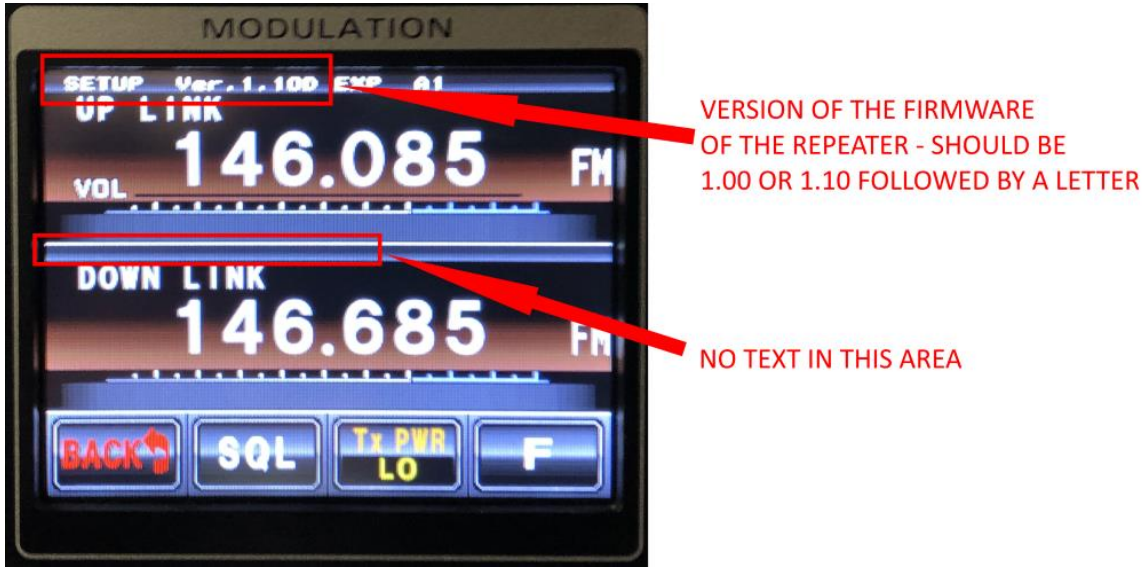
- Audio In
- Audio Out
- PTT
- GND

Almost all repeaters and most radios can be lightly modified to connect to this port

YAESU DR-1X WARNING

Many people want to convert DR-1X repeaters because A) they were cheap and B) they aren't that good of an analog repeater

Be warned – only "original" DR-1X repeaters can be used for conversions. DR-1X repeaters that went back for the recall, bought later as an "FR" version, and the DR-2X cannot be used. The internals of the repeater have been modified what prevent it.



An "original" DR-1X will have a firmware of 1.00 or 1.10 with a letter after it (e.g. 1.00a, 1.00n, 1.10j, 1.10q, etc.) and will not list any DSP version between the frequencies.

QUESTIONS TO PONDER

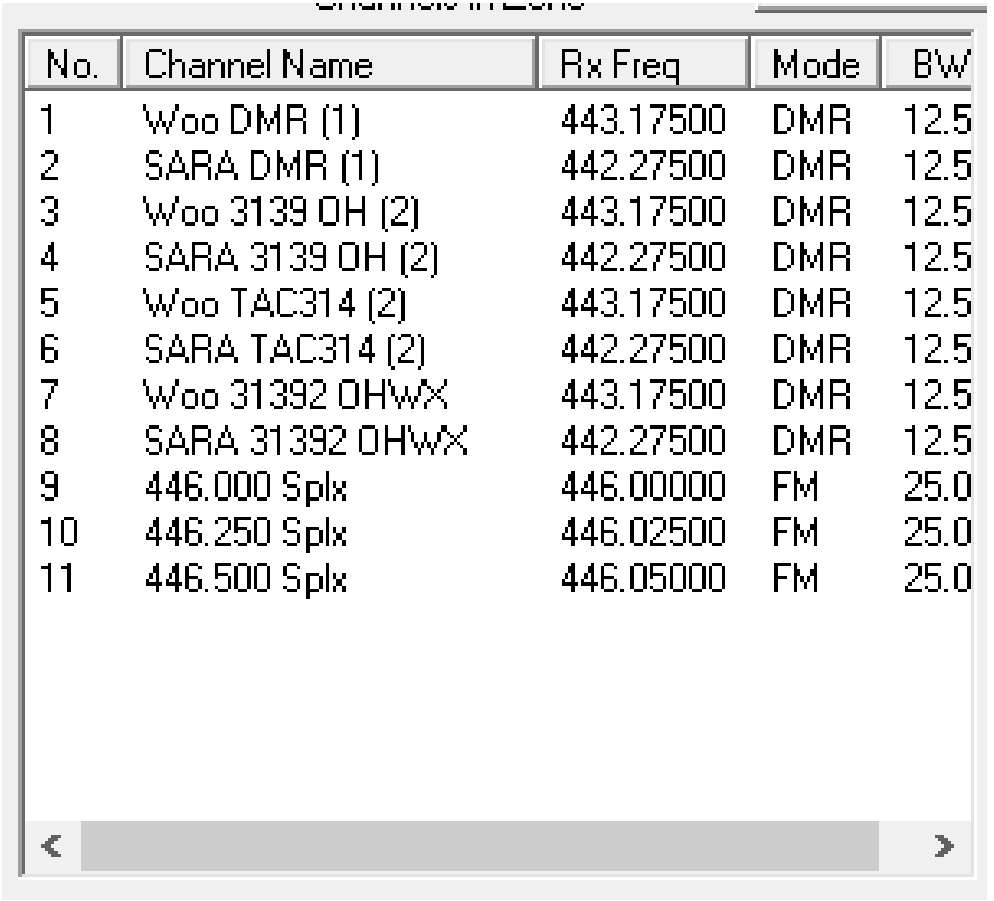
- Who are you users?
- What radios do they already have?
- What's the "core group" going to use and be able to support?
- What's your goal(s) in converting?
- How does this move play into retaining and attracting hams?
- How concerned are you with survivability? Emcomm?
  - Consider the "upstream" dependencies of the mode you choose

HOW TO DO THIS?

- Education of your club/group
- If possible, standardize on a platform and have a basic radio recommendation
- Deploy the system
- Educate your club/group again
- Hold a programming clinic (i.e. your tech people program people's radios)
- Develop programs/codeplugs for your group
  - Consistent naming!
  - Consistent terms!
  - Consistent setup!

EXAMPLE: WAYNE ARC + WAYNE ARES

- Standardized on DMR for EMComm/events
- Recommended a specific HT for beginners
- Developed a standard naming for channels
- Use a standardized codeplug with consistent naming and one "Wayne ARES" zone
- Education and practice!



No.	Channel Name	Rx Freq	Mode	BW
1	Woo DMR (1)	443.17500	DMR	12.5
2	SARA DMR (1)	442.27500	DMR	12.5
3	Woo 3139 OH (2)	443.17500	DMR	12.5
4	SARA 3139 OH (2)	442.27500	DMR	12.5
5	Woo TAC314 (2)	443.17500	DMR	12.5
6	SARA TAC314 (2)	442.27500	DMR	12.5
7	Woo 31392 OHWX	443.17500	DMR	12.5
8	SARA 31392 OHWX	442.27500	DMR	12.5
9	446.000 Splx	446.00000	FM	25.0
10	446.250 Splx	446.02500	FM	25.0
11	446.500 Splx	446.05000	FM	25.0

REFERENCES

W8WKY Repeaters: http://w8wky.org/repeaters

WW8TF Repeaters: https://ww8tf.club/repeaters

WTF DR-1X Modifications:

- https://ww8tf.club/yaesu-dr-1x-repeater-modification-common-concerns
- https://ww8tf.club/dr-1x-repeater-mods-for-digital-voice
- Allstar one coming soon…

Pi-STAR Forums: https://forum.pistar.uk

Repeater-Builders:

- http://www.repeater-builder.com/rbtip/index.html
- https://groups.io/g/repeater-builder/