DIGITAL AND NETWORK-CONNECTED REPEATERS

Jason McCormick N8EI
John Wagner N8CD
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

<table>
<thead>
<tr>
<th>Callsign</th>
<th>Frequency</th>
<th>Location</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>W8WKY</td>
<td>147.390+</td>
<td>Doylestown, OH</td>
<td>Bridgecom BCR-50V Allstar Pi Controller</td>
</tr>
<tr>
<td>W8WKY</td>
<td>442.275+</td>
<td>Doylestown, OH</td>
<td>Kenwood TKR-850 Pi-Star + STM32-DVM Multimode Controller</td>
</tr>
<tr>
<td>WW8TF</td>
<td>442.375+</td>
<td>Rittman, OH</td>
<td>Motorola Radius Pi-Star + STM32-DVM Multimode Controller</td>
</tr>
<tr>
<td>KE8LDH</td>
<td>442.5125+</td>
<td>Akron, OH</td>
<td>Vertex VXR5000 Pi-Star + STM32-DVM Multimode Controller</td>
</tr>
<tr>
<td>KE8LDG</td>
<td>442.7375+</td>
<td>Rittman, OH</td>
<td>Motorola Radius Pi-Star + STM32-DVM Multimode Controller</td>
</tr>
<tr>
<td>W8WOO</td>
<td>443.175+</td>
<td>Wooster, OH</td>
<td>Yaesu DR-1X Pi-Star + STM32-DVM Multimode Controller</td>
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<tr>
<td>N8XPK</td>
<td>53.17</td>
<td>Northeast Ohio</td>
<td>GE Mastr II w/ CAT1000 Controller Allstar Pi as remote base</td>
</tr>
<tr>
<td>N8XPK</td>
<td>444.200</td>
<td>Akron, OH</td>
<td>Motorola w/ RLC Controller Allstar Pi as remote base</td>
</tr>
<tr>
<td>N8XPK</td>
<td>1292.2000</td>
<td>Akron, OH</td>
<td>Yaesu FT-912R x2 Allstar Pi Controller</td>
</tr>
<tr>
<td>W8WOO</td>
<td>147.210</td>
<td>Wooster, OH</td>
<td>Yaesu DR-1X in FM mode w/ SCOM Controller Allstar Pi as remote base (COMING SOON)</td>
</tr>
<tr>
<td>WW8TF</td>
<td>146.685</td>
<td>Rittman, OH(?)</td>
<td>Yaesu DR-1X with lots of surgery Allstar Pi Controller (SPRING 2020)</td>
</tr>
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</table>
**REPEATERS**

KE8LDH – 442.5125 Pi-Star Multimode Digital
Akron

N8XPK – 1292.2 Allstar
Akron
REPEATERS

KE8LDG – 442.7375 Rittman Pi-Star Multimode Digital

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

WW8TF – 442.375 Rittman Pi-Star Multimode Digital
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
INTER-SITE LINKS

Standardized on Ubiquiti PowerBeam
INFRASTRUCTURE

- 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
W8WKY 147.390

- BCR-50V RX Radio
- BCR-50V TX Radio
- Masters Communications MICOR Squelch
- Comm Spec CTCSS Encode / Decode
- DMK URIx Audio Interface
- Raspberry Pi with HamVOIP Allstar

Rx Audio → Masters Communications MICOR Squelch → Tx Audio

Rx Audio → Comm Spec CTCSS Encode / Decode → Audio In

COS → DMK URIx Audio Interface

CTCSS → DMK URIx Audio Interface

Audio In → DMK URIx Audio Interface

Audio Out → DMK URIx Audio Interface

PTT → DMK URIx Audio Interface

RasPi is the repeater controller
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

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<th>Cost</th>
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<td>Raspberry Pi 3B Kit</td>
<td>Canakit Raspberry Pi 3 w/ case, heatsink, and power supply</td>
<td>$50</td>
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<td>(Note: Don’t use a Pi 4 yet; software is not ready)</td>
<td>Amazon Item: B01C6EQNNK</td>
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<td>MicroSD Card</td>
<td>Samsung EVO Select 32G</td>
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<td>- or - DMK URIx <a href="https://dmkeng.com/Products.htm">https://dmkeng.com/Products.htm</a></td>
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<td>TOTAL (except interface cable)</td>
<td>$121.50</td>
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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

https://pistar.uk
TKR-850 RX Radio

Note the lack of COS!

TKR-850 TX Radio

STM32-DVM Modem

Raspberry Pi running PI-STAR

Rx Audio

Tx Audio

PTT
**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

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<tr>
<td>MMDVM duplex-capable modem</td>
<td>Repeater Builder STM32-DVM PiHat + Pi Case</td>
<td>$110 (PiHat + Case + S/H)</td>
</tr>
<tr>
<td>TOTAL (except interface cable)</td>
<td></td>
<td>$166.50</td>
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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
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!
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:
  https://groups.io/g/repeater-builder/