Diving into D-STAR (with a hotspot)

March 2017
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Longmont Amateur Radio Club (LARC), w0eno.org

Thanks to the many Elmers who have helped me including Starr, N0AES, LARC president

Diving into D-STAR (with a hotspot)

1. Before we get started
2. What Digital Voice is
3. How D-STAR can be used
4. Personal access point devices (hotspots)
5. Choosing a way forward
6. Just can’t wait to get on the road again
7. Get registered, get online, and have some fun
8. Appendices

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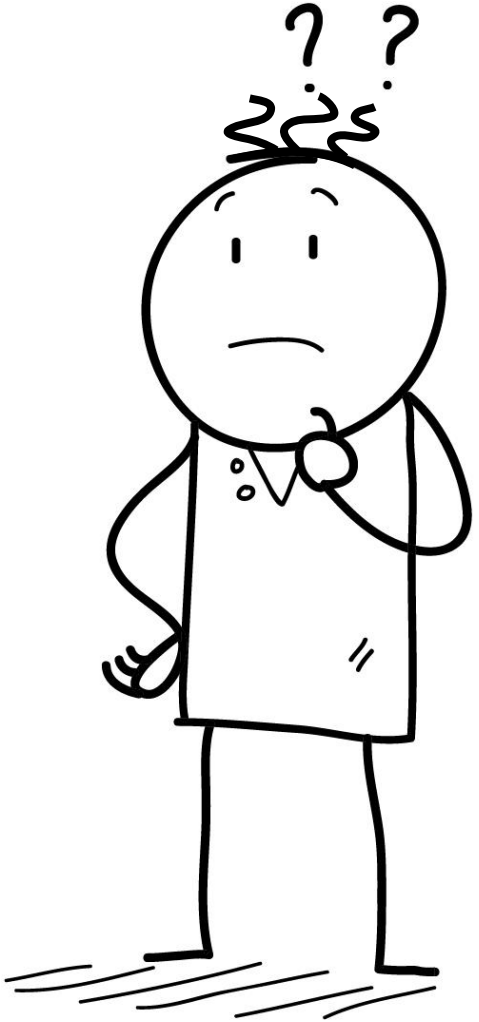
Why?

You know that age when
kids ask **Why?** about everything.



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I never grew out of that.

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Same with Digital Voice:
Sure, I wanted to figure out how it works.
I also always want to understand **Why? Why? Why?**

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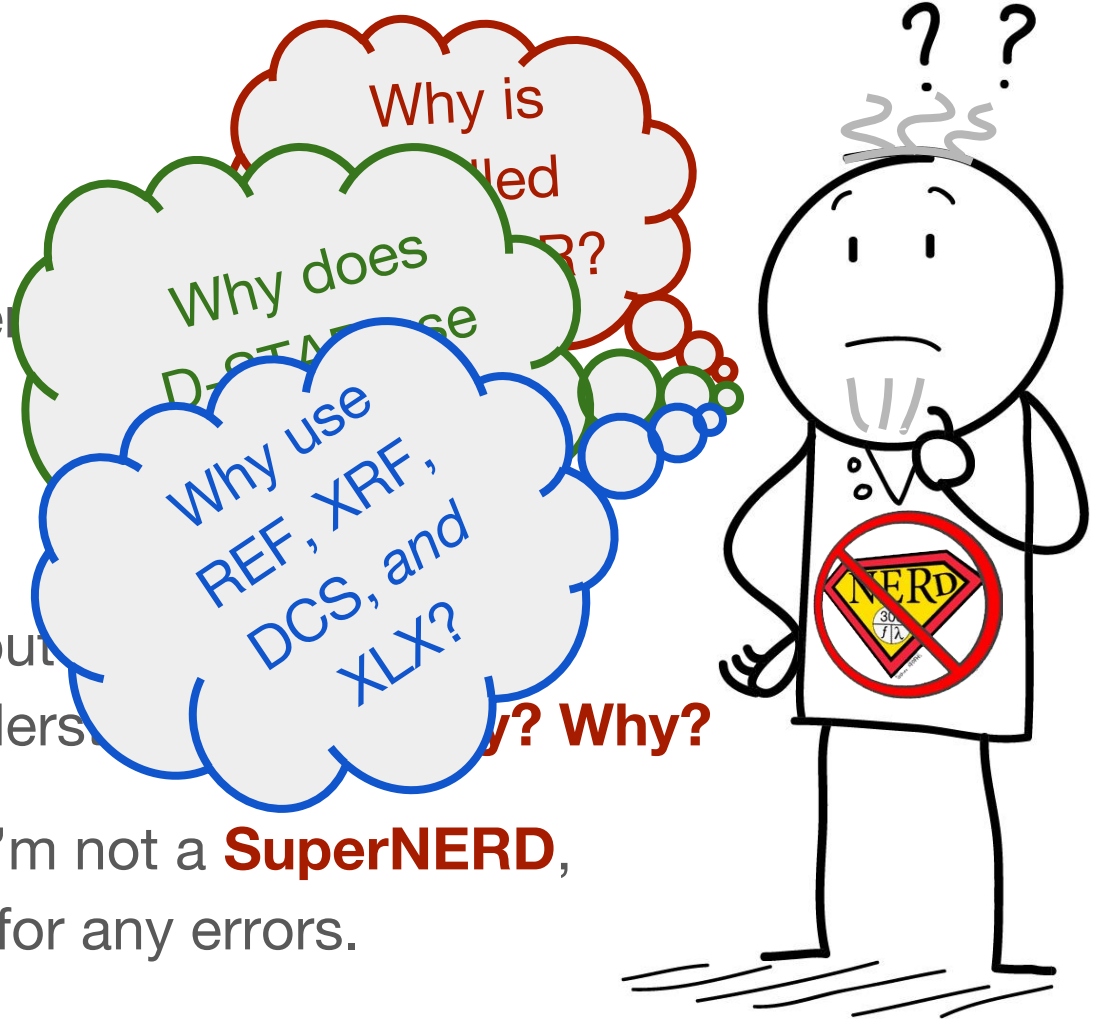
That said, unfortunately I'm not a **SuperNERD**, so apologies in advance for any errors.



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Based on my experience, Digital Voice can be a big bowl of bewilderingly murky info soup for a newbie! **So why bother?**

International communication with a Technician class license, some simple, inexpensive equipment, and a bit of effort and learning.

Also, it advances the hobby, and can be accessed from just about anywhere. **Pretty awesome!**

Why not just plunge in?

Digital Voice is a bit like a Wild West frontier

1. Lots of experimentation with excitingly rapid progress, but some branches of exploration are abandoned dead-ends

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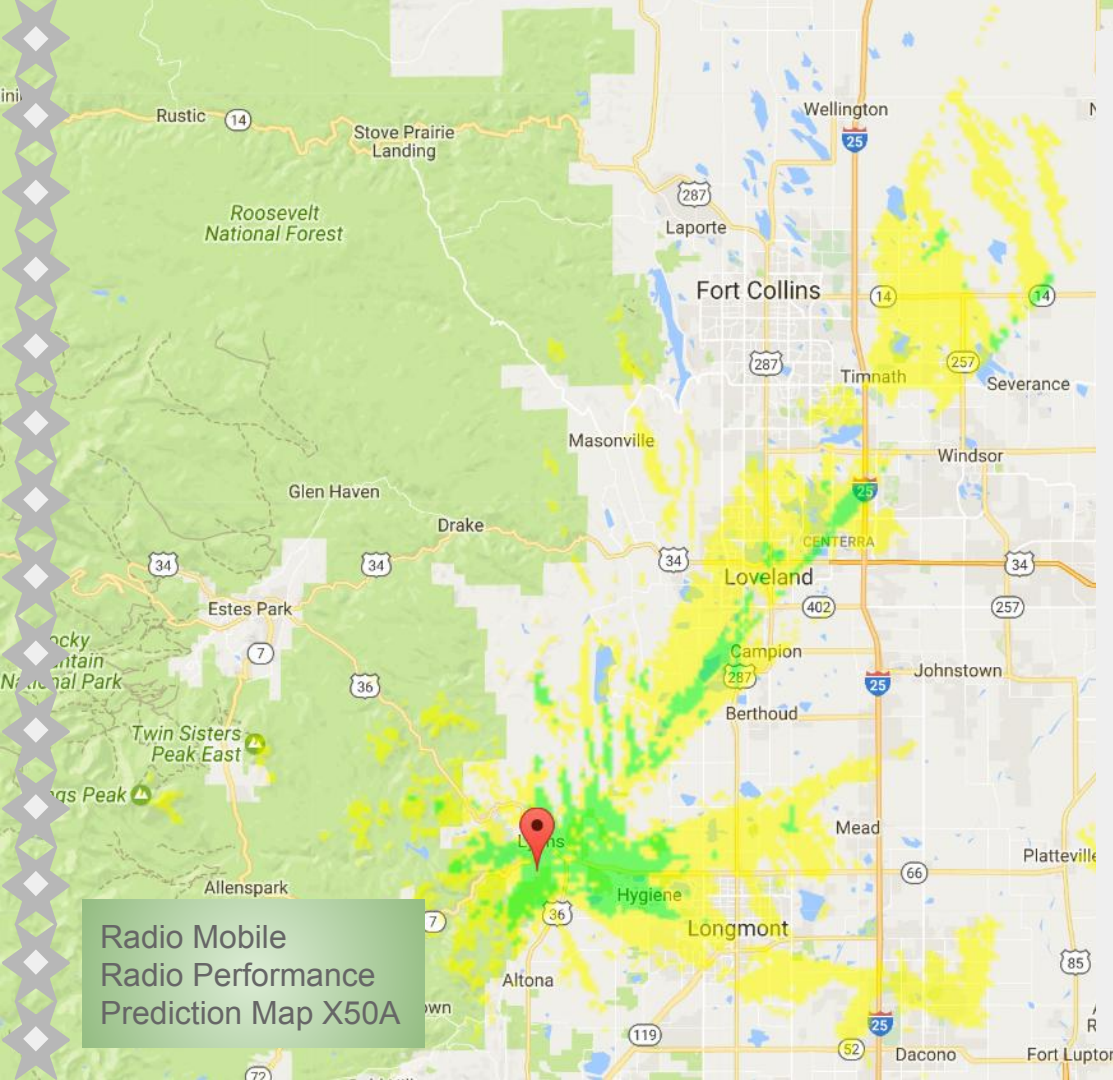
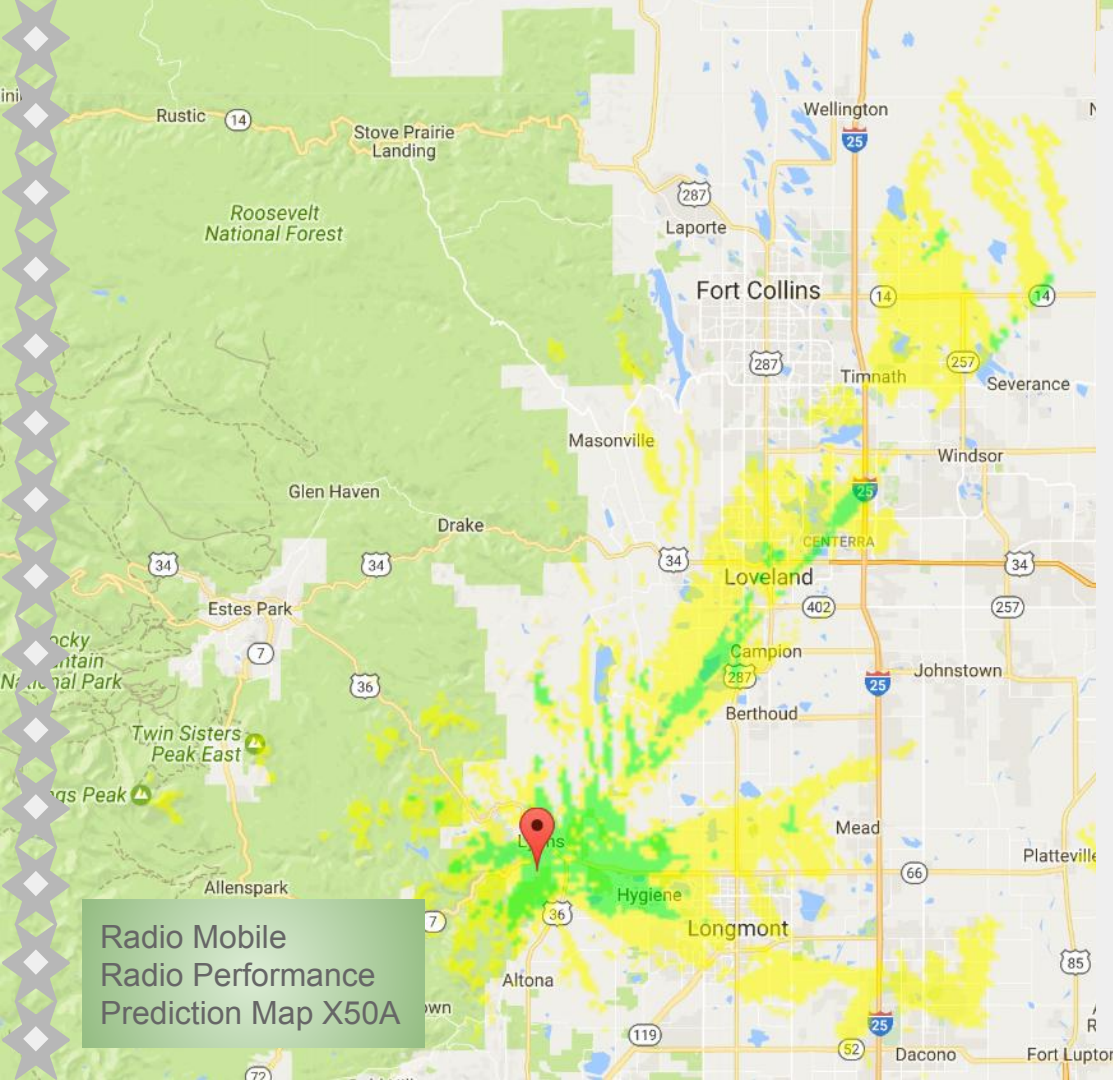
Digital Voice is a bit like a Wild West frontier

1. Lots of experimentation with excitingly rapid progress, but some branches of exploration are abandoned dead-ends
2. There is a bit of a learning curve
3. Some online info is #@$%!
4. And, you need to speak at least a little bit of **Alphabetsoupese**



Why a hotspot?

This is from the point of view of someone who doesn't live within range of a Digital Voice (DV) repeater, and so must rely on a personal access point device (hotspot).



Radio Mobile
Radio Performance
Prediction Map X50A

Why a hotspot?

This is from the point of view of someone who does not live within range of a Digital Voice (DV) repeater, and so must rely on a personal access point device (hotspot).

However, a hotspot can offer advantages to everyone. (So it just might be worth staying awake for this. ;)

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What Digital Voice is: **Multiple competing systems**

What Digital Voice is: **Multiple competing systems**

D-STAR is the first. The Japan Amateur Radio League began work on the **D**igital **S**mart **T**echnologies for **A**mateur **R**adio standard in the late 90s and published it in 2001.

- Started ramping up in the U.S. ten years ago.
- Icom is the D-STAR trailblazer; Kenwood recently joined in.
- Tens of thousands of hams worldwide using it now.
- Mostly open standard, except for the AMBE vocoder.
- Lots of small manufacturer and homebrew hardware/software.

What Digital Voice is: **Multiple competing systems**

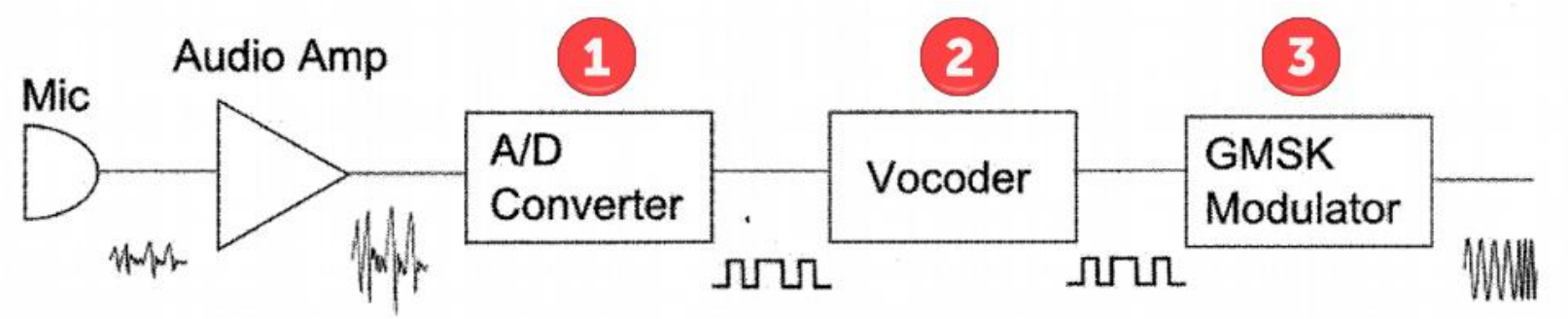
Other Digital Voice systems being developed:

- **DMR**, a caommercial standard developed by ETSI with equipment by Motorola, Hytera, Connect Systems, and others
- **System Fusion** by Yaesu

Also, an open system is in development, a combination of **FreeDV** software and an open source speech codec (vocoder), **Codec 2**.

“DV modes are 95% the same and 100% incompatible.”
- John Hays, K7VE

What Digital Voice is: **The digital in DV**



1. The audio from the microphone is amplified and then converted to digital (zeros & ones)
2. The vocoder (AMBE) compresses the digitized audio
3. The compressed audio is modulated onto the carrier wave using, for D-STAR, Gaussian Minimum Shift Keying (GMSK)

What Digital Voice is: **The digital in DV**

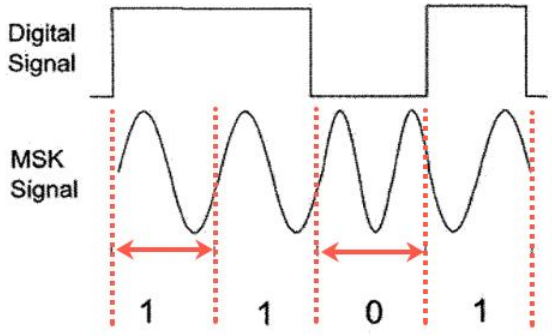
2. The vocoder compresses the digitized audio

- **A/D conversion** - Simply digitizing an analog voice waveform actually results in needing more bandwidth than the analog original.
- **To solve this conundrum** - The AMBE vocoder splits the human voice signal into frequency bands, analyzes the audio energy of the major voice sound components in each frequency band, and then creates a summary of the audio energy characteristics.
- **The compression** - Both maximizes human voice fidelity and minimizes bandwidth requirements, resulting in a signal that is more efficient than the analog original while sounding fairly true to life.

What Digital Voice is: **The digital in DV**

3. The compressed audio is modulated onto the carrier wave using, for D-STAR, Gaussian Minimum Shift Keying (GMSK)

- **Gaussian** - The type of filter used to shape the waveform (a rounded waveform tends to create a narrower bandwidth signal)
- **Frequency Shift Keying** - One frequency is used for zeros; another for ones
- **Minimum Shift Keying (MSK)** - A more efficient type of frequency shift keying

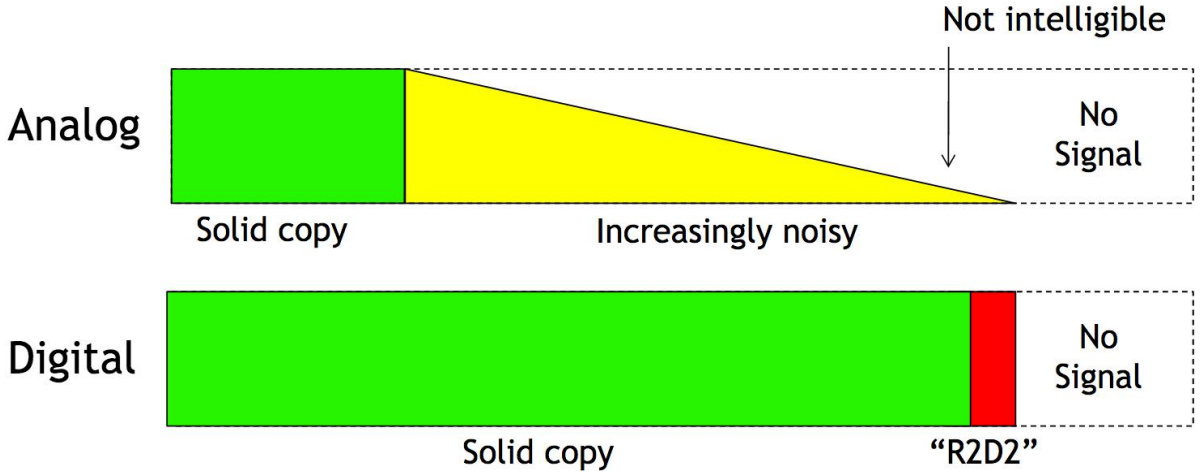


In this example:
0 = 1.5 sine waves
1 = 1.0 sine waves

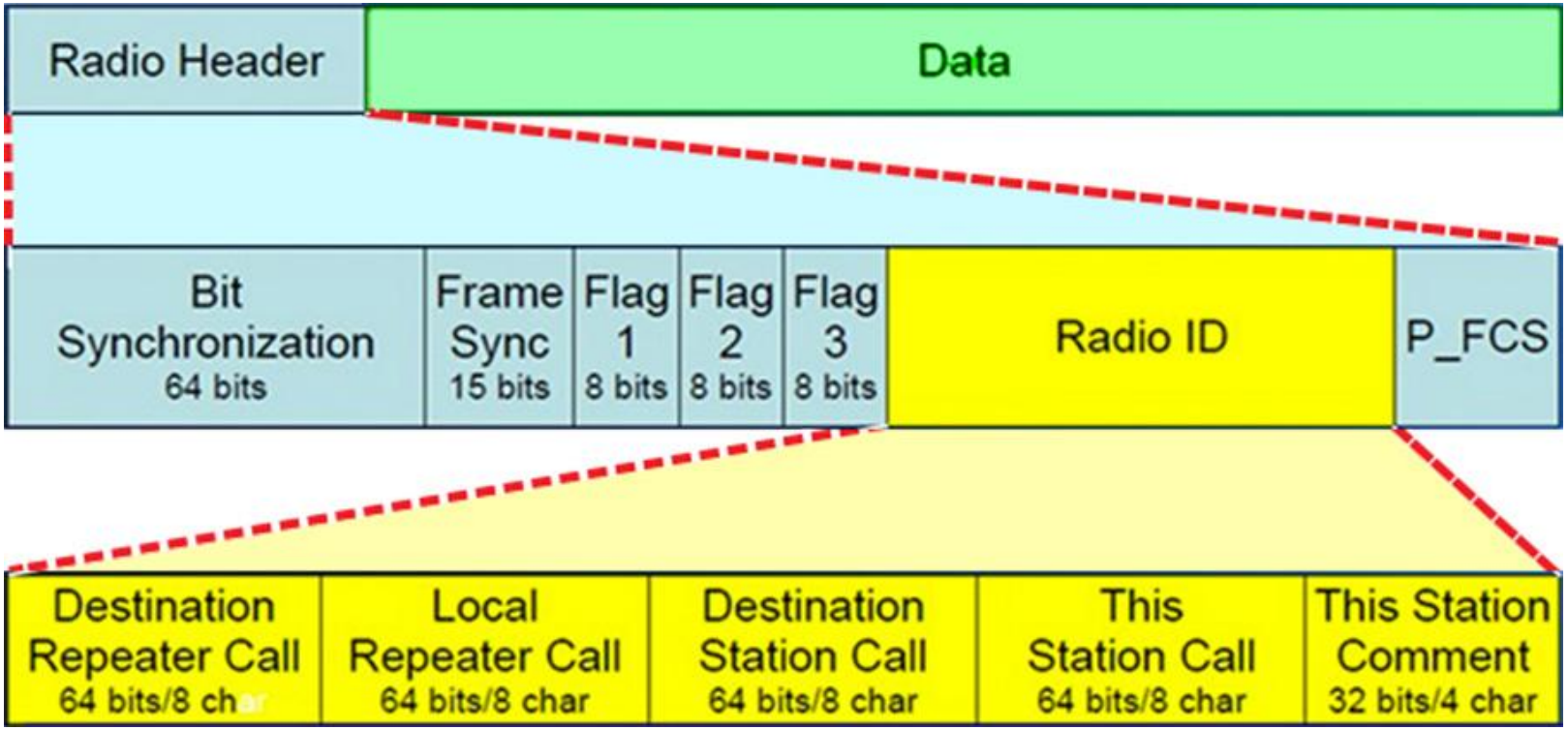
What Digital Voice is: **The digital in DV**

Why GMSK is a good choice:

- **Lower cost** - Efficient bandwidth usage and relatively simple
- **Less noise** - Signals have constant amplitude so they're not affected by amplifier nonlinearities



What Digital Voice is: **The digital signal**



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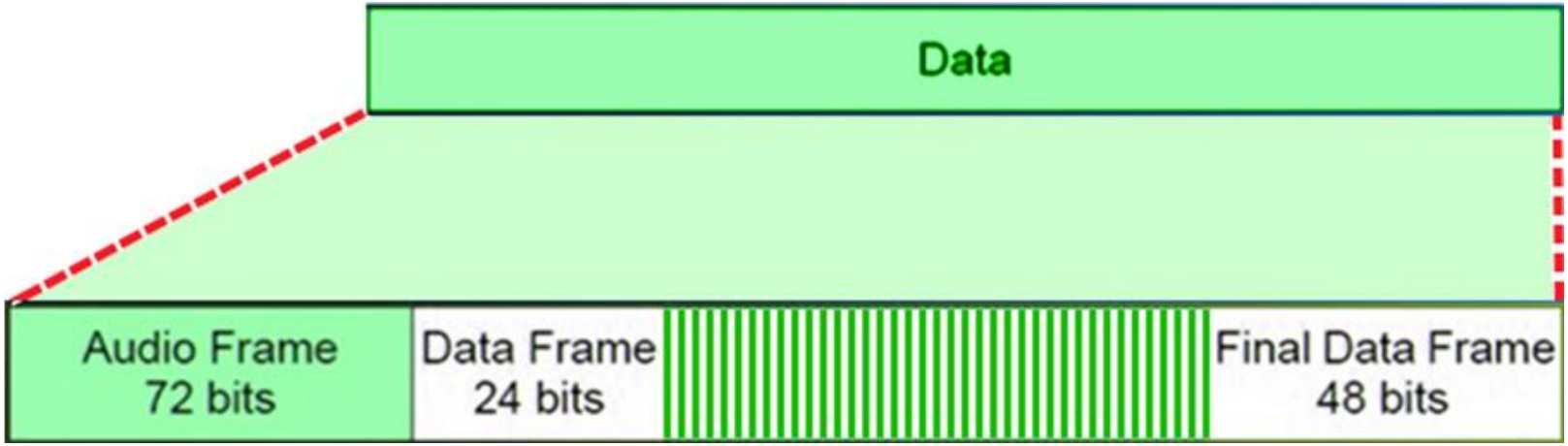

Repeating of alternating audio and data stream Forward Error Correction on the audio only

End of current stream

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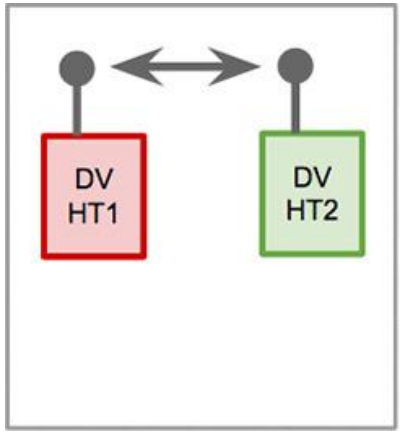
How D-STAR can be used: **1. Simplex**



Just as with transceivers in FM mode,[1]
you can use transceivers in DV mode for simplex

[1] The DV simplex frequencies are 145.670 (2 M) and 446.225 (70 cm)

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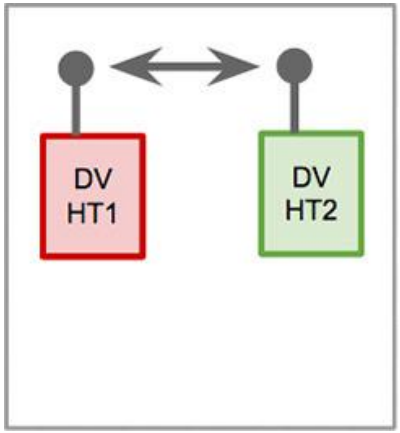

Frequency: most commonly 2 M or 70 cm

UR = UR CALL = CQCQCQ / callsign / link info

RPT1 = Calling from (local repeater & port)

RPT2 = Destination (repeater & port)

MY CALL = Your own callsign

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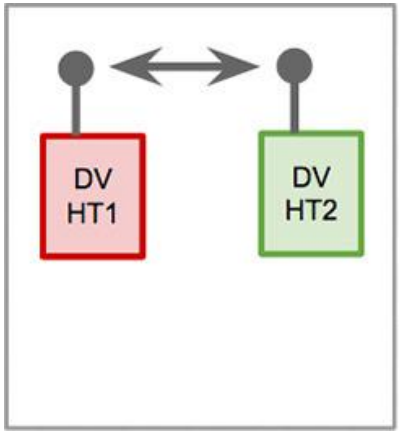

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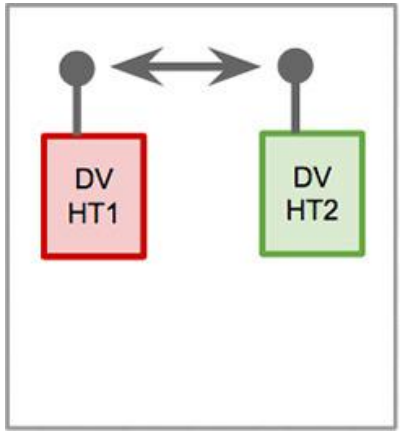
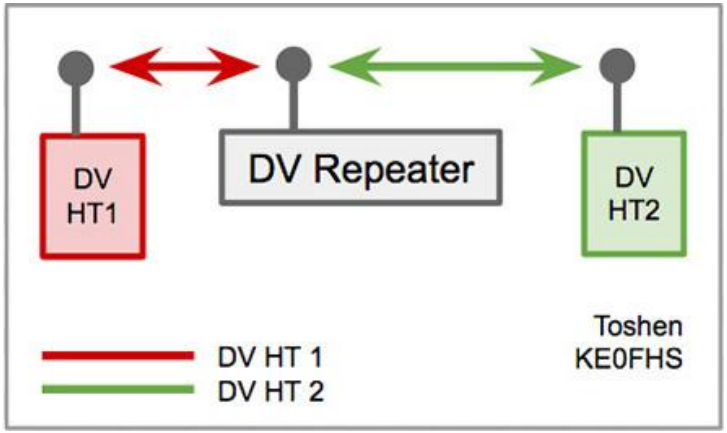
446.2250	446.2250
UR: CQCQCQ	UR: CQCQCQ
R1:	R1:
R2:	R2:
MY: KE0FHS	MY: N0AES

How D-STAR can be used: **2. Via a repeater**





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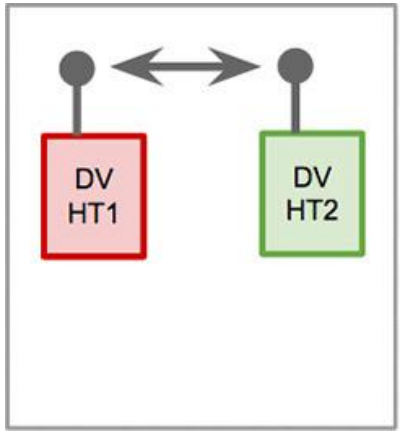

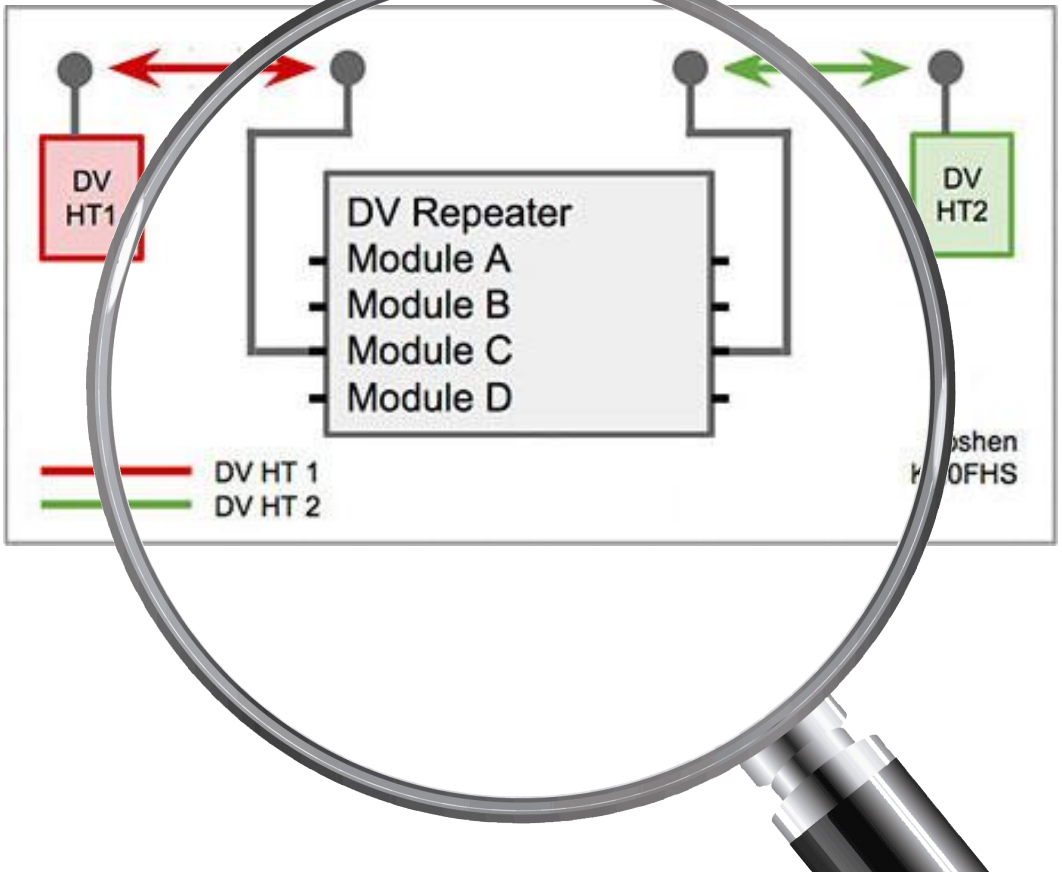

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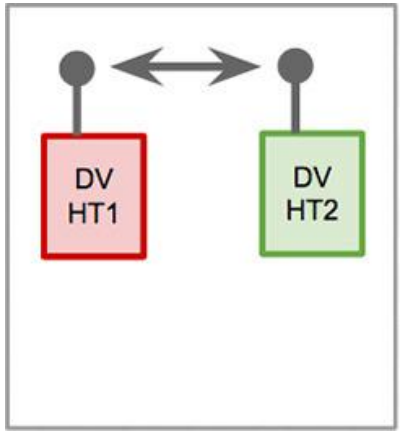

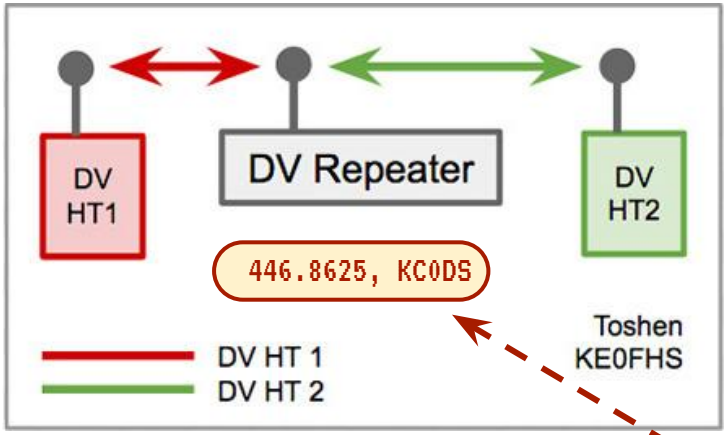

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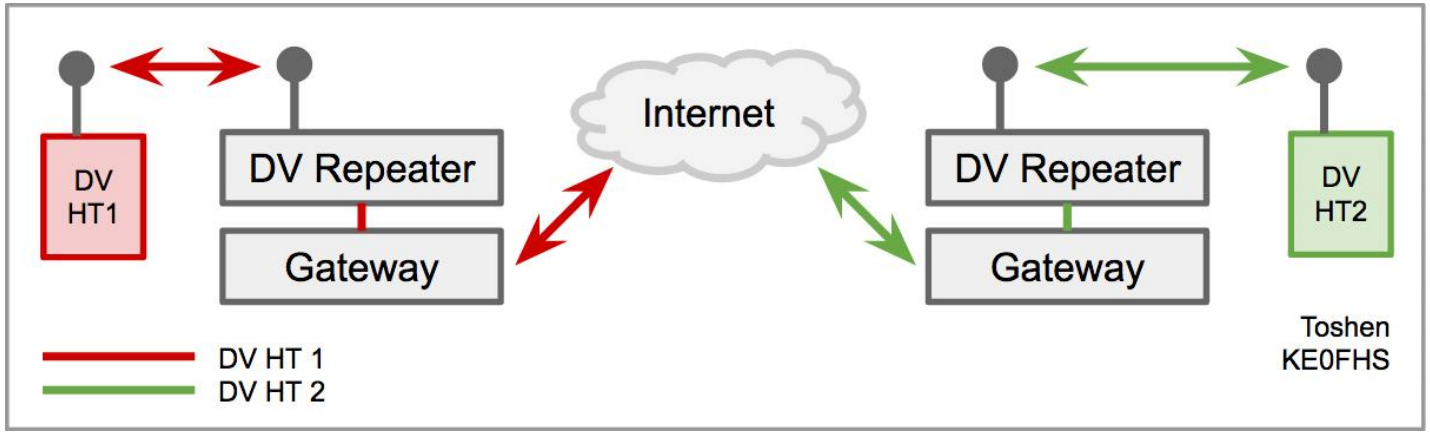
446.8625	446.8625
UR: CQCQCQ	UR: CQCQCQ
R1: KC0DS B	R1: KC0DS B
R2:	R2:
MY: KE0FHS	MY: N0AES

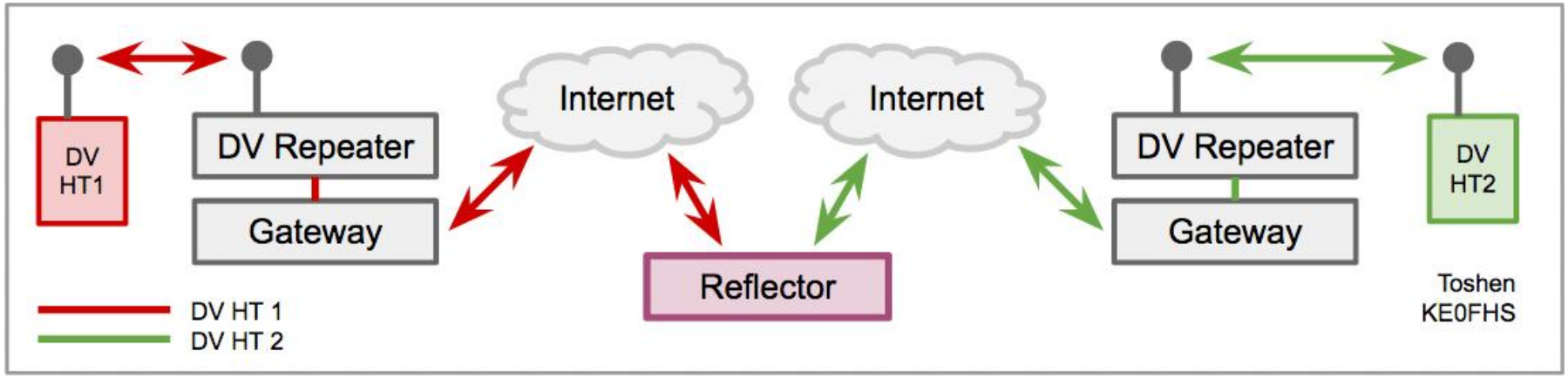
How D-STAR can be used: **3. Node routing**



Just as with transceivers in FM mode,
you can use transceivers in DV mode for simplex as well as for chats via a DV repeater.
Also possible: repeater-to-repeater node routing.

446.8625	145.2500
UR: /W0CDS B	UR: /KC0DS C
R1: KC0DS B	R1: W0CDS C
R2: KC0DS G	R2: W0CDS G
MY: KE0FHS	MY: N0AES

How D-STAR can be used: **4. Via a reflector**



DV repeaters can be bridged together.
In D-STAR, the bridge is called a Reflector:
Transmissions are *reflected* to all repeaters linked to the reflector.

446.8625	145.2500
UR: REF001CL	UR: REF001CL
R1: KC0DS B	R1: W0CDS C
R2: KC0DS G	R2: W0CDS G
MY: KE0FHS	MY: N0AES

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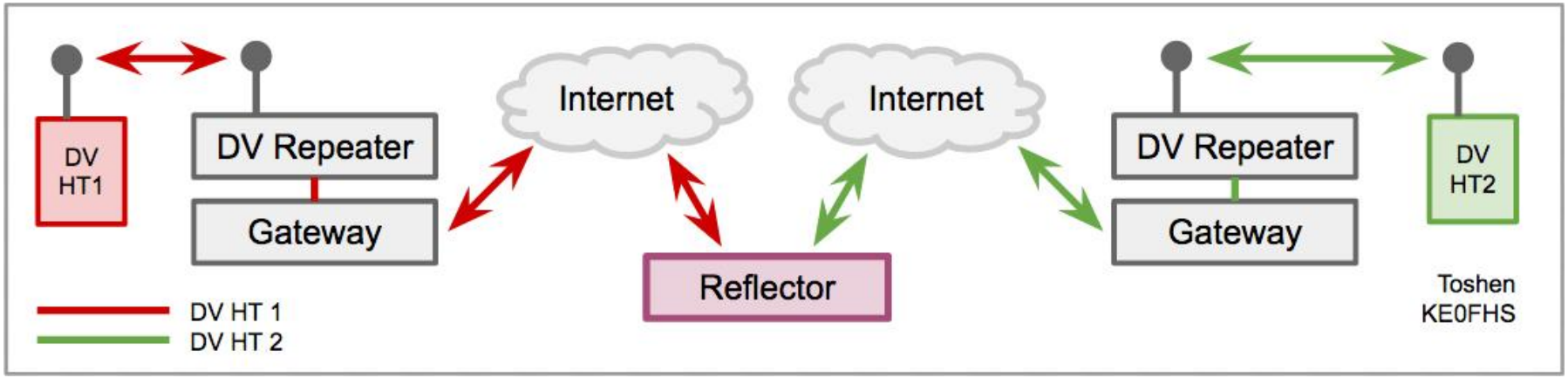

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446.8625	145.2500
UR: CQCQCQ	UR: CQCQCQ
R1: KC0DS B	R1: W0CDS C
R2: KC0DS G	R2: W0CDS G
MY: KE0FHS	MY: N0AES

Speaking Alphabetsoupese: ***D-STAR reflectors***

- **REF: The DPlus reflector system**. First generation D-STAR reflectors, widely used in English-speaking countries. Example: London's "Mega Reflector": REF001.

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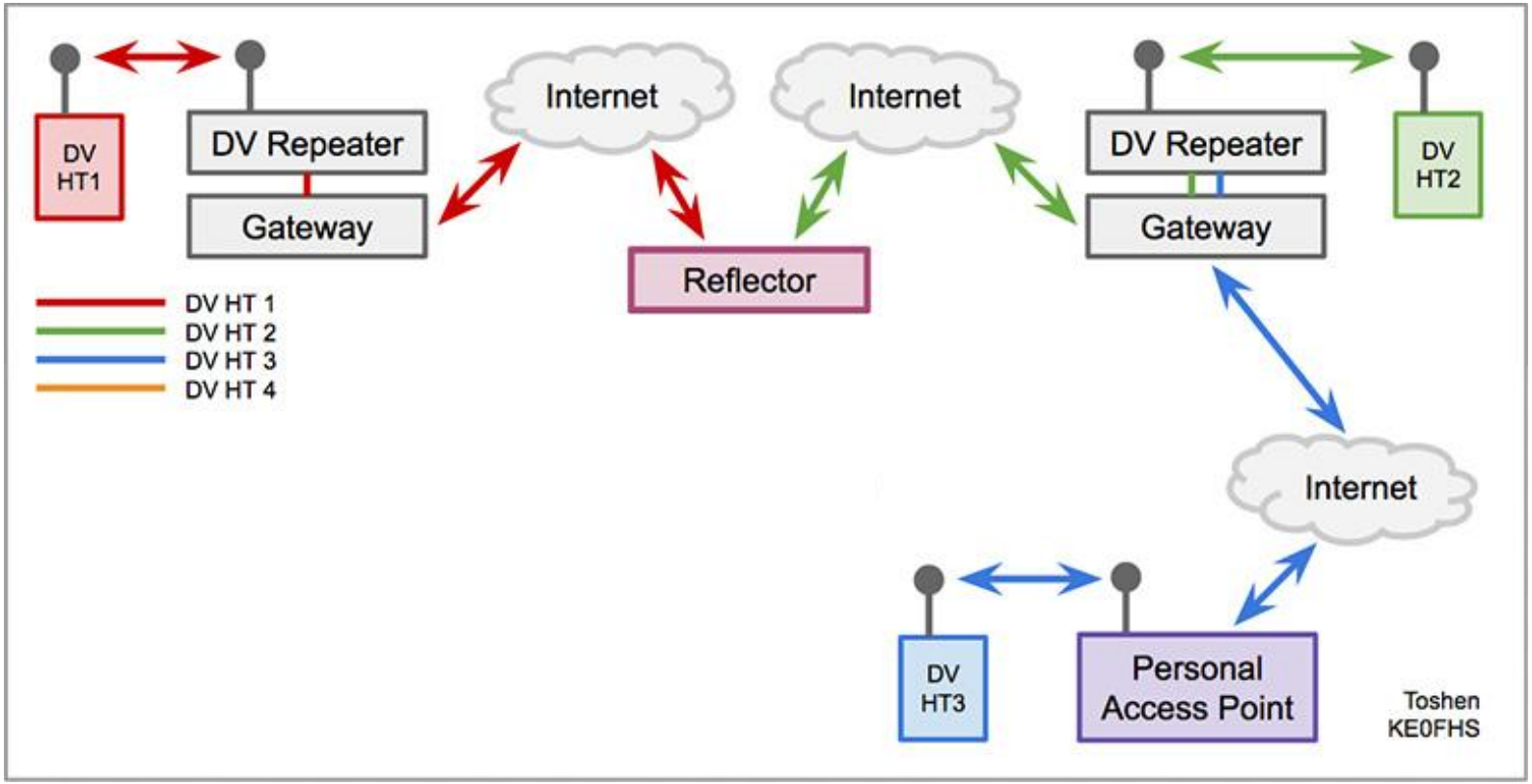
- **DCS: The Digital Call Server reflector system**. Even newer system being used worldwide.
- **XLX: The XLX reflector system**. Newest system. Supports all standard D-STAR protocols (REF, XRF, DCS).

How D-STAR can be used: **5. Via a hotspot**

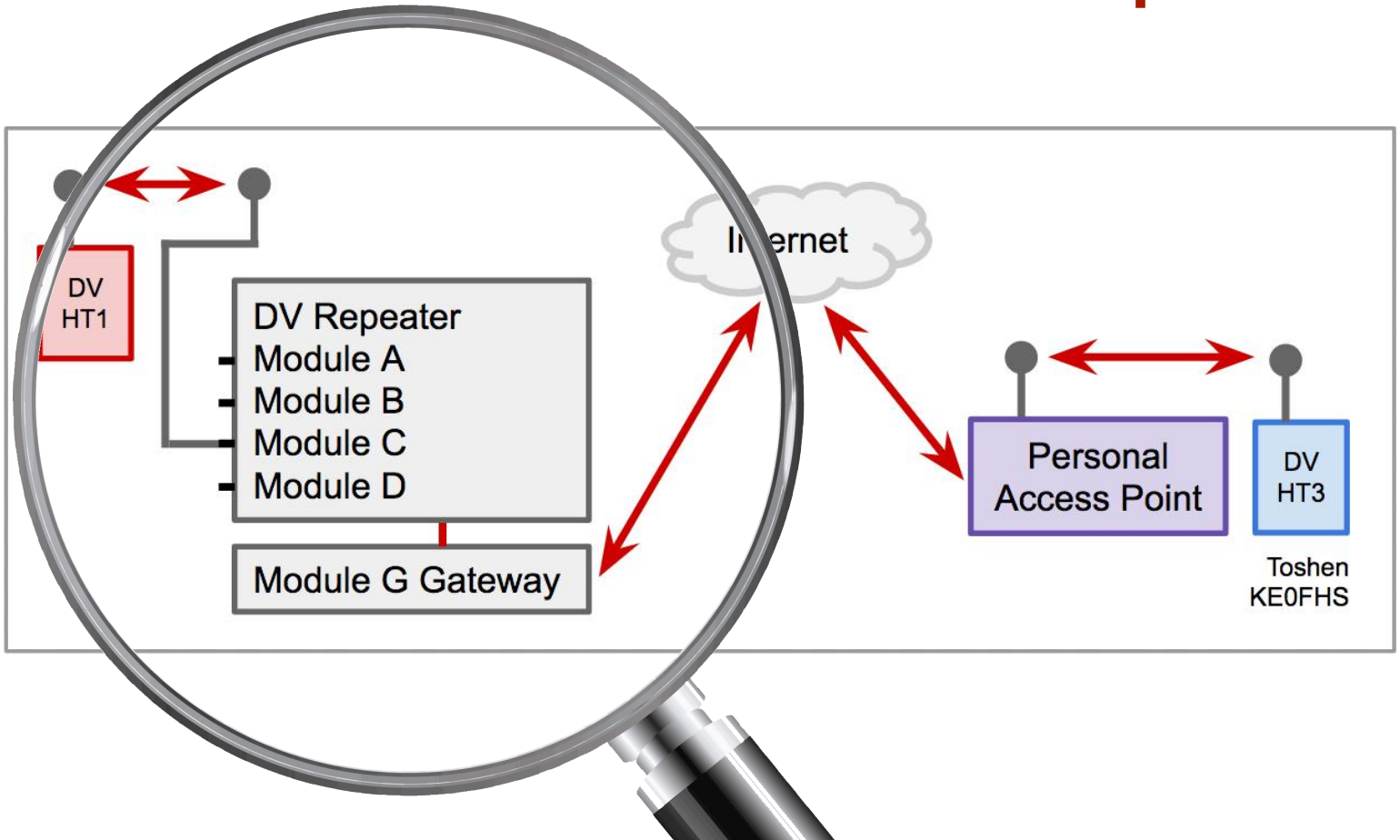


To a repeater:

```
431.0000
UR: KC0DS CL
R1: KE0FHS B
R2: KE0FHS G
MY: KE0FHS
```

```
431.0000
UR: CQCQCQ
R1: KE0FHS B
R2: KE0FHS G
MY: KE0FHS
```

How D-STAR can be used: **5. Via a hotspot**



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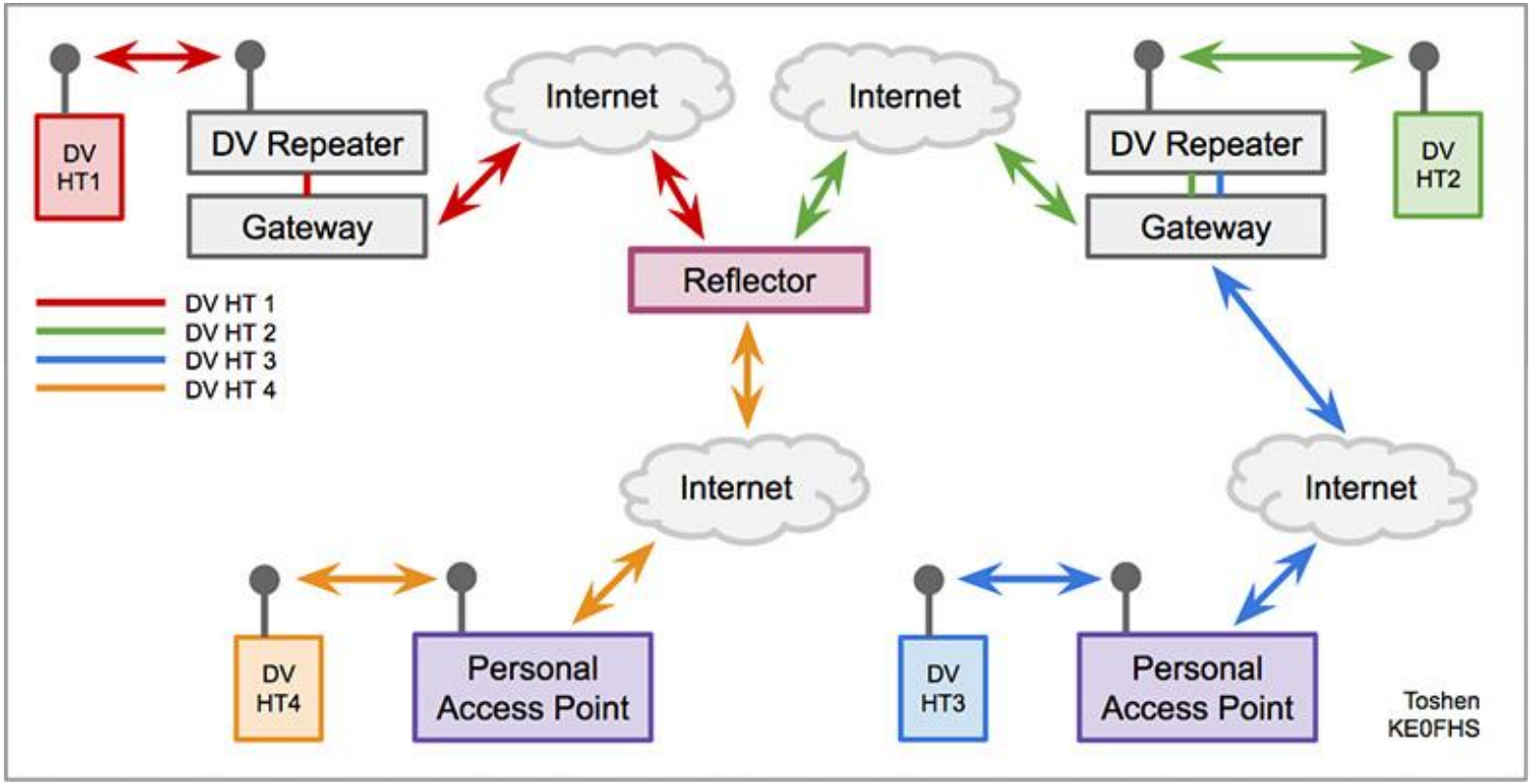

To a reflector :

```
431.0000
UR: XRF223BL
R1: KE0FHS B
R2: KE0FHS G
MY: KE0FHS
```

```
431.0000
UR: CQCQCQ
R1: KE0FHS B
R2: KE0FHS G
MY: KE0FHS
```

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Dooren Electronic Solutions **DVMEGA**

- This model mounts on a Raspberry Pi (RPi)
- Supports D-STAR, DMR, System Fusion (w/ latest firmware)
- Requires a DV-capable radio (includes stubby antenna mount)
- Requires an app: DStar Commander or other images
- Created by Guus van Dooren, PE1PLM
- UHF: ~$170 VHF: ~$130 (boards only)
- Antenna, RPi, case, power supply, cables, microSD card are extra

SharkRF **openSPOT**

- Standalone device, uses a wired connection to a WiFi router
- Supports D-STAR, DMR, System Fusion
- Requires a DV-capable radio (and browser for setup)
- Easy to set up and use, and excellent documentation
- Created by Ákos Marton, HG1MA, Norbert Varga, HA2NON
- ~$240 (includes case, antenna, cables, power supply, app)

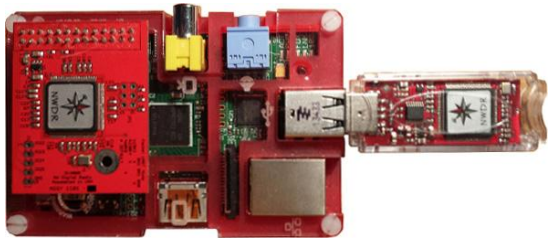
Internet Labs **DV Dongle**, **DVAP** & **DV3K**

- DV (blue) and DV3K include AMBE chip (no radio required)
- DV Access Point Dongle (red), requires D-STAR radio
- Both devices require a PC running Windows or a Mac
- Native DVTools or DVAPTools apps limited to REF reflectors
- Also possible to connect to RPi with a 3rd-party app
- Created by Robin Cutshaw, AA4RC, Moe Wheatley, AE4JY
- UHF: ~$260 VHF: ~$240
- DV Dongle: ~$190
- DV3K: ~$150

Micro-Node International **Nano-DV**

- Standalone device with a small built-in display
- Requires a D-STAR, DMR, or System Fusion radio
- Plug-n-play, 70 cm
- $495 (includes stubby antenna, power supply, cables)

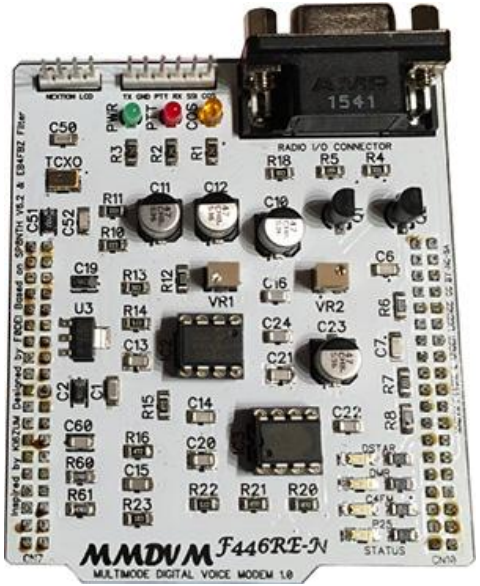
NW Digital Radio **PiDV** & **ThumbDV**



- PiDV shown mounted on an RP
- ThumbDV shown plugged into an RPi, but also can be plugged into a PC running Windows or a Mac
- Both devices include an AMBE chip (no radio required)
- D-STAR only
- Created by Bryan Hoyer, K7UDR, Basil Gunn, N7NIX, John Hays, K7VE, and Dennis Rosenauer, AC7FT
- PiDV: $100 ThumbDV: $120

MMDVM **Multimode Digital Voice Modem**

- Supports D-STAR, DMR, and System Fusion
- Requires an RPi, a ZUM board and microcontroller, a radio, possibly a DR-1X repeater, etc.
- Requires appropriate apps
- Most technically challenging/interesting
- Created by Jim Mclaughlin, KI6ZUM, Bruce Given, VE2GZI, Jonathan Naylor, G4KLX
- ~$60 - $85



Wireless Holdings **DV4mini**

- USB stick that can plug into a PC running Windows or Linux, or a Raspberry Pi
- Requires a D-STAR, DMR, or System Fusion radio
- Comes in UHF and VHF flavors
- App: DV4mini Control Center
- Created by Uli Altvater, AG0X/DH6SAB, Torsten Schultze, DG1HT
- UHF: ~$150 VHF: ~$170 AMBE: ~$230

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Choosing a way forward: **Two key questions**

Who do you want to talk with and which systems do they use?

Choosing a way forward: **Two key questions**

Who do you want to talk with and which systems do they use?

- D-STAR
- DMR
- System Fusion

Choosing a way forward: **Two key questions**

Who do you want to talk with and which systems do they use?

- D-STAR
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How close to the cutting edge can you travel comfortably?

Choosing a way forward: **Two key questions**

Who do you want to talk with and which systems do they use?

- D-STAR
- DMR
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How close to the cutting edge can you travel comfortably?

- Safe, but limited option: DV3K
- More interesting: openSPOT, DVMEGA
- Cutting edge: MMDVM

Choosing a way forward: **Radios**

- There are a lot of good Icom D-STAR-capable radios available

- Kenwood also now has a D-STAR HT, the TH-D74

- There are a lot of DMR radios available, many inexpensive
- And Yaesu has a few System Fusion radios available

Choosing a way forward: **Hotspots**

A means to an end or part of the journey?

Choosing a way forward: **That's a feature . . .**

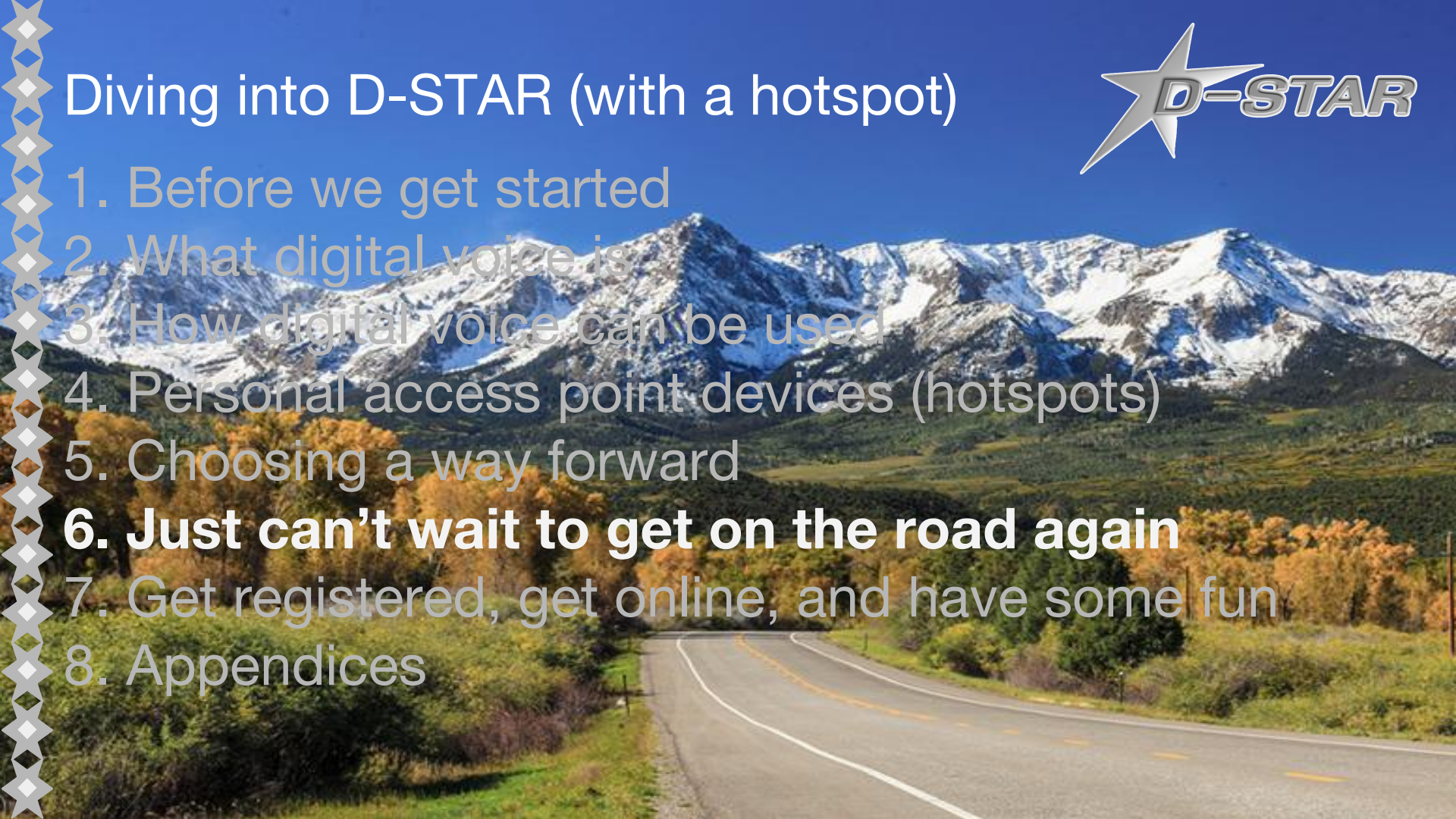
"Still, the Raspberry Pi is far, far away from being as user friendly as a PC or Mac.

That's a feature, not a bug.

The Raspberry Pi is built
to force you to learn troubleshooting,
and that's still one of my favorite things about it."

- Thorin Klosowski, "What I've Learned From Tinkering With the Raspberry Pi for Five Years"

Diving into D-STAR (with a hotspot)



1. Before we get started
2. What digital voice is
3. How digital voice can be used
4. Personal access point devices (hotspots)
5. Choosing a way forward
6. **Just can’t wait to get on the road again**
7. Get registered, get online, and have some fun
8. Appendices

On the road: **BlueStack** & **BlueDV**

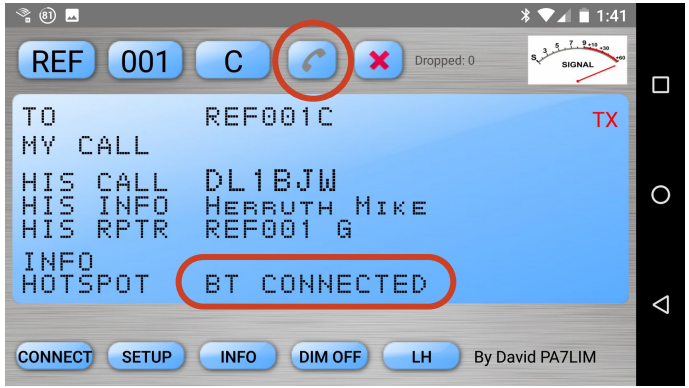
- Dooren Electronic Solutions BlueStack-Micro-plus
- Provides connectivity from a DVMEGA RPi board
  - **via Bluetooth** to an Android phone running BlueDV app
  - **via USB Ser2net** to a PC running BlueDV app
- BlueDV app provides connectivity for D-STAR, DMR, System Fusion
- Requires a DV-capable radio

On the road: **BlueStack** & **BlueDV**

Internet

Reflector REF001C

BlueDV
Android



DVMEGA
& BlueStack

D-STAR
Radio

On the road: **BlueStack** & **BlueDV**

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Get registered: **D-STAR Gateway** & **CCS7**

For D-Plus REF, register with the D-STAR Gateway System:

- D-STAR Self Registration Instructions
  http://dstargateway.org/D-Star_Registration.html

For D-STAR DCS and DMR, register for a CCS7 ID:

- DMR User / Repeater Registration form
  https://dmr-marc.net/cgi-bin/trbo-database/register.cgi

Get online: **Some D-STAR nets**

MON Charlotte Raspberry Pi Net: REF038 C, 8p MTN

MON PRA D-STAR Net: XRF223 B, 8:30p MTN

TUE Colorado D-STAR Net: REF035 B, 8p MTN

TUE PAPA System DSTAR Tech Net: REF012 A, 9p MTN

THU DSTAR Roundtable Net: XRF002 A, 9p MTN

THU PAPA All Digital Round Table: REF012 A, 9p MTN

SAT Saturday Night D-STAR Net: REF029 A, 8p MTN

SUN Arizona D-STAR Net: REF009 C, 5p MTN

SUN Int'l D-STAR Net: REF001 C, 6p MTN

Have some fun: **Experiment!**

Today's amateur radio experimenter is as likely to use a keyboard as a soldering iron for experiments, and as a digital enthusiast, I can only cheer and encourage you to get involved and have some fun.

Don Rotolo, N21RZ
Vocoding: Creating Digital Voice, CQ Amateur Radio

Diving into D-STAR with a hotspot

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8. **Appendices**

Thanks, Elmers!

Starr, N0AES, president of the Longmont Amateur Radio Club, W0ENO
Parker Radio Association, K0PRA, XRF223
John Hays, K7VE, Northwest Digital Radio
Ed Woodrick, WA4YIH, D-STAR Info
Mike, N0VF

For more info

Diving into D-STAR: www.ke0fhs.com/d-star.htm
Demodulating DMR: www.ke0fhs.com/dmr.htm

In both articles, especially see section 6) Links to resources I've found helpful:

- D-STAR: www.ke0fhs.com/d-star.htm#helpfullinks
- DMR: www.ke0fhs.com/dmr.htm#helpfullinks

References

For a full list, visit Diving into D-STAR > Links I've found helpful

D-STAR Info website
Hotspot Soup, 2016, and Trends in Digital Voice, 2016, by Adam, W0AKO, Parker Radio Association
Digital Voice Progress - 2016 (PDF) by Roland Kraatz, W9HPX, Charlotte Digital Radio Group
A Look inside D-STAR Modulation by Bob Witte, K0NR, 2009
Intro to D-STAR by George Zafiropoulos, KJ6VU, 2011
Kenwood TH-D74 Group
D-STAR Training (YouTube video) presented by John Davis, WB4QDX, at D-STAR InfoCon 2016
Kenwood TH-D74 Quick Start (YouTube video), 2016, by Don Arnold, W6GPS
Kenwood MCP-D74 Memory Control Program for the TH-D74A/E
Vocoding: Creating Digital Voice, by Don Rotolo, N21RZ, *CQ Amateur Radio*
D-star, DMR, Fusion, Which is right for you?, 2016, by Mike Myers, K3DO
What I've Learned From Tinkering With the Raspberry Pi for Five Years, 2017, Thorin Klosowski
DVMEGA, DStar Commander, BlueStack-Micro-plus, BlueDV
ircDDB Call Sign Routing: Using Node Routing via a Raspberry Pi D-STAR Hotspot, 2017, by Jeff, VE6DV

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for my Diamond X50A antenna
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