Many slides adopted from:
Roland Kraatz  W9HPX
John Davis  WB4QDX
Background and Update on DSTAR
with
A Comparison of Amateur Radio Digital Voice Systems

KENT HUFFORD
KQ4KK
APRIL 21, 2015
Topics

- DSTAR
- Digital voice description
- Technical comparison
- Operational features
- Programmability
- Radio choices
- Q & A

See p30 April 2015
QST
What is Digital Voice?

- Digital data modulating an RF carrier
- The data is digitized audio from an A/D converter
- It is processed through a vocoder to compress the data and add forward error correction
- The data is sent serially in uniform length packets
- Header data is pre-pended to provide sync bits, routing instructions and user identity
- Other data is often interleaved or substituted for the voice to send text, pictures or other files
D-STAR Continues to Grow

- As of January 1, 2015 – 1,147 DPlus Gateways, over 2,738 Voice Repeaters, 225 Data Modules and 38,724 registered users on US Trust Server.
- Over 1,200 Internet connected repeaters in US,
- Over 270 DSTAR Reflectors
- Does not include ircDDB repeaters
DSTAR Repeater Stack Locations

47 repeaters in GA (less 1.2g)
19 repeaters in SC (less 1.2g)
115+ DSTAR “Devices” in CSRA

VHF/UHF Stack going to Beech Island
D-STAR Radio Generations

1st Generation
- Utilize Standard Memories for D-STAR or FM

2nd Generation
- First Implementation of DR Mode

3rd Generation
- Current Implementation of DR Mode
- Nearest D-STAR Repeater

3rd Generation Plus
- Nearest FM Repeater
- CSV Import from SD Card
- High-Speed DV Data

<table>
<thead>
<tr>
<th>Generation</th>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Generation</td>
<td>ID-1</td>
<td>Aug-03</td>
</tr>
<tr>
<td></td>
<td>IC2200H</td>
<td>Mar-04</td>
</tr>
<tr>
<td></td>
<td>ID-800H</td>
<td>Mar-05</td>
</tr>
<tr>
<td></td>
<td>RP2000, RP4000</td>
<td>May-06</td>
</tr>
<tr>
<td></td>
<td>IC-91AD</td>
<td>May-06</td>
</tr>
<tr>
<td></td>
<td>RP2C, RP2D, RP2V – Upgraded Repeater</td>
<td>Jul-06</td>
</tr>
<tr>
<td>2nd Generation</td>
<td>ID-80 / ID-880H</td>
<td>Apr-09</td>
</tr>
<tr>
<td></td>
<td>ID-9100</td>
<td>Mar-11</td>
</tr>
<tr>
<td></td>
<td>ID-31</td>
<td>Apr-12</td>
</tr>
<tr>
<td></td>
<td>ID-51</td>
<td>Apr-13</td>
</tr>
<tr>
<td></td>
<td>ID-7100</td>
<td>Jul-13</td>
</tr>
<tr>
<td>3rd Generation</td>
<td>ID-5100</td>
<td>Apr-14</td>
</tr>
<tr>
<td></td>
<td>RS-MS1A Android App</td>
<td>Mar-14</td>
</tr>
<tr>
<td></td>
<td>ID-51+ Anniversary Edition</td>
<td>Oct-14</td>
</tr>
</tbody>
</table>
Software Extensions to D-Star By 3rd Parties

• **DPlus** linking and REF-type Reflectors (REF014)
  – Add-on to existing ICOM Gateway server
  – D-Star’s “Killer App“ – Linking is easier and natural

• **ircDDB** – faster Callsign Routing (add-on)

• **G4KLX ircDDBGateway** (replaces ICOM gateway)
  – DPlus, DExtra, DCS Linking support
  – CCS - MUCH Improved Callsign Routing
  – Split Repeater
DR Mode – Easiest to Use

- DR Mode is Digital Repeater Mode
- Current generation of radios have two sets of memories
  - Regular Memories for traditional frequency storage
  - Repeater List is geocoded for location-based lookup
- Easy to Use
  - Press DR
  - Select Source Repeater in FROM field
    - Pick by region
    - Find Nearest Repeater to current location
  - Select function in TO field
- Automatic Programming of Radio
What Repeater?

- Select FROM field:
- **Repeater List** shows region, then list of repeaters
- **Near Repeater** uses built-in GPS to show list of nearest repeaters
Which CQ?

- Select TO on screen
- DO NOT USE Local CQ
  - Shows as CQCQCQCQ
- 3rd Generation (ID-31, ID-51, ID-7100)
  - Select “Your Call Sign”
  - Select “Use Repeater” to talk
- 3rd + Generation (ID-51+, ID-5100)
  - Select (“Reflector”)
  - Select (“Use Reflector”) to talk
Linking to Reflectors

- To link to a Reflector, select Reflector, Link to Reflector, Direct Input, then select Reflector and Module.

Once a Reflector has been selected, it’s listed for quick selection.
D-STAR ICOM Android App

- Free app for Android phones, tablets – RS-MS1A
  - Works with ID-51A, (+), 7100, with OPC-2350LU cable
  - ID-5100 using cable or Bluetooth
- Use to display DR and radio settings
- Send/receive photos between compatible radios
- Text messaging in familiar look
- Expanded Repeater List
The optional OPC-2350LU data cable is required to connect to an Android™ device.

DV Fast Data Mode

Text messaging example

DR function setting example

Repeater map example
Windows 8.1 Tablets

- Windows 8.1 tablets have full size USB A host port
- Supports DV Dongle, DVAP or connection to D-STAR radio data port for D-RATS
- Programming radios using current Windows-based programs
- WinBook 7” for $69.99 from MicroCenter and Amazon
- Also available in 8” and 10” versions
D-RATS

Use on any DSTAR device

Also as x.25 Packet software

Free
New Raspberry Pi

- Raspberry Pi 2 Model B now available
- Faster Processor – Quad core ARM 7
- More RAM – 1 GB
- Keeps 4 USB ports and micro SD as in Model B+
- Great for DV Dongle, DVAP, D-RATS applications

$35
AMBE 3000 Info

- Field reports indicated better audio in devices using AMBE 3000.
- DVS1 reports that improved algorithm results in better voice quality
  - AMBE 3000 to AMBE 2020
  - AMBE 3000 to AMBE 3000
- No difference in AMBE 2020 to AMBE 3000
- AMBE 3000 chip has the “ability” to hold DSTAR, DMR and FUSION “code”
Pictorial view

Radio Header:
- Bit Sync
- Frame Sync
- Flag 1
- Flag 2
- Flag 3
- 8 byte
- 8 byte
- 8 byte
- 4 byte
- 2 byte
- 72 byte
- 24 byte

Data Frame:
- Voice Frame
- Data Frame
- Voice Frame
- Data Frame

Error correction: 660 bit

30 ms
- Data
- Data
- Data

330 ms
- Voice
- Voice
- Voice
- Voice
- Voice
- Voice
- Voice
- Voice
- Voice
- Voice
- Voice

30 ms
- Voice
- Voice
- Voice

Number of bits:
- FS
- FICH
- DCH (0)
- VCH (0)
- VCH (1)
- DCH (1)
- VCH (1)
- DCH (2)
- VCH (2)
- DCH (3)
- VCH (3)
- DCH (4)
- VCH (4)
- Total 960 bit
<table>
<thead>
<tr>
<th></th>
<th>D-STAR</th>
<th>DMR</th>
<th>Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocoder (see note)</td>
<td>AMBE+</td>
<td>AMBE+2</td>
<td>AMBE+2</td>
</tr>
<tr>
<td>Forward Error Corr.</td>
<td>Voice Only</td>
<td>Voice Only</td>
<td>Voice Only</td>
</tr>
<tr>
<td>Modulation</td>
<td>GMSK</td>
<td>4FSK</td>
<td>C4FM</td>
</tr>
<tr>
<td>Multiplex Method</td>
<td>FDMA</td>
<td>TDMA</td>
<td>FDMA</td>
</tr>
<tr>
<td>Transmission Rate</td>
<td>4.8 kbps</td>
<td>4.8 kbps x 2</td>
<td>9.6 kbps</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>6.25 kHz</td>
<td>12.5 kHz</td>
<td>12.5 kHz</td>
</tr>
<tr>
<td>Channels supported</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Standard Developer</td>
<td>JARL</td>
<td>ETSI</td>
<td>Yaesu</td>
</tr>
</tbody>
</table>

GMSK = Gaussian Minimum Shift Keying
4FSK = 4-level Frequency Shift Keying
C4FM = Continuous 4-level Frequency Modulation
FDMA = Frequency Division Multiple Access
TDMA = Time Division Multiple Access

Note: Newer radios implement the vocoder in the DSP chip
Bandwidth Comparison

- **D-STAR**: 6.25 kHz
- **DMR**: 12.5 kHz
- **Fusion**: 12.5 kHz
# Official FCC Emission Designators

<table>
<thead>
<tr>
<th>Mode</th>
<th>Designator</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM</td>
<td>16K0F3E</td>
<td>16 KHz</td>
</tr>
<tr>
<td>D-STAR</td>
<td>6K00F7W</td>
<td>6 KHz</td>
</tr>
<tr>
<td>DMR</td>
<td>7K60FXE</td>
<td>7.6 KHz</td>
</tr>
<tr>
<td>NXDN</td>
<td>4K00F1E</td>
<td>4 KHz</td>
</tr>
<tr>
<td>P25</td>
<td>8K00F1E</td>
<td>8 KHz</td>
</tr>
</tbody>
</table>

FUSION(C4FM) similar to DMR 7.6-8 KHZ

Mixed mode tho would be FM

Source – GA SERA Freq Coordinator
User Identification

<table>
<thead>
<tr>
<th>Registration required?</th>
<th>D-STAR</th>
<th>DMR</th>
<th>Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>User identity</th>
<th>Call sign</th>
<th>Subscriber ID</th>
<th>Call sign</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>ID displayed on radio’s display</th>
<th>Call sign</th>
<th>Subscriber ID*</th>
<th>Call sign</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Other text display options</th>
<th>4 characters</th>
<th>20 characters</th>
<th>No</th>
<th>No</th>
</tr>
</thead>
</table>

| Adequate for FCC ID?            | Yes†        | No            | Yes† |

* Call sign displayed if the receiving station’s subscriber ID is in the radio’s contact list; otherwise subscriber ID appears.

† IDing by voice is still a good idea for the benefit of everyone listening.
## Repeater Connectability

<table>
<thead>
<tr>
<th>Feature</th>
<th>D-STAR</th>
<th>DMR</th>
<th>Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talk locally</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Link to another repeater</td>
<td>Yes</td>
<td>No</td>
<td>No (end of 2015)</td>
</tr>
<tr>
<td>Multi-repeater connection</td>
<td>Reflectors</td>
<td>Talk Groups</td>
<td>Rooms</td>
</tr>
<tr>
<td>Selection method</td>
<td>UR entry</td>
<td>Channel Dial</td>
<td>DTMF</td>
</tr>
<tr>
<td>Route to another ham</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Echo test</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Request link status</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
## Radio Operating Features

<table>
<thead>
<tr>
<th></th>
<th>D-STAR</th>
<th>DMR</th>
<th>Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeater channel selection</td>
<td>Dial</td>
<td>Dial</td>
<td>Dial</td>
</tr>
<tr>
<td>Repeater connection selection</td>
<td>Dial</td>
<td>Dial</td>
<td>DTMF code</td>
</tr>
<tr>
<td>Mode selection method</td>
<td>Key press</td>
<td>Program</td>
<td>Key press *</td>
</tr>
<tr>
<td>Radio programming complexity</td>
<td>Difficult/Easy ◊</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
<tr>
<td>Newbie learning curve</td>
<td>Steep</td>
<td>Fairly easy</td>
<td>Easy</td>
</tr>
<tr>
<td>User manual pages - older HT</td>
<td>131 (IC-91)</td>
<td>65 (CS-700)</td>
<td>247 (FT-1D)</td>
</tr>
</tbody>
</table>

* Fusion radios have AMS (automatic mode select)

◊ Older D-STAR radios are more difficult to program. Newer ones are pre-programmed, but must be updated occasionally as repeaters change.
## Signal Readability

<table>
<thead>
<tr>
<th></th>
<th>FM</th>
<th>D-STAR</th>
<th>DMR</th>
<th>Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice naturalness</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Best</td>
</tr>
<tr>
<td>Signal noise</td>
<td>Varies</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Sync robustness</td>
<td>N/A</td>
<td>Fair</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Sync recoverability</td>
<td>N/A</td>
<td>Poor</td>
<td>Best</td>
<td>Best</td>
</tr>
</tbody>
</table>

Sync robustness is the tendency to fall out of sync
Sync recoverability is the ability to recover sync quickly

The opinions shown here are highly subjective. Your opinion may be different.
Networking Characteristics

- **D-STAR**
  - User control capability – excellent
  - Networking options – G2, D-Plus, ircDDB
  - Innovation ability – many efforts and accomplishments

- **DMR**
  - Centrally controlled structure – inflexible
  - Networking options – c-bridge, hytera
  - Innovation ability – limited

- **Fusion**
  - Yaesu controlled servers – inflexible
  - Networking options – WIRES-X
  - Innovation ability – limited
## D-STAR HT’s

<table>
<thead>
<tr>
<th>ID-31A</th>
<th>ID-51A Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single band (70cm)</td>
<td>Dual band</td>
</tr>
<tr>
<td>5W</td>
<td>5W</td>
</tr>
<tr>
<td>uSD card record</td>
<td>uSD card record</td>
</tr>
<tr>
<td>500 memories</td>
<td>1300 memories</td>
</tr>
<tr>
<td>Internal GPS</td>
<td>Internal GPS</td>
</tr>
<tr>
<td>Repeater geo search</td>
<td>Repeater geo search</td>
</tr>
<tr>
<td>$295 new</td>
<td>$450 new</td>
</tr>
</tbody>
</table>
D-STAR Mobile’s

Older – ID-880H
- Dual band
- 50W
- 1050 memories
- $420 new

Newer – ID-5100A
- Dual band Touch Screen
- 50W
- 1000 + 1200 DR memories
- Internal GPS & DPRS
- uSD card data base and recording
- Repeater geo search
- $600 new
D-STAR HF/VHF/UHF Transceivers

**IC-7100**
- DSTAR on all bands
- 100/50W
- Touch Screen
- SD Card and Full USB control
- $1200 new

**IC-9100**
- DSTAR on all bands with card
- 100/100/100W
- Two bands at once
- Satellite tracking mode
- Full USB control
- $2500 new, plus DSTAR card
D-STAR on HF

- Icom IC-7100 and IC-9100 are both DV capable on HF
- Other ICOM, YAESU AND KENWOODs with 6 pin DATA ports can be made DV capable with STAR board and DVDongle
- Operates at similar bandwidth to AM – 6.2khz
- D-STAR HF net now operating six times a week
D-STAR on HF

International DSTAR HF Testing Net –

- Routinely have two way communications coast to coast, to Canada, Europe and Australia. We have had two way contacts to Japan. And have been heard in South Africa
- We are on each band only for 5 min
- MONITOR REF030C to coordinate
- Do not want to step on any AM or SSB activity
- Use web page to keep track - [http://hf.dstar-relay.net/](http://hf.dstar-relay.net/)
- Check-in to this web site anytime 24/7 to find a DSTAR HF Ham
- FREE FORM PRENET for 30 min. before the start of the scheduled NET.
- See how to do DSTAR HF with an ICOM at- [http://www.youtube.com/watch?v=oGF-qkdoid4](http://www.youtube.com/watch?v=oGF-qkdoid4)
- "Digital voice is defined in the Commission’s rules as voice (i.e. phone), not data, per Section 97.3(c)(5) of the Rules."

AMATUER DMR
Networked Repeaters

12 REPEATERS in GA

14 REPEATERS in SC

221 in USA
DMR HT’s

MotoTrbo – XPR-7550

- 440 MHz band
- 4W
- 1000 channels
- $700 new

Hytera PD782G-U1

- 440 MHz band
- 4W
- 1024 channels
- $545 new
DMR HT’s (cont.)

Connect Systems – CS700

- 440 MHz band
- 4W
- 1000 memories
- $200 – 250 new
Beifeng TD501 DMR
UHF 400-470MHz
Digital

$270
AMAZON.COM
DMR Mobile’s

MotoTrbo - XPR-5550

- 440 MHz band
- 40W
- 1000 channels
- $ 600 new

Hytera – MD782G-U1

- 440 MHz band
- 45W
- 1024 channels
- $ 530 new
DR-1X Duty Cycle

- 50% at 50 Watts
- Will cut power back with excessive heat
- Even though power is cut back, excessive heat is still causing abuse of the finals/relays.
- Be Aware of your power settings and adjust appropriately.
System Fusion HT’s

Yaesu – FT-1DR

- Dual band
- 5W
- Automatic Mode Select
- 900 memories
- GPS & APRS
- $300-310 new

Yaesu FT-2DR (new)

- Dual band
- 5W
- Automatic Mode Select
- 1245 channels
- GPS & APRS
- Touch screen
- On sale late May 2015
  $550 new
System Fusion Mobile

Yaesu – FTM-400DR

- Dual band
- 50W
- Automatic Mode Select
- 900 memories
- GPS & APRS
- Bluetooth
- uSD Card
- Color Touch screen
- $500 new
YAESSU FUSION WIRES-X HRI-200

$125
HRI-200 Interface

- Only Supports DR-1X in Analog Mode
- Digital Linking coming soon
- All repeater features not yet known
- Plugin System in WiRES-X Software
- Requires a PC and Internet Connection
17 YAESU WIRES-X IDs issued in Georgia
   (1 in the CSRA)
5 Yaesu System Fusion (C4FM) capable repeaters found in Georgia
   (2 in Waynesboro)

NO WIRES capable REPEATERS FOUND in Georgia

1 WIRES-X ID issued in South Carolina

1 Yaesu System Fusion (C4FM) capable repeater found in South Carolina

1 WIRES capable repeater found in South Carolina

358 WIRES-X IDs issued in USA

As of Apr 21, 2015
System Fusion HF/VHF/UHF

Yaesu – FT-991

- All Mode MF/HF/VHF/UHF
- C4FM Digital Capable
- 100/50W
- USB Capable
- Color Touch screen
- $1670 new
Installation Program Shirts - First Quarter 2015

- 300 Shirts are on Order
- Estimated Shipping Day May 5th, 2015.
- Club name and callsign will appear
- Some people will receive a final confirmation
- If you have already received a confirmation please disregard
Other Digital Voice Suppliers

**DV Dongle**
- Internet Labs
- **DSTAR** on your PC
- $190 new

**Thumb DV**
- Northwest Digital Radio
- **DSTAR** on your PC
- Uses AMBE 3000
- Other modes?
- $120 new
Other Digital Voice Suppliers

**STAR Board**

**GMSK Node Adapter**

- Make your PC or PI a **DSTAR** Hot Spot with FM mobile
- Add DVDongle and make FM or HF a DSTAR radio
- $119 new

**STAR* DV**

- **D-STAR** on your PC or PI
- Uses AMBE 3000
- Connector for Speaker/Mike
- $129 new
Other Digital Voice Devices

**DV Access Point**
- Internet Labs
- **DSTAR** Hotspot repeater
- Single band
- 2M $240 new
  70 cm $270 new

**DV Mega**
- Guus van Dooren PE1PLM
- **DSTAR** Hotspot repeater
- Dual band
- $139 new or PI kit from GigaParts for $230
D-HAP

- Add DVAP (DSTAR HOT SPOT)
- Contains Raspberry PI, Wi-Fi, Batteries
- $300
Transmit D-Star DV over Analog FM radio

Diagram showing the connection process:
- Mike connected to a DV Dongle
- DV Dongle connected to a PC with 1 soundcard
- PC with 1 soundcard connected to a GMSK modem
- GMSK modem connected to an Analog Radio
Not near a D-STAR Repeater? Make your own – with this...
Or this…
Raspberry Pi G4KLX GUI
The End of Modes

- Amateur Radio is facing the end of modes.
- While voice, text, and video were formerly their own modulations, these all become just different kinds of data carried over some form of digital radio.
- What formerly were modes will now just be different bandwidths of digital radio channels. What “mode” those channels carry will change from moment to moment.

Bruce Perens K6BP
For More Information

- www.dstar101.com
- www.dstarinfo.com
- www.dstarusers.org
- www.maryland-dstar.org - for Raspberry Pi enthusiasts
- www.dmr-marc.net
- www.trbo.org
- www.youtube.com/watch?v=C1ClH3R17m0 – Unscientific simplex field comparison.
- https://www.moencomm.com// - STAR*DV board
QUESTIONS?

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