

A Comparison of Amateur Radio Digital Voice Systems



We want to thank
Roland Kraatz W9HPX of the
Charlotte Digital Radio Group
Who let us use some of these Slides
from a presentation he gave at the
Charlotte Hamfest

A Comparison of Amateur Radio Digital Voice Systems



Presented and Modified by:

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BARC April 11th 2015 Club Meeting



Topics

- Digital voice description
- Technical comparison
- Operational features
- Programmability
- Radio choices
- Utah DV repeaters
- Information sources
- Q & A



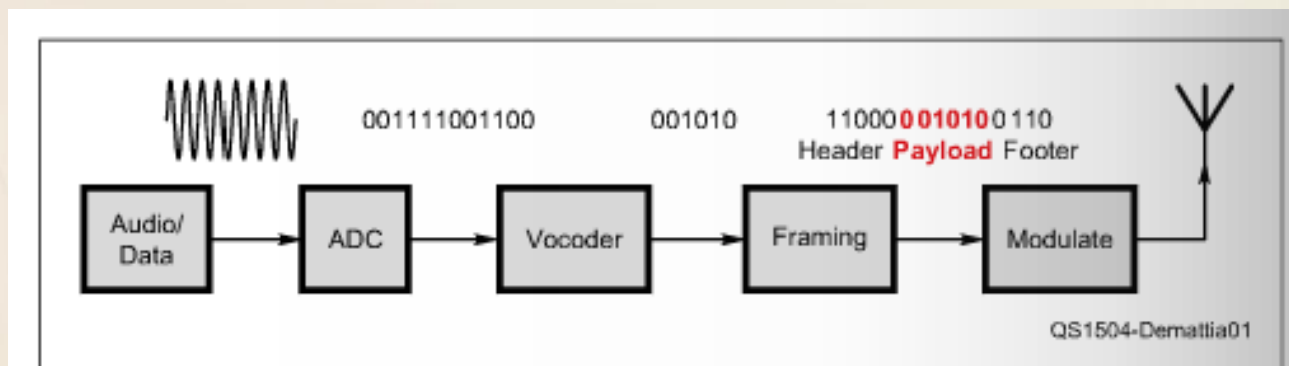
See p30 April 2015 QST

Something to think about First!

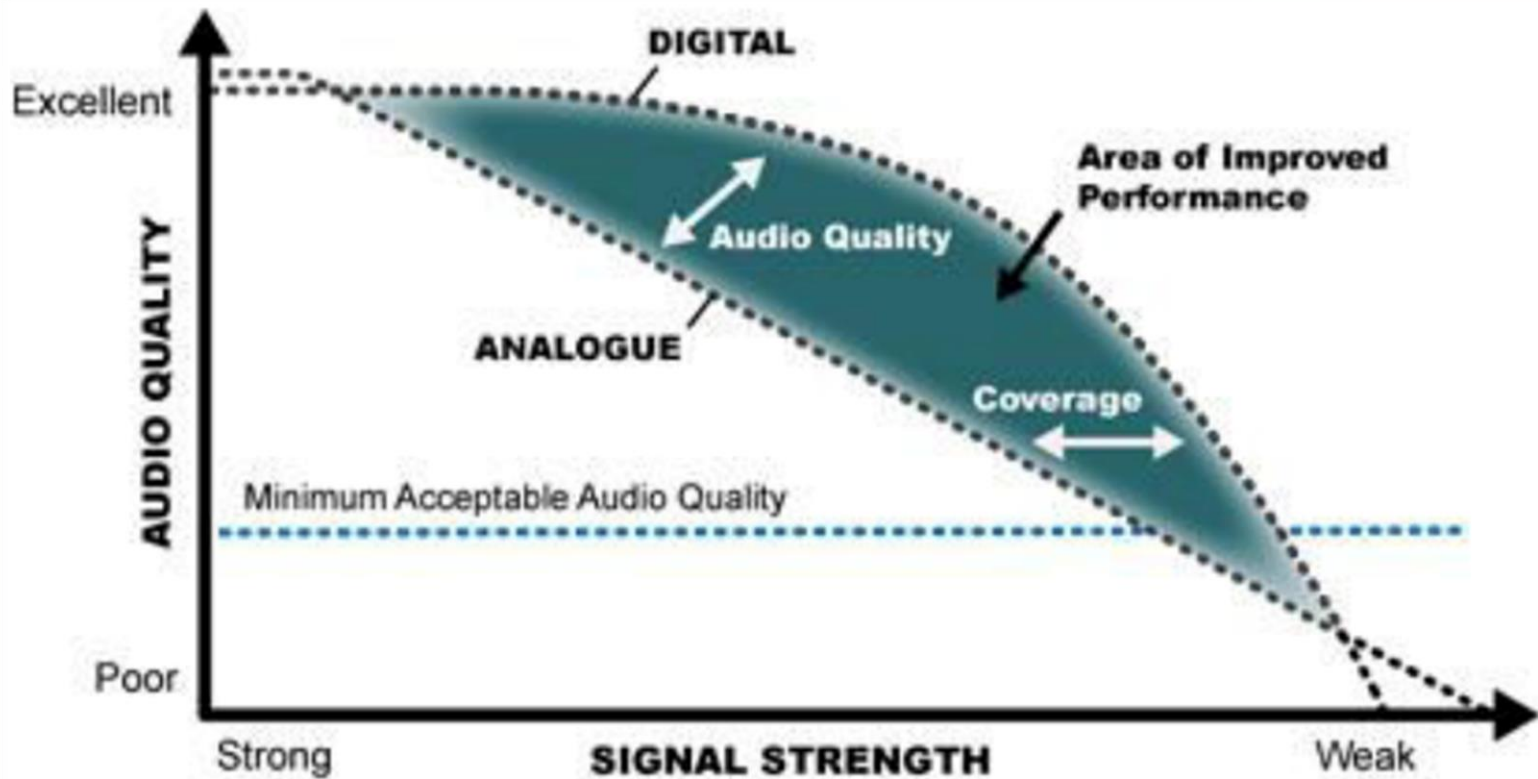
- If you're thinking of making the leap from analog FM to digital, the system that is best for you will depend on several factors.
- The most important question to ask is the most obvious: which modes are active in your area?
- With out a compatible digital repeater, you'll be confined to simplex operation and maybe with no one to talk to but yourself!

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



Digital Voice has Improved Performance



Tech Spec Comparison

	D-STAR	DMR	Fusion
Vocoder (see note)	AMBE+	AMBE+2	AMBE+2
Forward Error Corr.	Voice Only	Voice Only	Voice Only
Modulation	GMSK	4FSK	C4FM
Multiplex Method	FDMA	TDMA	FDMA
Transmission Rate	4.8 kbps	4.8 kbps x 2	9.6 kbps
Bandwidth	6.25 kHz	12.5 kHz	12.5 kHz
Channels supported	1	2	1
Standard Developer	JARL	ETSI	Yaesu

GMSK = Gaussian Minimum Shift Keying

4FSK = 4-level Frequency Shift Keying

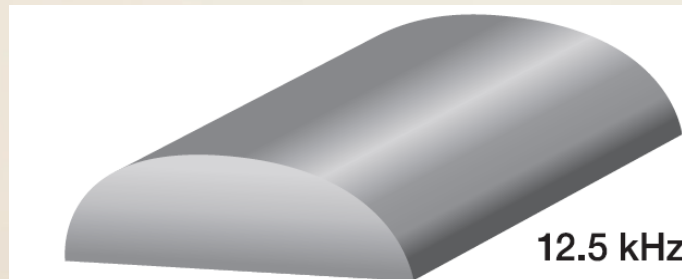
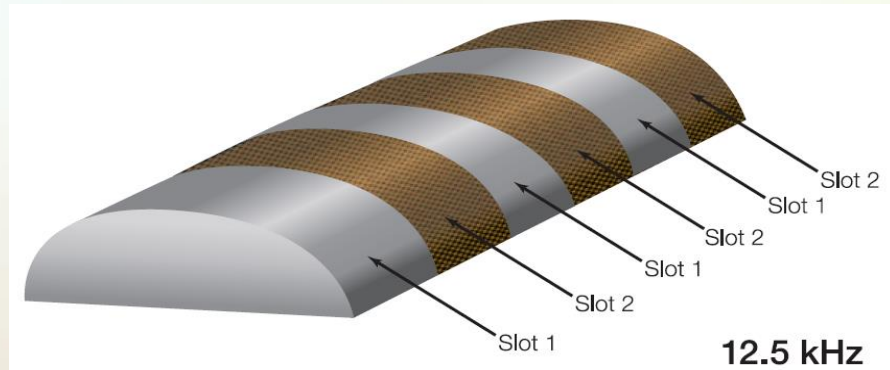
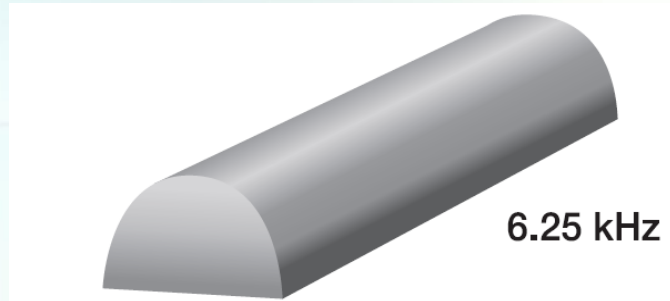
C4FM = Continuous 4-level Frequency Modulation

FDMA = Frequency Division Multiple Access

TDMA = Time Division Multiple Access

Note: Newer radios implement the vocoder in the DSP chip

Bandwidth Comparison



User Identification

	D-STAR	DMR	Fusion
Registration required?	Yes	Yes	No
User identity	Call sign	Subscriber ID	Call sign
ID displayed on radio's display	Call sign	Subscriber ID*	Call sign
Other text display options	4 characters 20 characters	No	No
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.

Registration

www.dmr-marc.net



Contact Us

How can we help?

Please choose one of the following:

- [I have a general question or comment](#)
- [I'd like to report a system bug or suggest a feature to the Support Team](#)
- [I'd like a USER ID for my radio](#)
- [I'd like a REPEATER ID](#)



NU7TS.COM

[HOME](#) [NEWS AND EVENTS](#) [NEW SITES](#) [D-STAR USERS](#) [CONTACT US](#) [REGISTRATION](#) [NEW SITES](#)

Registration

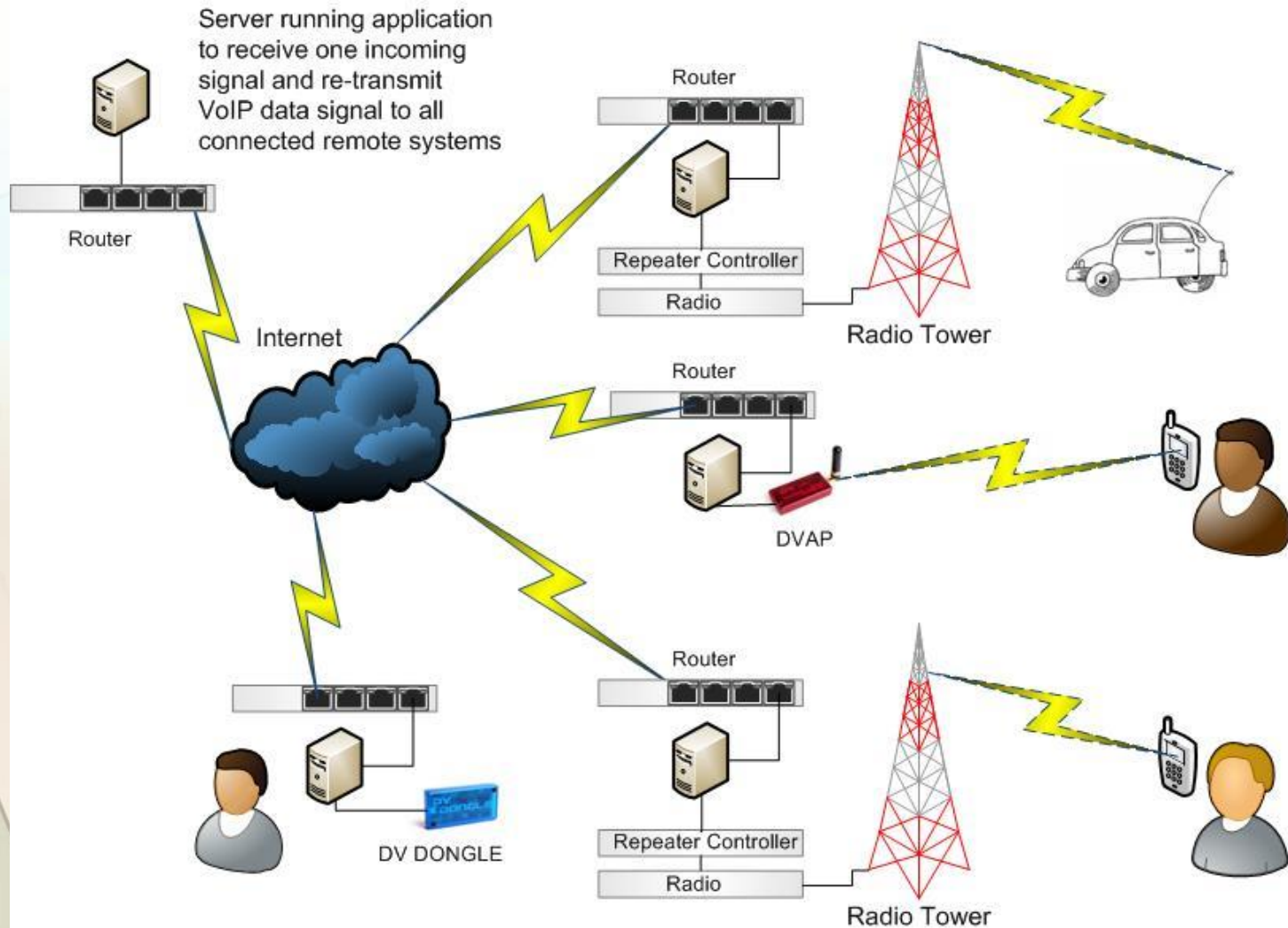
**NU7TS D-Star Gateway Repeater
Self Registration Instructions**

<https://nu7ts.dstargateway.org/Dstar.do>

D-Star CallSign Settings

- 4 CallSign Settings needed
 - Your Call = Destination **User or Command**
 - CQCQCQ, WA7KMF, REF029CL, -----U
 - Repeater 1 = Originating **User System**
 - NU7TS B, N7RDS B, KF7VJO B, AC70 C
 - Repeater 1 = Local or Gateway
 - NU7TS G, N7RDS G, KF7VJO G, AC70 G,
AC70 B
 - My Call = Originating **User**
 - AC7II

D-Star Reflectors



Reflector REF029

DPLUS Dashboard | Reflector Status and Control

Registration

REF029 Reflector System

DREFD version 1.28

Linked Gateways

Module A	Module B	Module C	Module D	Module E
		AC7O B		
		AC7O C		
		KF7YIX B		
		KF7YIX C		
		KM7ARC B		
		KM7ARC C		
		NU7TS B		
		WR7AAA B		
		WR7AAA C		

Remote Users

Callsign	User Message	Last TX on	Type
AC7II		C	HotSpot
WA7KMF	Logan, Ut	C	HotSpot

Last Heard

Callsign	User Message	Last TX on	Time
W7JZU		C	2015/04/06 14:47:10

Status as of 2015/04/07 11:47:49

DMR - Digital Mobile Radio



What is Digital Mobile Radio

- Commonly known as “DMR”
- A standard for digital voice communications
- Published by the European Telecommunications Standards Institute (ETSI) in 2005
- The goal of the standard is to create digital systems that are:
 - Low cost
 - Low complexity
 - Interoperable between vendors





MOTOROLA

MOTOTRBO™

Shift into digital.

HARRIS

ZETRON.

Hytera
Respond & Achieve

DMR
DIGITAL MOBILE RADIO ASSOCIATION

ICOM

BFDX®

Vertex Standard

JVCKENWOOD

**东信
EASTCOM**

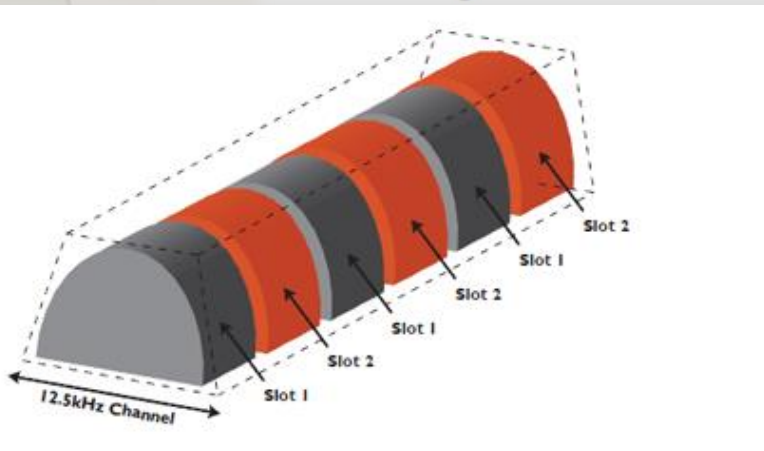
DMR - Longer Battery Life

“For each hour of usage the TDMA radios show between 19% and 34% less battery capacity is required than for the FDMA models.”

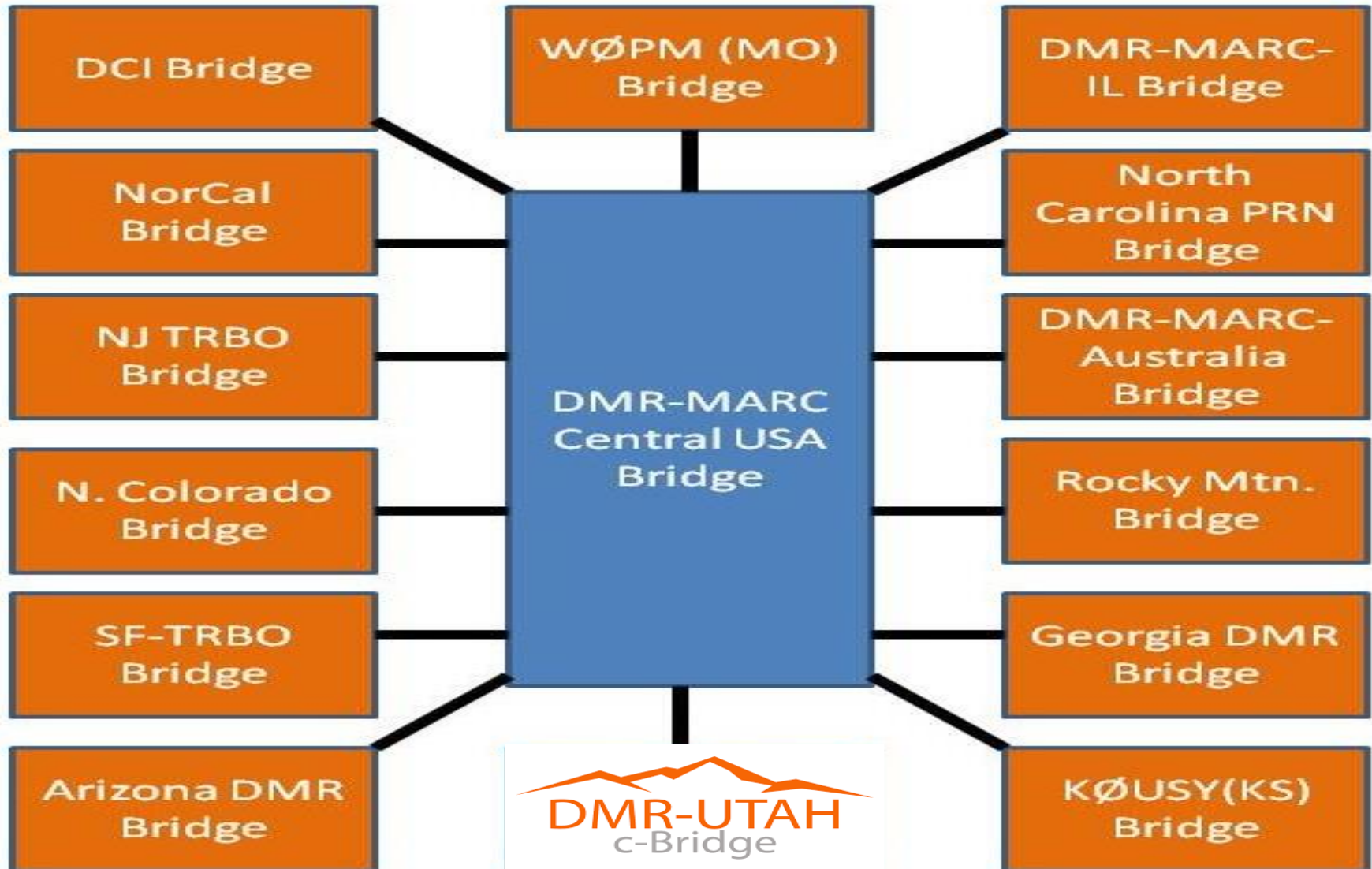
“By cutting the effective transmit time in half, two-slot TDMA can enable up to 40 percent improvement in talk time in comparison with analogue radios.”



- DMR Association



DMR Network Architecture



DMR Talk Groups

Repeater Info	Timeslot	Talkgroup ID	Talkgroup Name
NU7TS Logan 447.000- CC1 NU7TS Riverside 447.125- CC1	Timeslot 1	1	Worldwide
		13	WW English
		3	N America
		13149	Utah 2
		311	TAC 311
		9998	Echo Test
		9999	UV Meter
		2	Local
		3149	Utah 1
	Timeslot 2	76	76ers
		3177	Mountain
		310	TAC 310
		3100	Bridge
		314900	Salt Lake Local
		314901	Utah County Local
		222222	All TG's On
		111111	All TG's Off

Repeater Connectability

	D-STAR	DMR	Fusion
Talk locally	Yes	Yes	Yes
Link to another repeater	Yes	No	No
Multi-repeater connection	Reflectors	Talk Groups	Rooms
Selection method	UR entry	Channel Dial	DTMF
Route to another ham	Yes	No	No
Echo test	Yes	Yes	No
Request link status	Yes	No	No

Radio Operating Features

	D-STAR	DMR	Fusion
Repeater channel selection	Dial	Dial	Dial
Repeater connection selection	Dial	Dial	DTMF code
Mode selection method	Key press	Program	Key press *
Radio programming complexity	Difficult/Easy ◇	Difficult	Easy
Newbie learning curve	Steep	Fairly easy	Easy
User manual pages - older HT	131 (IC-91)	65 (CS-700)	247 (FT-1D)
User manual pages - newer HT	425 (ID-51)		

* 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

	FM	D-STAR	DMR	Fusion
Voice naturalness	Good	Fair	Good	Best
Signal noise	Varies	None	None	None
Sync robustness	N/A	Fair	Good	Good
Sync recoverability	N/A	Poor	Best	Best

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, Quadnet
 - Innovation ability - open standard, many accomplishments
- DMR
 - Common Air Interface
 - Centrally controlled structure - inflexible
 - Networking options - c-bridge, Smart PTT, IP Site Connect
 - Innovation ability - limited
- Fusion
 - Yaesu controlled servers - inflexible
 - Networking options - WIRES-X
 - Innovation ability - limited

D-STAR HT's



ID-91A

- Dual band Single Receive
- 5W
- 1304 memories
- Discontinued
- \$400 new



IC-92AD

- Dual band
- 5W
- 1304 memories
- GPS Mic. Available
- Water Proof
- \$450 new



D-STAR HT's



ID-31A

- Single band (70cm)
- 5W
- uSD card record
- 500 memories
- Internal GPS
- Repeater geo search
- \$295 new



ID-51A Plus

- Dual band
- 5W
- uSD card record
- 1300 memories
- Internal GPS
- Repeater geo search
- \$450 new



D-STAR Mobile's



Older - IC-2820

- Dual band Dual Receive
- Diversity Receive
- 50W VHF/UHF
- 522 memories
- \$600 new
- Requires Add on GPS and DV Module
- Discontinued Model



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
- SD card recording
- Repeater geo search
- \$600 new





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



Ham Friendly Dealers

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



DMR HT's (cont.)



Connect Systems - CS700 - Workhorse

- 440 MHz band
- 4W
- 1000 memories
- \$ 200 new
- Programming Cable \$15



New Connect System Radios

CS7000, CS700A & CS750



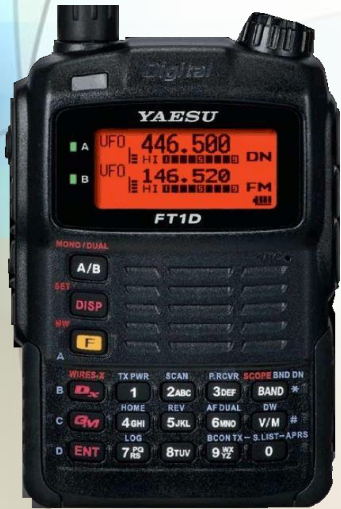
DMR
DIGITAL MOBILE RADIO ASSOCIATION

+

D-STAR



Yaesu System Fusion



System Fusion HT's



Yaesu - FT-1DR

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



Yaesu FT-2DR (new)

- Dual band
- 5W
- Automatic Mode Select
- 1245 channels
- GPS & APRS
- Touch screen
- \$600 new



System Fusion Mobile



Yaesu - FT-400DR

- Dual band
- 50W
- Automatic Mode Select
- 900 memories
- GPS & APRS
- Color Touch screen
- \$400 new



What Makes it “Fusion”?



- What sets this new technology apart from Dstar, DMR (MotoTRBO), etc? It's automatic backwards compatibility with analog FM
 - Every Fusion radio and repeater is aware of the current QSO and it's mode
 - If a QSO input starts as FM, the repeater “repeats” FM
 - If the QSO input starts as C4FM, it “repeats” C4FM
 - Each endpoint (HT, mobile, etc) auto-switches
 - GM function



What is C4FM and Fusion? (continued)

- Fusion framing has been openly documented by Yaesu in 2013 (unclear if it's freely licensed)
- FM envelope uses 12.5Khz BW (narrow FM)
- Uses a similar DVSI AMBE DSP chip used in DMR & P25 but newer than what's used in D*star - patent encumbered

Fusion's Wide Data mode - What can use it?

- Today, Yaesu sells a special hand-mic that includes a camera to send pictures to remote Fusion-enabled radios



- The radios also include a data cable to use the high speed data modes
 - Programs like D-RATS should be able to use this today

What's New & Next for Fusion?

- US Wires-X support for linking Fusion repeaters & Simplex nodes via the Internet



New base station radio: FT-991 that replaces the FT-897 with Fusion support



New FT-2D HT with touch Screen



Wires-X Internet Linking

- WIRES-X was recently released in the US so overall details and impressions are still too early
- “Rooms” are like IRLP Reflectors or Echolink Conferences
- When in a room, you can download “news” which can be text files, audio, & pictures
- Admins can individually “kick” or even “ban” callsigns

Other Digital Voice Suppliers

DV Dongle

- Internet Labs
- D-STAR on your PC
- \$200 new



Thumb DV

- Northwest Digital Radio
- D-STAR on your PC
- Uses AMBE 3000
- Other modes?
- \$120 new



Other Digital Voice Devices

DV Access Point

- Internet Labs
- Hotspot repeater
- Single band
- 2M \$240 new
- 70 cm \$260 new

DV Mega

- Guus van Dooren PE1PLM
- Hotspot repeater
- Dual band
- \$180 new



D-Hap

- Hardened Power Systems
- Self Contained Hotspot
- \$235 - \$365



Not near a D-STAR Repeater? Make your own - with this...



Raspberry Pi G4KLX GUI

The screenshot displays the Raspberry Pi desktop environment with a blue background and star patterns. The desktop includes icons for 'Other Icons', 'Read-Me's', 'LXTerminal', 'WiFi Config', 'Shutdown', 'Midori', and 'WDS Widget'. The taskbar at the bottom shows four active windows: 'Timer Control - 20150213', 'ircDDB Gateway - 20150213', 'D-Star Repeater (DVMEGA) - modem1 - 20150213', and 'D-Star Repeater (DVMEGA) - modem2 - 20150213'.

Timer Control - 20150213

Day	Time	Type	Reflector	Sunday
Sunday	21:00	60 min...	REF002 A	00 : 00
Sunday	22:00	Never	REF054 C	None A

ircDDB Gateway - 20150213

Status: Connected D-PRS: Inactive

Links:

- Repeater 1: W9HPX C Not linked
- Repeater 2: W9HPX B Not linked
- Repeater 3:
- Repeater 4:

Dongles:

Log:

```
M: 2015-02-16 00:53:19: USER: DVMMET Z M0KSP C M0KSP G 92.13.44.205
M: 2015-02-16 00:53:19: GATEWAY: LASXFA G 195.0.204.150
M: 2015-02-16 00:53:24: USER: ZW0KMU NOT FOUND
M: 2015-02-16 00:53:46: USER: VE2GF VE2GF B VE2GF G 104.229.88.92
M: 2015-02-16 00:53:48: USER: ZW0KMU NOT FOUND
M: 2015-02-16 00:54:25: GATEWAY: N3EER G 70.88.145.166
M: 2015-02-16 00:54:29: USER: WBSRF WBSRF B WBSRF G 73.6.4.9
```

D-Star Repeater (DVMEGA) - modem1 - 20150213

Status: RX State: Listening Rpt State: Listening TX: Off

Header:

UR: RPT1: RPT2:

MY: Flags: 00 00 00 Loss/BER: 0.0%

Timers:

Timeout: 0/226 Beacon: 0/0 Announce: 0/0

Gateway:

Ack Text: Status 1: Status 2:

Status 3: Status 4: Status 5:

Log:

```
I: 2015-02-15 13:00:02: Output 1 = 0, output 2 = 0, output 3 = 0, output 4 = 0
I: 2015-02-15 13:00:02: Control: enabled: 1, RPT1: MY, RPT2: COMMAND, shutdown: STOP, startup: START, status1:
I: 2015-02-15 13:00:02: Frame logging set to 0, in /root
```

D-Star Repeater (DVMEGA) - modem2 - 20150213

Status: RX State: Listening Rpt State: Listening TX: Off

Header:

UR: RPT1: RPT2:

MY: Flags: 00 00 00 Loss/BER: 0.0%

Timers:

Timeout: 0/225 Beacon: 0/600 Announce: 0/0

Gateway:

Ack Text: Status 1: Status 2:

Status 3: Status 4: Status 5:

Log:

```
I: 2015-02-15 13:00:02: Output 1 = 0, output 2 = 0, output 3 = 0, output 4 = 0
I: 2015-02-15 13:00:02: Control: enabled: 0, RPT1: ., RPT2: ., shutdown: ., startup: ., status1: ., status2: ., status3: ., status4: ., status5: .
I: 2015-02-15 13:00:02: Frame logging set to 0, in /root
```

The desktop background features the text 'Configs by KC4YOZ' in the top left, 'Western D-Star' in the top right, and 'The Universal Operating System' and 'debian' at the bottom.

D-RATS



A Communications Tool For D-STAR

<http://www.d-rats.com/>

D-RATS Message List

The screenshot shows the D-RATS application window. The title bar reads "D-RATS". The menu bar includes "File", "View", and "Help". Below the menu bar are tabs for "Messages", "Chat", "Files", and "Event Log". A toolbar contains icons for "New", "Send", "Email", "Reply", "Delete", "Mark Read", and "Mark Unread". On the left, a folder pane lists "Inbox", "Outbox", "Sent", and "Trash". The main area displays a message list with columns for Sender, Recipient, Subject, Type, and Date. The "Stations" pane on the right lists "K7HIO" and "VK3UR (00:03)". The "My Status" pane shows "Online" and "Available". A status bar at the bottom reads "Message 'D-RATS 0.3.0 Release' received from K7HIO".

	Sender	Recipient	Subject	Type	Date
Inbox	K7HIO	KK7DS	D-RATS 0.3.0 Release	memo	21:17:47 2009-07-23
Outbox	K7HIO	KK7DS	Need a status report	ICS213_US_OS	21:16:06 2009-07-23
Sent					
Trash					

Stations

- K7HIO
- VK3UR (00:03)

My Status

Online

Available

Message "D-RATS 0.3.0 Release" received from K7HIO

D-RATS Chat Display

The screenshot shows the D-RATS chat application window. The title bar reads "D-RATS" and the menu bar includes "File", "View", and "Help". The main chat area displays the following text:

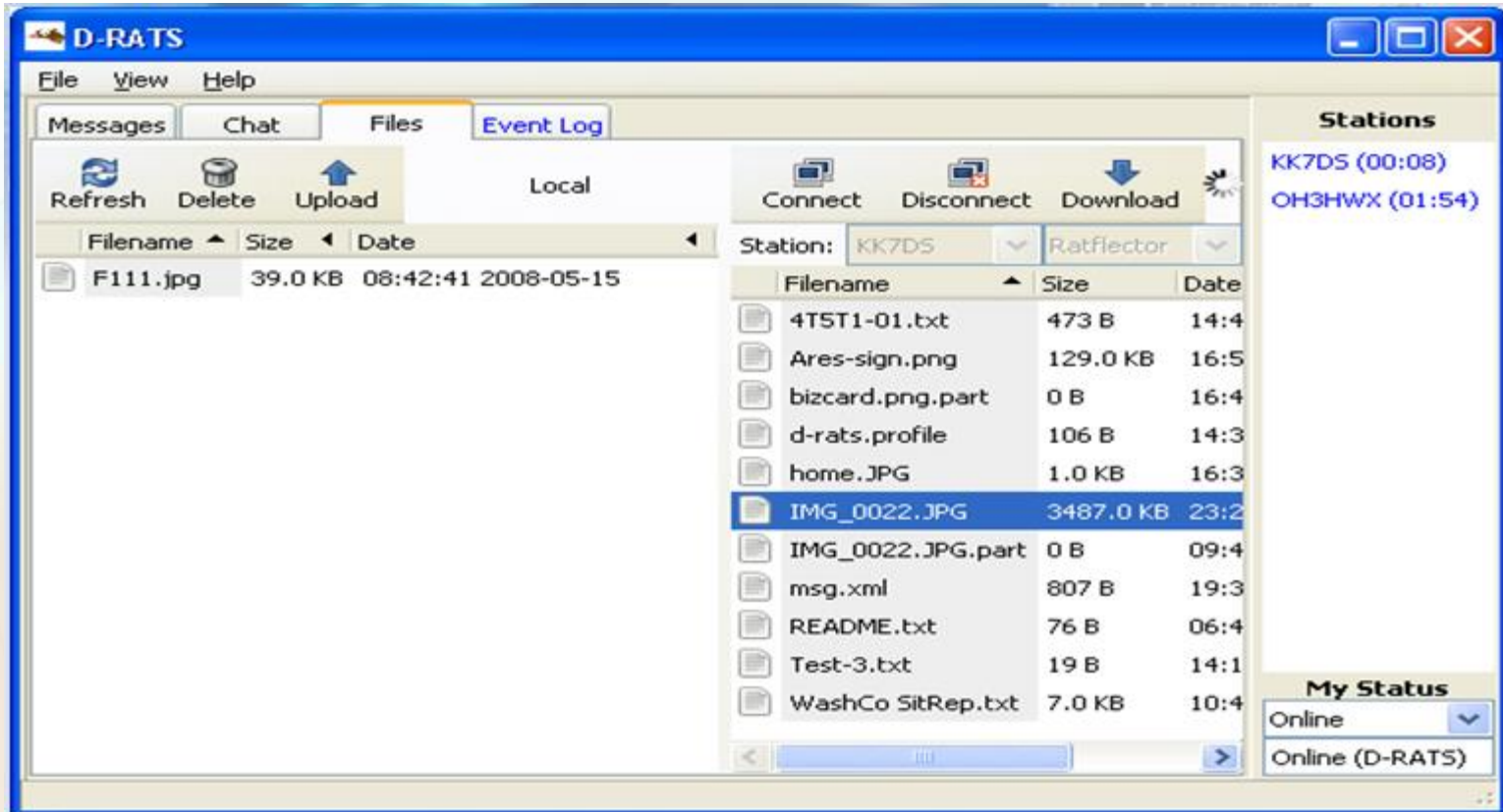
D-RATS v0.3.0b6
Copyright 2009 Dan Smith (KK7DS)

[2009-05-11 15:06:45] [Ratflector] CQCQCQ: KK7DS -
Ratflector - ref.d-rats.com:9000 - Please do not link RF to
this repeater to keep it clean for testing and training

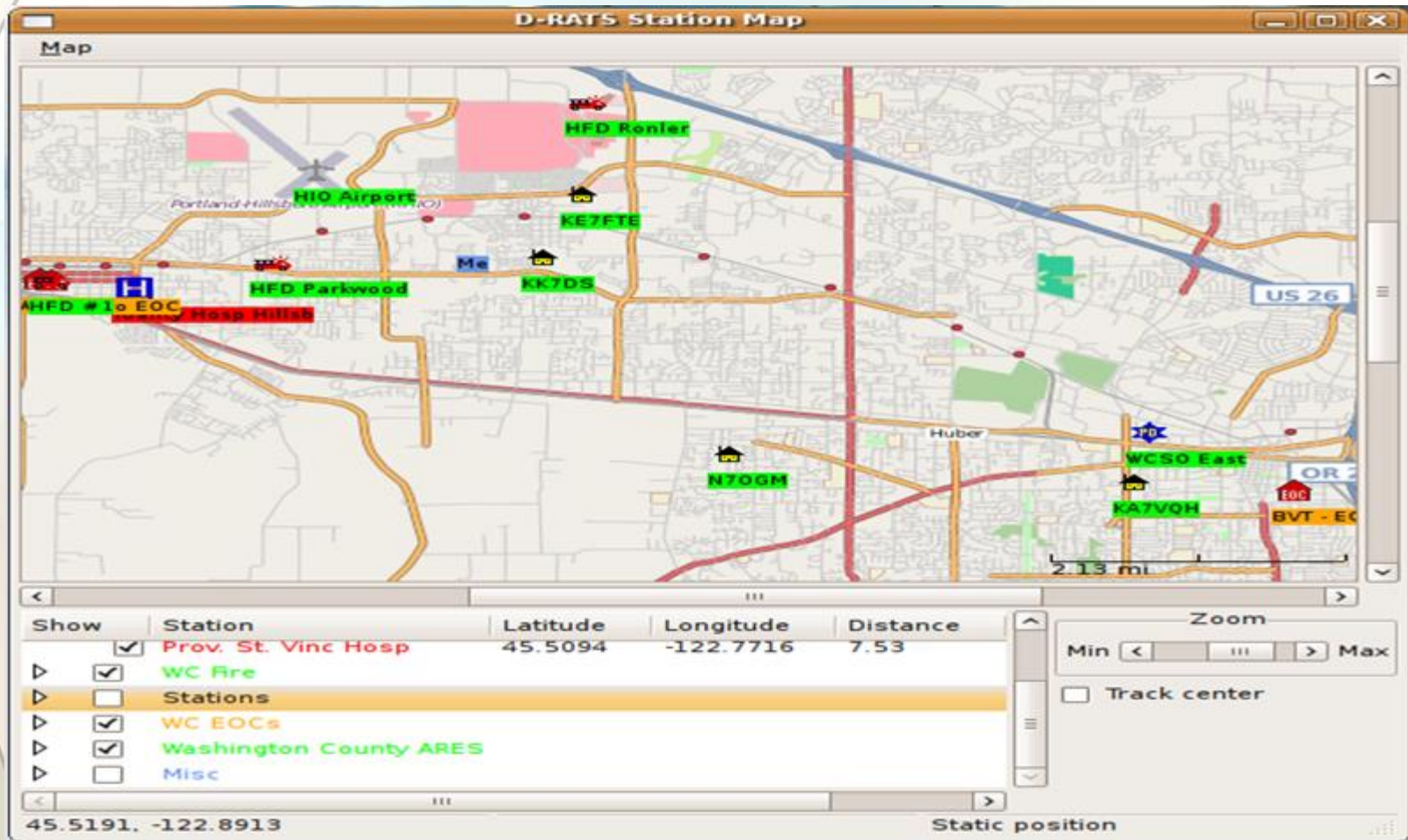
[2009-05-11 16:12:08] KK7DS: Now Online: Active
[16:12:09] OH3HWX: Now Online: Online (D-RATS)

The interface includes a "Main" tab, a "Ratflector" dropdown menu, a "Send" button, and a "Quick Messages" section with a "Test message" field containing "Hello world!" and "G'day from Dave in Ballarat, Victoria, Australia". There are also "Add" and "Remove" buttons. On the right side, the "Stations" list shows "OH3HWX" and "KK7DS". The "My Status" section shows "Online" and "Online (D-RATS)". A status bar at the bottom indicates "Station OH3HWX is now Online: Online (D-RATS)".

D-RATS File Transfer



D-RATS Map Display



D-RATS Forms

- Includes Form Editor to Create Any Form
- Only Data is Sent
- Fully printable ICS-213, ARRL Radiogram and NTS Forms Included

The screenshot shows a Mozilla Firefox browser window displaying two forms. The top form is titled "HICS 260 - Patient Evacuation Tracking Form" and contains fields for patient information, diagnosis, and accompanying equipment. The bottom form is titled "ICS-213 Form" and contains fields for message details and a message body.

HICS 260 - Patient Evacuation Tracking Form

Date: 01 May 2009 Unit: ER
Patient Name: L. Smith Age: 13 MR#: 887854321
Diagnosis: Fever Admitting Physician: D. Smith
Family Notified: YES NO

9. ACCOMPANYING EQUIPMENT

<input checked="" type="checkbox"/> Hospital Bed	<input type="checkbox"/> IV Pumps	<input checked="" type="checkbox"/> Isolate/Warmer	<input type="checkbox"/> Foley Catheter
<input checked="" type="checkbox"/> Gurney	<input checked="" type="checkbox"/> Oxygen	<input type="checkbox"/> Traxitan	<input type="checkbox"/> State Device
<input type="checkbox"/> Wheel Chair	<input checked="" type="checkbox"/> Ventilator	<input checked="" type="checkbox"/> Monitor	<input type="checkbox"/> Critical Bell/Screen
<input type="checkbox"/> Ambulatory	<input type="checkbox"/> Chest Tube(s)	<input type="checkbox"/> ALinet/Scan	<input type="checkbox"/> ID Device

10. DEPARTING LOCATION **11. ARRIVING LOCATION**

Departure Room # 123	Departure Time 13:04:00	Arrival Room #	Arrival Time 13:04:00
ID Band Confirmed: <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	Confirmed By: T. Smith	ID Band Confirmed: <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	Confirmed By:
Medical Record Sent: <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		Medical Record Sent: <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	
Addressograph Sent: <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		Addressograph: <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	
Belongs With Patient:		Belongs Received: <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO	

ICS-213 Form

Incident Name: Montgomery Flooding Date/Time of message: 07-May-2009 11:03:55 GENERAL MESSAGE ICS 213-OS
To: KF4LQK ICS Position: LOGISTICS-COMMUNICATIONS
Number: KD4CAL ICS Position: LOGISTICS-COMMUNICATIONS

Message:
MONTGOMERY FLOODING
Les, K4DJL EL from reports 2 to 5 feet of water are taking off partially blocking roads reported to K4NWS

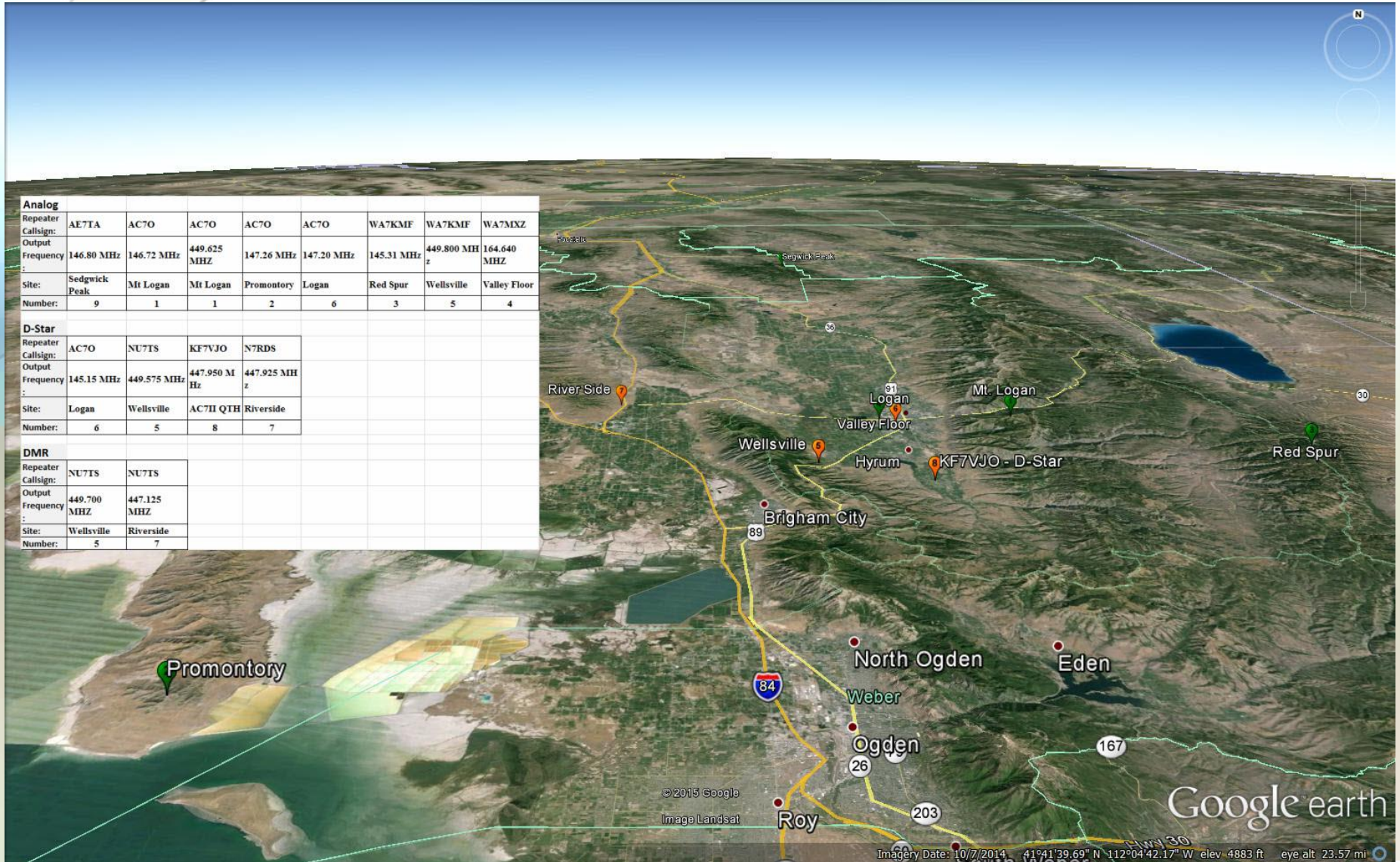
Signature / Position (person responsible):
GENERAL MESSAGE

ICS-213 Form

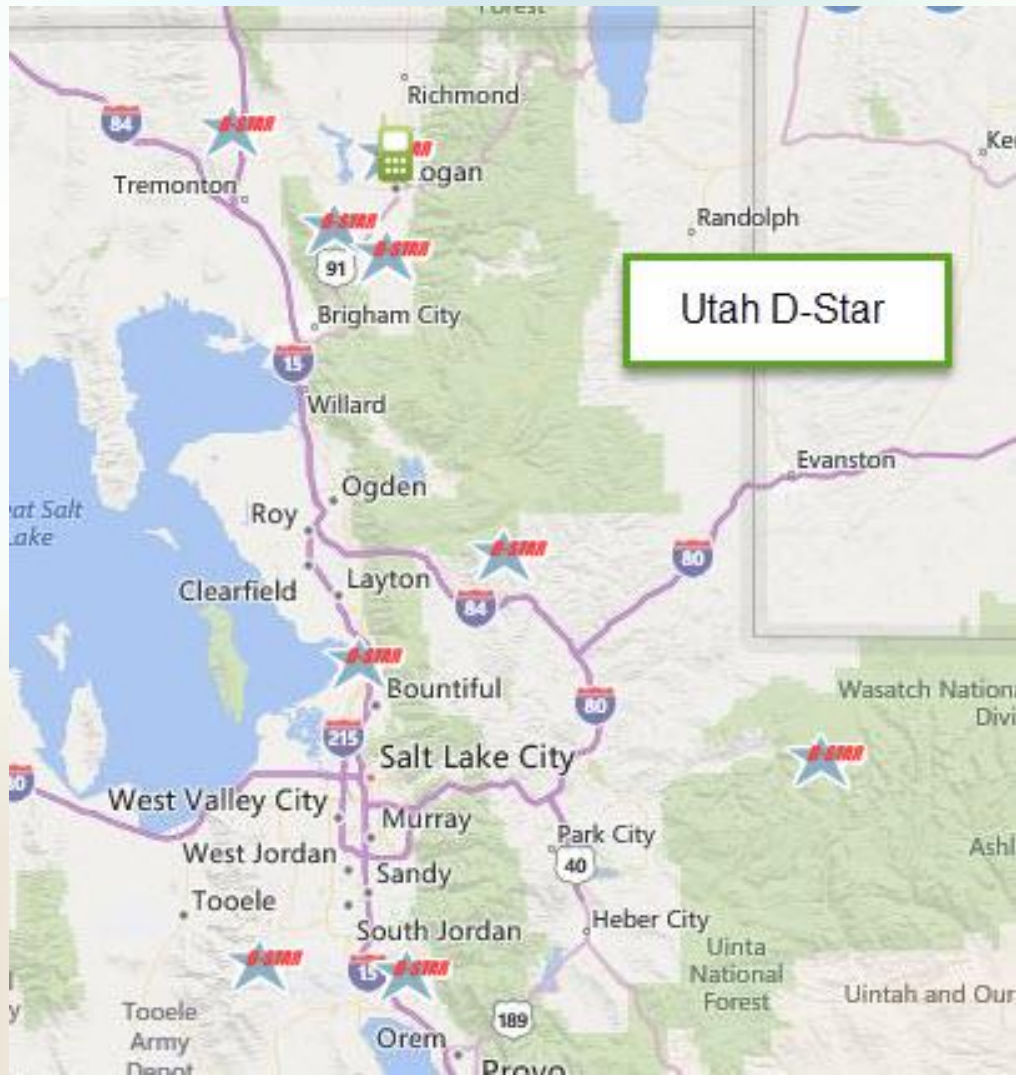
Incident Name: Alabama Hurricane Exercise Date/Time of message: 07-May-2009 9:30:19 GENERAL MESSAGE ICS 213-OS
Message:
Les, this is a list of D-STAR repeaters in Alabama that are linked up for the Alabama Hurricane Exercise. W4AP Montgomery, WB4GNA Cheaha, W4KCO Tuscaloosa, K4DSO Birmingham, K14SAZ Magnolia Springs Baldwin county, K14PPF Huntsville. Also ARRL HQ is on DV Dongle linked to us via Reflector 002 Modula B.

Signature / Position (person responsible):
07-May-2009 9:30:19

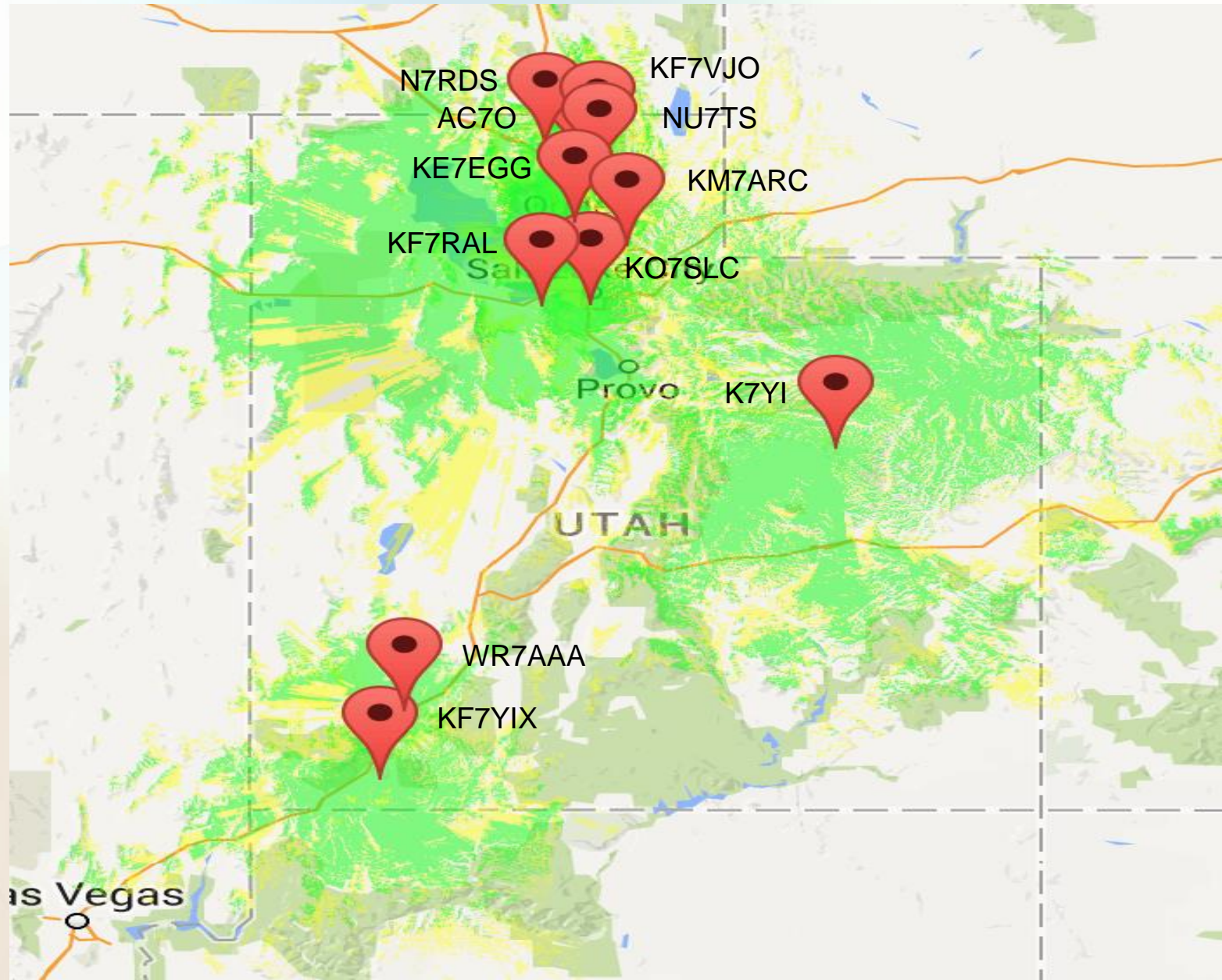
Analog								
Repeater Callsign:	AE7TA	AC7O	AC7O	AC7O	AC7O	WA7KMF	WA7KMF	WA7MXZ
Output Frequency :	146.80 MHz	146.72 MHz	449.625 MHz	147.26 MHz	147.20 MHz	145.31 MHz	449.800 MHz	164.640 MHz
Site:	Sedgwick Peak	Mt Logan	Mt Logan	Promontory	Logan	Red Spur	Wellsville	Valley Floor
Number:	9	1	1	2	6	3	5	4
D-Star								
Repeater Callsign:	AC7O	NU7TS	KF7VJO	N7RDS				
Output Frequency :	145.15 MHz	449.575 MHz	447.950 MHz	447.925 MHz				
Site:	Logan	Wellsville	AC7II QTH	Riverside				
Number:	6	5	8	7				
DMR								
Repeater Callsign:	NU7TS	NU7TS						
Output Frequency :	449.700 MHz	447.125 MHz						
Site:	Wellsville	Riverside						
Number:	5	7						



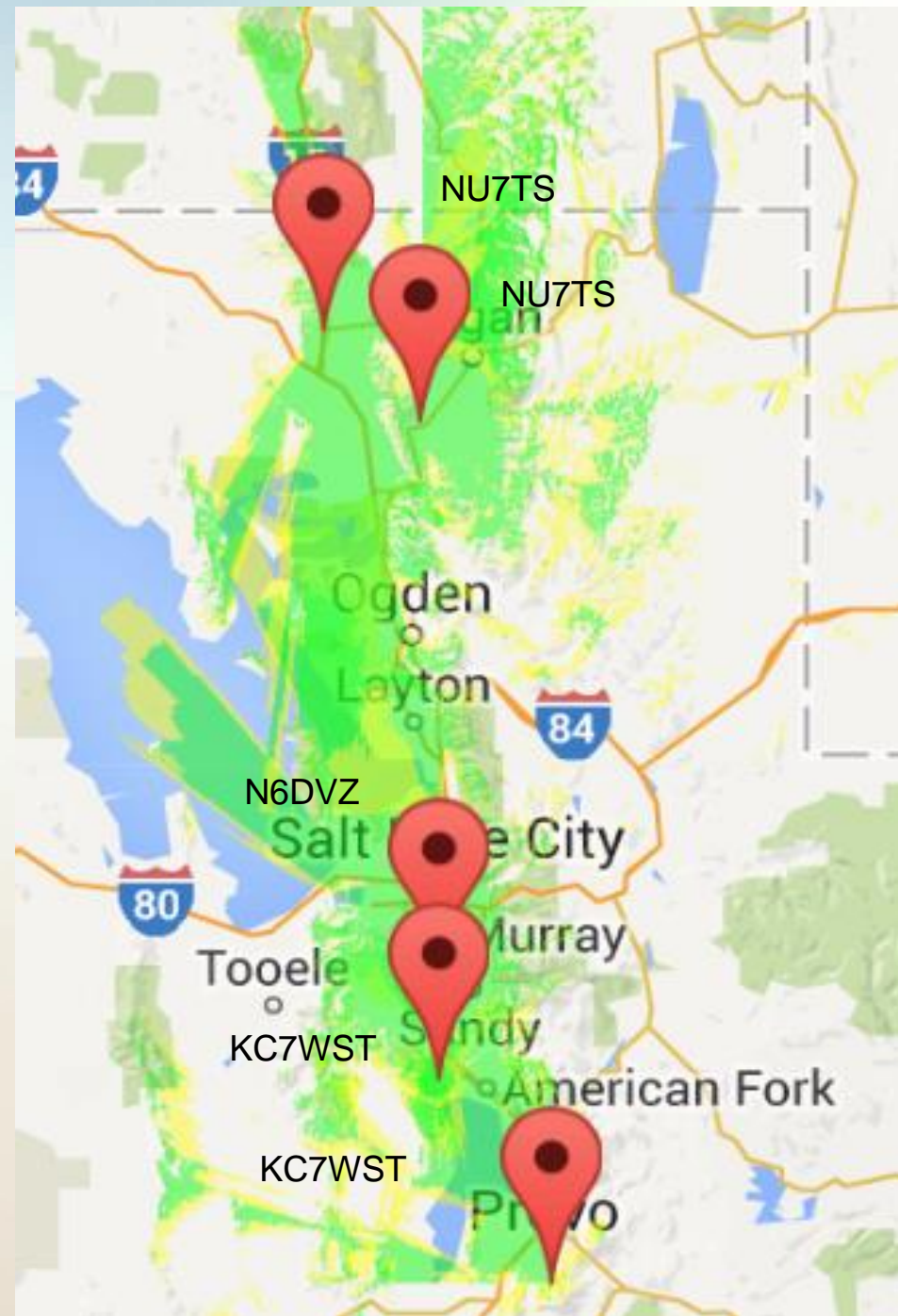
Imagery Date: 10/7/2014 41°41'39.69" N 112°04'42.17" W elev 4883 ft eye alt 23.57 mi



D Star Coverage

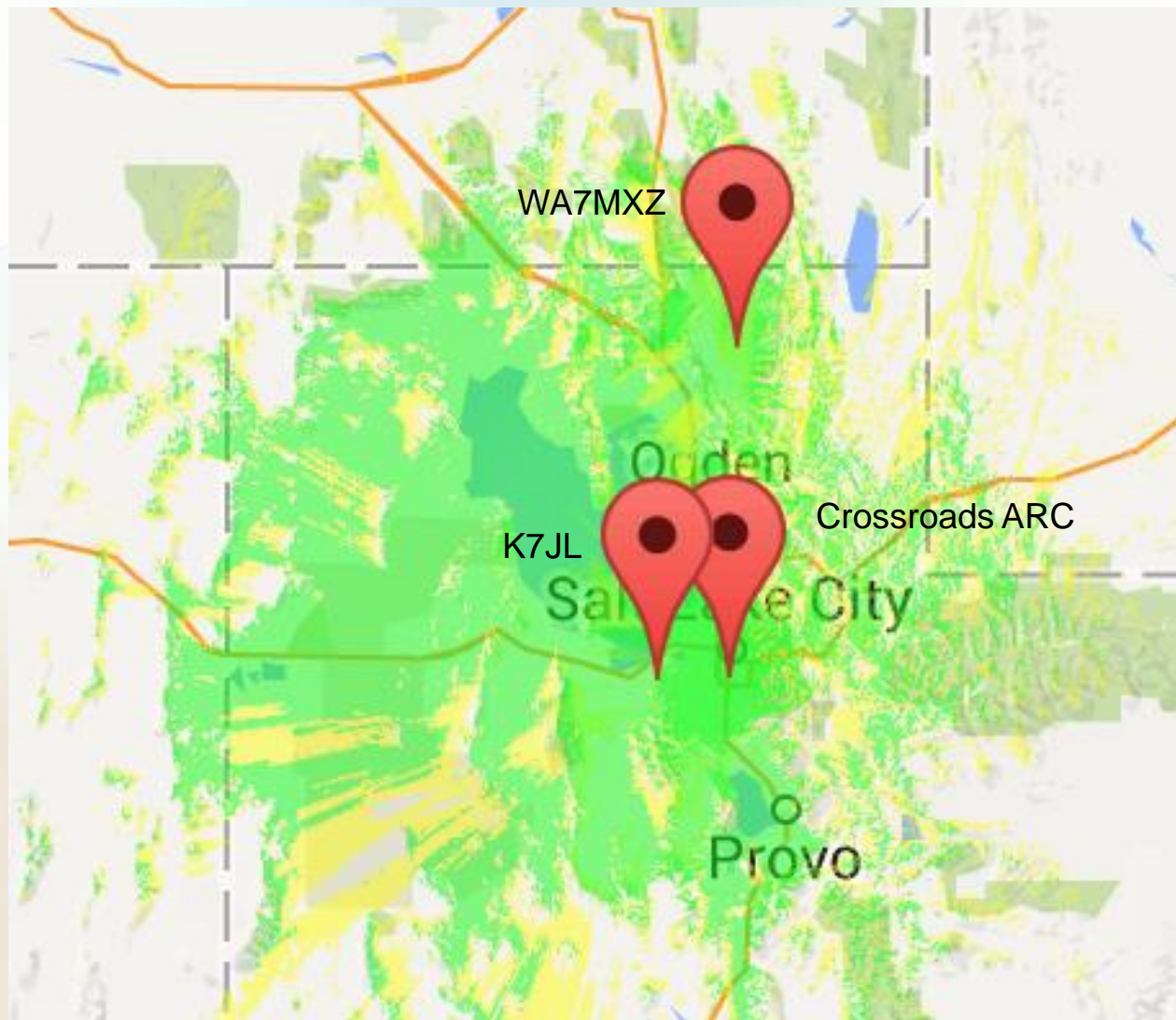


DMR Coverage



www.dmr-utah.net

Fusion Coverage



Digital Voice Summary

- D Star
 - Mature - Open Source - ICOM only
 - Lots of Options to get on D Star
 - Easy Programming - Robust Routing
- DMR
 - Growing - International Standard
 - CS700/7000 - Commercial Vendors
 - Proprietary Programming - Fixed Talk Groups
- Fusion
 - New & Sure to Grow - Yaesu Only
 - Easy Programming - Chat Rooms
 - Better Audio Plus APRS

For More Information

- www.nu7ts.com - This is our web site. Register for D-STAR.
- groups.yahoo.com/neo/groups/clt-dstar/info
This is our Yahoo group, but search for other Yahoo groups of interest such as D-STAR, Fusion, DMR, Connect Systems, etc. There's many.
- www.dstar101.com
- www.dstarinfo.com
- www.dstarusers.org
- www.maryland-dstar.org - for Raspberry Pi enthusiasts
- www.dmr-utah.net - Web site for our area DMR repeaters & code plugs.
- www.dmr-marc.net
- www.trbo.org
- www.trinityos.com/HAM/Yaesu-System-Fusion/Yaesu-fusion-and-c4fm-v7.pdf - Talk given by David Ranch KI6ZHD at 2015 Bay-Net meeting.
- arvideonews.com/hrn/ - Ham Radio Now – watch episodes 161 & 195

Questions?