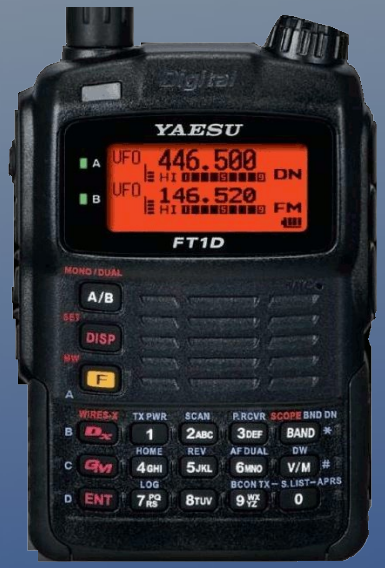
Yaesu Fusion and C4FM



David Ranch
KI6ZHD
Bay-Net Meeting 2015

What is C4FM?

- [Please see the slide deck's note's for additional details]
- Stands for Continuous Four Level Frequency Modulation – A special type of 4FSK

- Used in conjunction with FDMA (Frequency Division Multiple Access)
- This is the ***same*** mode used in P25 Phase1 which is used by Emergency Responders but isn't compatible

Why Digital over Analog?

- With weaker signals, digital can be easier to hear and understand

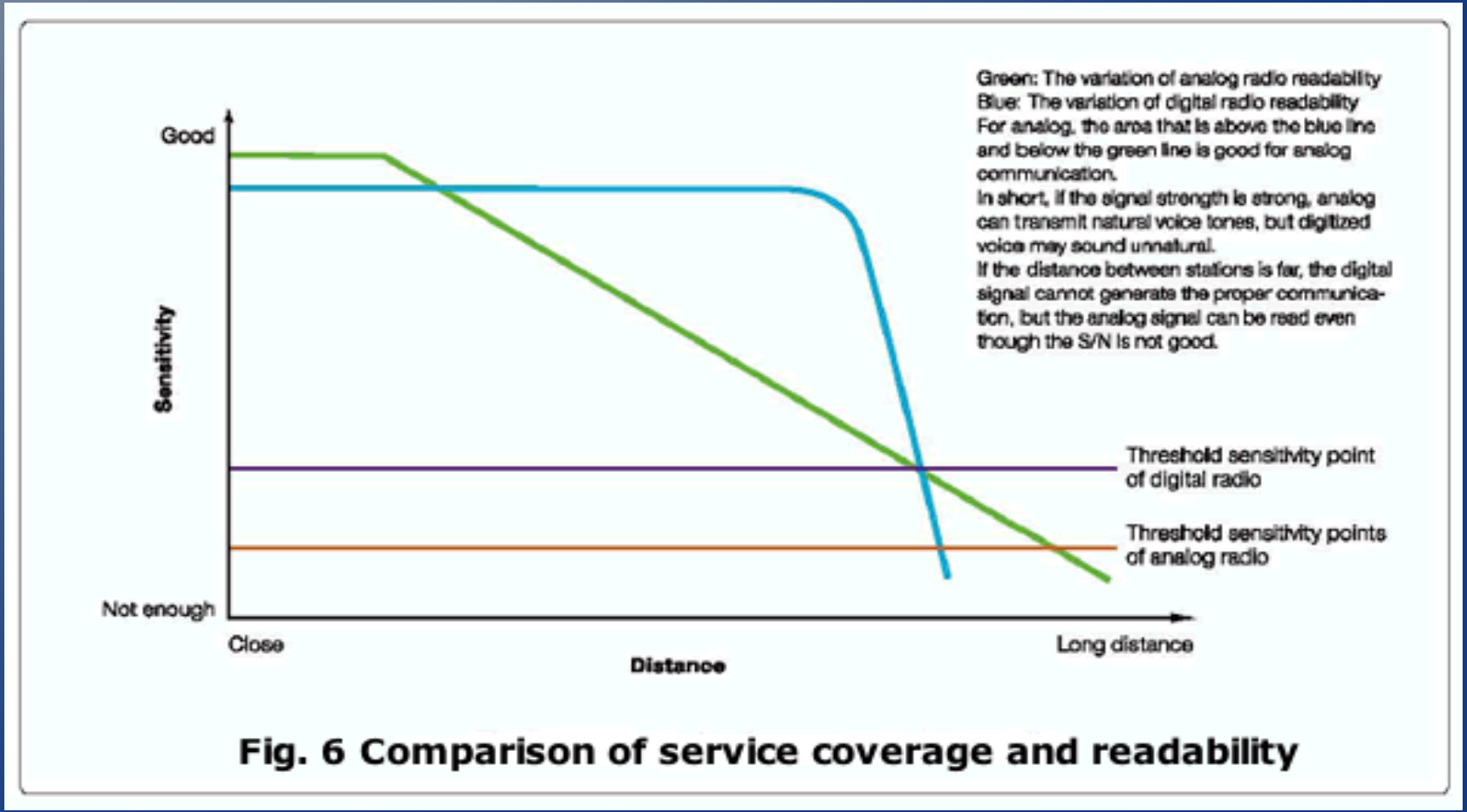
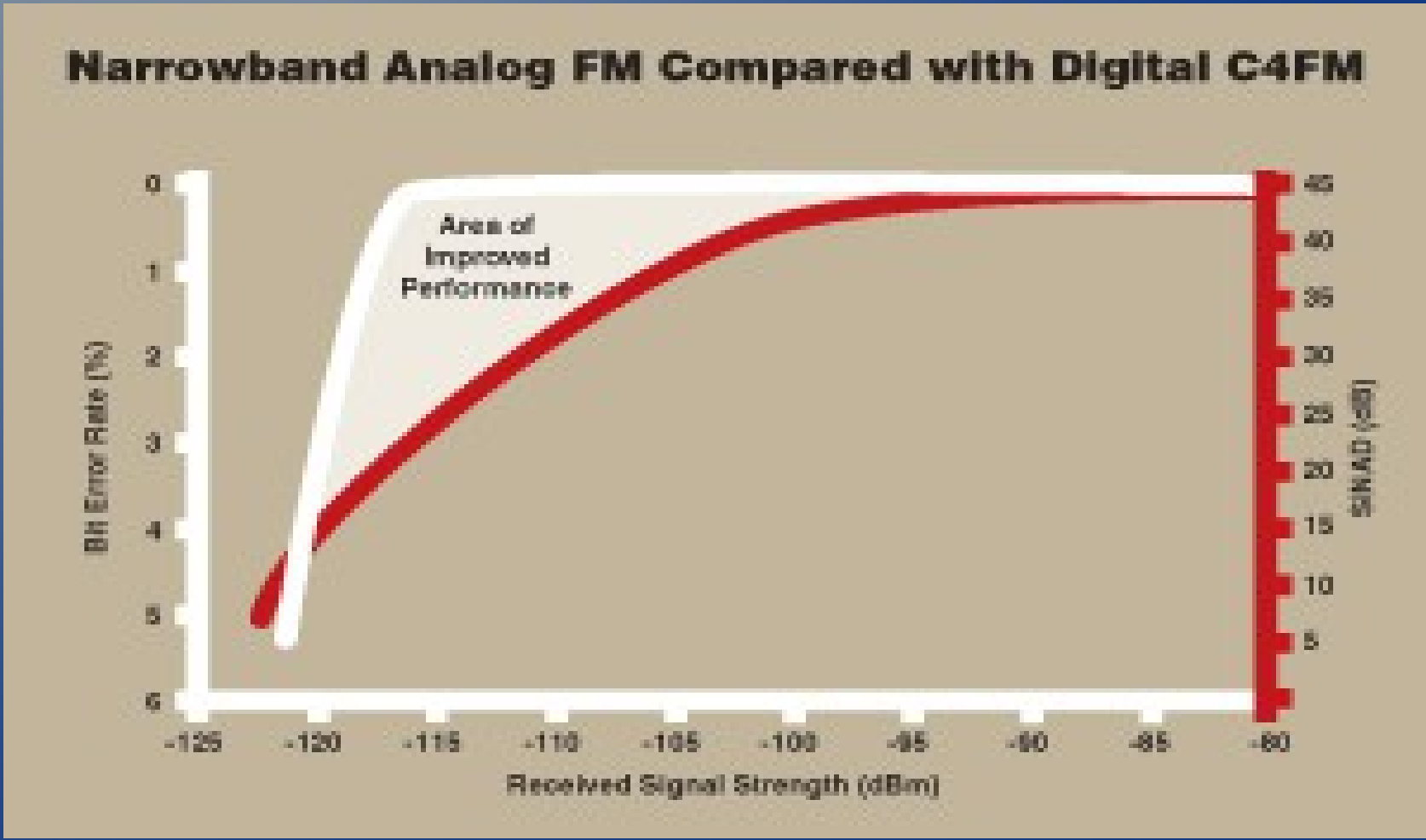


Fig. 6 Comparison of service coverage and readability

Digital vs Analog

- Technical levels of Analog breakdown



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)

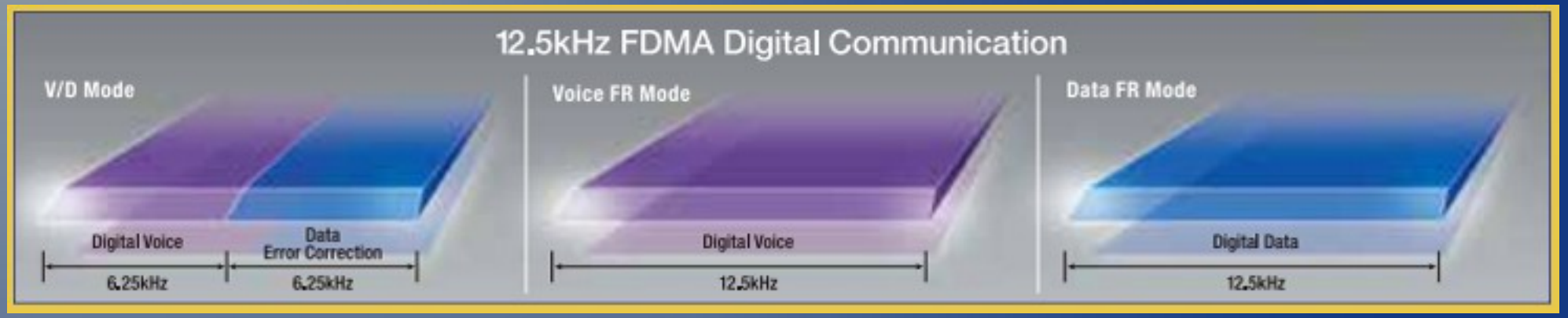
- Fusion framing has been openly documented by Yaesu in 2013 (unclear if it's freely licensed)
- FM envelope uses 12.5Khz BW (narrow FM)
- Uses a similar DVSI AMBE DSP chip used in DMR & P25 but newer than what's used in D*star – patent encumbered

Why a new VHF/UHF digital mode?

- GMSK used in D*Star is well known and proven via it's wide deployment in GSM cellular networks

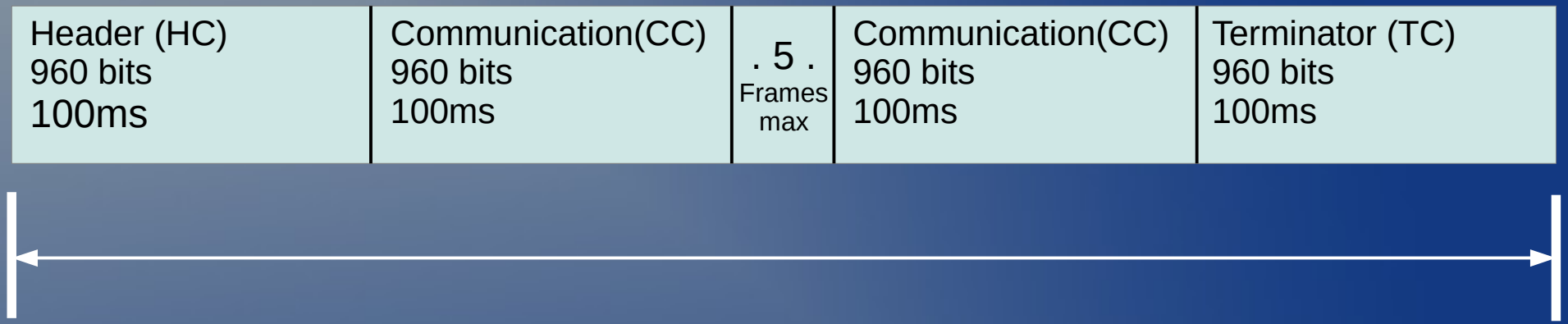
- DMR radios from Motorola, Hytera, Connect Systems, etc are using TDMA which was not a legal TX mode in FCC Part 97 at the time (FCC RM-11625 is the official request to change that)

Fusion's Four Digital Modes



- V/D (Voice / Data) mode has 2 sub-modes depending on volume of data
  - Examples of the data sent would be GPS location, text messages, pictures
- Voice Full Rate (VW)
  - 4400bps for voice, 2800bps for voice FEC
- Data Full Rate (DW) supports 7200bps, (no FEC)

C4FM Framing Details



Raw rate: 9600bps
Payload after framing: 7200bps

AMBE Voice:
100ms voice is compressed to 20ms of data

Dibit	Symbol	Frequency Deviation
01	+1	+900hz
01	+3	+2700hz
10	-1	-900hz
11	-3	-2700hz

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 else do these Yaesu radios do?

- Full 2m / 70cm analog FM and FM-narrow HT
- Full APRS Support:
  - APRS Voice Alert & 1-button QSY support
  - Built-in GPS
  - Built-in 1200/9600 BAUD AFSK TNC (not accessible for standard packet connections)
- Supports listening to Broadcast FM at the same time as listening to Ham frequencies (break in)
- Supports listening to AM (broadcast, Aircraft)

How does Fusion compare to D*Star for voice access and connectivity?

- D*star has a large head start to connect to remote repeaters
- Yaesu Fusion just released their Wires-X linking technology (1H 2015) but it's true feature set is unclear at this time

Audio Examples

My Impressions on the audio

- Seems to have a quality edge over D*star
- Said to be about the same audio quality as DMR
- Degrades better than D*star on fringe coverage
- Still doesn't have the fidelity of a full quieting analog signal IMHO

Current Radios / Gear

Radios and gear today..

- FT1D - a steal for an APRS radio alone but adding in C4FM Fusion makes it a very compelling HT

FTM-400DR - also inexpensive for a mobile APRS radio : Nice interface and touch screen

- Wires-X Linking module - $124.95

Quirks? Sure...

- FT1D
  - Complicated PL tone scan (done via tone SQL)
  - TXT messages via APRS & C4FM are done differently as are TXT RX notification
  - Requires the present of the MicroSD if you want to receive C4FM TXT messages (APRS TXT doesn't require this)
- DR-1
  - No linking support to existing analog controllers (maybe the new DR-1X fixes?)

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 a touch screen

Wires-X Internet Linking

- WIRES-X was JUST released in the US so overall details and impressions are still too early
  - SV HRO has 100+ on backorder as of 1/17/15
- “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

Available Fusion Repeaters in the Area

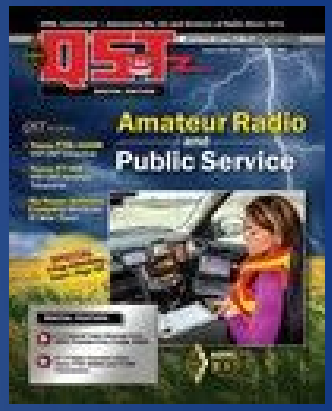
- WW6BAY - Bay-Net – Black Mountain – on the air!
  - 444.425 “+” offset – no WiresX yet
- N6ZX – Skyline Fire station, Woodside – on the air!
  - 145.370 “-” offset – No WiresX
- KE6YUV – Mt Berryessa - has unit, unclear on deployment

Challenges to Fusion's Adoption

- Like D*star, there is only one vendor supplying C4FM Fusion radios today - Yaesu
- Unless others start making compatible and competitive radios, the technology can only go so far
- Unclear if a similar homebrew community similar to what D*star will happen like Satoshi GSMK boards, DVAPs, etc.
  - Wires-X modules are registered by serial number so this might hinder the home brew

Getting More Details

- QST (September 2014) Review



- HamRadio Now Video (Aug 4, 2014) – 1h:37m

  http://arvideonews.com/hrn/HRN_Episode_0161.html

  - Audio comparisons of Fusion, Dstar, DMR, P25, and analog FM

- http://www.systemfusioninfo.com/

More URLs and Links

- Yaesu's Digital Fusion Facebook page
  - https://www.facebook.com/pages/Yaesu-C4FM-FDMA-System-Fusion/522744247816165?ref=stream
- Live Wires-X / Fusion status
  - https://www.yaesu.com/jp/en/wires-x/id/id_usa.php
- Technical specs on the Fusion framing, etc for possible homebrewing (found on FT1DR's “files” section):
  - http://www.yaesu.com/downloadFile.cfm?FileID=8239&FileCatID=263&FileName=Yaesu%5FAmateur%20Radio%20Digital%20Specs%5F1V01%5FEN%2DGB.pdf&FileContentType=application%2Fpdf

So who is the presenter anyway?

- First licensed 2009
- My bent on Ham Radio... all of the following on Linux
  - Digital modes (DRM, Codec2)
  - SDR
  - AFSK Packet Radio & AMPR – KI6ZHD on 145.050
  - Echolink – KI6ZHD-L on 441.000 simplex
  - 3.4Ghz Bay-Net data network (ask me about it... we're looking to add stations – South Bay and Oakland areas)

Thank you!

Any Questions?

Backup Slides

A bit of History about Yaesu's C4FM

- Yaesu was bought by Motorola in 2008 and sold back out in 2012
- In this period of time, Motorola released it's MotorTRBO digital mode (a 2 slot TDMA – Time Division Multiple Access mode)
- MotoTRBO conforms to the ETSI DMR (Digital Radio Mobile) standard with augmentation
- Though similar in technology, the Motrola MotoTRBO and Yaesu Fusion modes are NOT compatible

Yaesu Fusion and C4FM

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- Used in conjunction with FDMA (Frequency Division Multiple Access)
- This is the ***same*** mode used in P25 Phase1 which is used by Emergency Responders but isn't compatible

P25 Phase2 uses CQPSK instead

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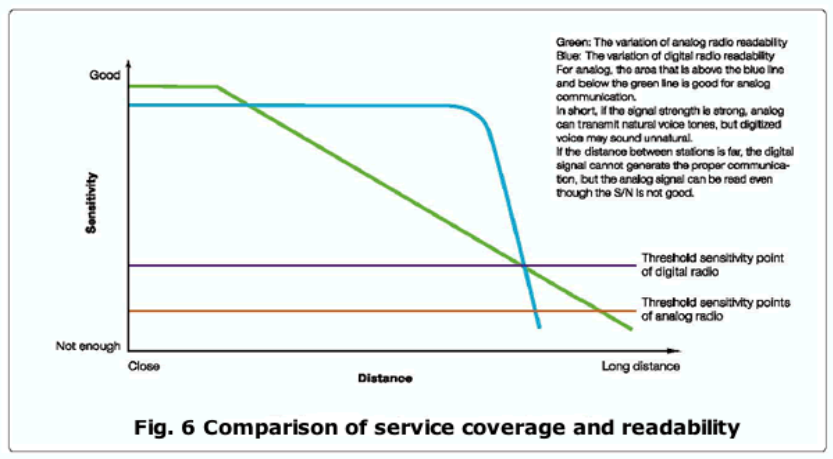

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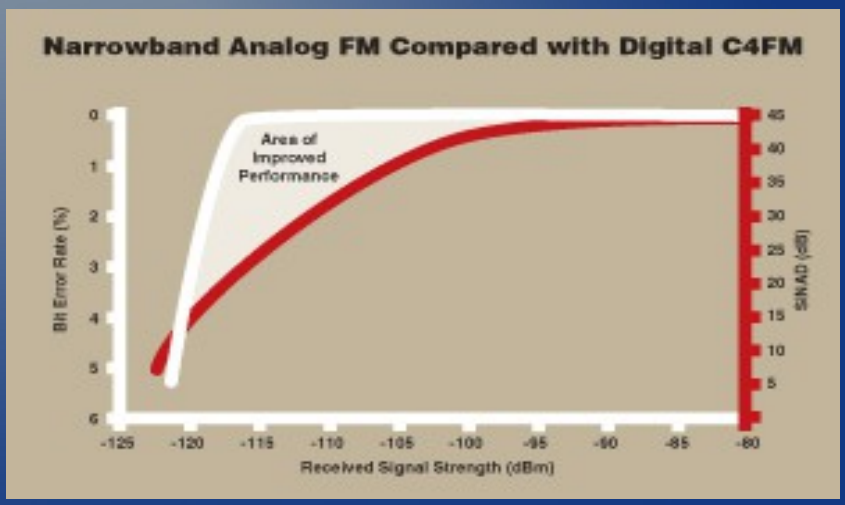


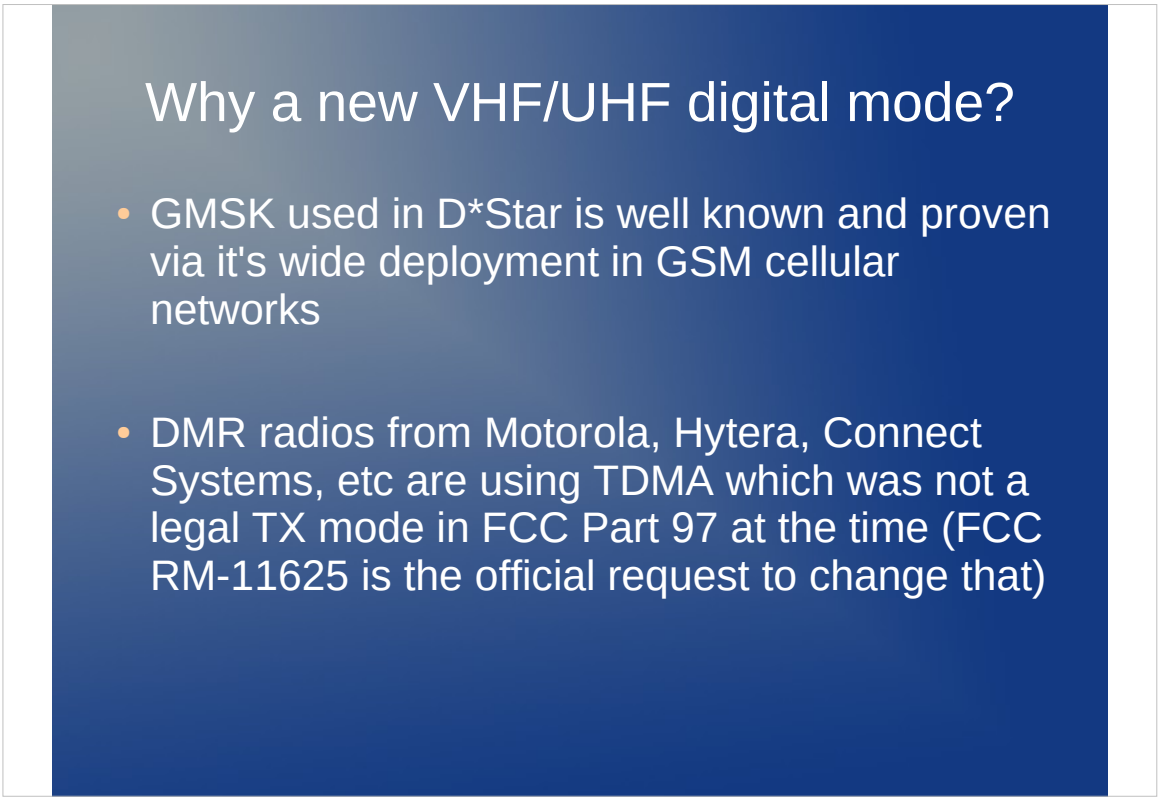
- GM function lists all Fusion users and their location on the current frequency
- Can group different users into different categories and only RX/TX to them while on the same repeater

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

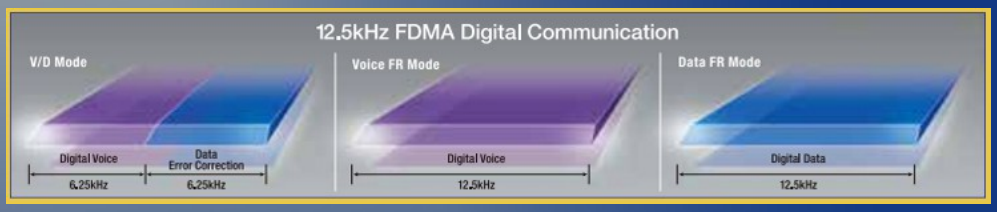
- Voice & Data FCC emission type: F1D
- Data FCC emission type: F7W

- 9600bps raw data rate: Uses a 4800 BAUD data transport with 2-bits per symbol



- GMSK over FM reduces the BER (bit error rate) performance – not optimal
- C4FM is also over FM but is supposedly a bit more robust but also more complicated

Fusion's Four Digital Modes



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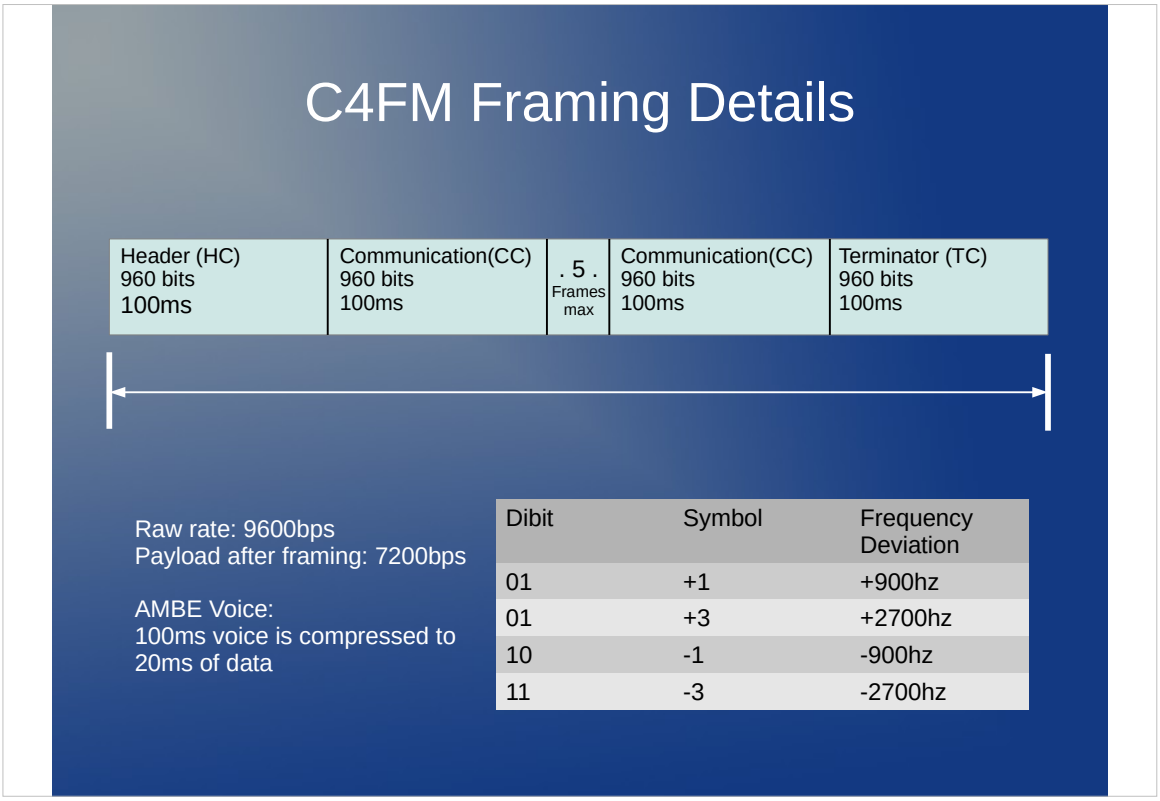
    - 4400bps for voice, 2800bps for voice FEC
  - Data Full Rate (DW) supports 7200bps, (no FEC)

- V/D (Voice / Data) mode uses the raw 9600 bps (7200bps usable - 2x that of D*star)
  - DN1: 2450bps for voice / 1150bps for voice FEC / 3600bps for data (no FEC)
  - DN2: 2450bps for voice, 1150bps for voice FEC, 1800 bps for data, +1800bps for V FEC
- VW can send higher voice quality for strong signals (no Data channel)



Total deviation: 5400hz

Voice & Data alternate sending 72bits per CC frame

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- Supports listening to Broadcast FM at the same time as listening to Ham frequencies (break in)
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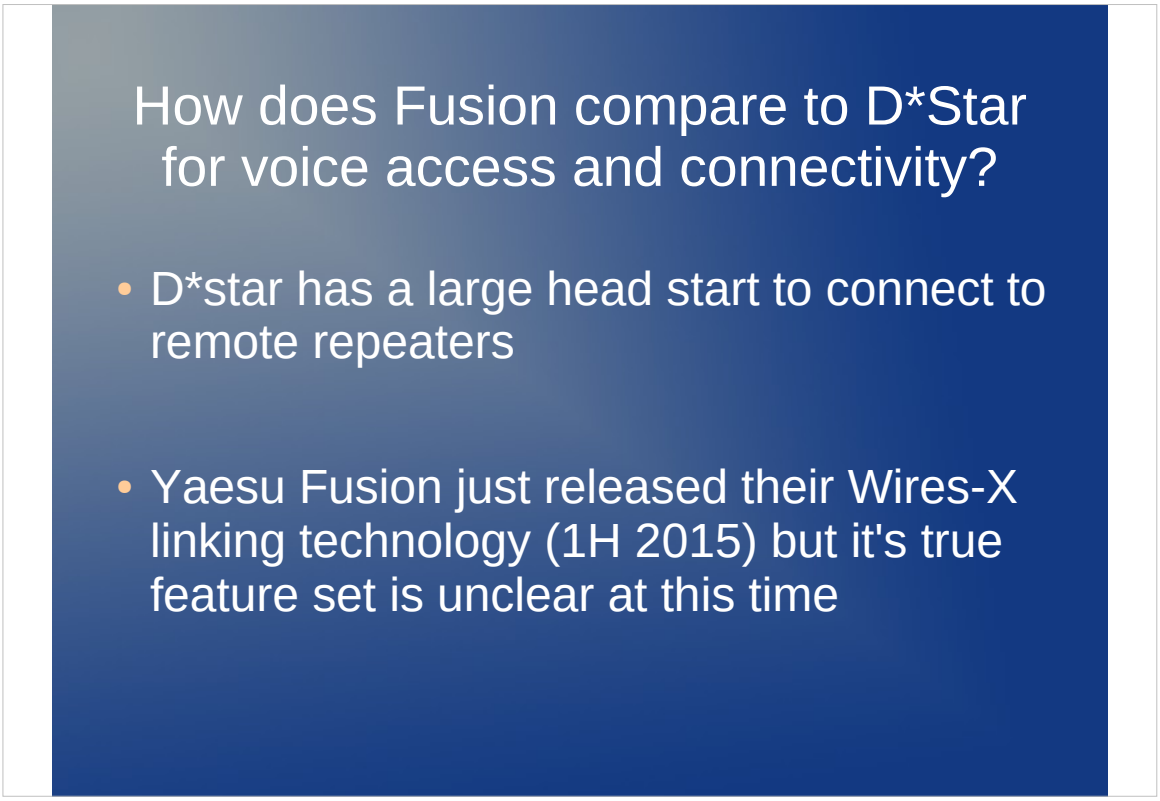
- Full tracking and messaging functionality built in (fully replaces the classic VX-8GR HT)



- Already has large groups of repeaters in a “conference”, reach specific HAMs via callsign routing, world-wide, etc.
- To be released to the US in 2015; already released in Japan

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- FT1D: $279.95* promotion [$309.95 list] - (Kenwood D72A is $449.95* [list] or Yaesu VX8DR - $339.95[list])
- FTM400: $499.95* promotion [$599.95 list] - (Kenwood D710G is $639.95* [679.95 list])
- MH-85A11U Camera Mic is $134.95*

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  - TXT messages via APRS & C4FM are done differently as are TXT RX notification
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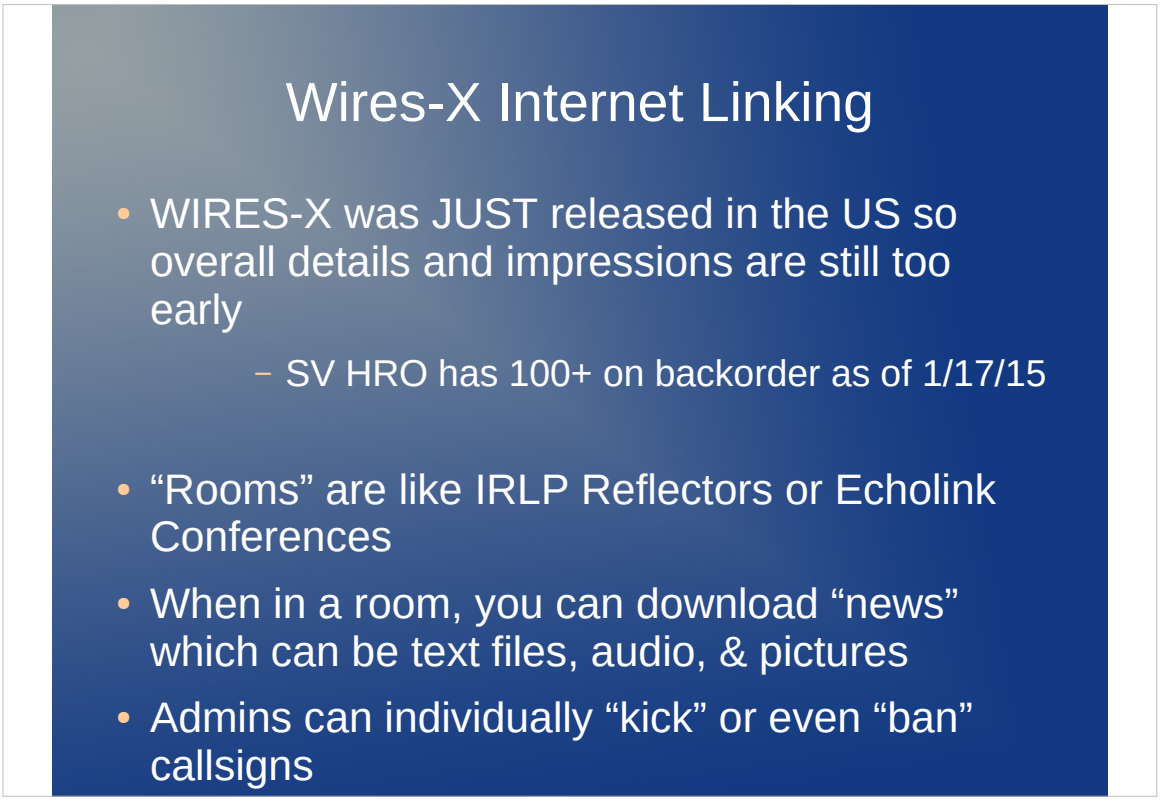

- Rooms can be connected via a browsable list, search, user-created catagories, or direct node entry
- Rooms can be open/closed
- “Up/Downloaded” files are locally displayed. “Imported” files are only saved to local micro-SD card
- Only supported file types can be Im/Exported (no list found so far)
- Audio can only be played, not imported
- Can mix Wires-X with Fusion GM feature
- 25 Wires-X nodes listed in Ca – all So.Cal

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- Unclear if a similar homebrew community similar to what D*star will happen like Satoshi GSMK boards, DVAPs, etc.
  - Wires-X modules are registered by serial number so this might hinder the home brew

- Since it uses FM as it's underlying modulation, existing Class-C FM amplifiers will work

- Home brewing solutions should be possible like D*star but will be more complex. SDRs are probably the path of least resistance here

Getting More Details

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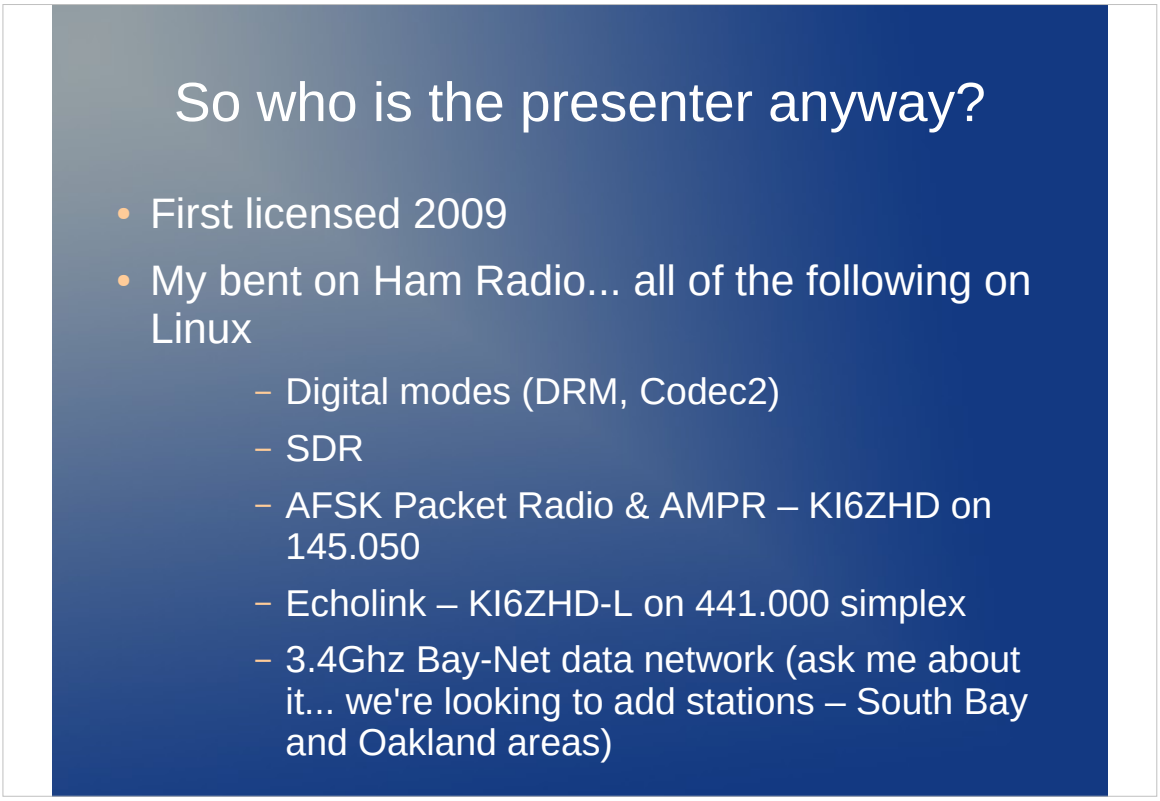
  - Audio comparisons of Fusion, Dstar, DMR, P25, and analog FM

- http://www.systemfusioninfo.com/

- Most digital modes sounded similar when at the edge but they fail differently (Dstar was the harshest sounding in breakdown)
- Analog FM was the worst when at the edge compared to all digital modes

More URLs and Links

- Yaesu's Digital Fusion Facebook page
  - https://www.facebook.com/pages/Yaesu-C4FM-FDMA-System-Fusion/522744247816165?ref=stream
- Live Wires-X / Fusion status
  - https://www.yaesu.com/jp/en/wires-x/id/id_usa.php
- Technical specs on the Fusion framing, etc for possible homebrewing (found on FT1DR's “files” section):
  - http://www.yaesu.com/downloadFile.cfm?FileID=8239&FileCatID=263&FileName=Yaesu%5FAmateur%20Radio%20Digital%20Specs%5F1V01%5FEN%2DGB.pdf&FileContentType=application%2Fpdf



Also the author of

- TrinityOS Linux Server documentation
- Linux IP Masquerade documentation
- Centos HamPacket documentation

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