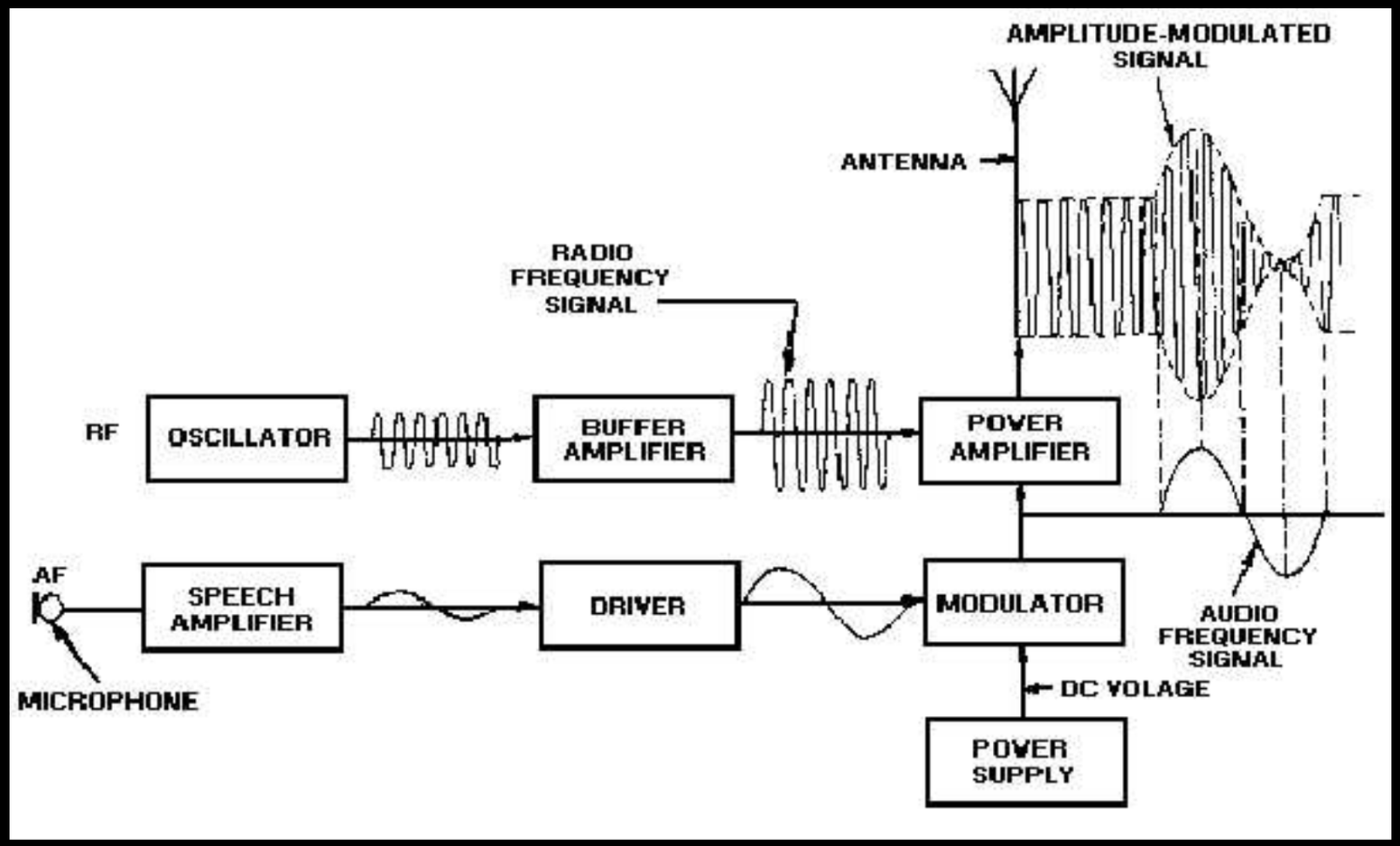
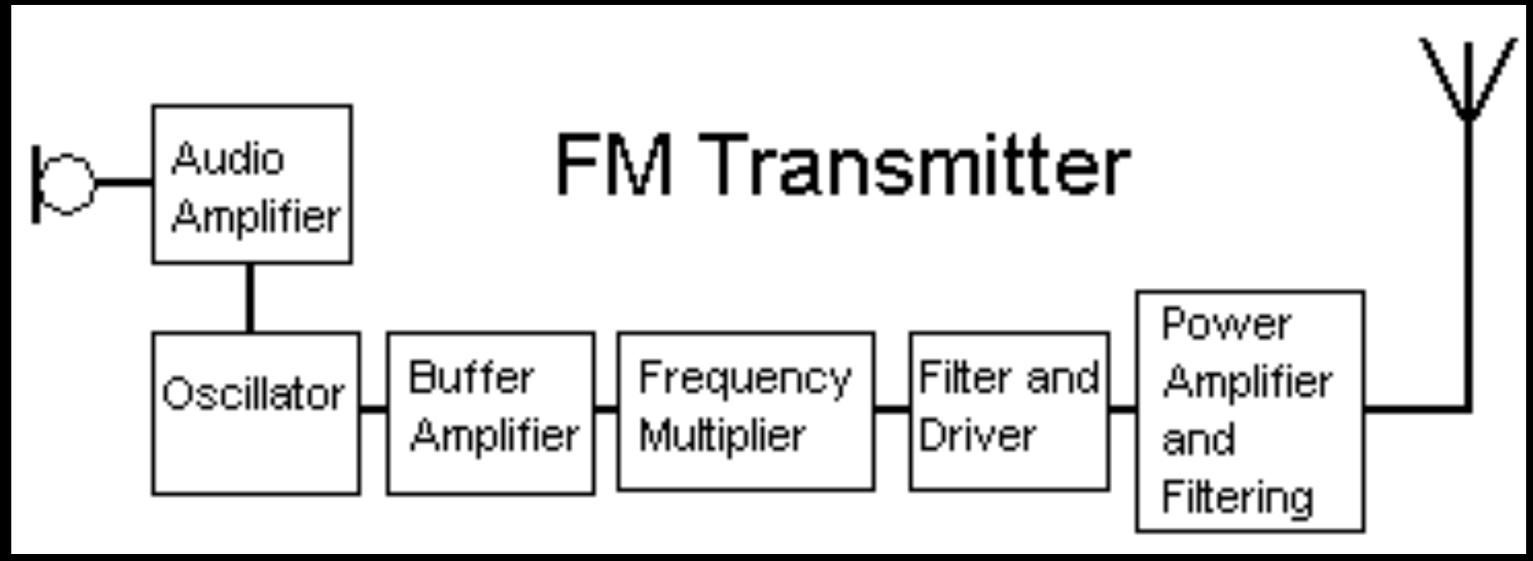
Digital Voice

VHF, UHF, and HF

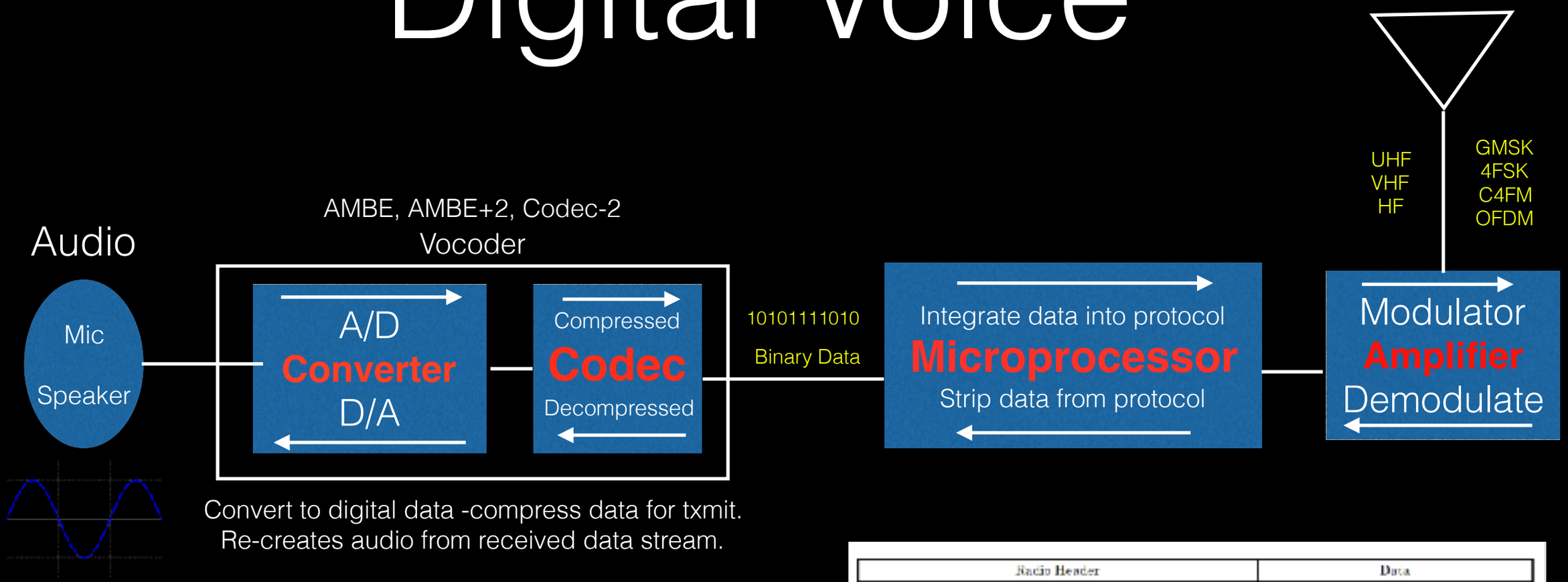
Analog Voice - AM/SSB



Analog Voice - FM



Digital Voice



Convert to digital data -compress data for txmit.
Re-creates audio from received data stream.

Received Digital Voice

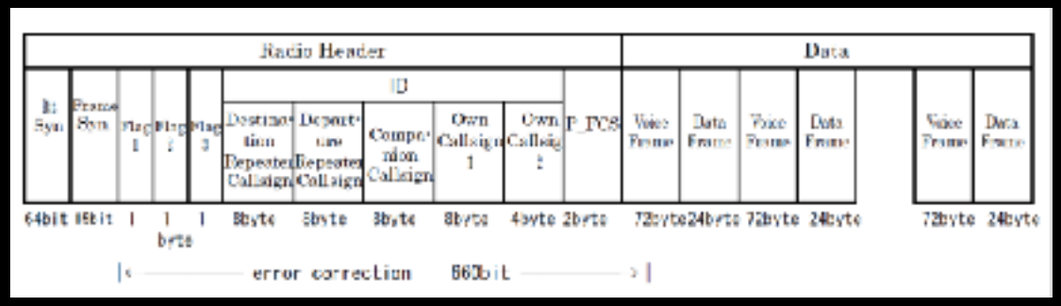
Extraneous noise is stripped from signal. Binary data only is used to recreate voice - no noise - normally.

As signal strength decreases or when phase shifting- occurs, eventually the data stream fails at low S/N.

Each mode has a different way of handling Data stream failure:

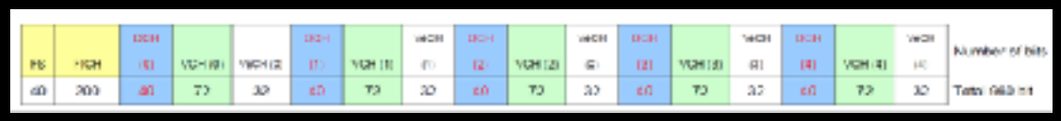
DSTAR - do your best - R2D2 - poor re-sync
DMR - silence the audio - No R2D2 - good re-sync
Fusion - Silence the audio - good re-sync

DSTAR



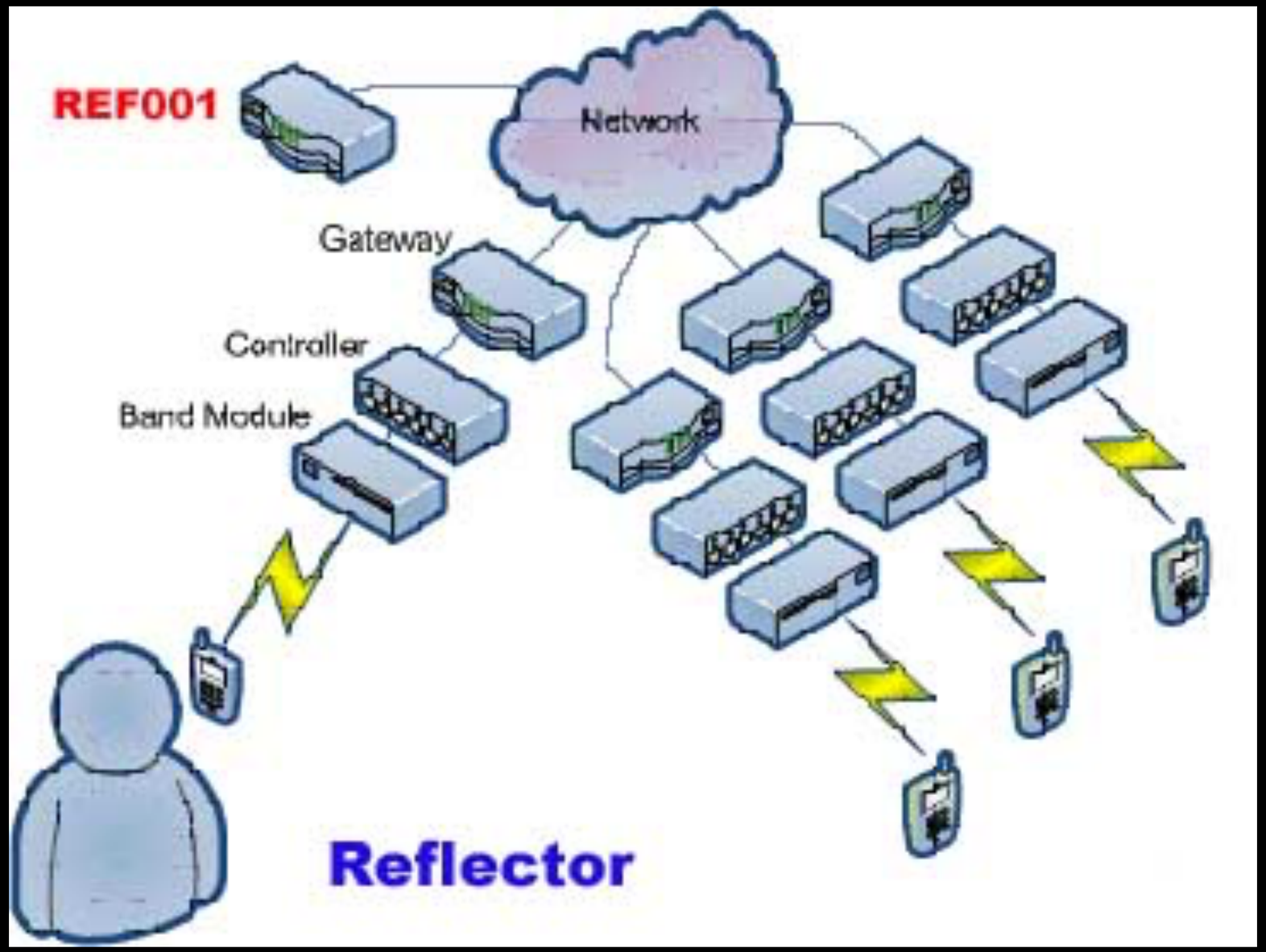
DMR

Fusion

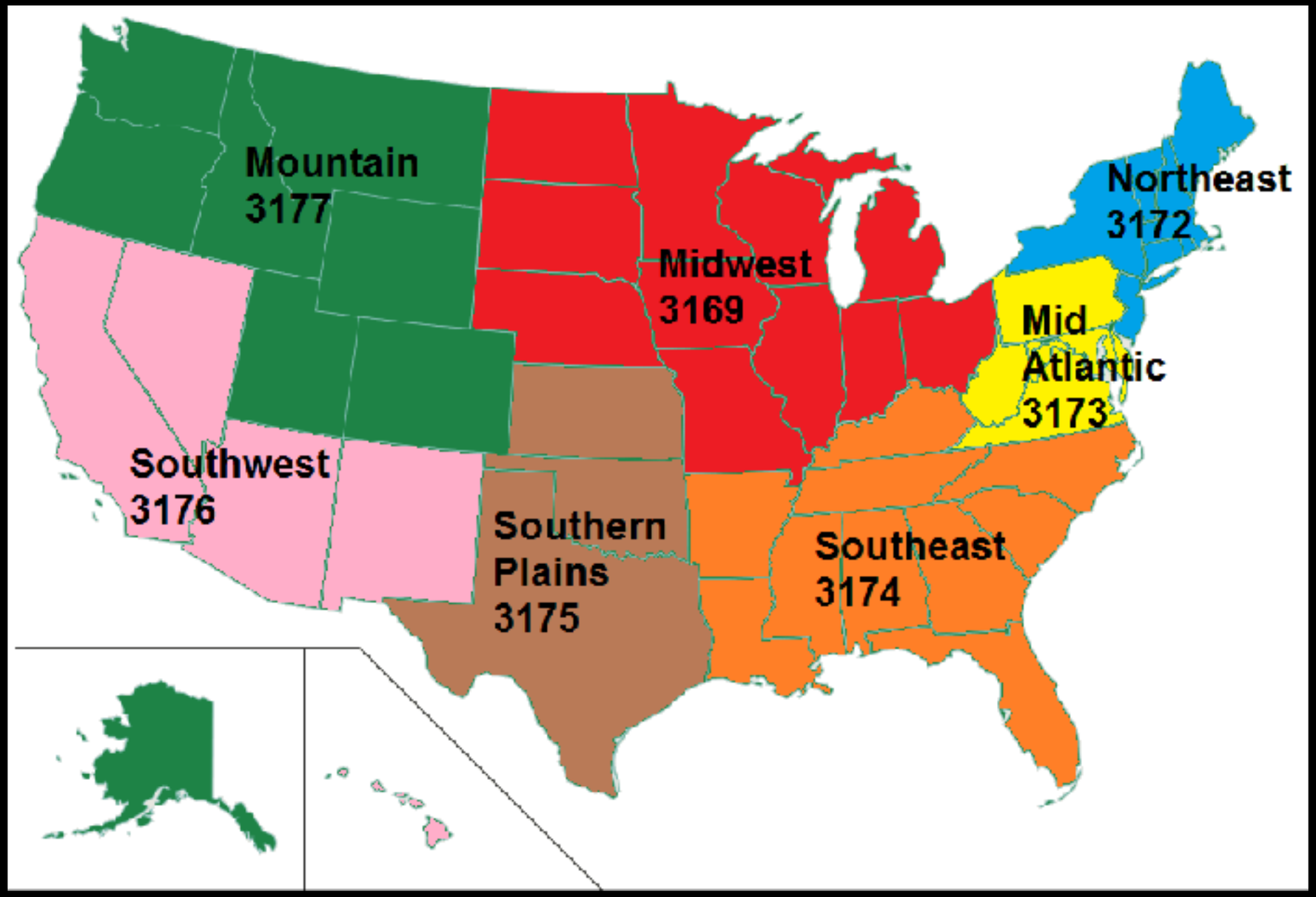


de WA3PNY

DSTAR



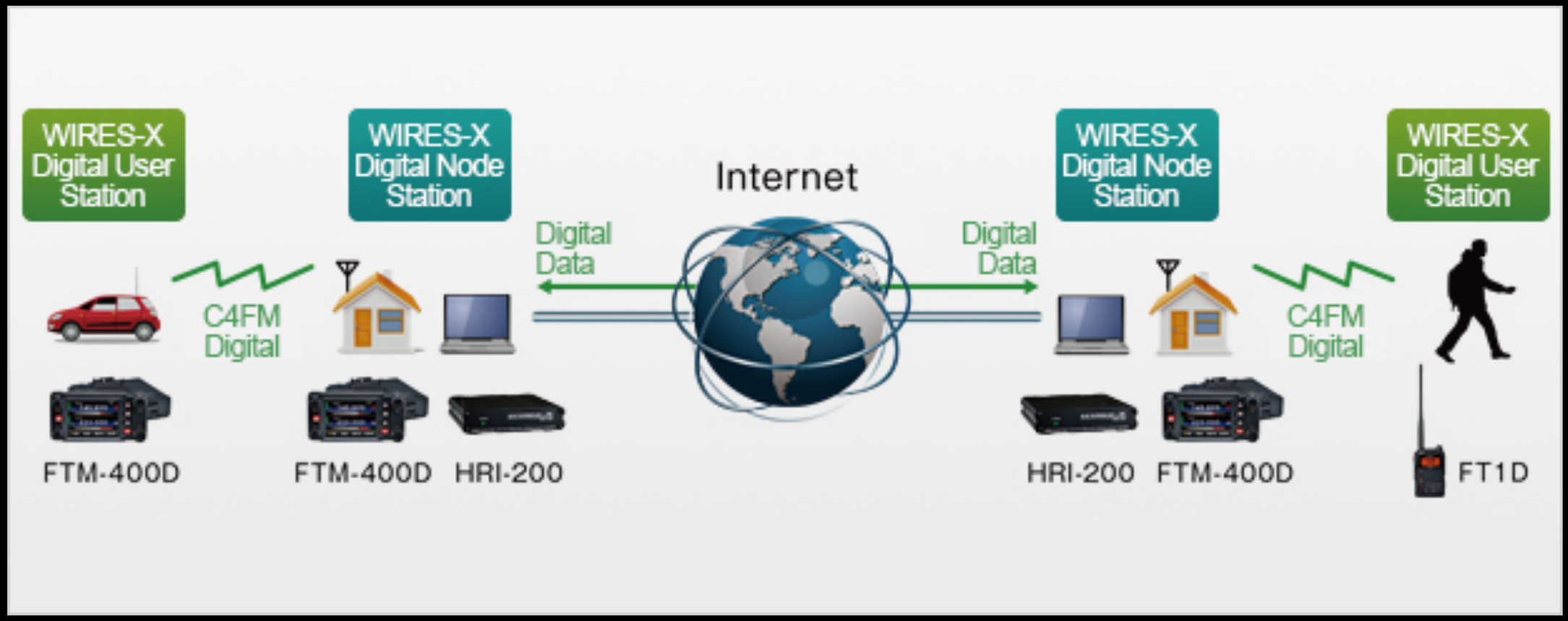
Brandmeister DMR



Brandmeister Regional Talk-groups

3100 - USA Wide
3142 PA State Wide

Yaesu C4FM Wires-X



Wires-X segmented into rooms on node computer

DV Voice Modes - Networking Characteristics

- D-STAR
  - User control capability –substantial
  - Networking options – G3, D-Plus (REF), DExtra (XREF), DCS, XLX, ircDDB, (Echo - end to end loop)
  - Innovation ability – many efforts and accomplishments (DV Access Point and DV Hotspots, XREF, DCS, XLX)
- DMR
  - Centrally controlled structure – inflexible (top - down)
  - Networking options: c-bridge, Hytera
  - Innovation ability – somewhat limited (4 networks: DMR-Marc, Hytera, DV4mini, Brandmeister)
- Fusion
  - Yaesu controlled servers – inflexible
  - Networking options – WIRES-X , DV4Mini Reflectors, MMDVM YSF Reflectors
  - Innovation ability – limited, but just beginning - Links to DV4Mini Reflectors , Latency Concerns

Table 1

Digital Voice Tech Spec Comparison						
	D-STAR	DMR	Fusion	AOR AR9800	FreeDV	AM/SSB
	VHF/UHF/23cm	UHF/VHF	UHF/VHF	HF (Mostly)	HF (Mostly)	HF
Vocoder	AMBE+	AMBE+2	AMBE+2	AMBE+	Codec 2	Analog
Forward Error Corr.	Voice Only	Yes	Yes	Golay – Hamming	None	
Modulation	GMSK	4FSK	C4FM	OFDM	OFDM	
Multiplex Method	FDMA	TDMA	FDMA	FDMA	FDMA	
Transmission Rate	4.8 kbps	4.8 kbps x 2	9.6 kbps	3.6 kbps	1.6 kbps	
Bandwidth	6.25 kHz	12.5 kHz	12.5 kHz	**2.5 kHz** Symbol rate 20ms/ 50 baud	**1.25 kHz** Symbol Rate 20ms/ 50 baud	**SSB 2.8 kHz AM 5.6 kHz** below 28.8 MHz
Channels supported	1	2	1	1	1	
Standard Developer	JARL	ETSI	Yaesu	AOR	FreeDV	
	Open Standard	Open Standard	Proprietary	Proprietary	Open Code	
Cost				EBAY $495	Free	
	FDMA – Frequency Division Multiplexing					
	TDMA = Time division Multiplexing					
	GMSK = Gaussian Minimum Shift Keying					
	4FSK = 4-level Frequency Shift Keying					
	C4FM = Continucus 4-level Frequency Shift Keying					
	OFDM (AOR) = Multiple Carrier Modulation - 36 carriers: DQPSK 3.6K)					
	(Dual-polarization Quadrature Phase Shift Keying)					
	OFDM (FreeDV) - Multiple Carrier Modulation - 16 carriers DQPSK 1.6K					

Is DSTAR Legal on HF?
Sec. 97.307 Emission standards *(<29.0 MHz)*

- (f) The following standards and limitations apply to transmissions on the frequencies specified in Sec. 97.305(c) of this part.

- (1) No angle-modulated emission may have a modulation index greater than 1 at the highest modulation frequency *(Angle Modulation = FM, PM)*. *(MSK is binary digital FM with a modulation index of 0.5.)1*

- (2) No non-phone emission shall exceed the bandwidth of a communications quality phone emission of the same modulation type.

- The total bandwidth of an independent sideband emission (having B as the first symbol), or a multiplexed image and phone emission, shall not exceed that of a communications quality A3E emission *(amplitude modulation telephony, double sideband)*.

- (3) Only a RTTY or data emission using a specified digital code listed in Sec. 97.309(a) of this part may be transmitted.

- The symbol rate must not exceed 300 bauds, or for frequency-shift keying, the frequency shift between mark and space must not exceed 1 kHz.

1 - *"GMSK in a nutshell" - https://www.researchgate.net/publication/2575678_GMSK_in_a_nutshell, by Thierry Turletti*

HF Digital - A Look Back

- 2005-2008 - Early work with FDMDV, DRMDV, and WinDRM; all used Melp Codec, an effective low bandwidth codec for HF.
- Melp was developed by US DD, and NATO, but was held by several private companies as licensed software.
- The Codec was initially OK for amateur use, but was pulled due to licensing concerns.
- That left AOR as the only effective HF Digital Voice application (hardware 2.5 KHz).
- Hams hoped that a replacement would be developed as an open source, but nothing was produced for years.

HF Digital with Codec-2

- 2015, an international group of amateurs was successful in developing Codec-2, allowing speech to be compressed to 700-1600 bps, in a 1.25 KHz bandwidth.

- 2016, FreeDV (based on FDMDV), was developed as a software HF DV transceiver using a PC/Mac. Sounds as good as Melp, theoretically allows 2 digital qso's in the bandwidth of a SSB signal.

- FreeDV was coded by David Witten (GUI, architecture) and David Rowe (Codec 2, modem implementation, integration). It is currently being maintained by David Rowe.

- **February 16 2017**: Ver 1.2 of FreeDV GUI program with 700C - speech quality close to **FreeDV 1600** with greatly improved low SNR performance. **FreeDV 700C** is approaching SSB in it's low SNR performance.

- **FreeDV 1600** affords near FM sound when SNR is high.

Current HF DV Modes

- HF DSTAR - 6.25 KHz bandwidth - IC-9100 & IC-7100 or (*GMSK Node Adapter with HF Rig with 9600 packet*) HF DSTAR HF DSTAR QSO Finder

- Yaesu Fusion - 12.5 KHz bandwidth - FT-991 (*above 28.8 MHz ?*) HF Fusion

- AOR - 2.5 KHz bandwidth - ARD-9800 or ARD-9000 AOR QSO AOR Raw

- FreeDV - 1.25 KHz bandwidth - Software solution

FreeDV Site FreeDV QSO Finder