



# Welcome to Ham Radio 102

## Intro to Digital Voice Modes

Sponsored by Bay-Net [www.bay-net.org](http://www.bay-net.org)



## Agenda

### New Technician / New Licensee

- 8:00 Kickoff
- 8:15 VHF/UHF Gear - David
- 9:00 VHF/UHF Operating - George
- 9:45 Digital Radio- George

### New General / Extra

- 10:15 HF Gear - George
- 11:00 HF Operating - David
- 11:45 Q&A
- 12:00 Wrap up

# Digital Voice Modes - So What's The Big Deal ???



- No static
- Better voice quality in noisy conditions
- Easy linking over the internet
- Send voice AND data
- Easier to setup than an analog repeater

# Most Popular Digital Voice Systems



- Developed by JARL
- Released in 2001
- Primarily Icom
- 1,163 repeaters
- Bay-Net 444.075

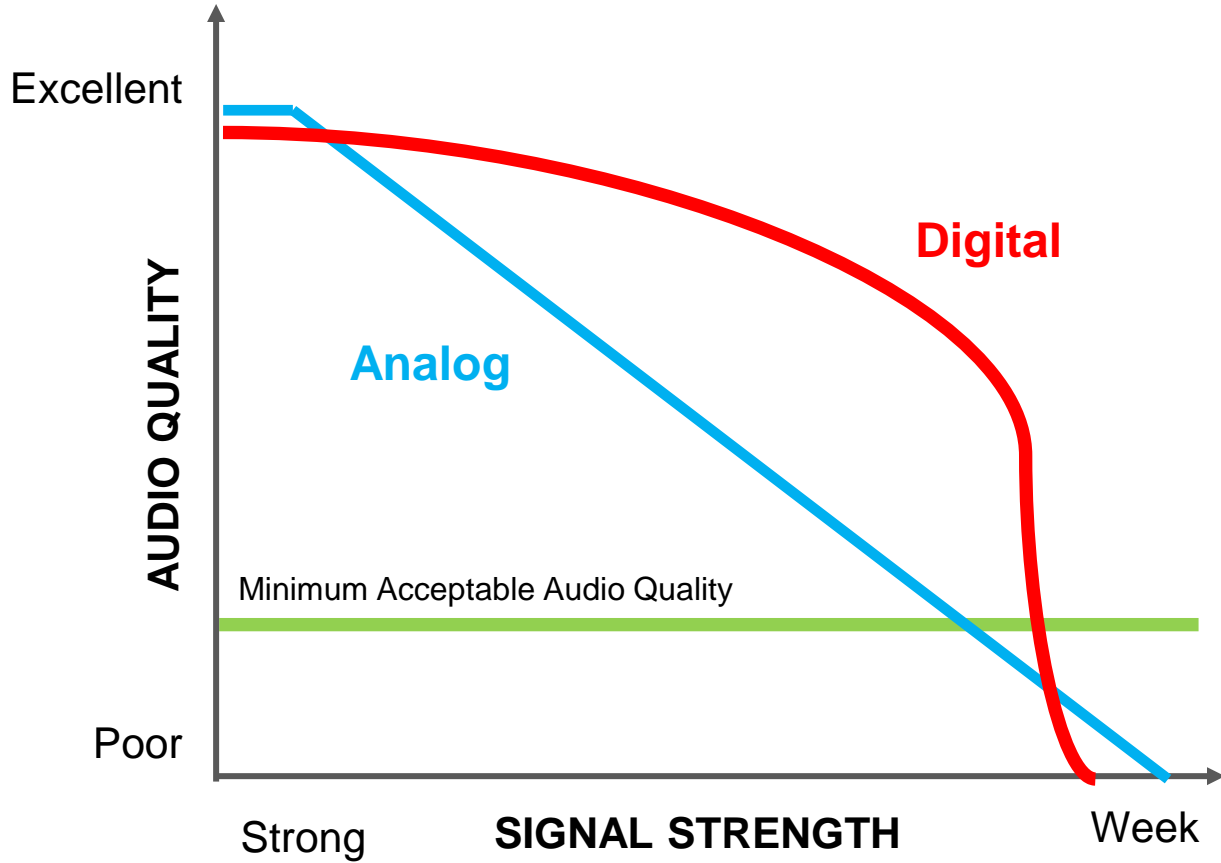


- Developed by Yaesu
- Released in 2014
- Only Yaesu
- 1,682 repeaters
- Bay-Net 444.425

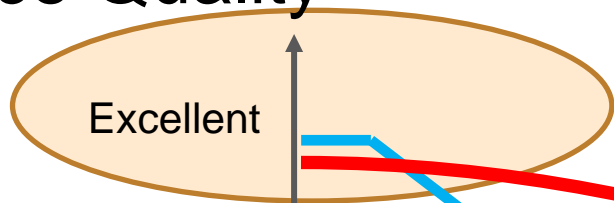


- ETSI Standard
- Released in 2005
- Motorola, Hytera, more
- 1,471 repeaters
- Bay-Net 444.350

# Voice Quality

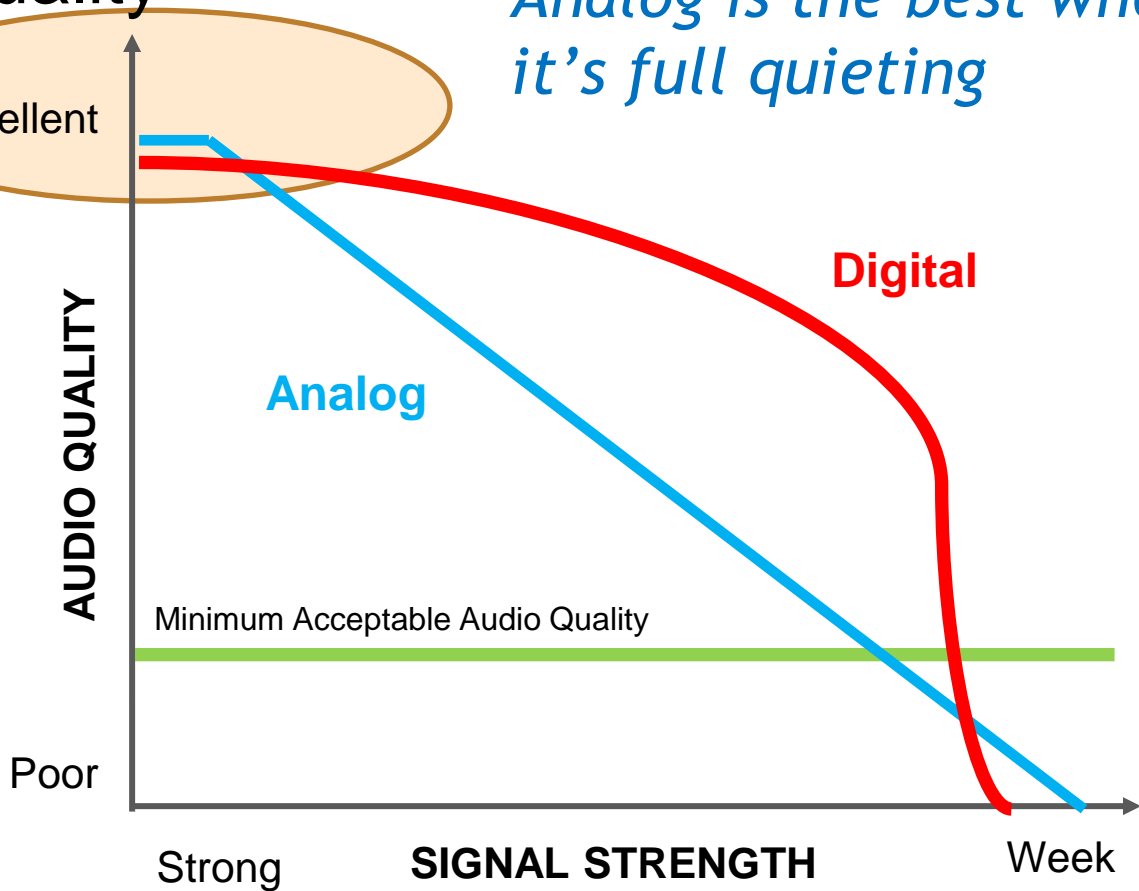


# Voice Quality

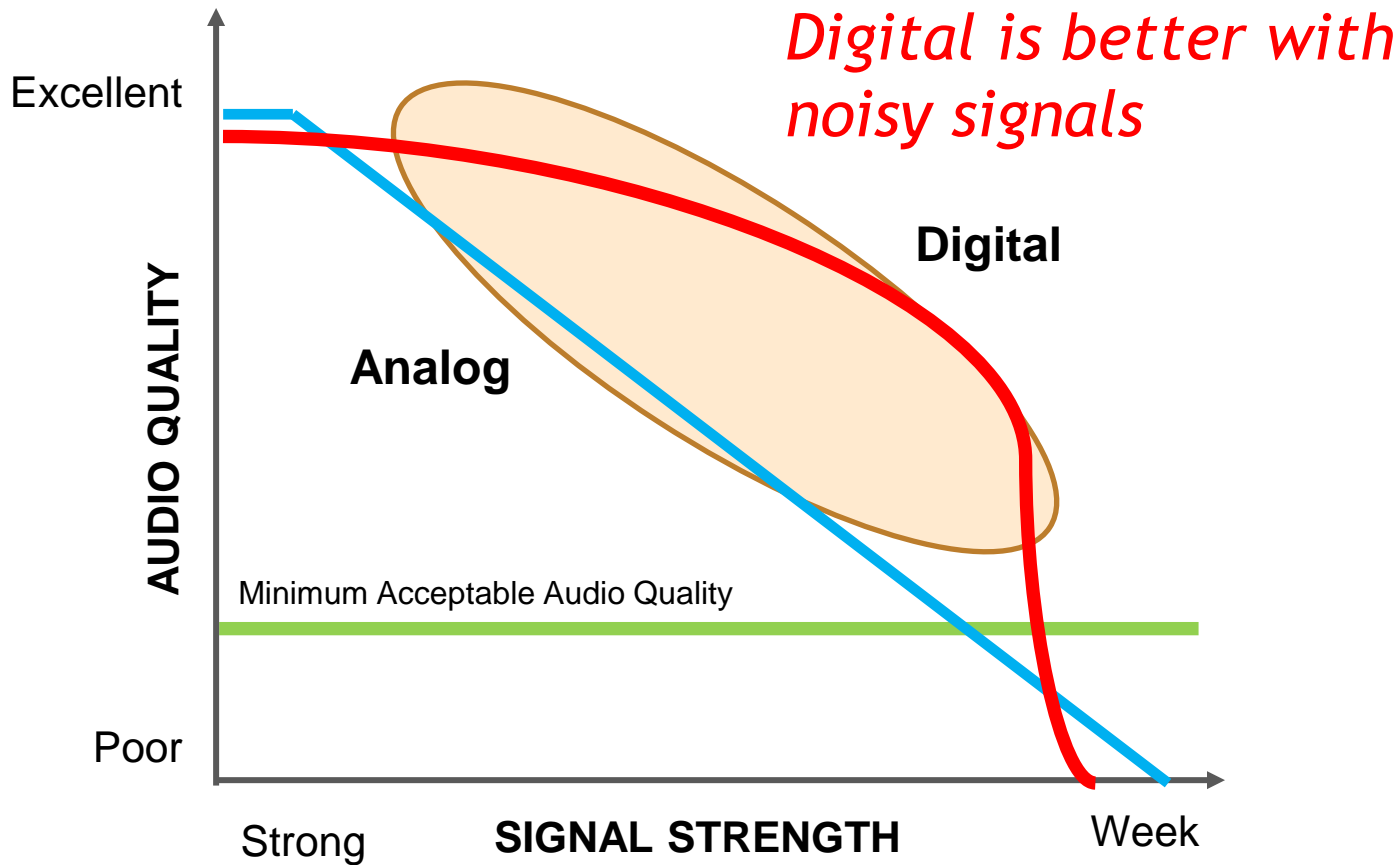


Excellent

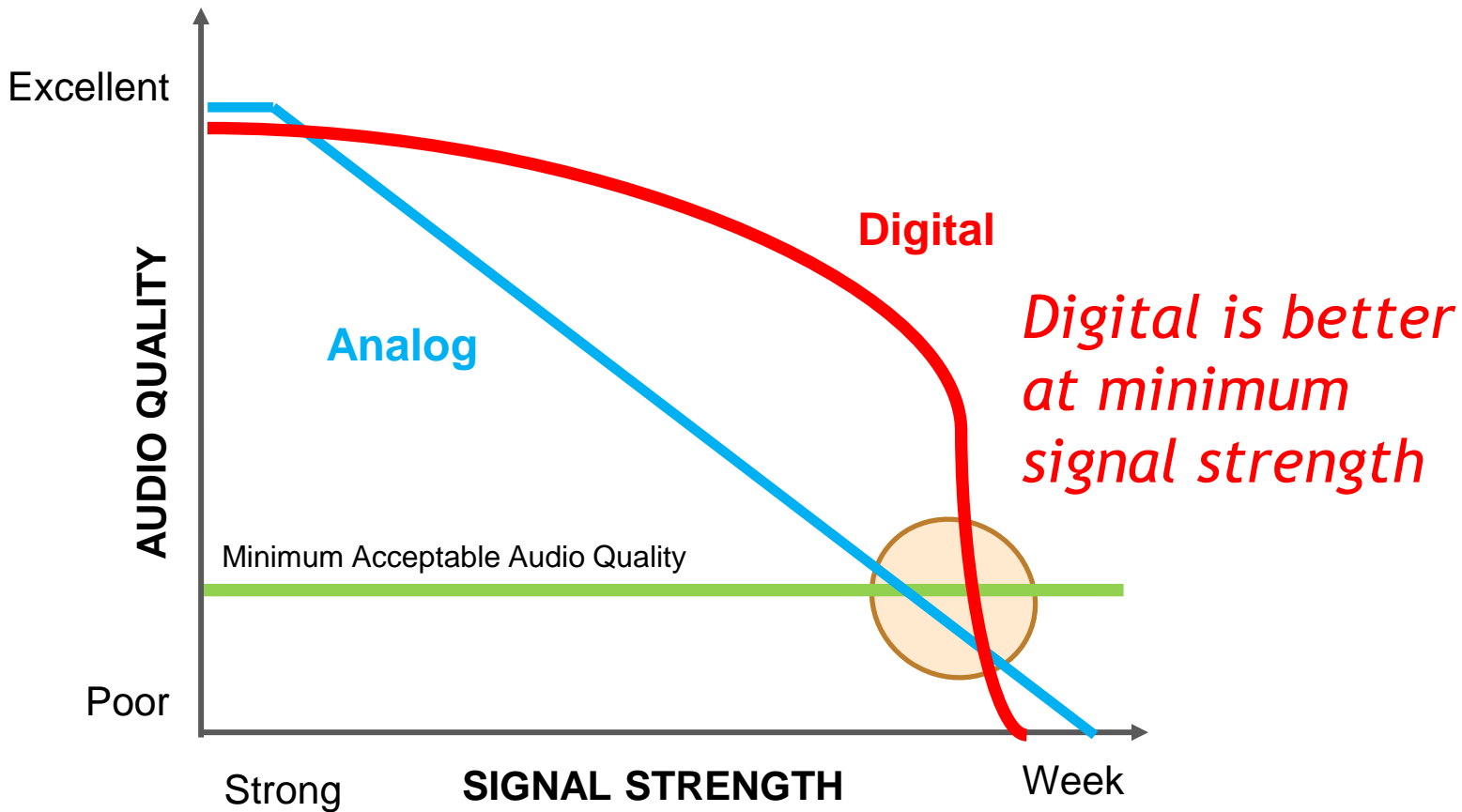
*Analog is the best when it's full quieting*



# Voice Quality

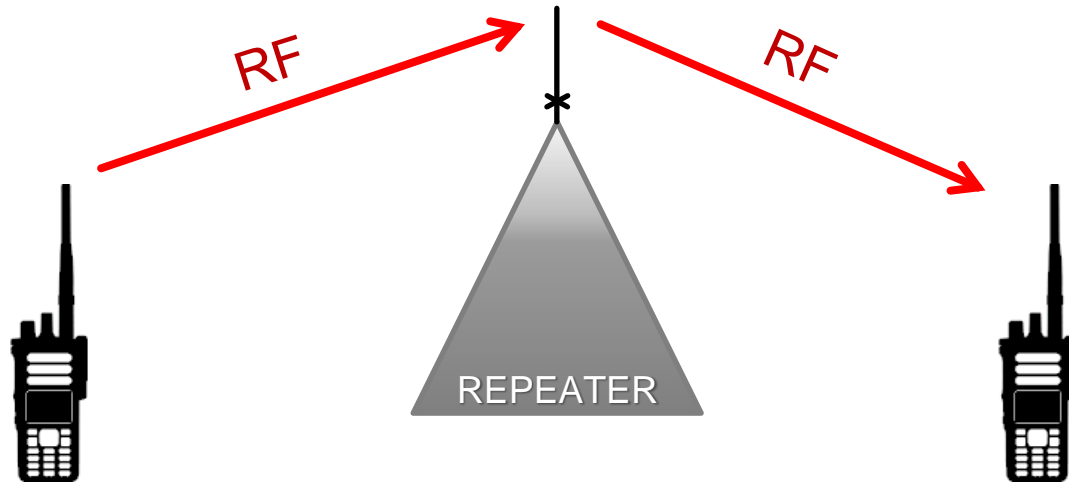


# Voice Quality

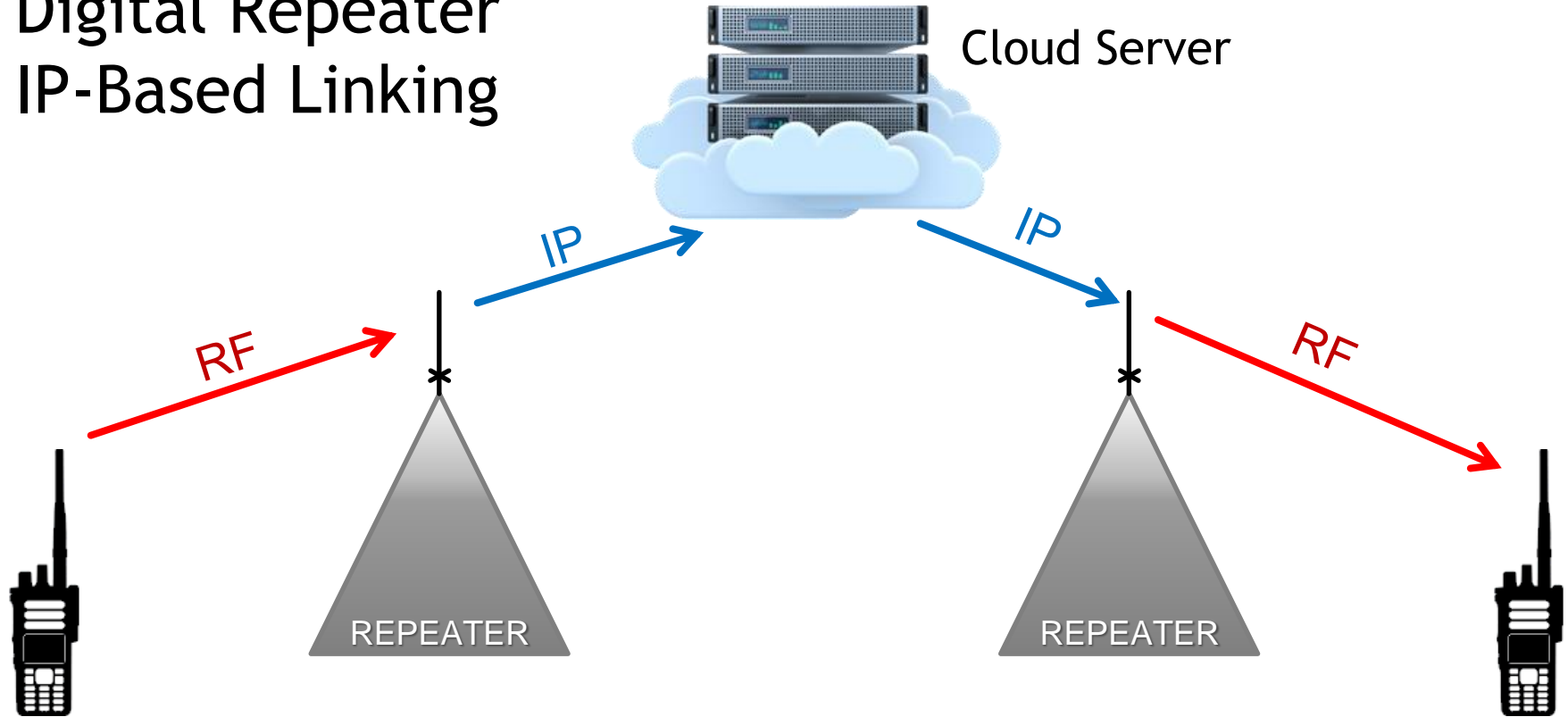




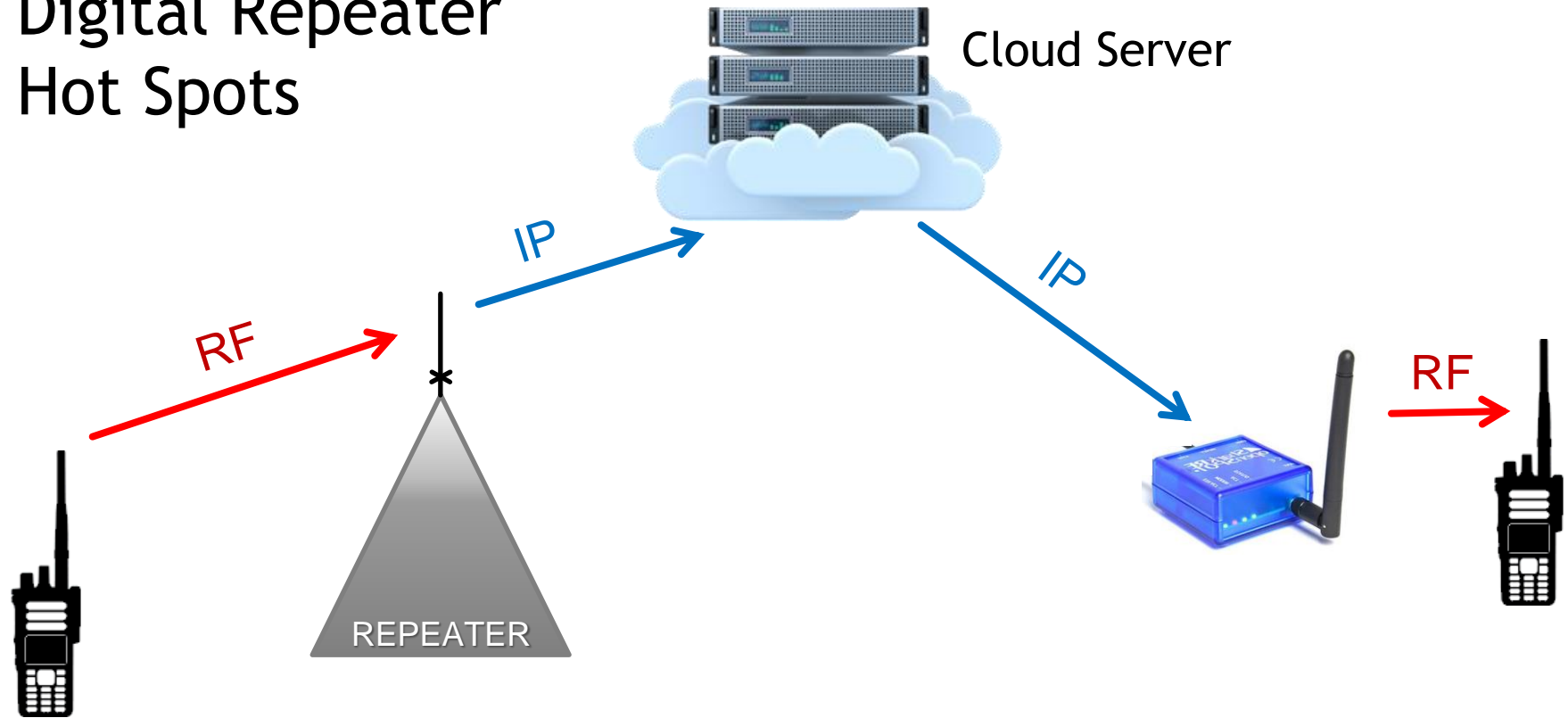
# Digital Repeater



# Digital Repeater IP-Based Linking



# Digital Repeater Hot Spots



# What's The Same ?



- Large and growing user base
- Digital repeater mode
- IP-based linking over the internet
- Conference bridges (reflectors, rooms, talk groups)
- Hot spots

# What's Different?



Designed for Ham Radio

Front Panel Programming

1 Voice Channel per Carrier

Amateur Grade Radios

Narrow Voice

Medium – High Cost

Voice Quality OK

Narrow & Wide Voice

Medium – High Cost

Voice Quality OK - Better

Designed for Commercial Users

Requires Programming SW

2 Voice Channels per Carrier

Commercial Grade Radios

Narrow Voice

Low – High Cost

Voice Quality - Better

# Technical Differences



Vocoder (see note)	AMBE+	AMBE+2	AMBE+2
Forward Error Corr.	Voice Only	Voice Only	Voice Only
Modulation	GMSK	C4FM	4FSK
Multiplex Method	FDMA	FDMA	TDMA
Transmission Rate	4.8 kbps	9.6 kbps	4.8 kbps x 2
Bandwidth	6.25 kHz	12.5 kHz	12.5 kHz

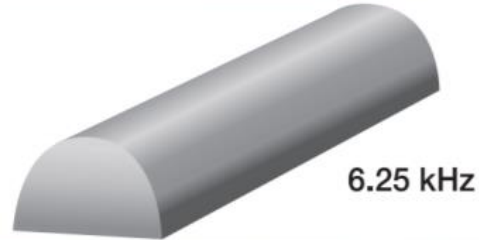
GMSK = Gaussian Minimum Shift Keying

4FSK = 4-level Frequency Shift Keying

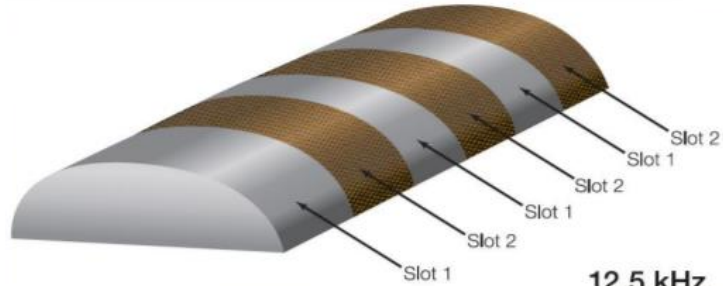
C4FM = Continuous 4-level Frequency Modulation

FDMA = Frequency Division Multiple Access

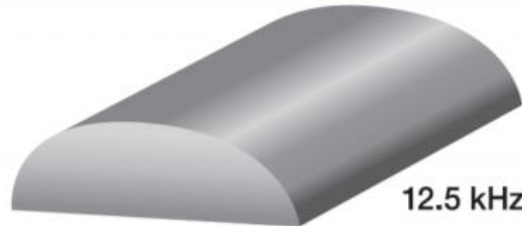
# Bandwidth



6.25 kHz

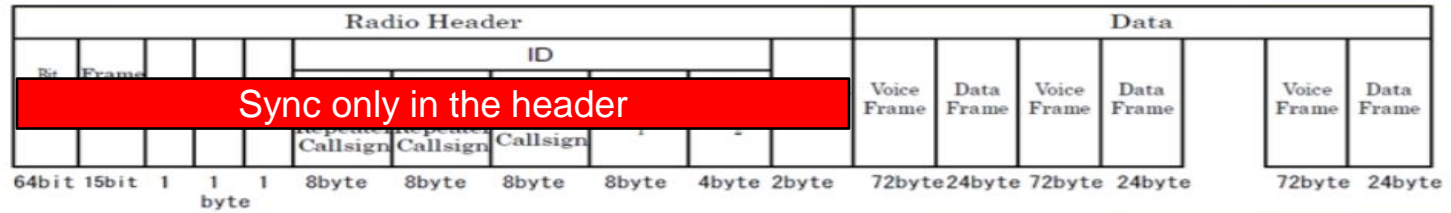


12.5 kHz

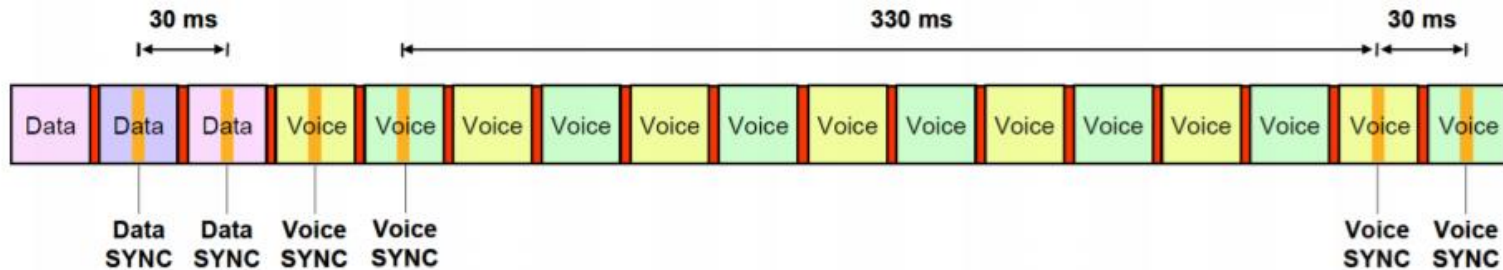


12.5 kHz

# Digital Frame Structure - DMR is the Most Robust



FS	FICH	DCH (0)	VCH (0)	DCH (1)	VCH (1)	DCH (2)	VCH (2)	DCH (3)	VCH (3)	DCH (4)	VCH (4)
40	200	72	72	72	72	72	72	72	72	72	72



Sync every 330 ms

Sync every 330 ms



# Repeater Owner's Perspective



- Ham Quality
- 4U
- Good Reliability
- OK to setup
- Needs a computer
- External 12 power
- \$500-\$1,500

**YAESU**



- Ham Quality
- 3U
- Poor Reliability
- Easy to setup
- Needs a computer
- External 12 power
- \$500-\$1,900

**DMR**  
DIGITAL MOBILE RADIO ASSOCIATION



- Commercial Quality
- 1U
- Excellent Reliability
- Easy to setup
- No computer needed
- Built in 12v & 120 VAC
- \$1,900 – “2 repeaters !”

# DMR Overview



# Intro To DMR



## Why is DMR hot ?

- Commercial quality gear
- High voice quality
- Cheap radios
- Hotspots
- Open network (Brandmeister)
- >1,600 repeaters in North America
- >5,200 repeaters world wide
- >85,000 registered users

## Ham Radio Workbench PODCAST

Episode 45 - DMR Basics Part 1 (Users)

Episode 46 - DMR Basics Part 2 (Network)

[www.hamradioworkbench.com](http://www.hamradioworkbench.com)

# Terms



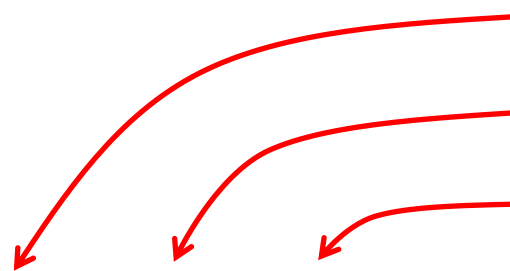
Codeplug	A file containing the memory channel configuration of your radio
Talk Group	A way to connect a common group of users on a radio channel, repeater or conference bridge
Time Slot	One of two time slots on a DMR repeater
Color Code	A number between 1 and 15 needed to access a specific repeater. Similar to a PL tone on an analog system
Zone	Bank of channels on the radio

# DMR Channel Configuration

## Analog Channel



## Digital DMR Channel



Time Slot 1 or 2

Color Code 1 – 15

Talk Group Blank or a number

# Radio Configuration Example



			Rx	Tx	Time	Color	Talk
Zone	Channel	Label	Freq	Freq	Slot	Code	Group
1	1	Black BayNet	444.350	449.350	2	1	31075
1	2	Black TAC 310	444.350	449.350	1	1	310
1	3	Black World	444.350	449.350	1	1	91
1	4	Black Santa Clara	444.350	449.350	1	1	31064
1	5	Loma BayNet	440.000	445.000	1	5	31075
1	6	Loma TAC 210	440.000	445.000	1	5	310
1	7	Loma World	440.000	445.000	1	5	91
1	8	Loma Santa Clara	440.000	445.000	1	5	31064
2	1	HotSpot BayNet	439.000	439.000	2	1	31075
2	2	HotSpot TAC 310	439.000	439.000	2	1	310
2	3	HotSpot World	439.000	439.000	2	1	91
2	4	HotSpot Santa Clara	439.000	439.000	2	1	31064

# Portable Radios



**\$500+**  
Motorola  
XPR7550



**\$200**  
Hytera  
AR482



**\$90**  
TYT  
MD380  
MD390



**\$300**  
Hytera  
PD682



**\$180**  
Hytera  
PD362



**\$170**  
AnyTone  
AT-D868

*Runbo*



**\$700**  
Runbo  
Android LTE  
DMR Raido

# Mobile Radios



Motorola XPR5550 **\$500+**



Connect Systems CS-800 **\$270**



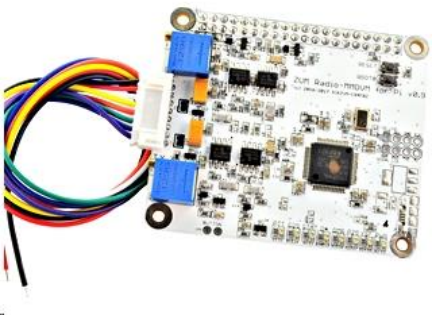
# Hot Spots



ZumSpot **\$135**  
Raspberry Pi Zero  
Modem board



SharkRF  
OpenSpot **\$230**  
Ethernet connected  
**Discontinued**



ZumSpot Modem **\$99**  
Must add Raspberry Pi  
and high power radio



SharkRF  
OpenSpot 2 **\$TBD**  
WiFi connected

# What Do I Need To Do To Start?

- Pick a system (D-STAR, Fusion, DMR)
- Register on the network
- Buy a radio
- Find a codeplug with local repeaters
- Consider getting a hotspot