



## *Unit 5*

# *Frequency Regulations and Usage*

# Unit Terminal Objective

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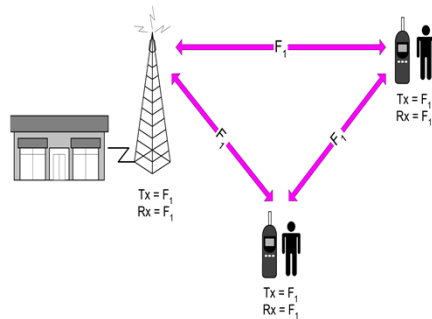
**At the end of this unit, students will be able to identify methods and standards relating to frequency regulations and use.**

# Terminology and Conventions of Use

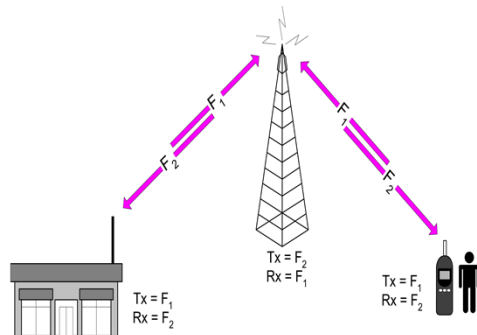
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- A *frequency* is a defined unit of electromagnetic spectrum
- A *channel* is a talk path and may utilize one or two frequencies
- A *talkgroup* is a virtual channel within a group of frequencies
- Frequencies are written as four places past the decimal and should be identified as “wide” or “narrow”
  - Example: 155.4750 W
  - All frequency references on an ICS Form 205 represent mobile and portable frequencies

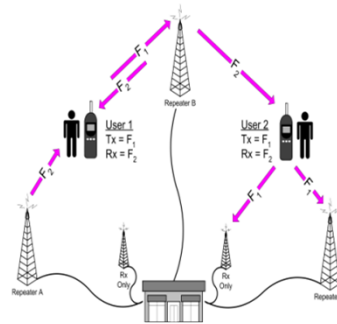
# Conventional Radio Systems - Modes



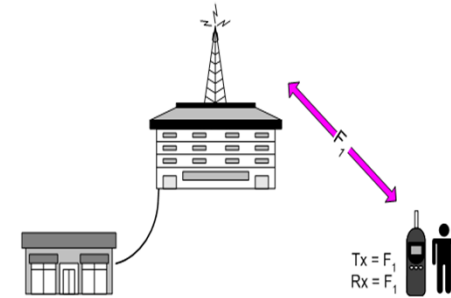
**Simplex**



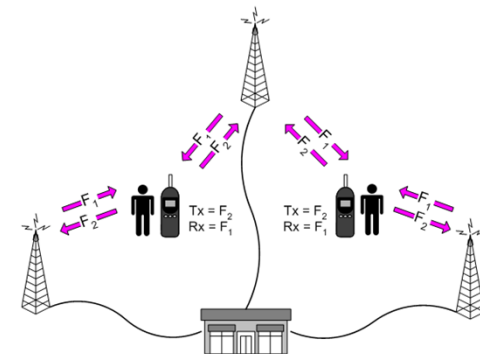
**Repeater**



**Repeater System with Remote Receivers**

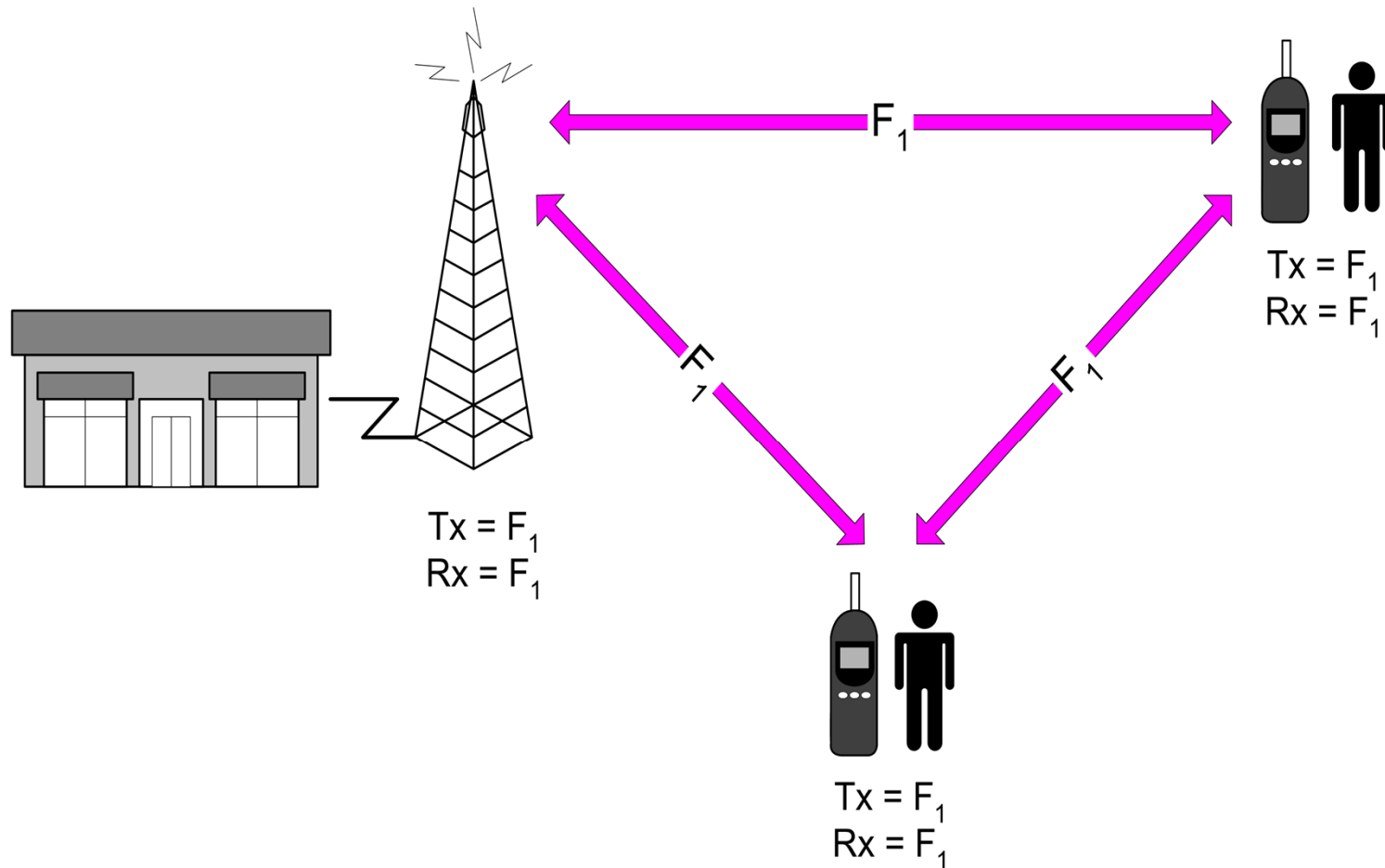


**Remote Radio**



**Simulcast**

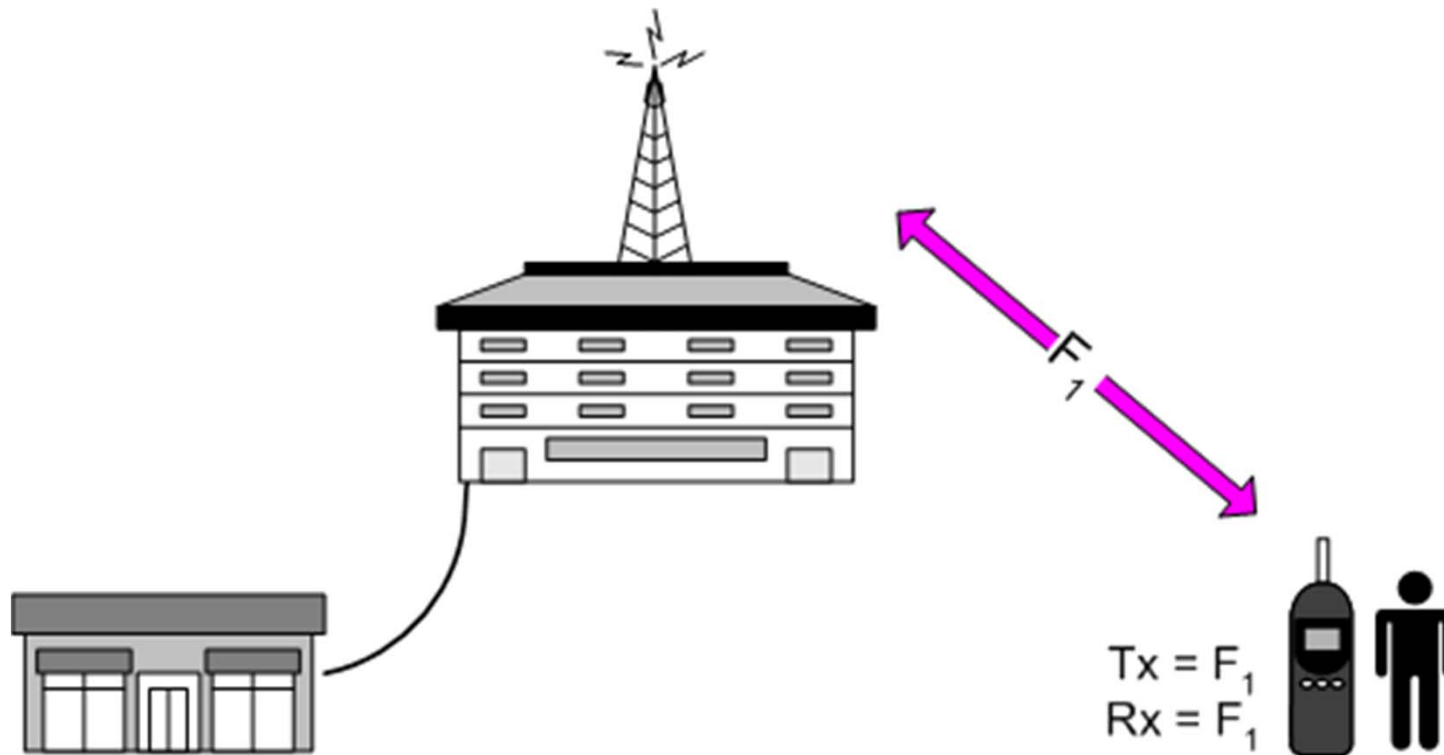
# Simplex Radio System



# Remote Base System

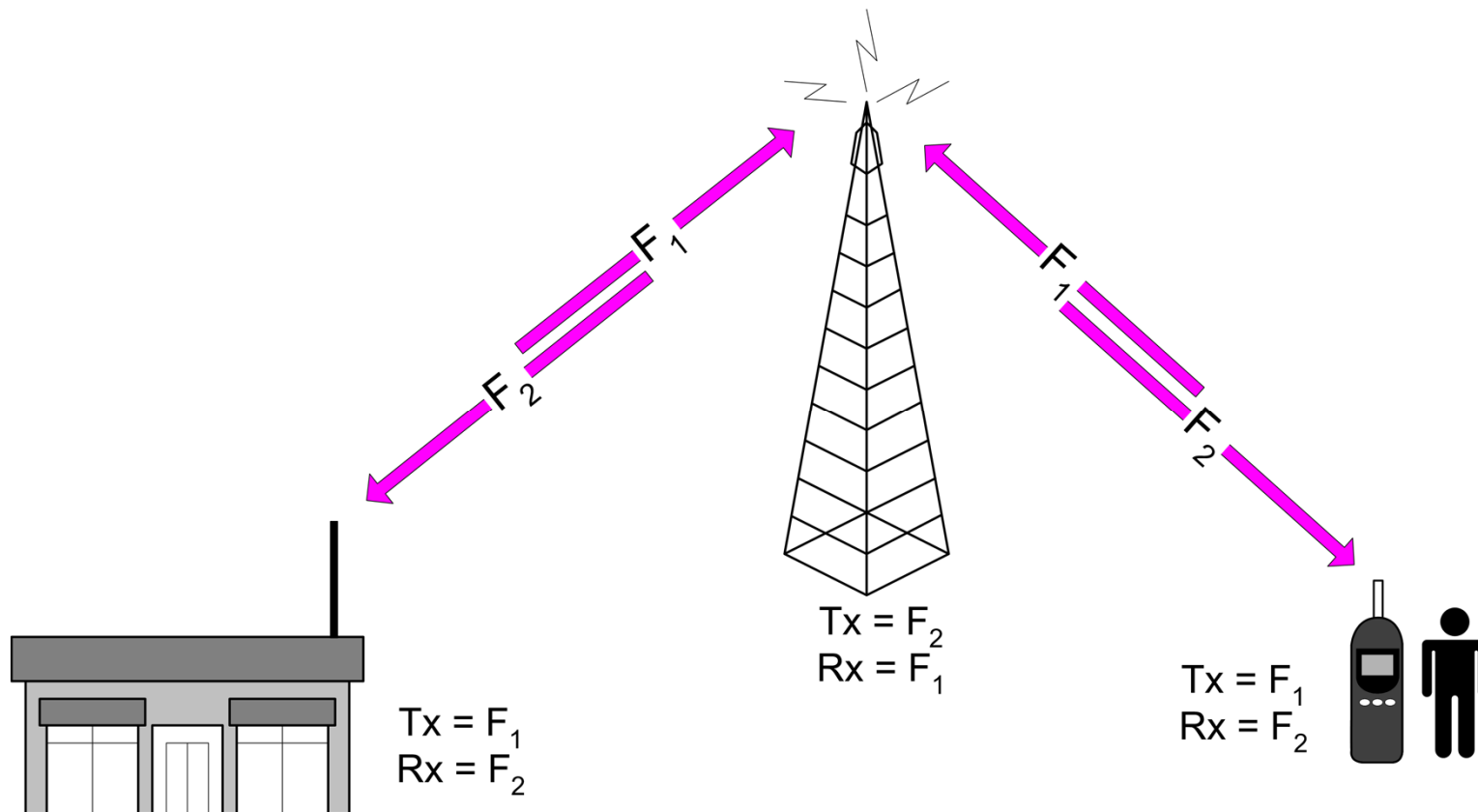
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This is the same as simplex, except the base station transmitter is on a hilltop or other high object

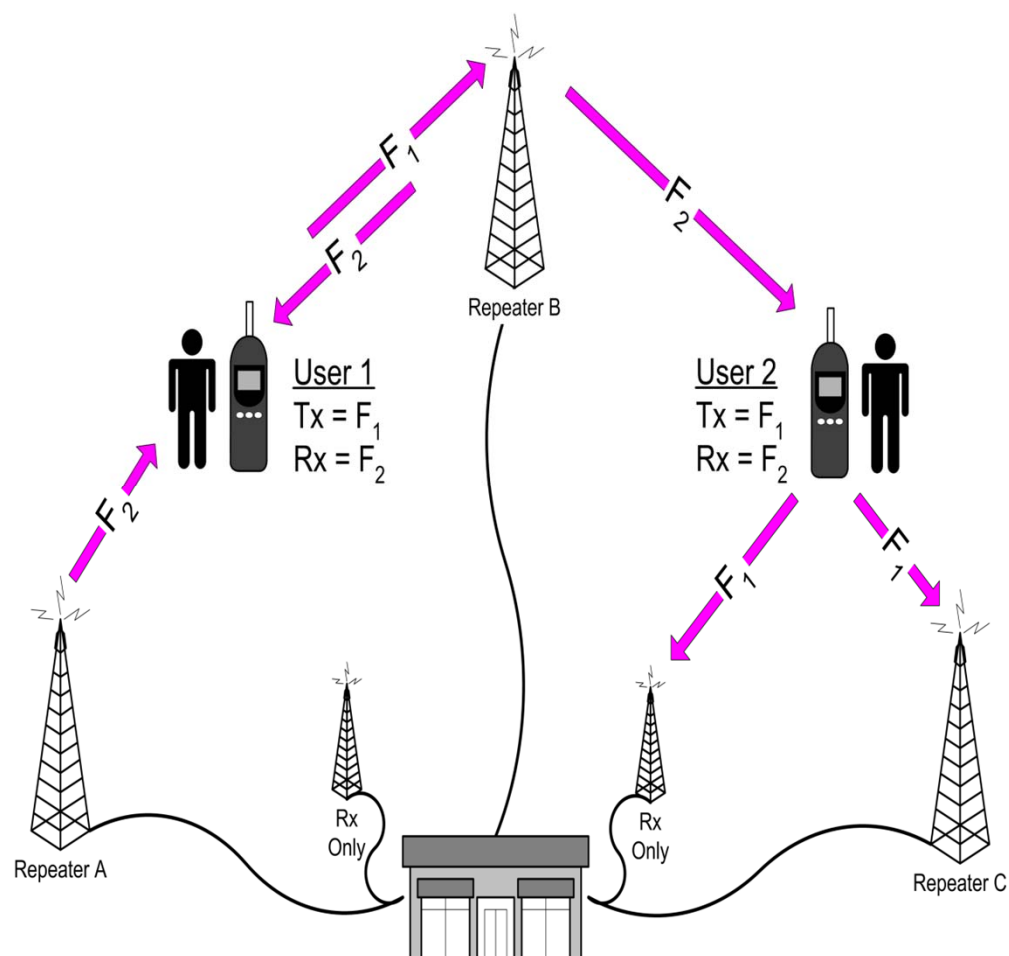


# Repeater System

Transmit and Receive on different frequencies.



# Voting/Remote Receivers





# Voting/Remote Receivers (cont'd)

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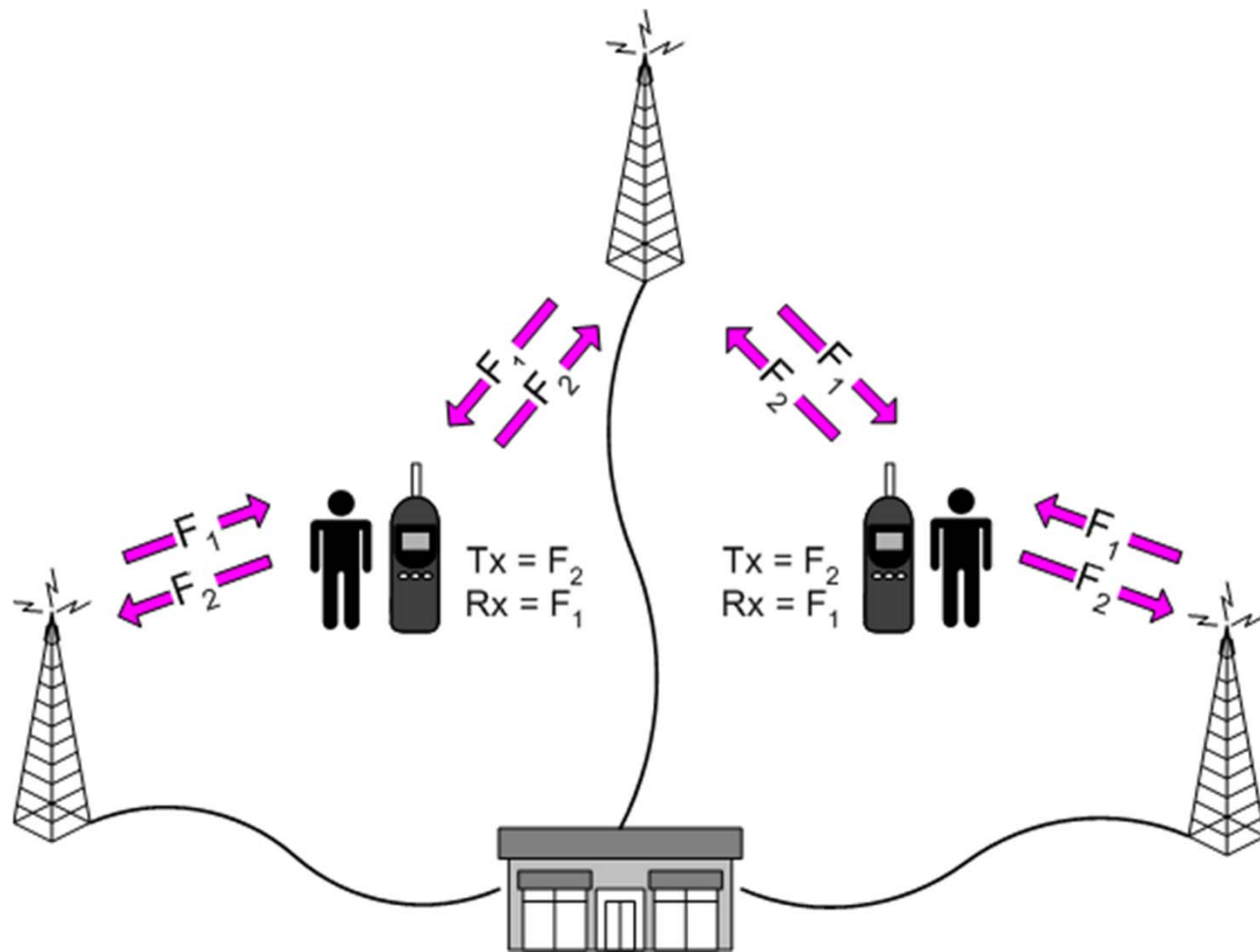
- Remote or satellite receivers are used in addition to regular repeater base station or trunk receivers to pick up relatively weak portable and mobile signals
- Audio from these receivers is routed to a central voting comparator or voter where the best received audio is selected
- The strongest signal is not always selected; that with the highest signal-to-noise ratio is typically best

# Voting/Remote Receivers (cont'd)

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- **Selected audio may come from multiple receivers during a single transmission**
- **Some systems are configured to lock onto a single receiver, once chosen, for a transmission**
- **Selected audio is routed to the ultimate receiving locations, such as consoles or repeaters for retransmission**

# Simulcast Radio System



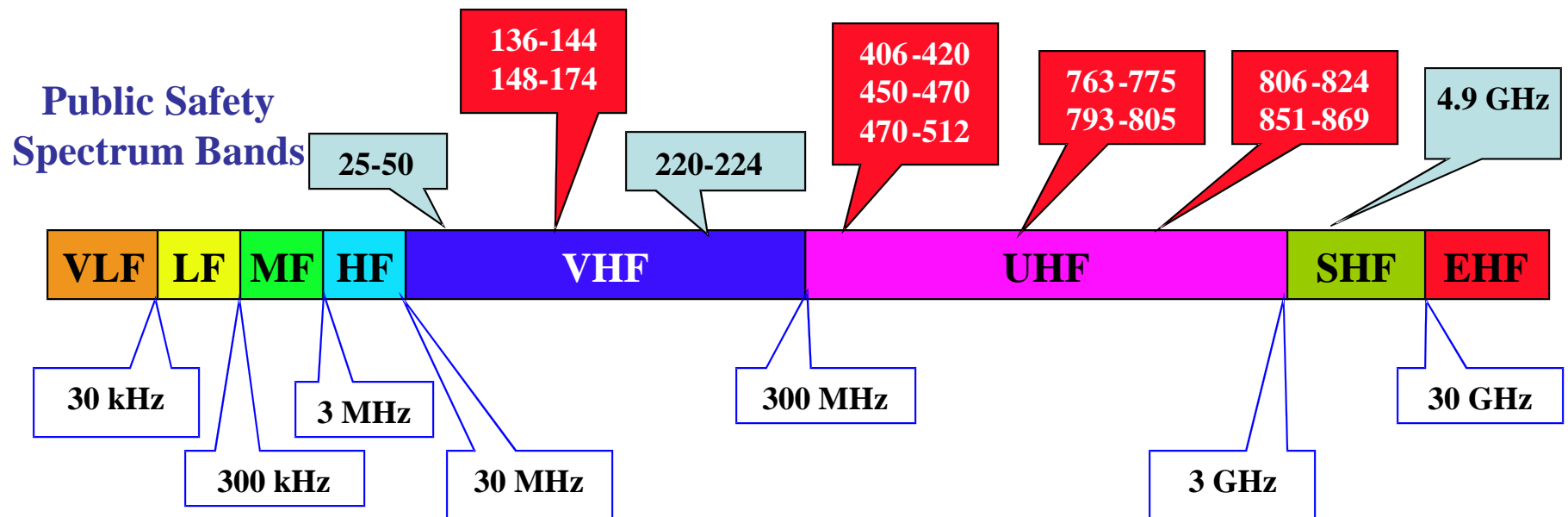
# The Radio Spectrum

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- Radio frequencies are the products of resonance or vibration
- These vibrations can be used for effective communication at a number of frequencies
- As the speed of the resonance increases, physical properties change
- Frequencies range from the audible to the production of light
- As frequencies pass above the audio range, the waves begin to travel through air and become radio frequencies

# Public Safety Spectrum Bands

- The FCC and NTIA have assigned spectrum for use by Land Mobile Radios
- Federal Communications Commission and National Telecommunications and Information Administration



# VHF Low Band

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- **Lowest effective frequency used by Public Safety**
- **30 MHz to 50 MHz**
- **Performs very well in mountainous terrain, primarily because the radio waves conform to the terrain well**
- **Susceptible to long distance “skip”, solar interference, and “industrial generated” noise**

# VHF High Band

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- **Widely mixed use – most commonly used public safety band**
  - **108-136 MHz – Exclusive to aviation (AM modulation)**
  - **138-144 MHz – Exclusive to Federal (military)**
  - **144-148 MHz – Amateur radio**
  - **148-150 MHz – Shared mobile and satellite**
  - **150-162 MHz – State & local public and private**
  - **156-174 MHz – Marine band**
  - **162-174 MHz – Primarily Federal**
- **Frequency pairings are random**
- **Extensive Federal use**
- **Good long-range propagation**

# UHF Band

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- **Duplex use**
  - **406-420 MHz – Federal Use**
  - **420-450 MHz – Amateur radio and radio-location**
  - **450-470 MHz – Non-Federal public and private**
  - **470-512 MHz – Non-Federal public and private (T-band)**
- **Standard frequency pairings**



# UHF Paired Frequencies

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- **Paired splits**
  - The standard split for 406 to 420 MHz is 9 MHz
  - The standard split for 420 to 470 MHz is 5 MHz
  - The standard split for 470 to 512 MHz is 3 MHz
- **VHF has no designated pairs**
  - Inconsistent use (high side/low side)
  - Inconsistent TX/RX splits
  - 175 kHz minimum

# 800 MHz

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## 800 MHz - Upper part of UHF band

- 806-824 MHz/851-869 MHz
- Paired channels – 45 MHz
- Trunked and conventional
  - Trunking requirements for certain capacity limits
- 5 dedicated interoperability channels
- General channels
- Rebanding (NEXTEL interference)

# 700 MHz

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## 700 MHz

- 763-775 MHz (Old TV band channels 62 and 63)
- 793-805 MHz (Old TV band channels 68 and 69)
- All 700 assignments are narrowband
- Mandated digital emissions
- Dedicated Interoperability channels
  - Mandated P25 Common Air Interface (CAI)
- 6.25 kHz equivalency (Frequency-Division Multiple Access [FDMA] versus Time-Division Multiple Access [TDMA])
  - Temporary 12.5 kHz authorization until about 2017

# 4.9 GHz

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## 4.9 GHz

- **Mesh Type Networks**
- **Point-to-Point Microwave Links**

# Aviation Radio

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- **Exclusive use for aircraft**
  - 108 MHz – 136 MHz
  - 225 MHz – 380 MHz (military)
  - AM modulation
- **Extreme caution must be used in frequency use**
- **Must coordinate with Aviation management**



# Aviation Radio (cont'd)

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- With appropriate licensing, may be used by ground mobile units for air-ground communications

***Air-to-ground operations should be on public safety FM channels***



# Analog Versus Digital Radio

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- **Analog radios use Frequency Modulation (FM) for Land Mobile Radio applications**
- **Susceptible to noise and sometimes noise can override intended traffic**
- **Usually users will know there is someone calling**
- **Gradual decay of signal quality versus distance**



# Analog Versus Digital Radio (cont'd)

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- Digital radio uses a vocoder to convert human voice into digital symbols for compression purposes
- Digital users either hear clear traffic or hear nothing
  - Sharp fringe area drop-off
  - Several studies have questioned the reliability of digital in high noise environments, such as fire ground operations (IAFC report link)

<http://www.iafc.org/displaycommon.cfm?an=1&subarticlenbr=719>

- Signal blocking by unintended third party transmission in conventional digital usage





# Trunking

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- Trunked radio systems differ from conventional
- Trunked systems have a number of frequencies pooled into one system
- Primary difference is the use of “talkgroups” instead of discrete frequencies
- Each transmission is between talkgroups and is moved between frequencies as frequencies are available
  - Dynamic frequency assignments
  - Channel loading is based on probability

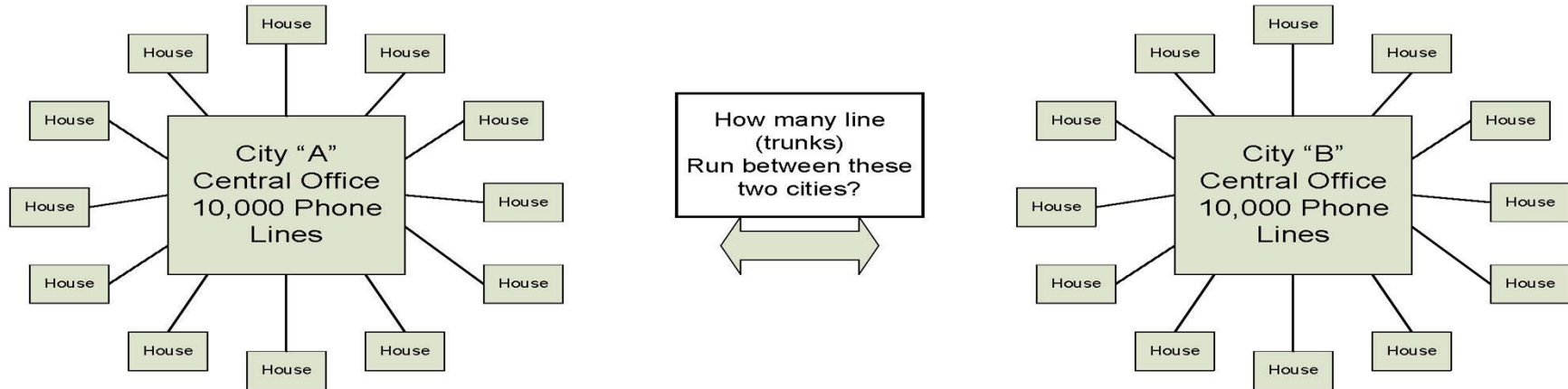
# Trunking (cont'd)

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- When was trunking invented?
- Talkgroups capacity enhanced by probability of channel availability
  - Instantaneous capacity is limited to the actual frequency capacity
- Fleet mapping should include interoperability talkgroups

# How Many Lines Run Between the 2 Cities?

- The answer is very few, possibly as few as 20. This is based upon the probability that a very small percentage of the City “A” population will want to talk to the City “B” population at the same time (Erlang Theory)
- This is the exact same theory used in Trunked radio, a large number of users sharing a small number of trunked channels, making the utilization very efficient



# How a Trunked System Differs

## Conventional System

Message on Channel 1 same frequency

Reply on Channel 1 same frequency

If the system uses a repeater, then TX and RX are different frequencies, but do not change

## Trunked System

Message on Talkgroup 1, uses frequency 1

Reply on Talkgroup 1, uses frequency 6

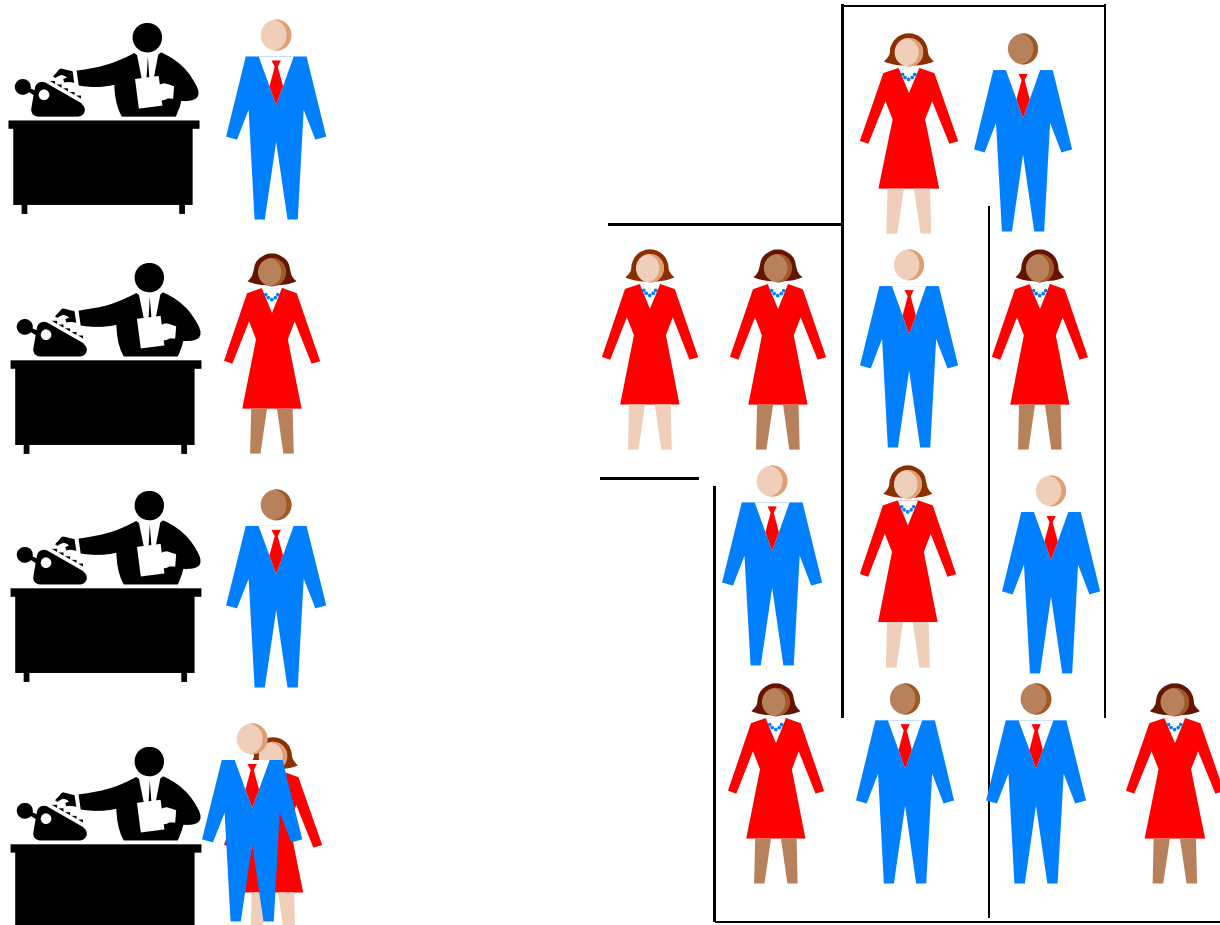
Next message on Talkgroup 1, uses frequency 3

Next reply on Talkgroup 1, uses frequency 8

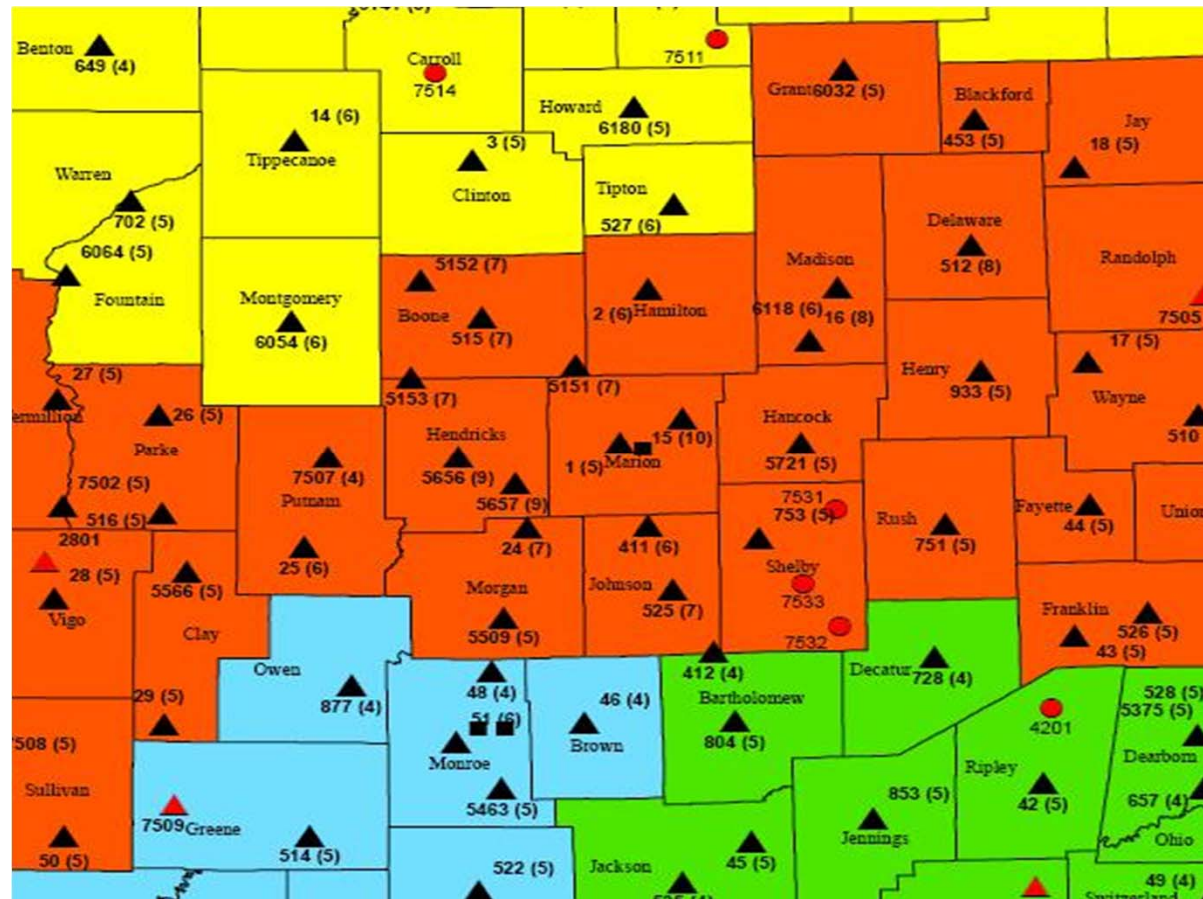
The frequencies are entirely random within the system, and dependant upon which frequencies are available at that exact moment

# Bank Teller Line

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# Trunked System Capacity





# Narrowband – VHF/UHF

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**Federal Communications Commission (FCC) Deadline:**  
*December 31, 2012*

- 150-174 MHz and 421-512 MHz

<http://www.imsasafety.org/PDFs/Narrowbanding%20V2%20R2.pdf>

**Convert from...**

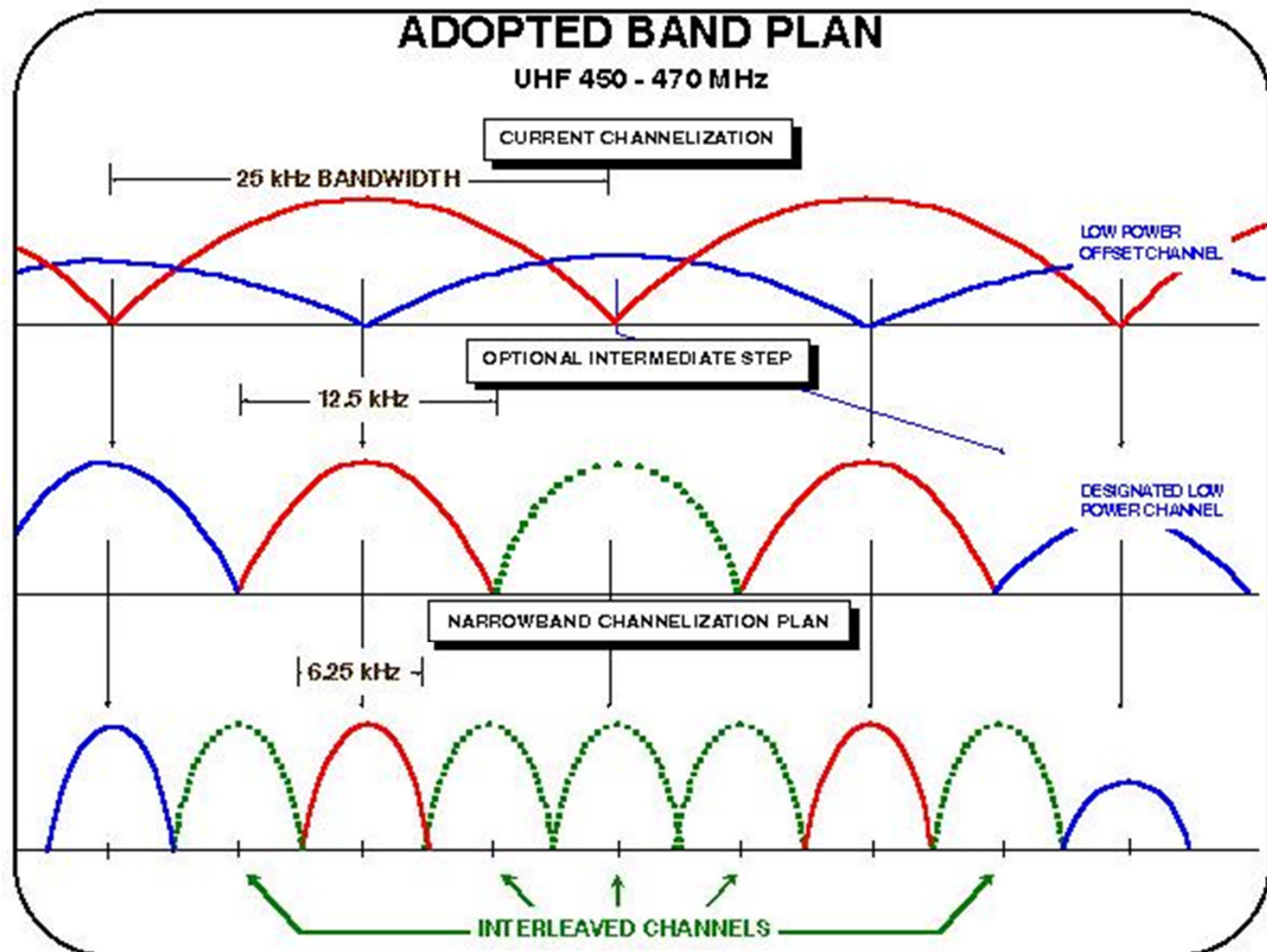
- 25 kHz bandwidth channels to 12.5 kHz bandwidth channels, or equivalent voice talk paths – one per 12.5 kHz)

# Narrowband – Adopted Band Plan

**Current**

**Dec 2012**

**Future 2017 ?**





# Interference

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**This issue becomes bigger every day**

- **Mechanical interference – rusty bolts, bad grounds**
- **Broadband noise**
- **Inter-modulation (transmitter mixes)**
- **Co-channel – on frequency**
- **Adjacent channel – near frequency**
  - **Try to identify the offending station by monitoring; listen for call signs or geographical information to assist in locating the station**



**Be aggressive in eliminating interference. It can get worse at exactly the wrong time and compromise operations**

# Interference (cont'd)

- First choice may be to contact the agency or licensee directly, and try to find out if they changed something recently, such as antennas or power output
- Most public safety agencies will cooperate to rectify interference
- The FCC may also be of assistance finding the offending station
- Make contact; operator information can be obtained via the FCC Universal Licensing System (ULS) database

<http://wireless.fcc.gov/uls/index.htm?job=home>



# Willful Interference

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- This is a criminal act; involve the FCC and law enforcement early on in the process
- Willful interference can be a more pervasive problem, depending upon the motive of the perpetrator and their skill level
- The station may be moved to prevent easy detection
- They may or may not identify themselves
- The FCC, radio shops, and amateur radio operators may all be of assistance solving this problem

# Tone-Coded Squelch

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- **Continuous Tone-Coded Squelch System**
  - Analog sub-audible frequency tone continuously transmitted
  - 38 standard tones ranging from 67.0 Hz to 250.3 Hz
  - Provides protection from errant on-frequency RF signals
    - Radio will not open audio without the presence of the required tone
    - Particularly required for repeater operations to control repeat function
- **DCS – Digital-Coded Squelch**
  - Equivalent action as analog using digitally encoded 134.4 Hz sub-audible tone
- **The P25 Network Access Code (NAC) performs a similar function to CTCSS**

# Radio Programming

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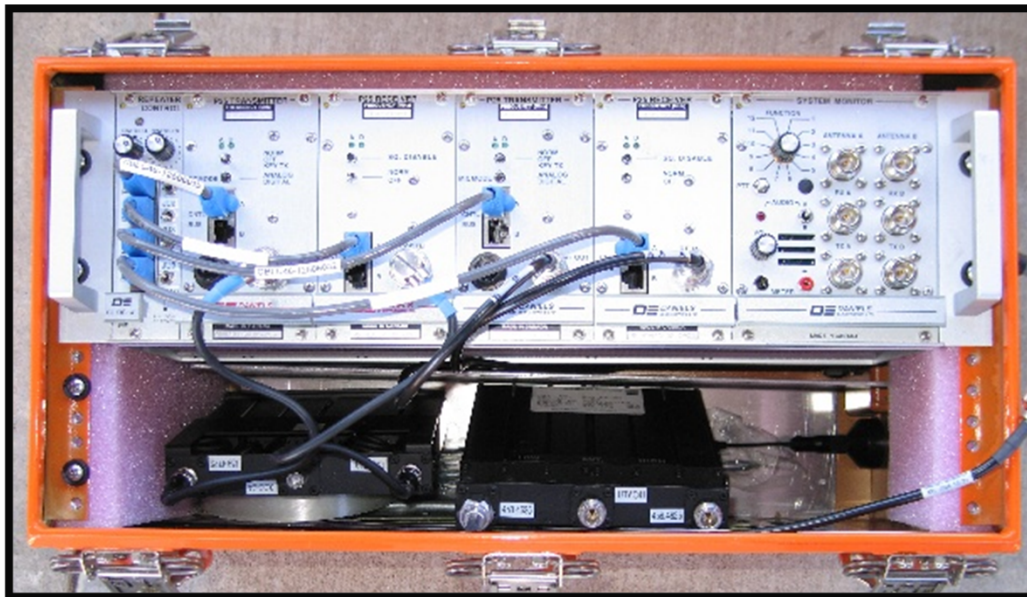
- Laptop – Radio Interface Box (RIB)
- Cloning cables
- Logistics considerations
- De-programming radio





# Portable Repeaters

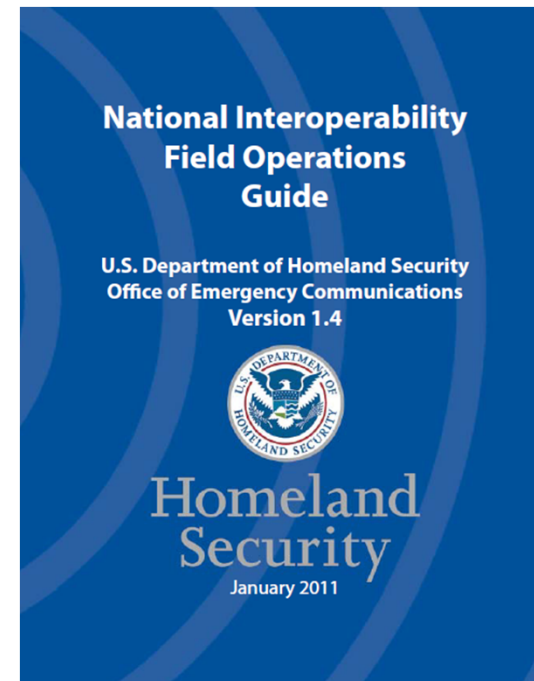
- Transportable
  - Repeat mode
  - Relay mode



# NIFOG - Resource

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- **National Interoperability Field Operations Guide**
- **Common interoperability channel lists**
- **Technical reference for the Communications Unit**





# NIFOG

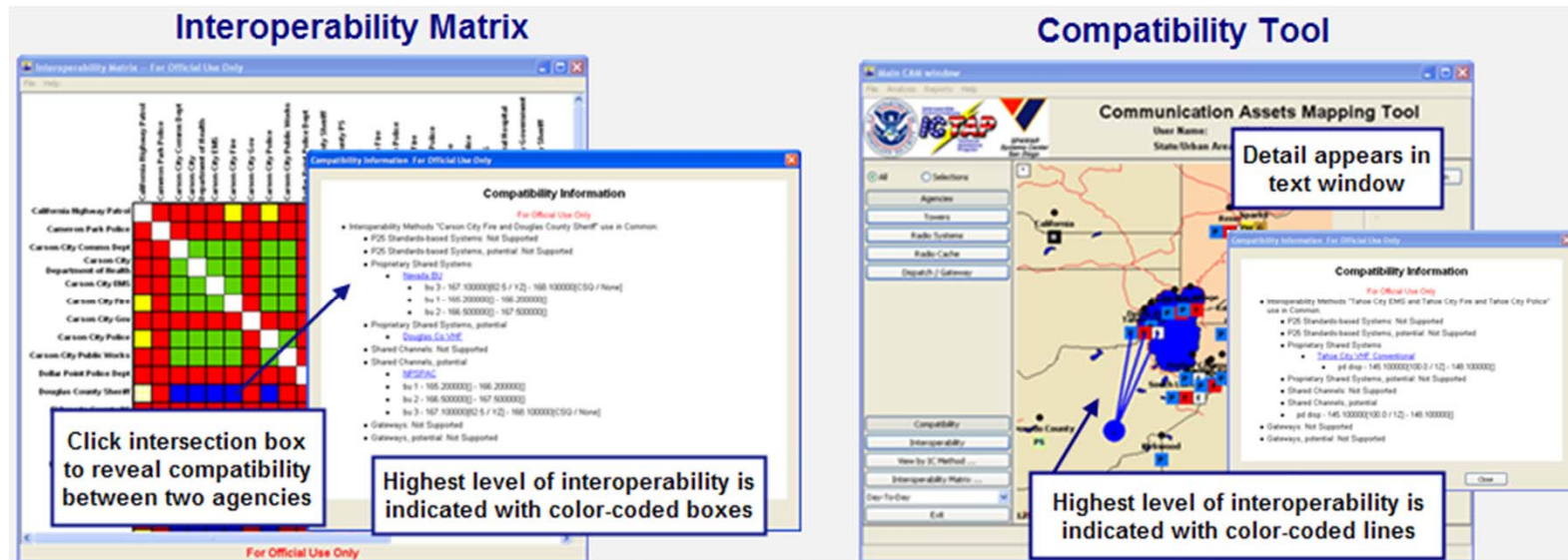
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- **Regulations and guidelines for national interoperability**
- **Interoperability channels**
- **Common communications references**

# CASM

## CASM: Assets Survey and Mapping Tool

- Displays communication interoperability on a regional basis
- Available by contacting the Local Area Manager for CASM



# Communications Interoperability

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- One of the most misunderstood terms
- Does not mean everyone is speaking to everyone else
- Must be carefully managed to avoid mass confusion
- Extremely easy to overload a system



# Interoperability Channels

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- **National Interoperability Channels:**
  - **VHF: 1 Calling, 4 Tactical, and 6 Tactical Repeater**
    - **Calling: VCALL10**
    - **Tactical: VTAC11, VTAC12, VTAC13, VTAC14**
    - **Tactical Repeater: VTAC33, VTAC34, VTAC35**
    - **Tactical Repeater: VTAC36, VTAC37, VTAC38**
  - **UHF: 1 Calling and 3 Tactical**
    - **Calling: UCALL40**
    - **Tactical: UTAC41, UTAC42, UTAC43**

# Interoperability Channels (cont'd)

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- **National Interoperability Channels:**
  - **800 MHz: 1 Calling and 4 Tactical**
    - **Calling: 8CALL90**
    - **Tactical: 8TAC91, 8TAC92, 8TAC93, 8TAC94**
  - **700 MHz Band are yet to be determined due to pending FCC action**

# Local Use Agreements

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- These are agreements for one agency to use another agency's system for a specific purpose
- These agreements are limited, are not in lieu of licensing, and are usually associated with mutual aid, use of gateways, or other special uses





# Special Temporary Authorizations

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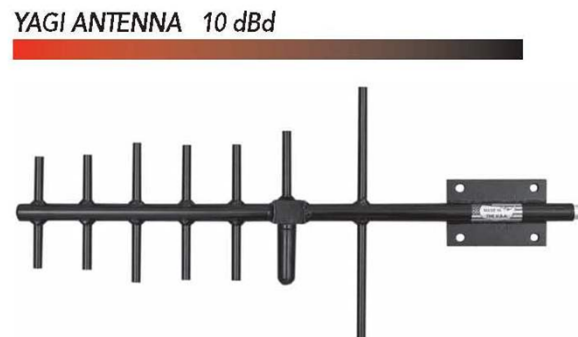
- It is possible to receive a Special Temporary Authorization to use a frequency under the Code of Federal Regulations 47 CFR Ch. I (10-1-06 Edition)
- These are obtained from the FCC
- This is not to be used in lieu of normal licensing procedures
- More information at:  
<http://www.fcc.gov/pshs/services/sta.html>



# RF Exposure

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- RF Exposure can harm human tissue
- Typically not an issue with the relatively low power and relatively low frequency equipment used in Public Safety
- RF hazards analysis required for FCC license applications and OSHA workplace safety
- Can be an issue with high-power base stations



# RF Exposure (cont'd)

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- Best shield is distance; RF exposure drops off very quickly
- High power broadcast (AM, FM, or TV) and radar antennas are the most hazardous
- If in doubt, get an engineer to evaluate your situation



*Exercise 5*

# ***Frequency Usage***

Unit 5:

Frequency Regulations and Usage

Visual 5-49

# Objectives Review

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- 1. What are the factors influencing frequency coordination efforts?*
- 2. Describe local use agreements and special temporary authorizations.*
- 3. What are considerations in recognizing and preventing interference?*
- 4. What are the modes of typical types of radio systems in use today?*
- 5. Describe the Public Safety Spectrum Bands.*
- 6. Identify issues related to RF safety.*

*Questions?*