Unit 5: Frequency Regulations and Usage

INSTRUCTOR GUIDE

Objectives

By the end of this unit, students will be able to:

- Identify methods and standards relating to frequency regulations and usage
- Identify the factors influencing frequency coordination efforts
- Understand local use agreements and special temporary authorizations
- Identify and describe considerations in recognizing and preventing interference
- Identify modes of typical types of radio systems in use today
- Describe the Public Safety Spectrum Bands
- Identify RF safety issues

Methodology

This unit uses lecture, discussion based activities, and exercises.

The purpose of this unit is to provide students with an orientation to methods and standards related to frequency regulations and usage.

The purpose of Exercise 5 is to provide the participants with an opportunity to identify how to address frequency issues and explain their solutions to address these challenges.

Knowledge of unit content will be evaluated through administration of the final exam (to be administered upon completion of the course). Instructors will evaluate students' initial understanding through facilitation of Exercise 5.

Time Plan

A suggested time plan for this unit is shown below. More or less time may be required, based on the experience level of the group.

Topic	Time
Lesson (first part, day 1)	30 minutes
Lesson (second part, day 2)	2 hours, 30 minutes
Exercise 5	20 minutes
Total Time	**3 hours, 20 minutes**

Reference Materials

- Projector & other equipment as necessary for PowerPoint presentation
- Easel chart/Easel pad
- Marking pens
- Exercise 5: Frequency Usage

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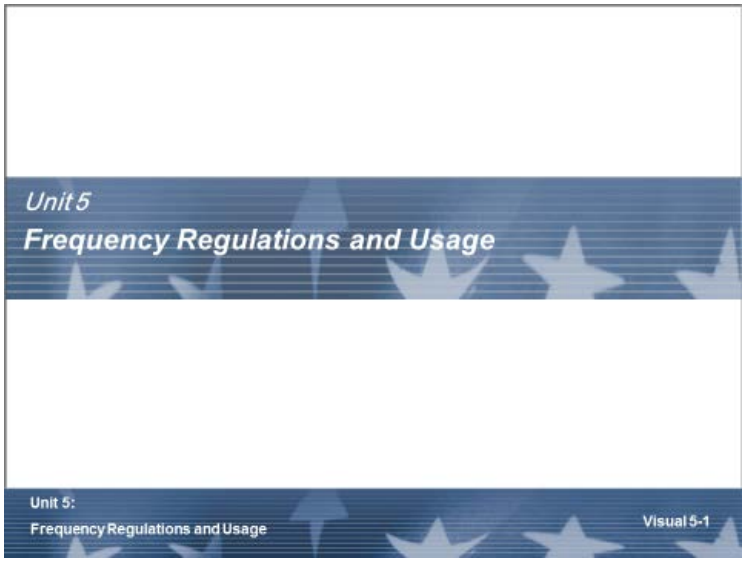
Topic Unit Title Slide



Explain the Following Key Points

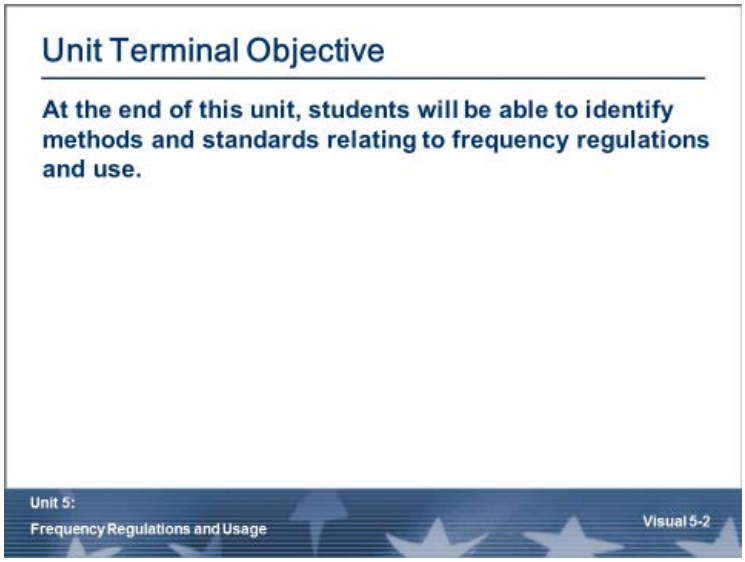
Introduce the unit and move quickly to the next slide.

This unit focuses on identifying the different radio systems in use today; multiple frequency bands utilized; licensing and frequency coordination responsibilities; and resolving interference issues.

Scope Statement

The Communications Unit Leader is responsible for identifying the different radio systems in use today; multiple frequency bands utilized; licensing and frequency coordination responsibilities; and resolving interference issues.

Topic Unit Terminal Objective



Explain the Following Key Points

Introduce and explain the Unit Terminal Objective to the class.

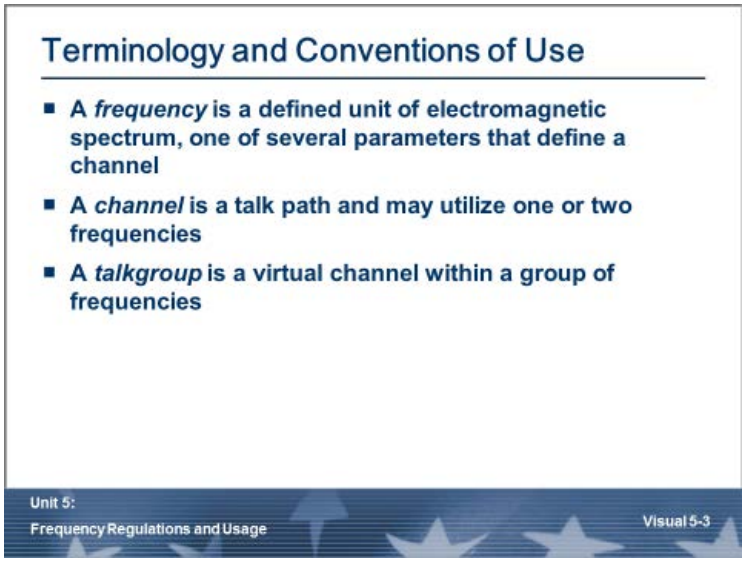
Unit Terminal Objective

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

Unit Enabling Objectives

- Identify the factors influencing frequency coordination efforts
- Understand local use agreements and special temporary authorizations
- Identify and describe considerations in recognizing and preventing interference
- Identify modes of typical types of radio systems in use today
- Describe the Public Safety Spectrum Bands
- Identify RF safety issues

Topic Terminology and Conventions of Use



Explain the Following Key Points

Explain terminology and conventions of use.

Frequency is a defined segment of radio spectrum capable of supporting voice and data transmissions; a unit of electromagnetic spectrum. Much like a street address, it identifies the location, but does not identify the size of the lot.

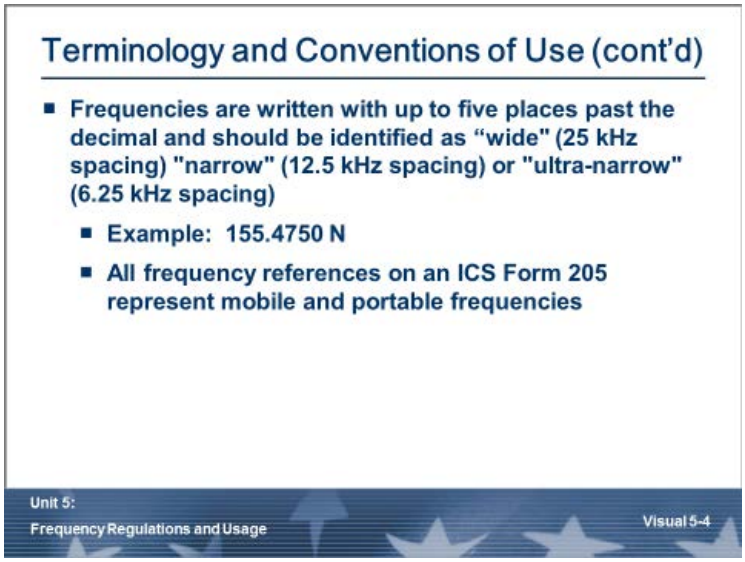
Channel is a frequency or pair of frequencies assigned to a specific purpose and typically preprogrammed into radio equipment, to allow easy and consistent use. A channel may also have additional associated technical characteristics such as tone coded squelch (CTCSS) or P25 Network Access Code (NAC).

Talkgroups are virtual channels used in a trunked radio environment. To the user they appear to be identical to a channel, but behind the scenes the radio is constantly seeking and acquiring different frequencies as needed to provide a reliable talk path to the user.

It is essential for the COML to recognize and understand the differences between these elements. Without this understanding the accurate creation of an ICS form 205 will be impossible.

Providing the fourth digit after the decimal is necessary in today's environment to accurately display and program frequencies. It is also essential to know if this is a narrowband or wideband frequency. With few exceptions, all frequencies between 150 MHz and 512 MHz were converted to narrowband by 2013. Thus, it will likely always require the N or W designation for safety's sake below 512 MHz into the future.

Topic Terminology and Conventions of Use (cont'd)



Explain the Following Key Points

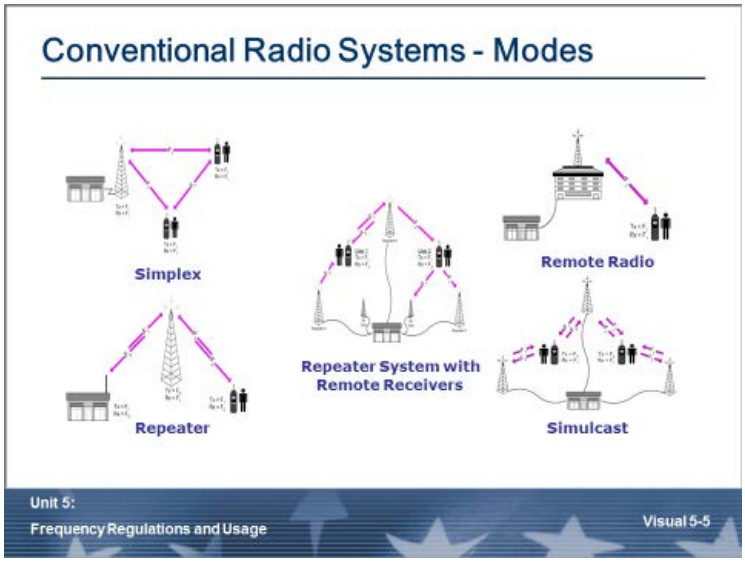
Explain terminology and conventions of use.

Fully explain the reason for writing the frequency out four digits after the decimal place.

Explain that in the future, five digits after the decimal place may become necessary.

Stress last bullet, the ICS form 205 is filled out from the subscriber's/end user's perspective not the infrastructure's.

Topic Conventional Radio Systems Modes



Explain the Following Key Points

Show the different types of conventional radio systems available for use. This is a lead-in slide. Each of the modes has its own slide.

Conventional systems are, and will continue to be, in heavy use in public safety communications. Even in state-of-the-art trunked systems, conventional resources are utilized in the system plan.

These terms indicate how channels are used. The terms Analog and Digital describe how frequencies (within a channel) are modulated or are “carried” through the air. These four terms are not necessarily related. Conventional systems can be analog or digital as can trunked systems.

Simulcast, narrowband, wideband, digital, trunked, voted, and encrypted are all mutually exclusive terms. One term does not imply that any of the other terms are in play.

Conventional systems are not old or being phased out. New conventional systems are being built regularly.

Overview of Radio Frequency (RF) Systems: Conventional or Trunked

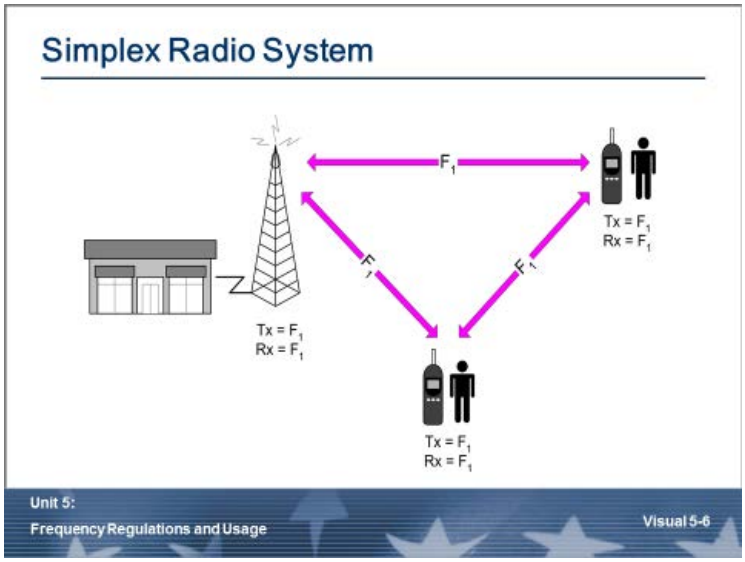
- Conventional radio system modes:
  - Simplex
  - Repeated
  - Simulcast
- Trunked radio system modes
  - Repeated

- Simulcast

How does a Multicast network differ from a Simulcast network?

Multicast systems are similar to simulcast systems with the exception of the radio channels transmitted. While a simulcast system transmits on the same RF channels simultaneously from each base station/repeater, multicast systems use different RF channels at each site.

Topic Simplex Radio System



Explain the Following Key Points

Show the basic principle of Simplex.

Simplex is the simplest type of system; relying on only one frequency, it is very reliable, but has very limited range, particularly around terrain or other obstructions. It is very effective for tactical and other high risk, short range applications. Commonly referred to as “car-to-car” or “direct,” the Simplex Mode is used heavily in all system designs.

Suggested Discussion

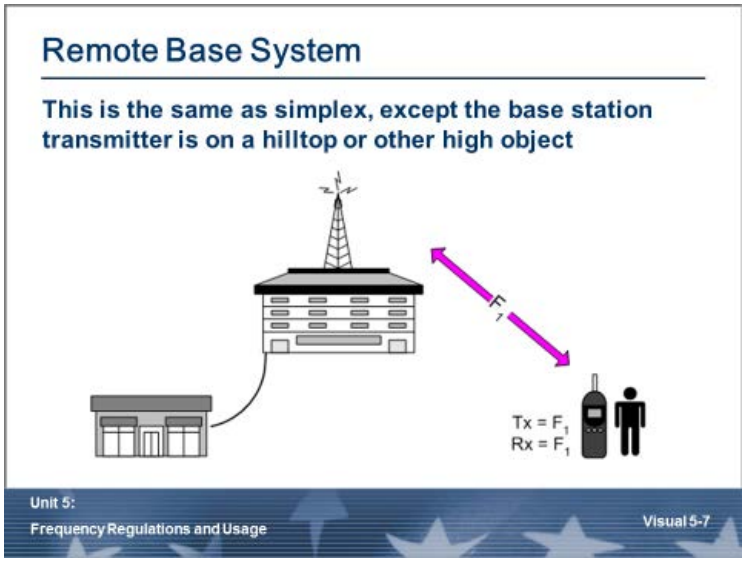
By FCC rules, can Simplex be used with digital modulation? Simple question, but it offers a chance to clear up any confusion between analog, digital, trunked and conventional.

What is a Simplex network?

In Simplex operation, one radio of the system transmits while the other radio(s) receives. Simultaneous transmission and reception at a radio is not possible with Simplex operation. The Simplex dispatching system consists of a base station, mobile/portable units, all operating on a single frequency. Simplex operation is generally limited to a line-of-sight. Simplex requires no additional external equipment, infrastructure or systems to work. Simplex mode remains a valuable tool within all system types, and is commonly used in tactical environments.

“Car-to-car” or “direct” are common terms for this.

Topic Remote Base System



Explain the Following Key Points

Show a method of increasing the range of a Simplex radio channel, at least from the Base Station to the end user.

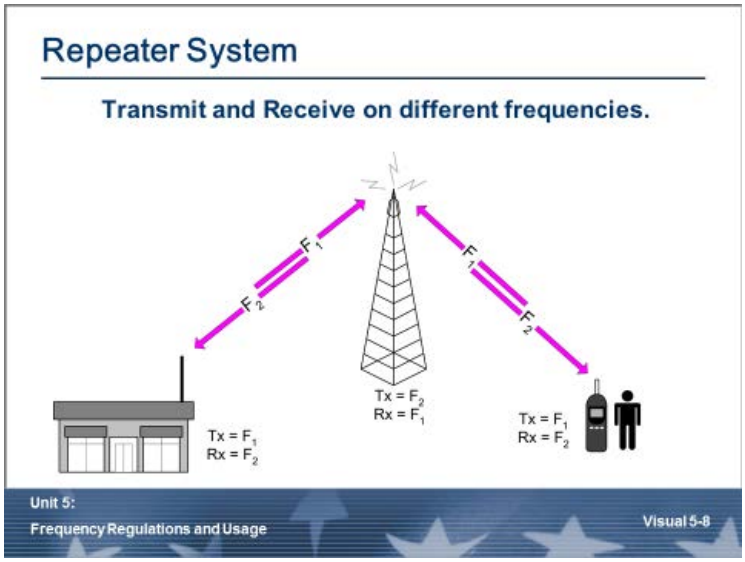
By installing the Base radio on a high structure, building, or hill, the base station can send and receive from mobiles and portables over a much wider area than otherwise.

This method does not improve the car-to-car range at all, just the base-to-mobile coverage.

What is the limiting factor on remote base system's usable transmit range?

The base transmitter in a Land Mobile Radio (LMR) system typically has much more power than mobile or portable radios. The base antenna is typically at a much higher elevation than mobile or portable radio antennas. For these reasons, mobile and portable communications are limited by their talk-back capability.

Topic Repeater System



Explain the Following Key Points

Show the way a repeater works, using two frequencies—one to receive and the other to simultaneously transmit.

The portable or mobile or base station transmits on “F1” and the repeater is listening for “F1.” As soon as it detects a signal, the repeater starts transmitting on “F2.” All the portable, mobile or base station radios on this channel are listening on “F2.”

Frequency separation is important. This is problematic in VHF.

The coverage using this method is vastly improved. A low-power portable radio can suddenly talk great distances through the repeater.

This method requires two frequencies to work. This may be difficult to achieve in some areas of the country due to frequency congestion.

Suggested Discussion

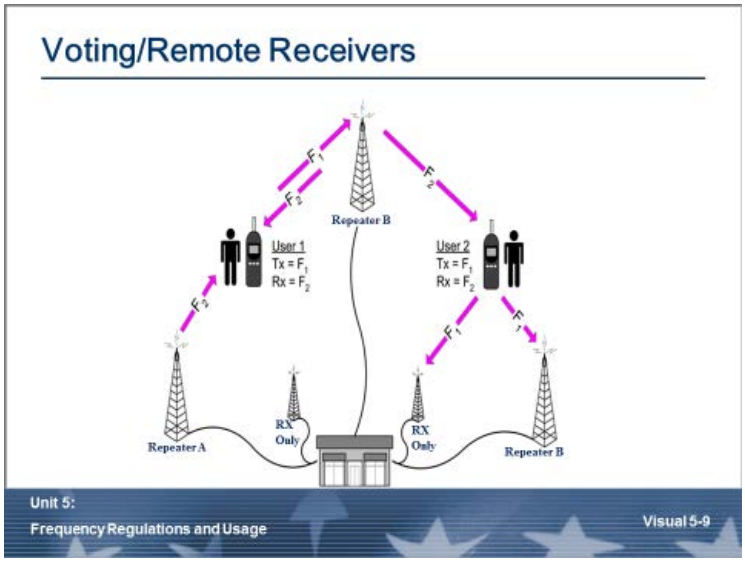
Where are good possible locations to install a repeater in this area? What might some of the issues be installing it there?

What is a Half Duplex/Repeated network?

A repeater is an electronic device that receives a weak or low level radio signal and retransmits it to overcome obstacles and increase range. In repeated systems, a channel is made up of two different frequencies. The repeater transmits on the mobile’s receive frequency and vice versa. Repeated systems are deployed to overcome “line-of-sight” obstacles presented by terrain, obstructions, or distance.

These systems are used to extend range, but only one person can speak at a time.

Topic Voting/Remote Receivers (cont'd)



Explain the Following Key Points

Show a method of providing improved portable coverage.

Remote receivers are installed to "balance a system." If a base station or repeater is located on a high object, has a high gain antenna, stable power supply and is engineered, the mobile—and especially the low power portable radios—are at a significant disadvantage replying to the fixed station. Installing remote receivers allows the lower power radios to access the system at a much closer location.

Remote receivers are typically tied back to the infrastructure by telephone circuits, data circuits or microwave to bring all the received signals into a central location.

Voting solves the problem that can occur when more than one device receives a given signal. If this occurs without a "Voter," the received audio from a receiver may become overwhelmed by noise from a lesser source. The Voter compares the signal, and using various methods "compares" the signal and tries to select the most appropriate and best signal to present to the Dispatcher, or in some cases back out to the repeater to be rebroadcast.

It does not require a repeater system to use remote receivers and/or voters.

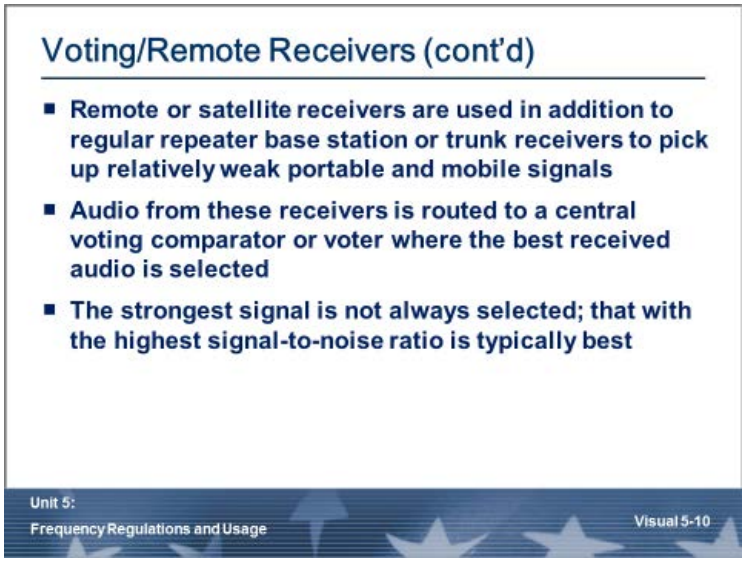
Why would you use voting/remote receivers? Answer: To improve the talkback capability.

How do voting/remote receivers work?

A number of radio receivers located in strategic areas receive the RF signal from a mobile or portable unit. Receive-only sites act as "listening-only" base stations that receive the lower power signals of mobiles and portables and relay them back to a base station or repeater, usually via dedicated telephone or microwave links. By using one or

more receive-only sites in conjunction with a high-power base station or repeater transceiver, the overall system talk back coverage can be expanded.

Topic Voting/Remote Receivers (cont'd)



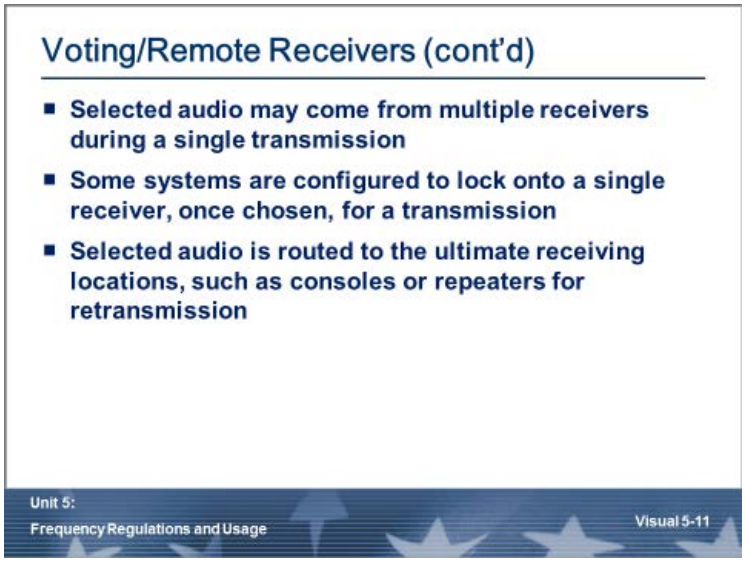
Explain the Following Key Points

Continue showing a method of providing improved portable coverage.

How are remote or satellite receivers used?

Remote/satellite receivers act as "listening-only" base stations that receive the lower power signals of mobiles and portables and relay them back to a base station or repeater, usually via dedicated telephone or microwave links.

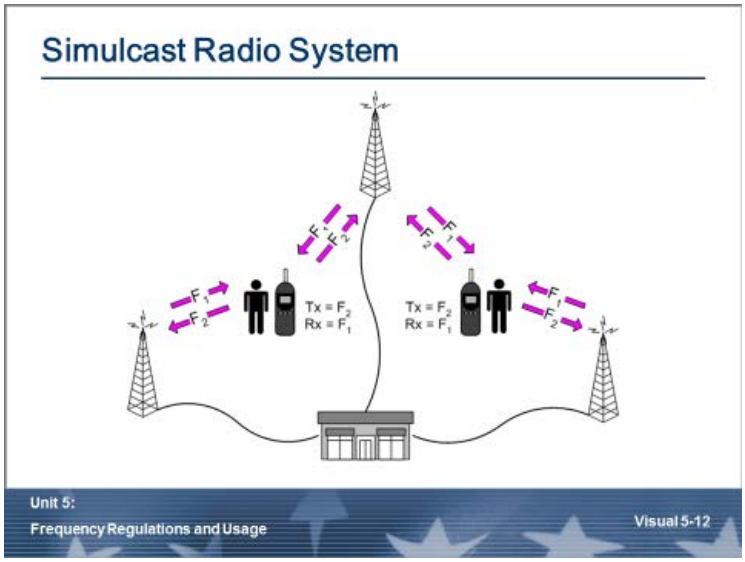
Topic Voting/Remote Receivers (cont'd)



Explain the Following Key Points

Continue showing a method of providing improved portable coverage.

Topic Simulcast Radio System



Explain the Following Key Points

Show a method of creating a very wide area radio system.

In a simulcast system, all the fixed transmitters—remote base or repeaters—transmit the identical traffic at the same time.

This requires very accurate timing to avoid the heterodyne often heard when two transmitters are on the same frequency at the same time.

The use of simulcast prior to the invention of GPS was very limited, due to the enormous cost of providing the accurate timing. Now with low-cost GPS devices, time accuracy is easy to achieve.

This method does not add any capacity to a channel, in fact to some degree it reduces capacity, since before two far away users could use a channel at the same time, without interfering with each other. On the other side of this argument, all users hear everything on the given channel regardless of how far away they are, assuming they are within the radio system footprint.

Suggested Discussion

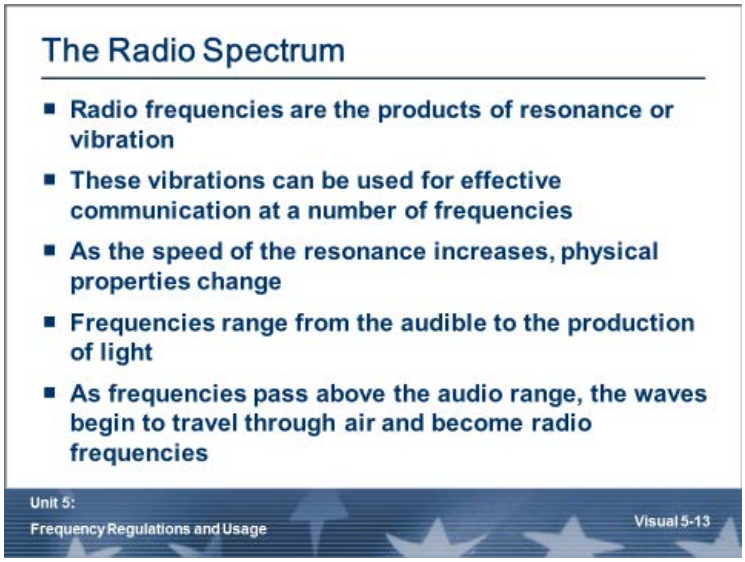
Simulcast does not increase capacity; it increases channel loading.

What is a Simulcast network?

Simulcast systems use several geographically separated base stations/repeaters that transmit on the same frequencies simultaneously. Through this type of a system deployment, a single radio channel can be radiated over a wider region than with a single-site transmitter. These networks require a timing system to synchronize each transmitter on the network to assure that transmissions on the same frequency are in phase thus reducing heterodyne interference.

Systems are complex to engineer and require thoughtful design. Simulcast systems do not increase capacity; in fact, they add to system loading.

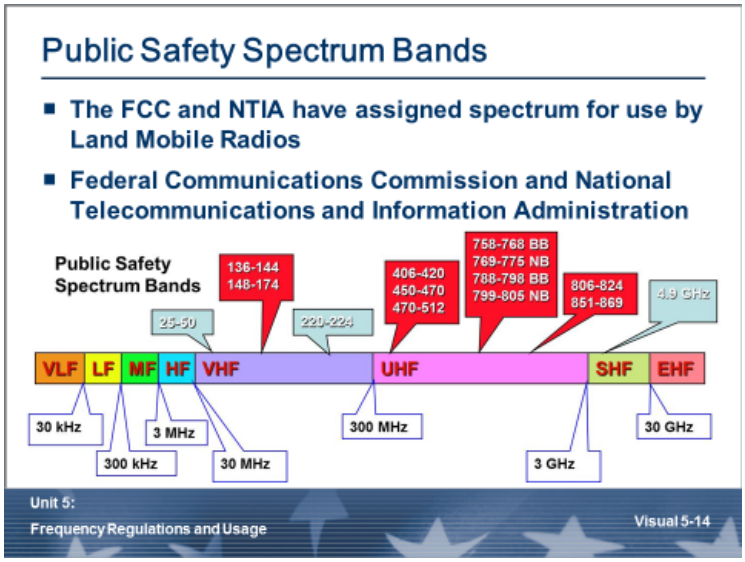
Topic The Radio Spectrum



Explain the Following Key Points

Explain the basics of radio spectrum. Review the various frequency bands used in land mobile radio in the United States.

Topic Public Safety Spectrum Bands



Explain the Following Key Points

Show the various bands used by Public Safety in the United States. Discuss the FCC and the NTIA and their functions.

Discuss the various elements of the chart; more detail on each band follows.

Who assigns State and local (non-Federal) frequency assignments?

The Federal Communications Commission (FCC) assigns State and local frequencies.

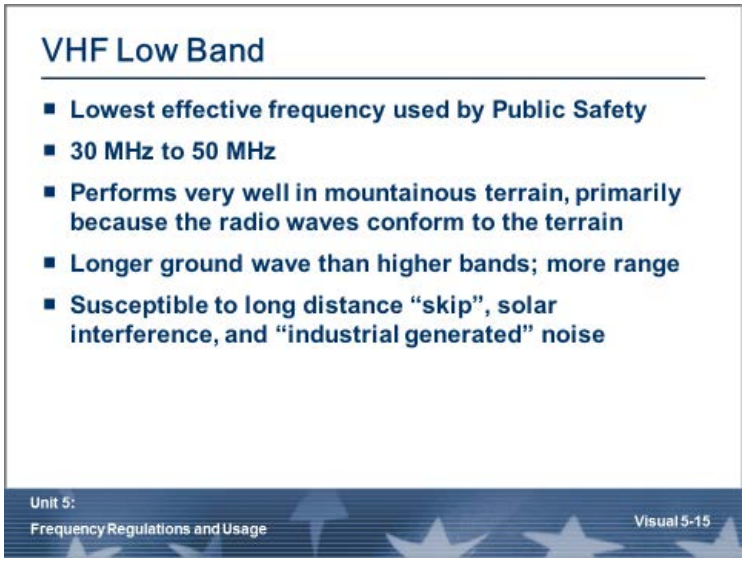
Who assigns the Federal frequency assignments?

National Telecommunications & Information Administration (NTIA) allocates bands for public safety use (as indicated on the chart), which are small segments of the overall spectrum.

What are the primary frequency bands being used for public safety today? (FCC & NTIA)

- VHF low band (30 - 50 MHz)
- VHF high band (136-174 MHz)
- UHF (421-512 MHz)
- 700 (769-775 and 799-805 MHz)
- 700 MHz, Public Safety now has 10+10 MHz of Broadband Spectrum for FirstNet, 2 MHz guard-band, and still retains 6+6 MHz of Narrowband Spectrum
- 800 band (806-824 and 851-869 MHz; 806-816 and 851-861 MHz after rebanding)
- 4.9 GHz (4.940 – 4.990 GHz)

Topic VHF Low Band



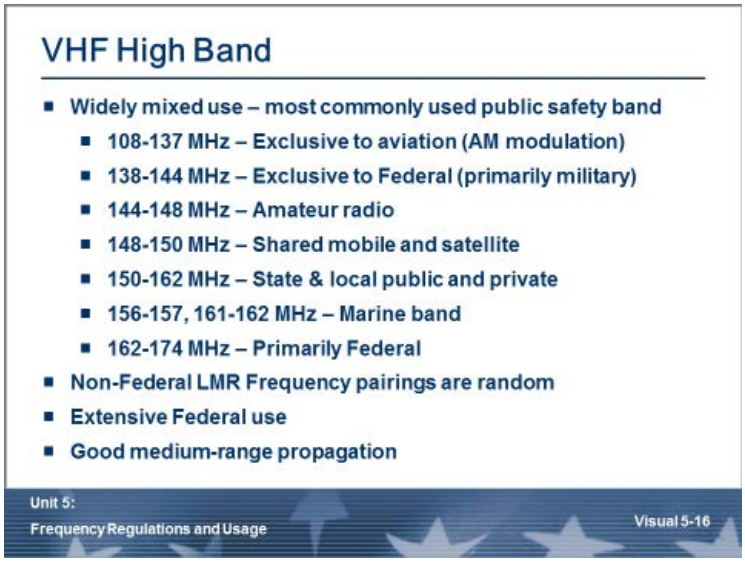
Explain the Following Key Points

Discuss Low Band. Review the positives of Low Band, such as the long range achievable without infrastructure such as repeaters. It also works very well in hilly terrain.

Discuss "skip" and the implications of hearing people from very far away.

- VHF Low Band can travel great distances, so the person to whom you are speaking may not be who you wanted
- Low band is still in use in many States, though very few manufacturers still make low band equipment
- Susceptible to background noise, which has increased greatly due to the proliferation of other technologies
- Caution should be used in placing low-band channels in gateways due to potential interference

Topic VHF High Band



Explain the Following Key Points

Discuss VHF High Band. Show the various frequency areas where VHF High Band can be used. Talk about the different modulation types, AM and FM, and why aviation uses AM when almost all other Public Safety radio is FM.

AM radio gradually gets quieter as the signal is lost. This allows aircraft to “turn up” the radio to hear farther away, resulting in a much noisier signal. FM will “capture” the signal and for the most part the quality will be either good or very poor—not much degradation just because of distance.

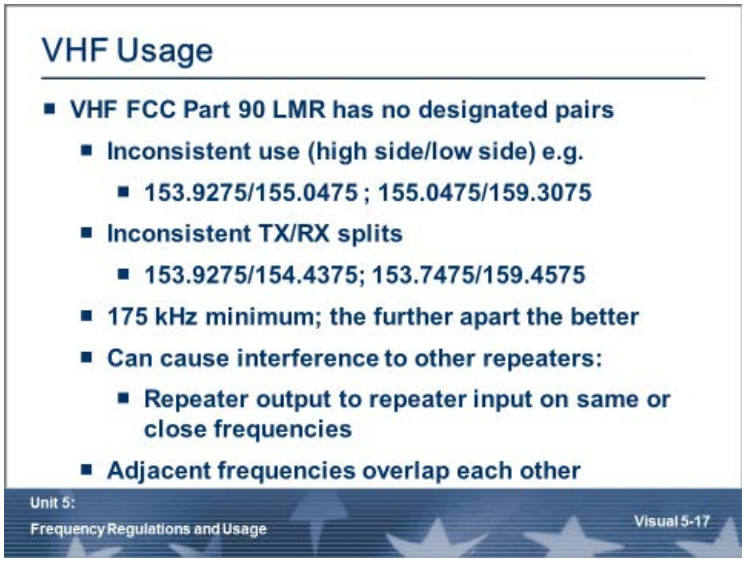
Even though Marine Band is in the middle of VHF FM, it will NOT be narrow-banded at the end of 2012. There are also two high-output paging frequencies that are exempt from this change.

If used in repeaters, the pairings are random—this makes some systems susceptible to receiver desensitization.

VHF High Band

- Most commonly used frequency band in public safety (50% of licensed systems)
- No standard frequency pairings for repeaters
- Most Federal law enforcement and Federal land management (fire) is on VHF

Topic VHF Usage



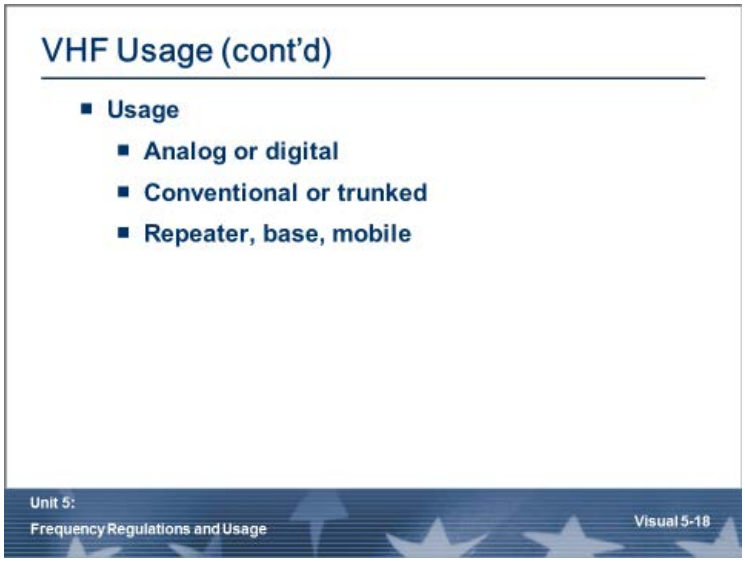
Explain the Following Key Points

Review VHF Usage

When equipment was invented that could use the VHF high band spectrum, repeaters hadn't been invented yet, so the powers that be (FCC and NTIA) never designated repeater pairs.

When repeaters were finally invented, so many frequency assignments had been given out, there wasn’t room to make a consistent channel plan. Repeater pairs that were assigned had to be placed were there weren’t any assignments. Since this is the most heavily used spectrum, it led to inconsistent spacing which makes the assignments appear random.

Topic VHF Usage (cont'd)



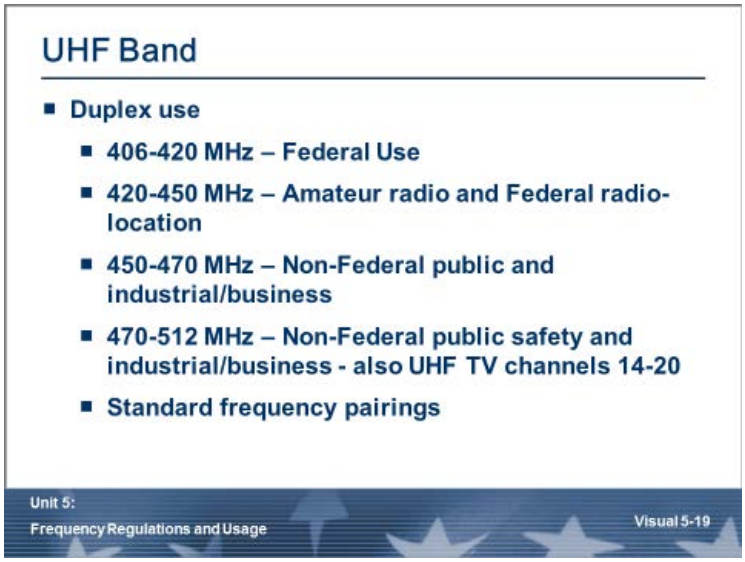
Explain the Following Key Points

Review VHF Usage (cont'd)

This is the most widely used (congested) frequency band, it supports:

- All modes of transmission (analog or digital)
- All forms of system design (conventional or trunked)
- All form factors (repeaters, base stations, mobiles, portables).

Topic UHF Band



Explain the Following Key Points

Review UHF Band.

UHF is less capable in terrain than VHF, but works inside buildings better than VHF.

Frequency pairs for repeaters are standard splits, making programming and other issues more predictable.

Many radios will not span the Federal UHF and the State & local UHF splits.

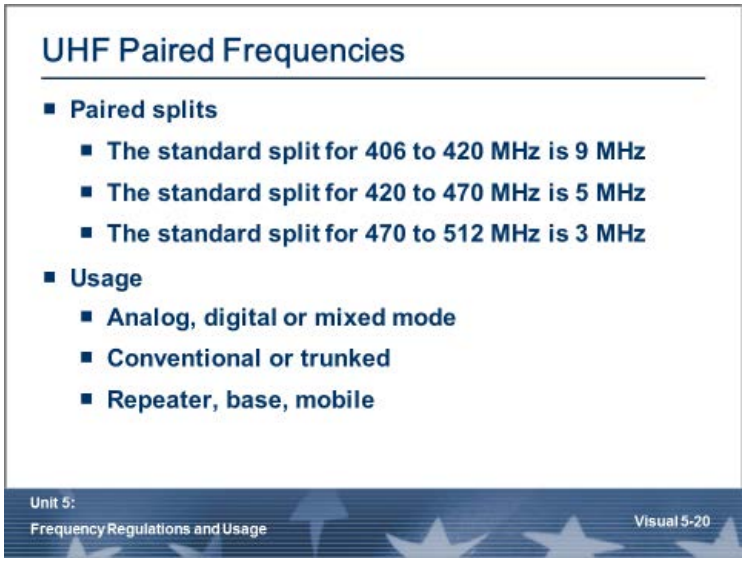
Suggested Discussion

Are the 10 MED Channels in use in the regions?

UHF Band

- Two way communications were already invented when we started using this band so standard frequency pairings were established.
- “T-Band” came from reallocated television channels 14 – 20; public safety occupies this spectrum in some coastal areas of the U.S.
- An example of standard frequency pairing includes 453/458.2125

Topic UHF Paired Frequencies



Explain the Following Key Points

Show the different combinations of frequencies in different bands.

The various combinations are shown on the slide.

Suggested Discussion

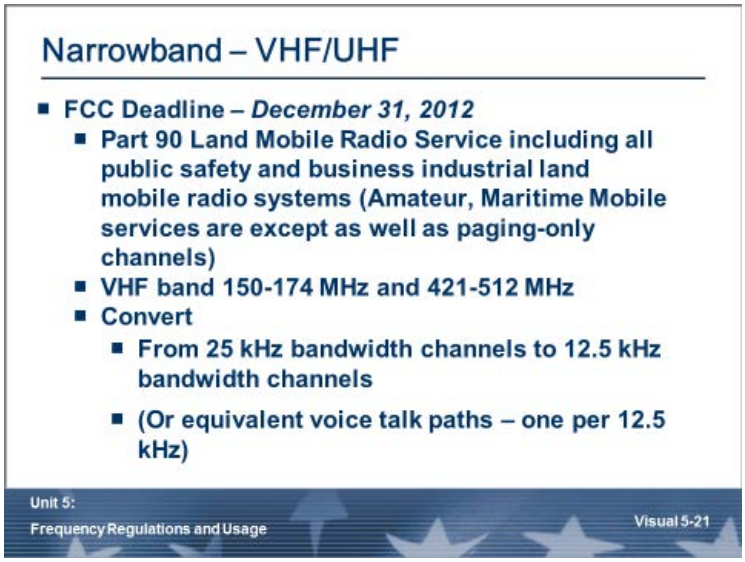
Discuss why a plan is a good idea, versus VHF where there is no plan.

- UHF is allocated in pairs
  - 9 MHz separation—Federal allocations
  - Bandwidth between TX and RX pair
  - The standard split for 420 to 470 MHz is 5 MHz
  - The standard split for 470 to 512 MHz is 3 MHz, corresponding to half of a TV channel (6MHz)

Usage

- All modes of transmission (analog or digital)
- All forms of system design (conventional or trunked)
- All form factors (repeaters, base stations, mobiles, portables)

Topic Narrowband – VHF/UHF



Explain the Following Key Points

Discuss the merits and issues of Narrowband – VHF/UHF

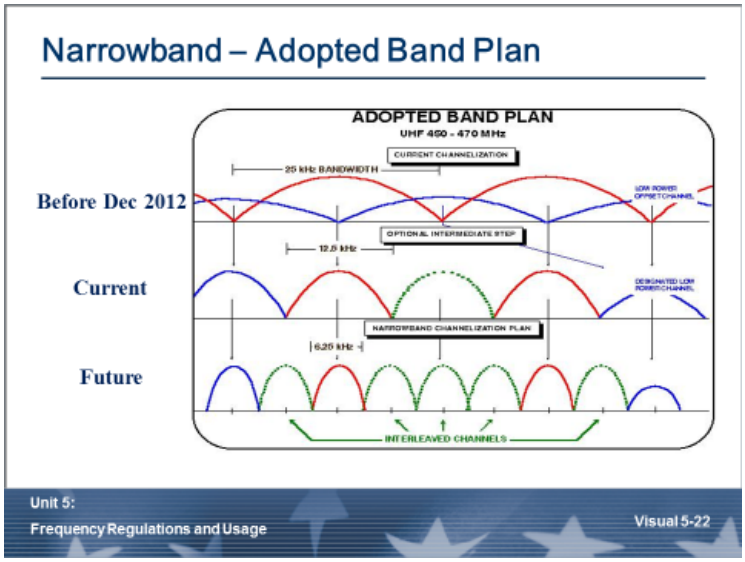
Discussion regarding the FCC mandate to reduce bandwidth of transmissions in order to create additional channels and greater spectrum efficiency.
FCC Deadline – *December 31, 2012*
Only applies to Part 90 Land Mobile Radio Service Exceptions to the basic Narrowband Requirements

- Paging-only channels - Public Safety paging channels 152.0075 MHz and 157.450 MHz are exempt
- Amateur Service
- Maritime Mobile service

VHF Band 150-174 MHz and 421-512 MHz Convert

- From 25 kHz bandwidth channels to 12.5 kHz bandwidth channels
- (Or equivalent voice talk paths – one per 12.5 kHz)

Topic Narrowband – Adopted Band Plan



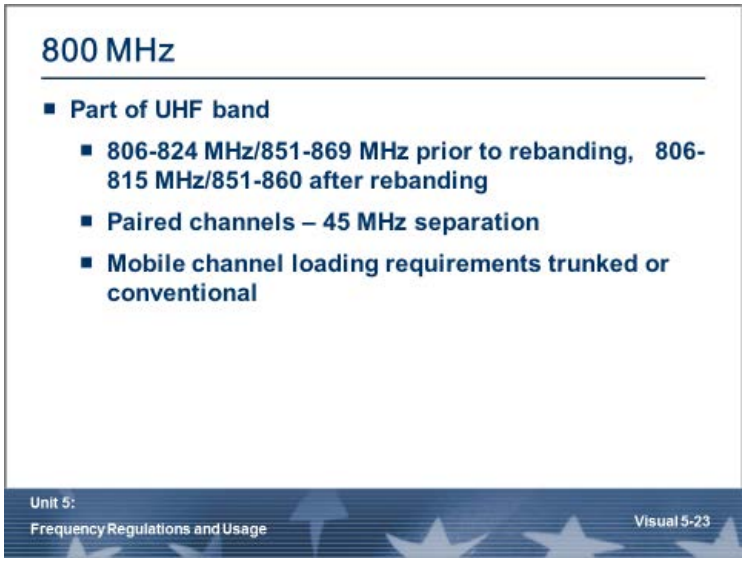
Explain the Following Key Points

Discuss Narrowband – Adopted Band Plan

The radio spectrum is a finite amount of space.

- As technology improves more and more people are using radio waves. The narrowband plan was a way to allow more people to use radios without interfering with each other and still use the same amount of spectrum.

Topic 800 MHz

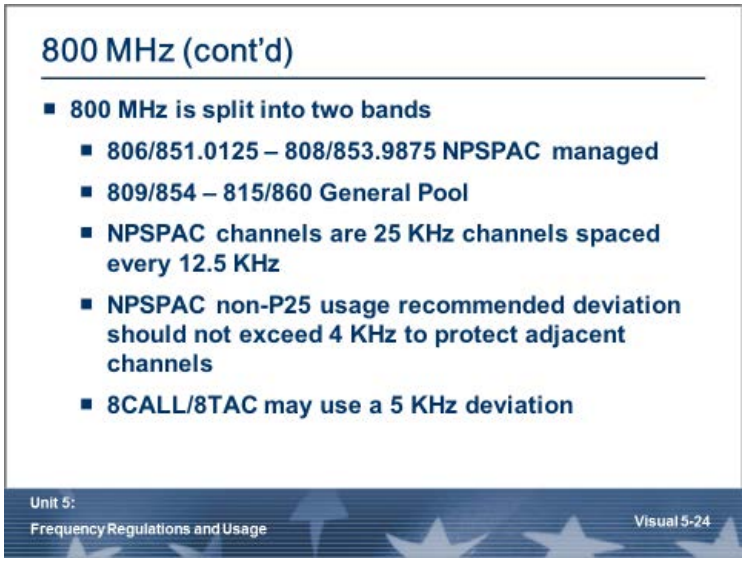


Explain the Following Key Points

Discuss the merits and issues of 800 MHz

- Part of the UHF band which is 300 – 3000 MHz
- Primarily trunked operations
- Frequencies allocated by Regional Planning Committee (RPC) plans
- Some general pool frequencies not allocated by RPCs
- Good building penetration, but reduced range compared to VHF and UHF

Topic 800 MHz (cont'd)

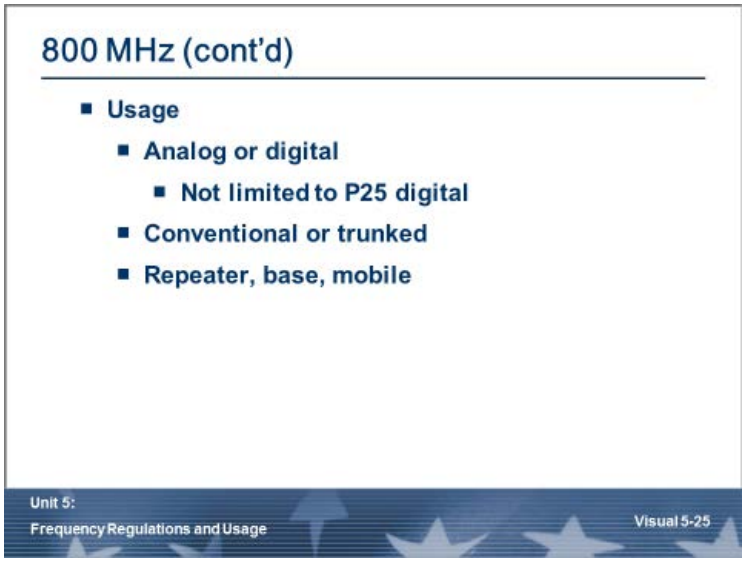


Explain the Following Key Points

800 MHz (cont'd)

For FCC licensees, the non-Federal National Interoperability Channels VCALL10-VTAC14 and VTAC33-38, UCALL40-UTAC43D, the 800 MHz interoperability channels, and 8CALL90-8TAC94D are covered by a "blanket authorization" from the FCC: "Public safety licensees…can operate mobile units on these interoperability channels without an individual license."

Topic 800 MHz (cont'd)



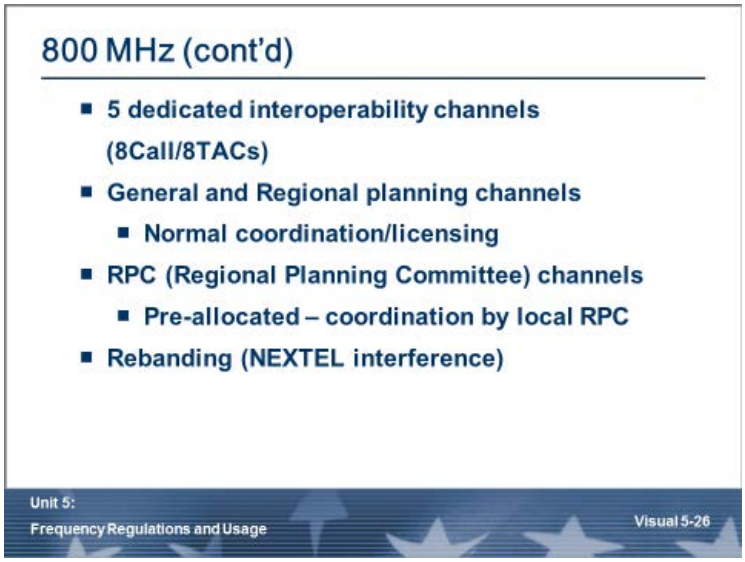
Explain the Following Key Points

800 MHz (cont'd)

This band supports:

- All modes of transmission (analog or digital)
- All forms of system design (conventional or trunked)
- All form factors (repeaters, base stations, mobiles, portables)

Topic 800 MHz (cont'd)



Explain the Following Key Points

800 MHz (cont'd)

As we progressed, developing newer equipment capable of using high frequencies, we learned from past mistakes. Realizing one is not an island, and we all need help from time to time, this is the first time we dedicated 5 interoperability channels for use nationwide.

Taking a play from the amateur band, created RPC to aid in coordination use to prevent interference.

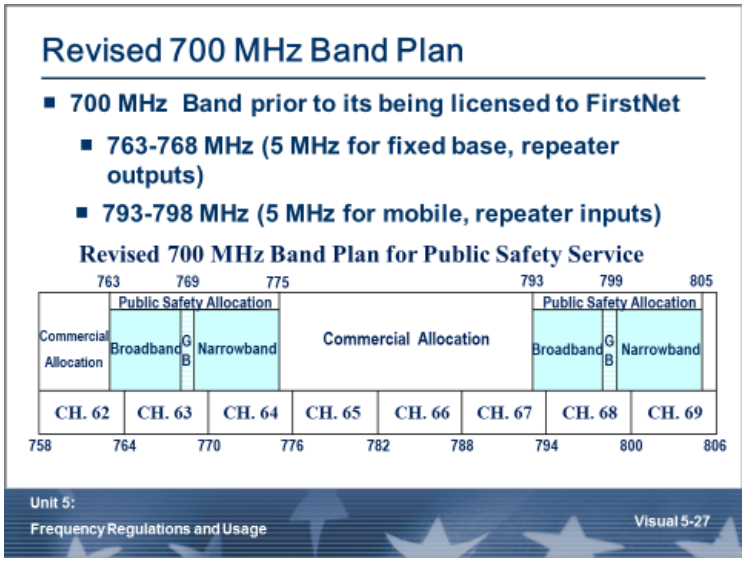
Rebanding - Why did we need it? As LMR moved into the 800 MHz spectrum, new technology was developed; cellular telephones. Cellular technology provides a similar service to LMR but in a completely different way.

LMR uses few high sites with high power and no interference is acceptable

Cellular uses multiple low sites with low power and is designed with acceptable interference

When cellular was activated throughout the nation, the RF noise floor increased and LMR users found their systems, which were capable of transmitting and receiving 50 miles yesterday, suddenly wouldn't work past 10 miles. To prevent interference, NEXTEL created a plan where all cellular systems would move up in spectrum and LMR systems would move down with a band between to prevent the LMR receivers from being desensitized. NEXTEL offered to pay two billion dollars to help pay for the move.

Topic Revised 700 MHz Band Plan



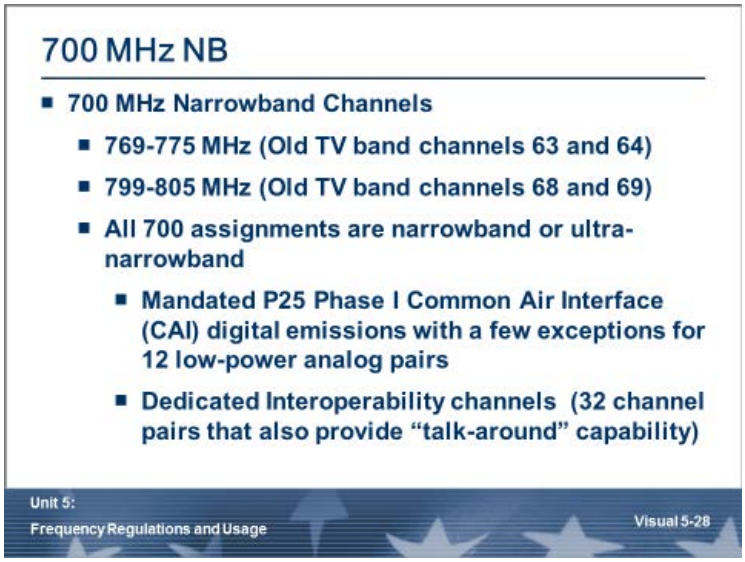
Explain the Following Key Points

Discuss the merits and issues Revised 700 MHz Band Plan.

In July 2007, the Federal Communications Commission (FCC) revised the 700 MHz band plan and service rules to promote the creation of a nationwide interoperable broadband network for public safety and to facilitate the availability of new and innovative wireless broadband services for consumers. The Commission designated the lower half of the 700 MHz Public Safety Band (763-768/793-798 MHz) for broadband communications. The Commission also consolidated existing narrowband allocations to the upper half of the 700 MHz Public Safety block (769-775/799-805 MHz). Further, in order to minimize interference between broadband and narrowband operations, the Commission adopted a one megahertz guard band (768-769/798-799 MHz) between the public safety broadband and narrowband segments. Finally, the Commission established a single nationwide license – the Public Safety Broadband License – for the 700 MHz public safety broadband spectrum.

This is all prior to the Middle Class Tax Relief and Job Creation Act of 2012 that created FirstNet.

Topic 700 MHz NB

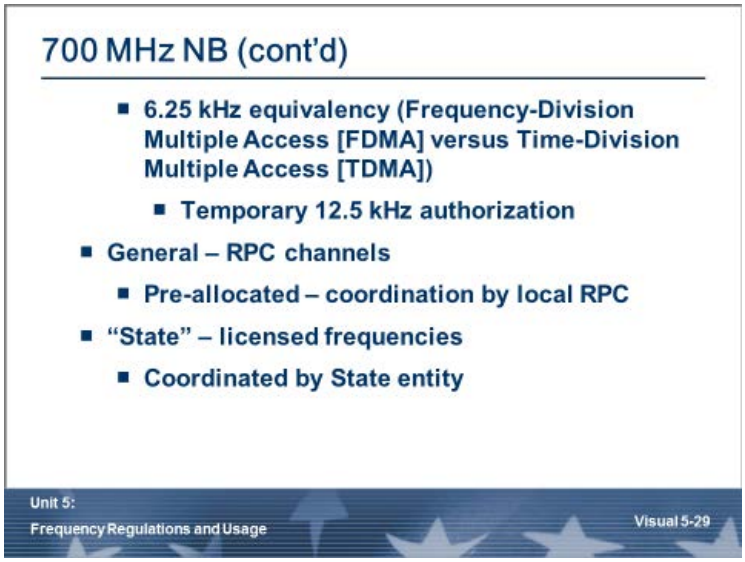


Explain the Following Key Points

Discuss the merits and issues with Revised 700 MHz NB.

- Adjacent to 800 MHz public safety band
- Digital requirement
- Dedicated interoperability channels (P25 CAI required)
- Original channelization shifted to address changes to 700 Broadband Rule changes
- Performance similar to 800 MHz

Topic 700 MHz NB (cont'd)



Explain the Following Key Points

Discuss the merits and issues with Revised 700 MHz NB (cont'd).

- Adjacent to 800 MHz public safety band
- Digital requirement
- Dedicated interoperability channels (P25 CAI required)
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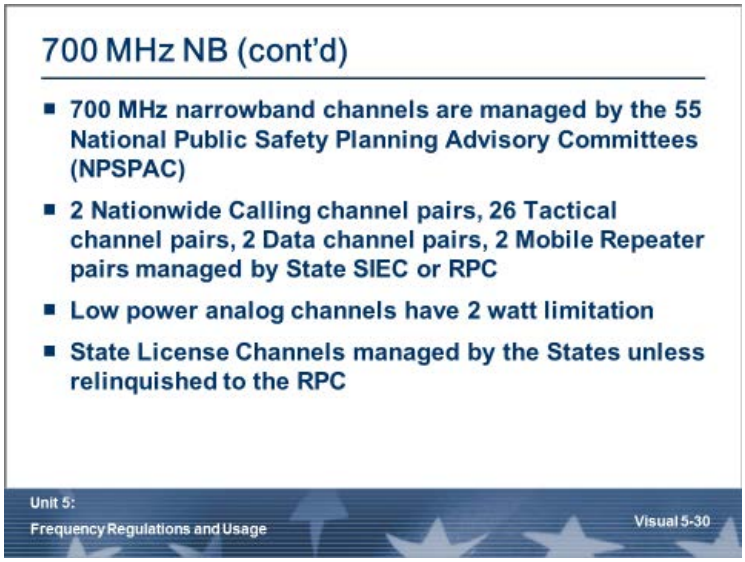
- Performance similar to 800 MHz

Topic 700 MHz NB (cont'd)



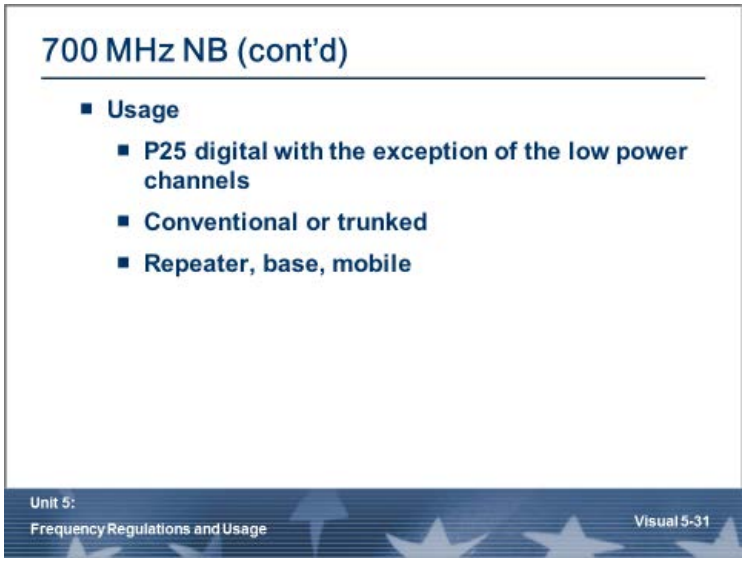
Explain the Following Key Points

Discuss the merits and issues with Revised 700 MHz NB (cont'd).

As we progressed, developing newer equipment we learned from past mistakes.

- Realizing five interoperability channels are not enough during a large incident, 32 nationwide channels were reserved in the band.
- Channel pairing was set at 30 MHz separation
- State licensed channels are managed by the state where they know the user's requirements
- This is the first time a transmission mode was designated
  - Everything must use P25 phase 1 narrowband common air interface. Performance similar to 800 MHz

Topic 700 MHz NB (cont'd)



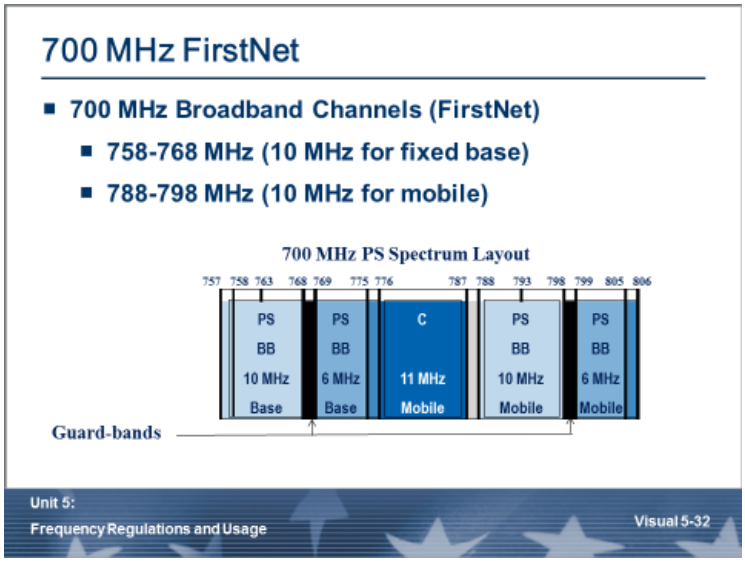
Explain the Following Key Points

Discuss the merits and issues with Revised 700 MHz NB (cont'd).

This band supports:

- P25 digital with the exception of the low power channels
- All forms of system design (conventional or trunked)
- All form factors (repeaters, base stations, mobiles, portables)This is the first time a transmission mode was designated

Topic 700 MHz FirstNet



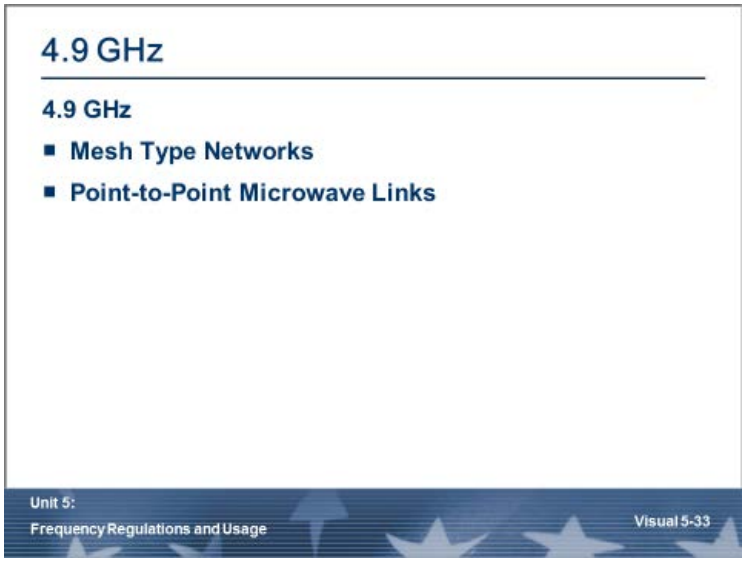
Explain the Following Key Points

Discuss the merits and issues 700 MHz FirstNet.

With the passage of the Middle Class Tax Relief and Job Creation Act of 2012 (Spectrum Act), some existing public safety licenses in the 700 MHz Band and an additional license (known as the D Block), together totaling 22 MHz, have been designated by Congress to support a broadband communications network for public safety. As required by the act, the initial, 10-year license to use these frequencies was assigned by the FCC to FirstNet. It is renewable for an additional 10 years, on condition that FirstNet has met its duties and obligations under the act.

A total of 34 MHz of spectrum capacity available for public safety networks within the 700 MHz band: the 20 MHz designated for broadband (data), 2 MHz guard-bands and 12 MHz allocated for narrowband communications (primarily voice).

Topic 4.9 MHz



Explain the Following Key Points

Discuss the merits and issues of 4.9 GHz.

A portion of the 4.9 GHz Band (50 MHz) was made available through FCC rules for Public Safety use. These uses include:

- Mesh type networks where multiple nodes operate as an area-wide network
- Point-to-point microwave links
  - Point-to-point links are frequently used on a itinerant basis to make data connections to mobile communications vehicles, video links to public safety aircraft and other incident related support

Topic Aviation Radio

Explain the Following Key Points

Discuss the issues of using Aviation Bands.

Air-to-air and air-to-flight control facilities:

- 108 MHz–136 MHz (civil and military aviation)
- 225 MHz–380 MHz (military aviation)
- AM modulation

Most emergency services aircraft include conventional FM public safety LMR channels appropriate to their area of operation

Protection of AIR-TO-GROUND channels is critical to safe air Operations

- Selection of FM frequency (LMR) is critical due to interference with adjacent systems (altitude of airplanes).
- Do not patch AM aviation frequencies without express approval of aviation management.

Topic Aviation Radio (cont'd)

Explain the Following Key Points

Discuss the issues of using Aviation Bands.

Anytime aviation assets are in the air, there is great risk. Good, reliable communications are critical to aviation safety.

Key point: Most Public Safety air assets have FM capability to communicate with ground operations. These are intended for air-to-ground communications.

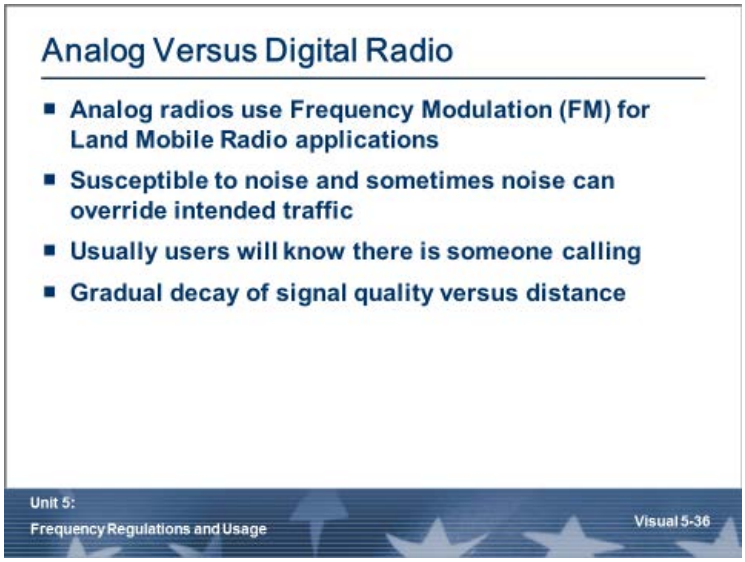
Air-to-air and air-to-flight control facilities:

- 108 MHz–136 MHz (civil and military aviation)
- 225 MHz–380 MHz (military aviation)
- AM modulation

Most emergency services aircraft include conventional FM public safety LMR channels appropriate to their area of operation.

- ***Protection of AIR-TO-GROUND channels is critical to safe air Operations.***
- Selection of FM frequency (LMR) is critical due to interference with adjacent systems (altitude of airplanes).
- Do not patch AM aviation frequencies without express approval of aviation management.

Topic Analog vs. Digital Radio



Explain the Following Key Points

Start discussion of Analog vs. Digital radios.

Analog (FM modulation) is the mainstay of historical public safety radio systems.

- Most established systems use analog
- Susceptible to noise – worse at low band, less at upper UHF
- Usually has some minimal indication of a transmission
- Gradual decay of signal in fringe areas of operation

Topic Analog vs. Digital Radio (cont'd)

Explain the Following Key Points

Discus digital modulation.

- Digital vocoder converts analog audio to digital format.
- Consistent quality out to fringe with rapid drop of signal Bit error rate.
- High ambient noise environments may tend to "confuse" the vocoder and cause poor performance in areas such as fire ground operations
- IAFC Report on Fire Ground Noise link:
- http://www.iafc.org/displaycommon.cfm?an=1&subarticlenbr=719
- May drop a desired signal in the presence of a "hidden" third-party transmitter where an alternate transmitter (or channel) keys up.

Topic Trunking

Explain the Following Key Points

Discuss trunking. This slide deserves a fair amount of discussion time. Communications Unit Leaders need a solid understanding of trunking systems.

Trunking is based on probability. Channel loading can impact system availability.

Suggested Question

What are the limitations of trunking?

Answer

Trunking is a system of probability and is trying to make efficient use of a small number of channels by maximizing the availability on a dynamic basis.

Typically 800 MHz (700 MHz), UHF and VHF high band trunking is growing.

Dissimilar vendor systems are often incompatible due to proprietary features.

Theory of Trunking

- Greater number of potential talk paths than available frequencies due to the statistical probability length of given radio calls and the statistical availability of frequencies
- Number of simultaneous calls limited to the total number of talkpaths available on a given trunked site
- Quality usually indicated by the number of "busy" indications
- Systems are typically scaled for very few "busies"
- Interoperability talkgroups should be pre-defined in local/regional systems and part of system pre-planned fleet mapping

- Trunking is based on the theory of probability; there is no guarantee of access in congested time periods

How long has trunking existed?

Trunking has been used in the telephone systems since 1923 to share a limited number of lines. Telephone company interoffice lines were referred to as “trunk lines.”

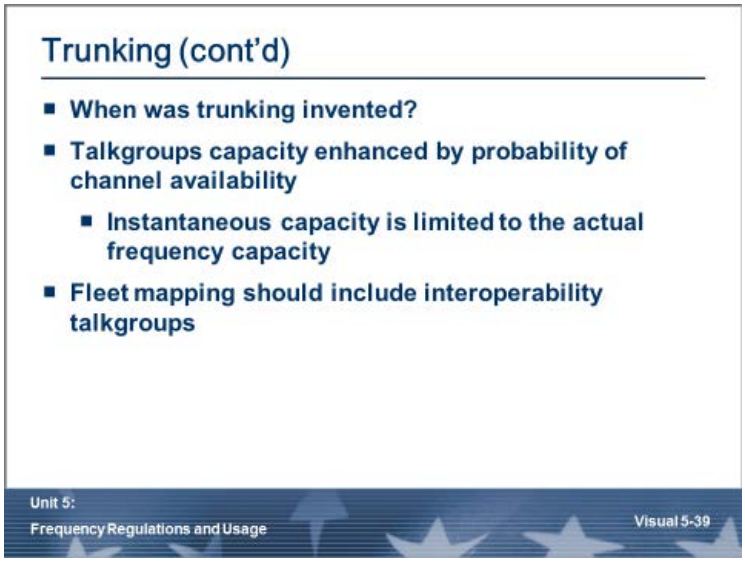
How does a trunked talkgroup work?

User A wants to contact all of the units in his/her talkgroup. The Push-to-Talk (PTT) is keyed, which causes the radio to send a short burst of data to the control channel repeater.

This data identifies the caller attributes and enters a channel request to the system controller. User A’s radio then switches to receive mode to await a data response from the controller. Upon receipt of the request, the system controller attempts to select an available voice channel.

If a voice channel is available, the system controller sends a data message over the control channel switching all units in User A’s talkgroup to the available voice channel. Only units in this particular talkgroup are automatically switched to the assigned channel. When User A starts talking, all the members of the talkgroup will hear the conversation. This preempts any other use of that assigned channel for the duration of the call.

Topic Trunking (cont'd)

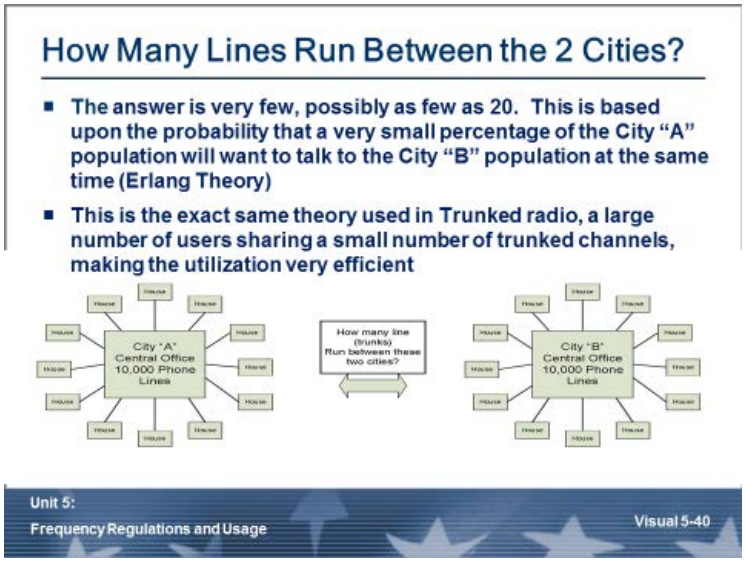


Explain the Following Key Points

Continue discussion on trunking. This slide deserves a fair amount of discussion time. Communications Unit Leaders need a solid understanding of trunking systems.

Trunking was invented in 1923 by AT&T.

Topic How Many Lines Run Between the Two Cities?



Explain the Following Key Points

Historically, cities used to assign a connection on limited long distance telephone lines.

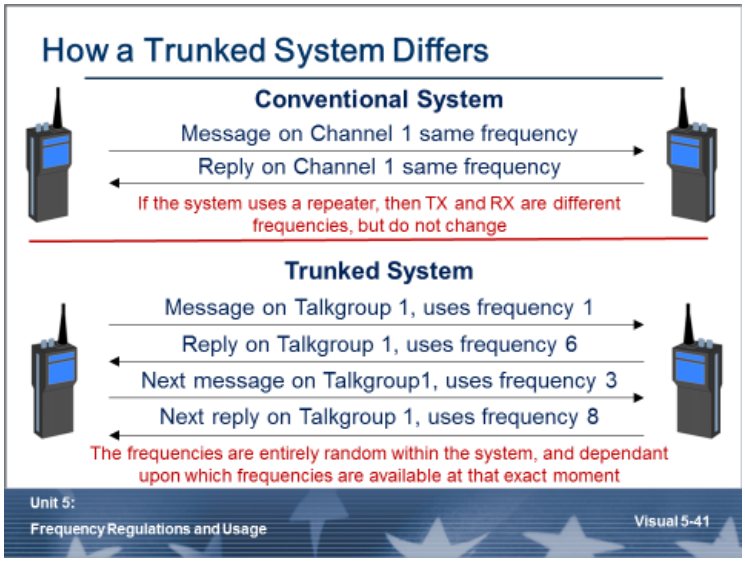
Greater number of potential talk paths than available frequencies due to the statistical probability length of given radio calls and the statistical availability of frequencies.

Number of simultaneous calls limited to the total number of frequencies used in the system.

Quality usually indicated by the number of "busy" indications.

Systems are typically scaled for very few "busies" (less than 1%).

Topic How a Trunked System Differs



Explain the Following Key Points

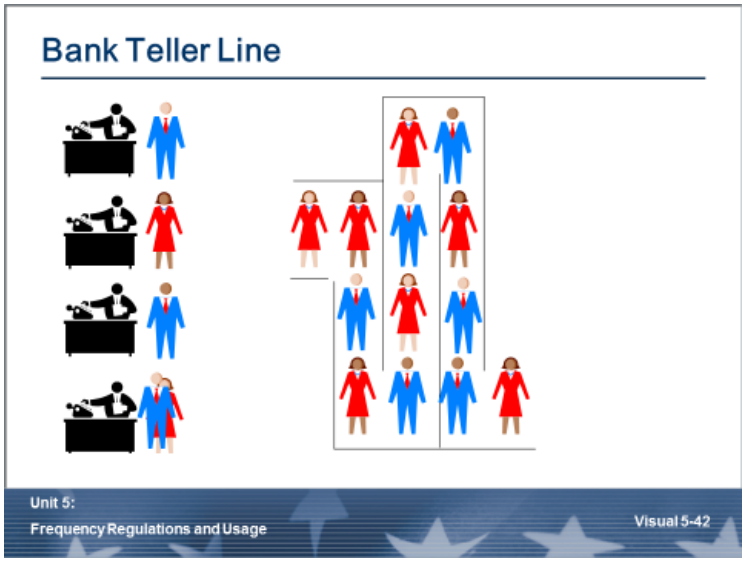
Discuss how a trunked system differs from a conventional system.

Conventional – If someone is using your system, you have to wait until they are done before you can use it

Trunking – Utilizes a pool of frequencies (channel pairs) that are dynamically assigned as needed. Every time you key your radio, it sends out a command channel stating you're ready to transmit.

The system sees what resources are available at that time and assigns the first available channel pair. It then sends an acknowledgment tone and you get a double beep meaning it is OK to talk. Every time you talk, you could be on a different channel pair.

Topic Bank Teller Trunking Analogy



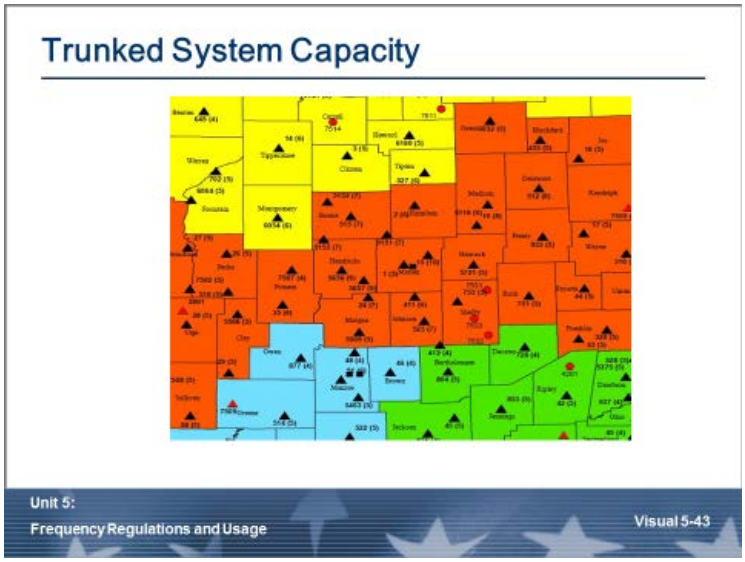
Explain the Following Key Points

Provide another graphic illustration of trunking. This slide has animation to help illustrate trunking by comparing a grocery store line to the bank teller line.

How a Trunked System Differs from Conventional

A good analogy is that a conventional system is like getting into the checkout line at a grocery store. Each person waits in line for their turn. Trunking is more analogous to waiting at the bank in a single queue for the next available teller.

Topic Trunked System Capacity



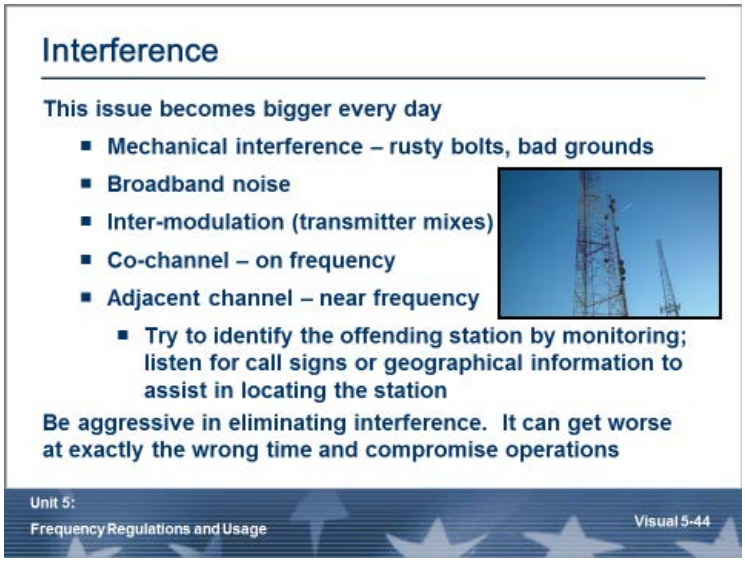
Explain the Following Key Points

Discuss talkgroups vs. channels.

Talkgroups do not equal talkpaths. A given site will contain a fixed number of available talkpaths. A COML should understand system architecture in order not to overload a site. This diagram depicts site locations followed by the number of talkpaths available in parentheses.

Shared channels are good, but scanning can be a mess. To avoid these problems, it can be recommended to not allow scanning.

Topic Interference



Explain the Following Key Points

Discuss accidental interference and how to resolve it.

Interference is becoming more of a problem everyday—more and more users occupying the finite spectrum available. Many sources of interference, including other radio users, thousands of wireless devices and even cash registers and other “not radio” devices.

When installing temporary equipment, being high (on rooftops) may not be the best option. For example during the New York 9/11 response, a number of temporary repeaters were installed. These were place out of windows mid-level in building. The advantage of this is to use the building to shield the radio from interference and to cover more specifically the area of need.

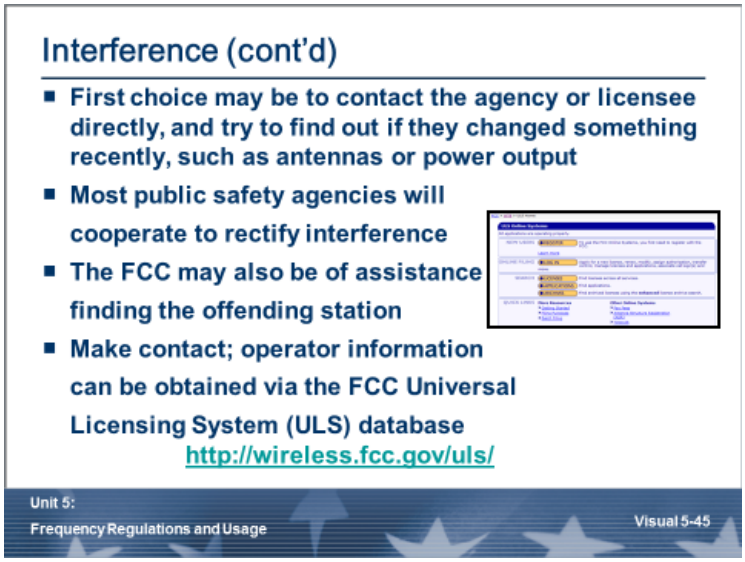
You will likely have to be a sleuth to find the cause. Use radio techs, amateurs or the FCC can assist if you need to.

How does interference affect radio communications?

- Congestion causes increased interference
- Licensed spectrum users
- Ambient commercial and industrial noise sources
  - Computers
  - Industrial systems (RF gluing, computer control)
- High power transmitters—near field overload
- Intermodulation (Intermod)— mixing of various frequencies
  - Direct frequency mixes in transmitters

  - Rusty bolts, fences
- Bidirectional amplifiers (BDAs)
- Digital TV over-the-air antenna amplifiers
  - Self-oscillation
- Co-channel (same frequency-different user)
- Adjacent channel—near frequency

Topic Interference (cont'd)



Explain the Following Key Points

Continue to discuss accidental interference and how to resolve it.

Get help if you need it. Most legitimate users will try to work to solve interference issues.

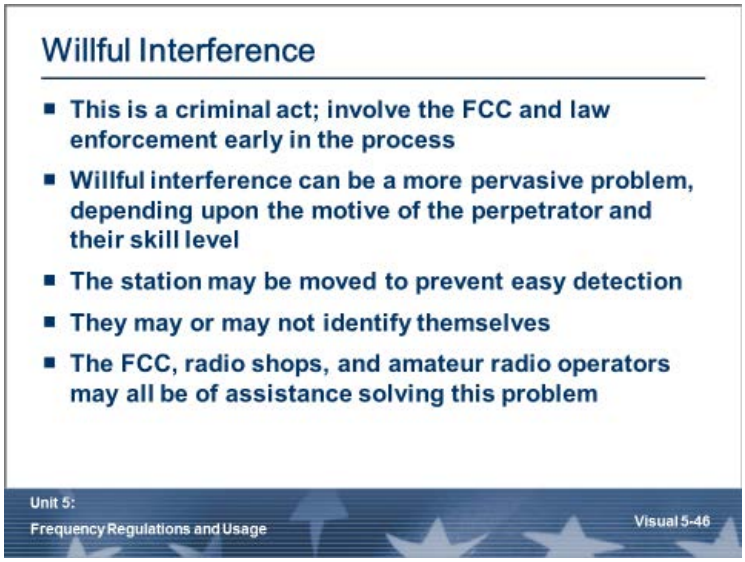
The best way to isolate the cause is to listen. If you hear voice traffic, try to identify locations or try to capture call signs, either voice or Morse code. The licensees of the call signs can be tracked down using the FCC ULS database.

Actions that can be taken to identify and eliminate interference:

- Direct "on frequency" interference
  - Attempt to contact licensees directly
- In extreme cases, the FCC may be able to assist in identifying dedicated interference sources
- Proper installation practices can help prevent interference
- FCC database may help to identify sources

With the exception of licensed trunked systems, the FCC classifies all other frequencies as "shared" without legal recourse to exclusivity.

Topic Willful Interference



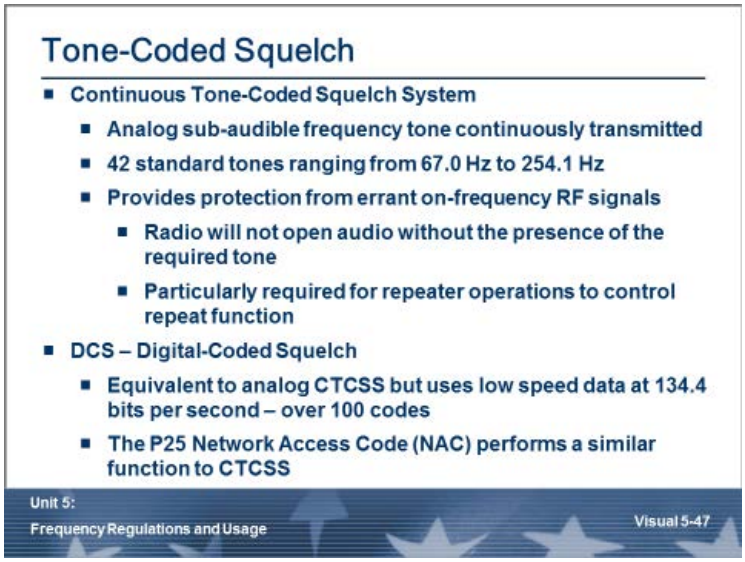
Explain the Following Key Points

Discuss willful interference.

Willful interference can be hard to track, some interferers will even identify themselves, but they tend to be fairly sophisticated and move around to prevent getting caught.

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.

Topic Tone-Coded Squelch



Explain the Following Key Points

Discuss Continuous Tone-Coded Squelch System (CTCSS).

Continuous Tone Coded Squelch System provides discrete access to shared channels by users. Excluding CSQ, there are 42 standard CTCSS tones; they have many trade names such as PL, QC, and others. There is also a digital version called DCS.

Continuous Tone-Coded Squelch System (CTCSS)

- Analog sub-audible frequency tone continuously transmitted
- Excluding CSQ, 42 standard tones ranging from 67.0 Hz to 254.1 Hz for analog channels
- 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
- Private Line (PL), Channel Guard (CG), Quiet Talk (QT), Quiet Channel (QC), Tone Guard (TG), and Tone Lock (TL), are all manufacturer-specific names for the CTCSS function

Digital-Coded Squelch (DCS)

- Equivalent action as analog using digitally encoded 134.4 Hz sub-audible tone
- P25 uses a digital equivalent of tone code squelch

Topic Radio Programming

Explain the Following Key Points

Discuss the pros and cons of field programming.

In the wildland fire world, all radios are usually programmed at each incident to reflect the needs of the incident. This is possible because there is a limited pool of equipment types and there is more control over the radios. In the "All Risk" environment, the COML has to be more cautious. First, there are many more radio types potentially at the scene. In addition, many require special software and cables; it would be very difficult to have every cable and the correct software for every incident.

Some radio software manufacturers will not allow previous versions of their software to program a radio that has been programmed with a newer version. This means if your software is older than the version that last programmed the radio; you are "locked out." Conversely, if you have newer software, the owner's radio shop may be "locked out." This requires a great deal of caution on behalf of the COML and COMT to make sure you are aware of the ramifications of programming.

System managers or radio owners must give permission prior to reprogramming. NEVER program the trunked side of a radio unless you have permission and have a full understanding of the configuration of the systems.

Requirements for Programming Modern Radios

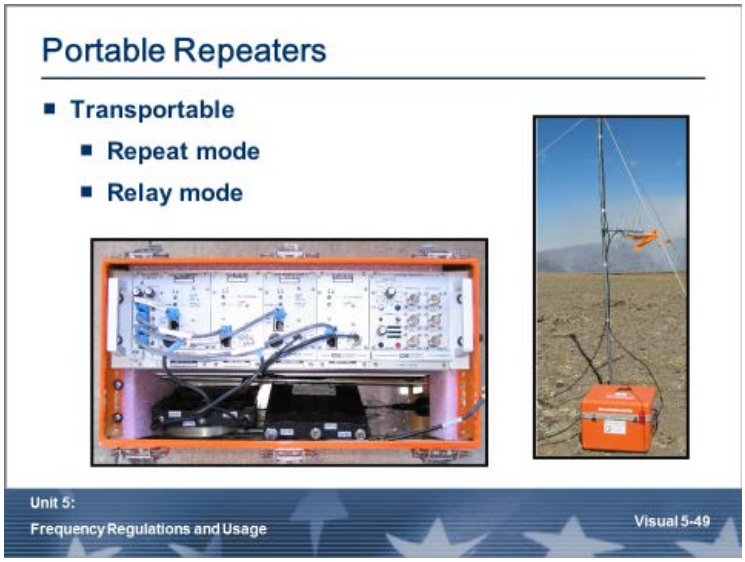
Virtually all modern radios are software-controlled to some degree.

- Programming requires:
  - Laptop with a Radio Interface Box (RIB)
  - Cloning cables to duplicate a similar make/model radio by directly loading configuration data from a master unit to a slave unit

- Logistical considerations:
  - Training of users (what channel, where)
  - Obtain system manager's authorization to alter radio programming
  - Logging program parameters
  - De-programming radios as required at the end of the incident
    - Retain copy of original program

Ensure programming software versions are the same. Programming a radio with a newer version of software than what is currently on the radio may prevent the radio from being reprogrammed with the older version.

Topic Portable Repeaters



Explain the Following Key Points

Discuss portable repeaters.

There are many types and configurations. Portable repeaters are a great asset to help in areas with no coverage or when damage has occurred to the infrastructure.

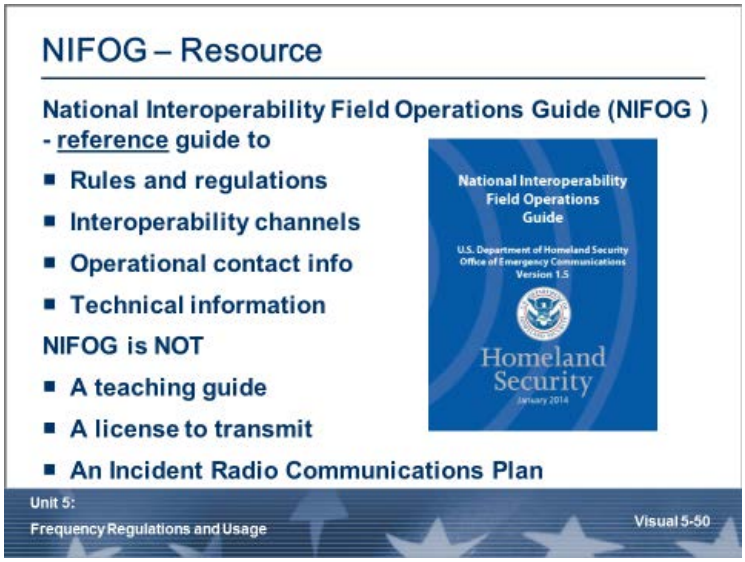
Some are vehicle mounted, which provides a stable power supply; however, where vehicles can go is not always the best place to install these devices.

Portable repeaters can be battery powered, solar, or AC powered. The solar and battery powered models are typically low power, but this can still provide great coverage with good placement and antenna selection.

Basic transportable repeaters:

- Mobile—Vehicle-mounted
- Transportable—Hand-carry (for example, helicopter, boat transport)

Topic NIFOG – Resource



Explain the Following Key Points

Discuss the use of this book by the Communications Unit Leader.

This resource is a great source for information; particular mention should be made of the regulatory sections in the front. This gives the Communications Unit Leader great flexibility to make things work in an emergency. It also discusses what is not an emergency and where the flexibility stops.

Great technical resource, the contents of the National Interoperability Field Operations Guide (NIFOG) include:

- Common interoperability channel lists
- Common used frequency lists
- Miscellaneous technical references
- Contact numbers

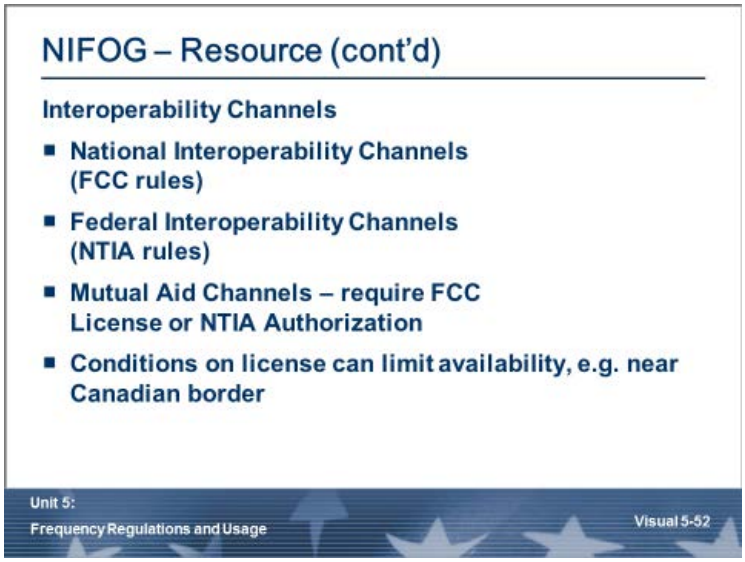
Topic NIFOG – Resource (cont'd)

Explain the Following Key Points

Continue discussing the contents of the National Interoperability Field Operations Guide (NIFOG):

- Rules and Regulations
- When can the frequencies be use?
  - Mobile and portable during times of emergency
  - Fixed repeaters require a license

Topic NIFOG – Resource (cont'd)

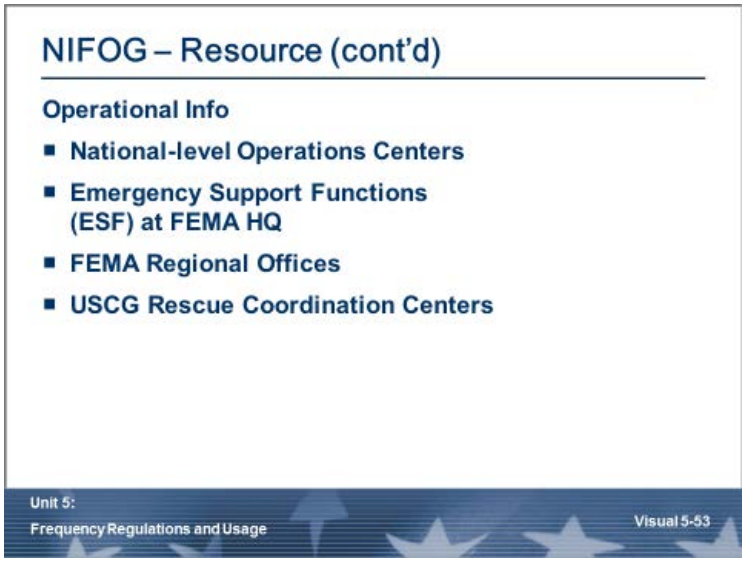


Explain the Following Key Points

Continue discussing the contents of the National Interoperability Field Operations Guide (NIFOG):

- Common interoperability channels: national and federal.
- Conditions on license can limit availability, e.g. near Canadian border.

Topic NIFOG – Resource (cont'd)



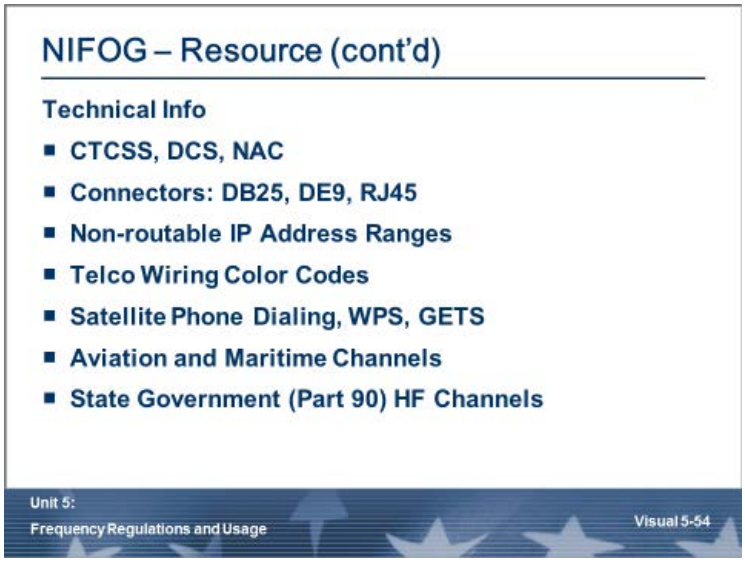
Explain the Following Key Points

Discuss the contents of the National Interoperability Field Operations Guide (NIFOG).

Telephone numbers for:

- National-level Operations Centers
- Emergency Support Functions (ESF) at FEMA HQ
- FEMA Regional Offices
- USCG Rescue Coordination Centers

Topic NIFOG – Resource (cont'd)



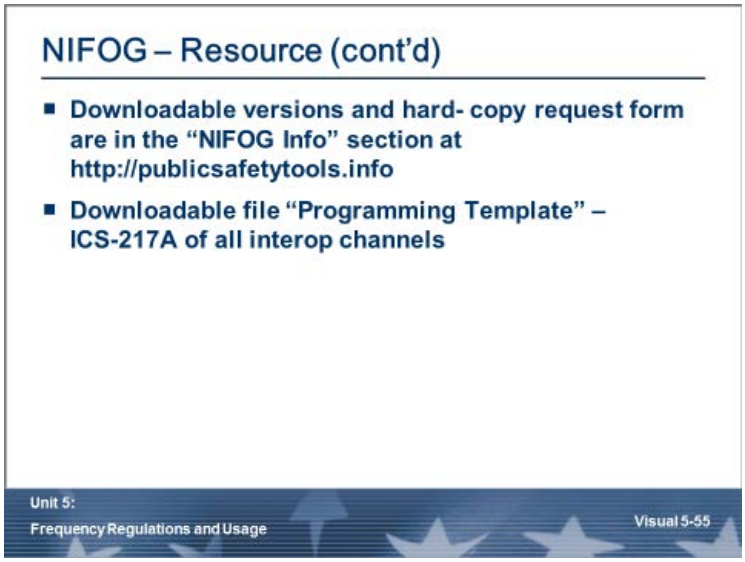
Explain the Following Key Points

Continue discussing the contents of the National Interoperability Field Operations Guide (NIFOG).

Reference information:

- Sub audible tones: CTCSS, DCS, NAC
- Wiring layout Connectors: DB25, DE9, RJ45
- Non-routable IP Address Ranges
- Telco Wiring Color Codes
- Satellite Phone Dialing, WPS, GETS
- Aviation and Maritime Channels
- State Government (Part 90) HF Channels

Topic NIFOG – Resource (cont'd)



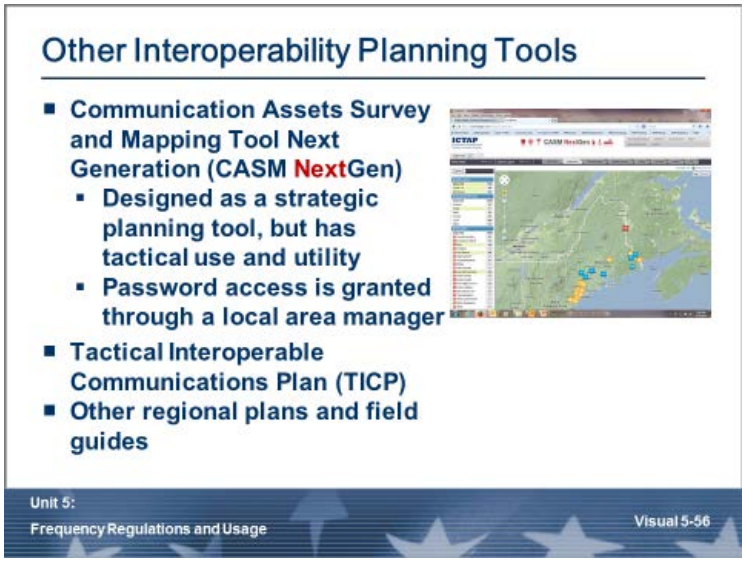
Explain the Following Key Points

Continue discussing the contents of the National Interoperability Field Operations Guide (NIFOG).

- Common interoperability channel lists
- Commonly used frequency lists
- Miscellaneous technical references
- Contact numbers

The NIFOG is downloadable from the "PublicSafetyTools" website. Using this method to obtain a soft copy of the NIFOG ensures you will receive notification of any updates: http://publicsafetytools.info

Topic CASM NextGen



Explain the Following Key Points

Lead-in to the discussion for a CASM NextGen (Communication Assets Survey and Mapping Tool Next Generation) demonstration/discussion.

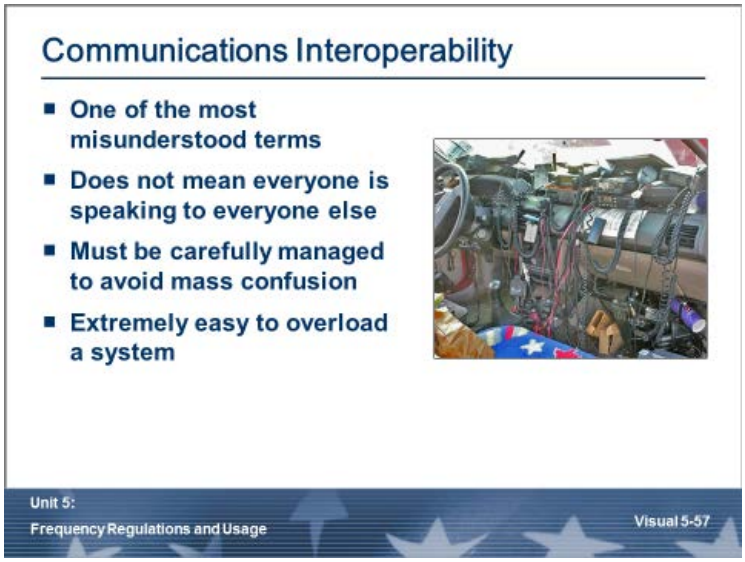
CASM NextGen was not intended as a tactical tool; however, it may provide useful data. CASM NextGen is only as good as the quality of data that it contains. Obtain the local CASM NextGen administrator's contact info for the students. CASM NextGen:

- Displays communication interoperability on a regional basis
- Users require a password
- All rights are tied to the password (create, modify, read)
- Passwords are available by contacting the Local Area Manager for CASM
- Log onto CASM and show 5 minute demonstration

Demonstration

Conduct a real-time CASM NextGen demonstration or arrange for a CASM NextGen demonstration with the State CASM Administrator. CASM NextGen was designed as a strategic planning tool but may have tactical applications. It requires real-time connectivity. Password access may be obtained through the State CASM Administrator.

Topic Communications Interoperability



Explain the Following Key Points

Introduce a discussion on communications interoperability and what it is.

Interoperability can be a great asset on incidents; it can also be a major problem. The need for radio interoperability needs to be a discussion held with the COML and Operations to determine what is practical and what the positives and negatives are.

Keep any interoperability efforts as simple as possible; complexity may lead to issues.

Communications interoperability is the ability of public safety service and support providers to communicate with staff from other responding agencies, to exchange voice and/or data communications as required, on demand and in real-time, as authorized.

- Communications interoperability is not a party-line
- Common mission, common area
- Interoperability might or might not be a priority

Keep it simple! Complex fixes increase risks and vulnerabilities.

Topic Interoperability Channels

Explain the Following Key Points

Discuss the number of channels assigned to interoperability.

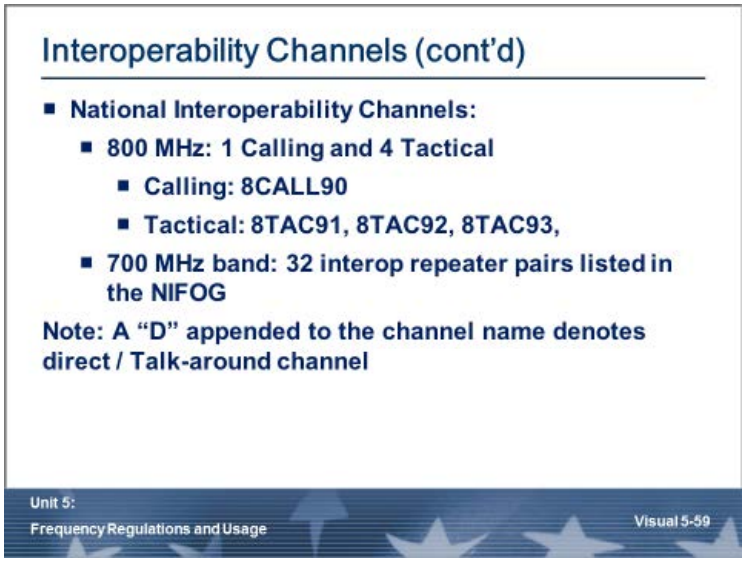
In the NIFOG, the channels are listed for each band. Most are narrowband, but there are channels that have not been converted yet, for example, the nationwide Fire mutual aid channels 154.2800, 154.2650, and 154.2950.

National Public Safety Telecommunications Council (NPSTC) has created a nationwide naming convention for all these channels. Not all agencies have adopted this convention, but most are leaning toward it.

VCALL and VTACs, UCALL, and UTACs are narrowband assignments. There are wideband interoperability channels available.

The VTAC repeater channels use two of the VTAC tactical channels to create a repeater pair.

Topic Interoperability Channels (cont'd)



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700 MHz band: 32 interop repeater pairs, plus 32 talk-around channels (append "D" to the channel name).

The 700 MHz repeater pairs are located in the NIFOG: 7CALL50, 7TAC51, 7TAC52, 7TAC53, 7TAC54, 7TAC55, 7TAC56, 7GTAC57, 7MOB59, 7LAW61, 7LAW62, 7FIRE63, 7FIRE64, 7MED65, 7MED66, 7DATA69, 7CALL70, 7TAC71, 7TAC72, 7TAC73, 7TAC74, 7TAC75, 7TAC76, 7GTAC77, 7MOB79, 7LAW81, 7LAW82, 7FIRE83, 7FIRE84, 7MED86, 7MED87, and 7DATA89.

Topic Local Use Agreements

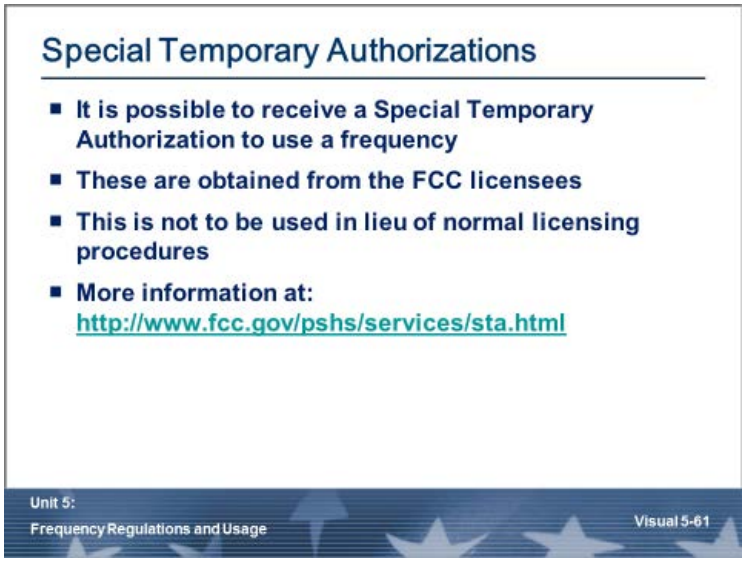
Explain the Following Key Points

Discuss local use agreements.

These are agreements to allow one agency to use another agency's radio system without requiring the first agency to license the channel. They can only be granted within the footprint of the license that has been issued. The agency with the license can revoke a local use agreement at any time. These agreements should be in writing.

This is not designed to replace the license requirements. You can only agree to the terms of your license, especially related to your licensed area of operation. You cannot authorize use outside of the terms of your FCC license. These should be written agreements. Agreements do not need to be complex.

Topic Special Temporary Authorizations



Explain the Following Key Points

Discuss Special Temporary Authorizations.

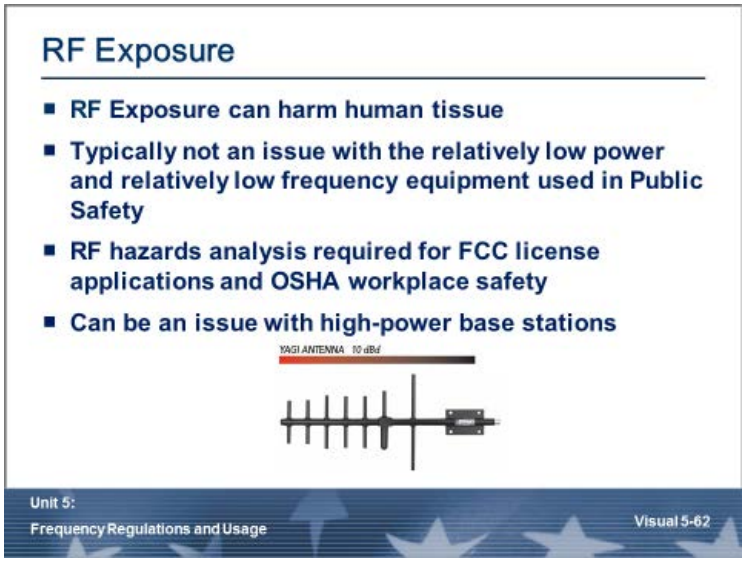
- Can be obtained to install infrastructure temporarily
- Easy to obtain, if the need is there
- Typically good for 6 months

When do you want to do this?

- These are obtained from the FCC licensees; see FCC rule 1.931
- Stations authorized by NTIA see NTIA Manual section 8.3.32
- These are used generally for fixed systems during system failures, not typically used for planned events or exercises.
  - They are allowed for emergencies involving danger to life and property
  - Informal application may be used
  - Grants are typically for 6 months

If you do need one, they are not difficult to get. Generally you can do this online. Be prepared to provide name and address of the applicant agency, the location of the proposed installation or area of operations, and the nature of the emergency.

Topic RF Exposure



Explain the Following Key Points

Explain and discuss the risks of RF exposure and safety measures to be taken.

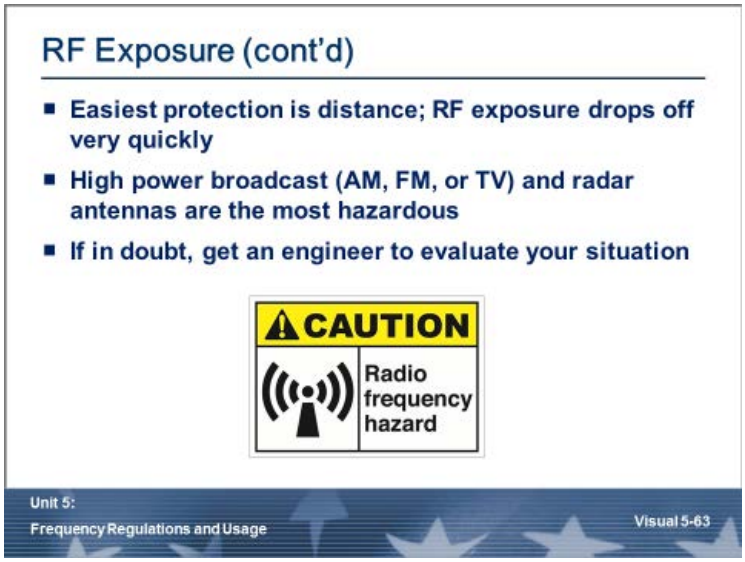
Humans can be at risk from RF exposure. Be wary of high power transmitters—they can cause human harm, particularly radar and broadcast antennas.

Found at high-power broadcast and military and aviation radar facilities, higher frequency emissions are the cause of more damage, typically to soft tissue such as the eyes.

Directional antennas such as dishes and Yagi antennas produce more focused energy.

Consult with radio engineering professionals for Maximum Permissible Exposure (MPE) evaluations for fixed high-power stations.

Topic RF Exposure



Explain the Following Key Points

Continue to explain and discuss the risks of RF exposure and safety measures to be taken.

Exposure level drops by 75% or more each time the distance from the transmitter is doubled.

FCC Encyclopedia - Radio Frequency Safety http://www.fcc.gov/encyclopedia/radio-frequency-safety

OET Bulletin 56 Questions and Answers about Biological Effects and Potential Hazards of Radio frequency Electromagnetic Fields

http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet56/oet56e3.pdf

OET Bulletin 65 Evaluating Compliance with FCC Guidelines for Human Exposure to Radio frequency Electromagnetic Fields

http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf

FM Model for Windows Software Program

http://www.fcc.gov/oet/info/software/fmmodel/

Topic Exercise 5

Explain the Following Key Points

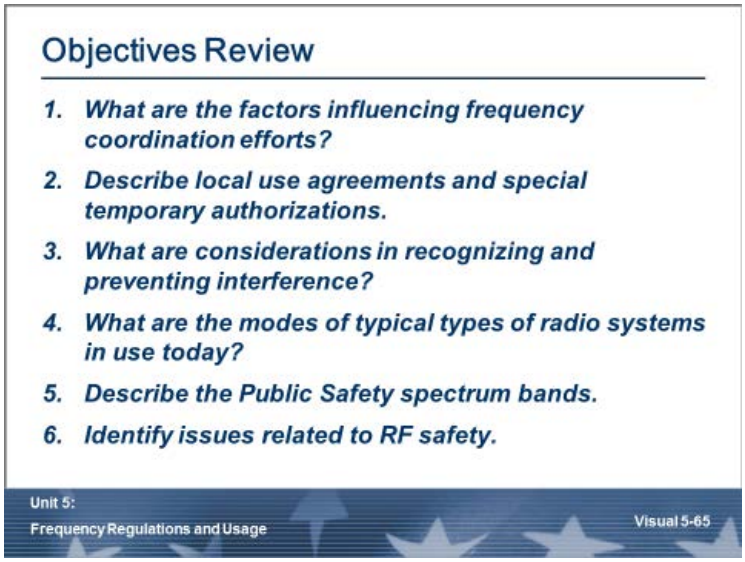
Retrieve Exercise 5 Instructor Guide located in the Unit 5 Exercise Tab before proceeding.

Refer to Exercise 5: Frequency Usage.

The purpose of the exercise is to provide the participants with an opportunity to identify how to address frequency issues and explain their solutions to address these challenges. The exercise will be an instructor-led discussion of frequency issues. Ask the participants of their experiences using local, regional, State, and national interoperable channels.

This exercise should last approximately 20 minutes.

Topic Objectives Review



Explain the Following Key Points

Review the Enabling Objectives for this unit to ensure that the class has obtained the knowledge necessary to successfully meet the Unit Terminal Objective.

Pose the Unit Enabling Objectives as questions. Ask the group to give a brief example/short explanation to answer each question. Try to call on a different student for each objective.

This is not intended to be an inclusive discussion of all material covered in Unit 5, but rather a quick and engaging way to wrap up the unit, and reconnect the students to the material before moving on to Unit 6.

Ask the students to write down the top 3-5 things they learned in this unit on their ICS Form 214.

Leave the Objectives Review slide up so that students can think about what they learned in relation to the objectives.

At the end of the day collect their ICS Form 214s. This will help identify what the students have learned and what areas may be especially important to highlight throughout the rest of the course.

This activity should be done at the end of each unit.

Unit Terminal Objective

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

Unit Enabling Objectives

- Identify the factors influencing frequency coordination efforts

- Understand local use agreements and special temporary authorizations
- Identify and describe considerations in recognizing and preventing interference
- Identify modes of typical types of radio systems in use today
- Describe the Public Safety Spectrum Bands
- Identify RF safety issues

Topic Questions

Explain the Following Key Points

Provide students an opportunity to ask questions and seek clarification on material presented in this unit.