



Radio 101

A Short Primer for Telecommunicators

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WARNING TECHNICAL TERMS WILL BE USED

- **This presentation will contain some technical terms and materials.** This is known to cause some anguish, nervousness and in some extreme cases can lead to a catatonic state in non-techie folks.
- **YOU HAVE BEEN WARNED!**

Some History

- Policing in America before the 1920s was an entirely different process than it is today. The main work was done by the beat policeman, who wandered his assigned neighborhood on foot. If he needed to communicate with his precinct officer, he used a street corner police callbox. Lights, bells or sirens at precinct stations were used to notify the beat policemen to call in. Fire was similar. As late as the 1970's San Bernardino County Fire districts used sirens to alert volunteers to come to the fire station to respond to a fire.
- In 1921, Detroit police commissioner William Rutledge was the first public safety official to use radio equipped vehicles. See <https://www.fcc.gov/sites/default/files/a-short-history-of-radio.pdf> for more radio history.
- In the 1950's two-way radio systems for public safety grew rapidly using low-VHF band (30-50MHz) and VHF band (150-174 MHz). By the 1960's UHF band (450- 470) systems were being built. All used FM modulation.
- By 1972, mobile data radio systems were being used in public safety vehicles to transmit and receive data from dispatch computers.
- The 1980's saw the 800 MHz band (806 – 869MHz) being used.
- The 1990's saw conversions from FM modulation to digital (like P25) modulation. Also, the 700 MHz was allocated to Public Safety.

A Few Technical Items

- Sound – Sound is analog and sound waves are pressure changes in the air. Sound is not electrical. That's why you use a microphone.
- Microphone – Microphones convert sound waves to electrical voltage. The electrical voltage can be sent to the radio transmitter and sent through the air as a radio wave.

Now we will define Radio waves- One by Einstein and one by Maxwell:

A Few Technical Items

- Radio Waves:

Albert Einstein, when asked, in 1938, to explain radio, is widely reported to have said:

"You see, wire telegraph is a kind of a very, very long cat. You pull his tail in New York and his head is meowing in Los Angeles. Do you understand this? And radio operates exactly the same way: you send signals here, they receive them there. The only difference is that there is no cat."

A Few Technical Items

- If you don't like Einstein's Version, I can give you the math using Maxwell's Equations:

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{j} + \frac{1}{c^2} \frac{\partial \mathbf{E}}{\partial t}$$

$$\nabla \cdot \mathbf{E} = \frac{\rho_v}{\epsilon}$$

$$\nabla \cdot \mathbf{H} = 0$$

$$\nabla \times \mathbf{E} = -\mu \frac{\partial \mathbf{H}}{\partial t}$$

$$\nabla \times \mathbf{H} = \mathbf{J} + \epsilon \frac{\partial \mathbf{E}}{\partial t}$$

(Gauss' Law)

(Gauss' Law for Magnetism)

(Faraday's Law)

(Ampere's Law)

God Said: Let There Be Light (and Radio Waves)

So, Let's Explore Radio Systems

- Dispatch Console – The equipment you sit at!
- Base Station (FB) – A base Station Transmits (TX) and Receives (RX) on one Frequency.
- Repeater Station - A base station that TXs on one Frequency and RX on a different one
- Trunked Radio System – Several repeater stations controlled by a computer. More efficient way to use frequencies

First – How are Radios Made?

Assembly



Activation

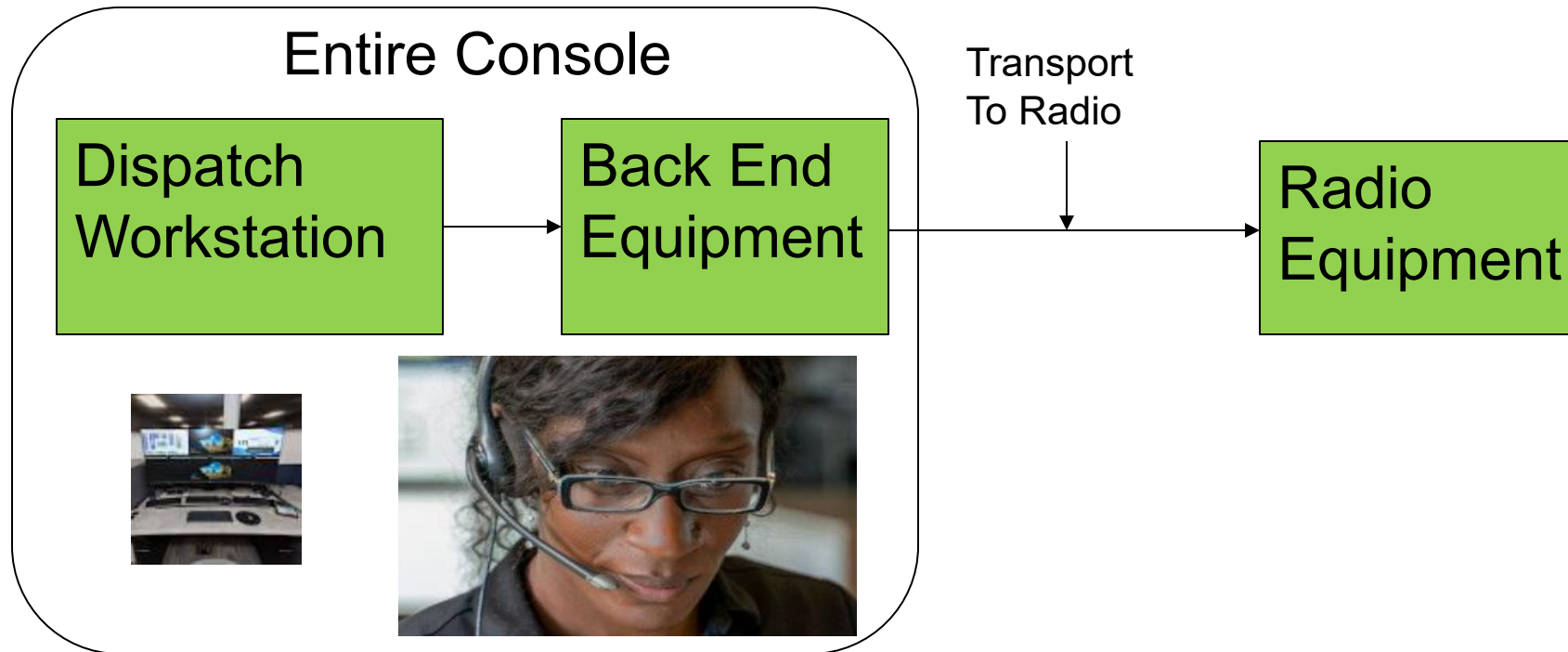


Quality Control



Dispatch Console

Console Block Diagram



Simplex – “Talk Around”

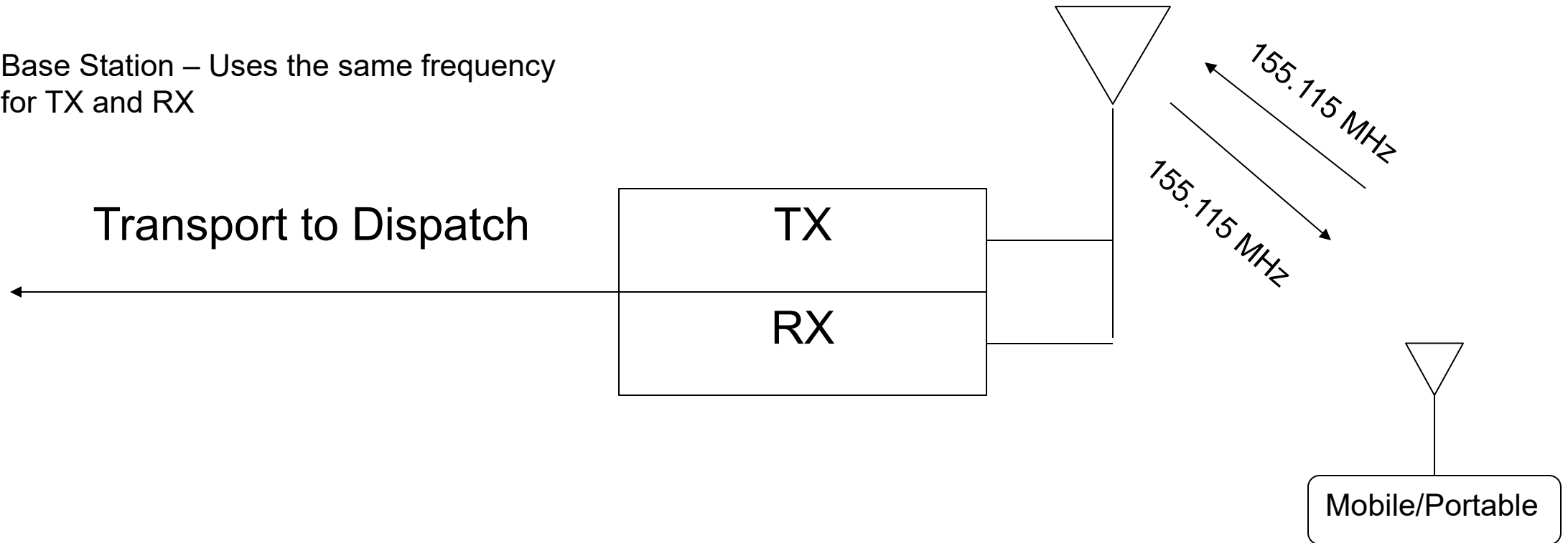
Land Mobile Radio – Typical Systems

- **Simplex (or Direct / Talk-around)** – A base, mobile or portable station’s ability to talk directly with each other without the use infrastructure (such as a repeater) “Talk-around” refers to talking “around” (e.g. not using) the repeater for direct mobile-to-mobile communications. Limited by distance between mobiles/portables and characteristics of radio band being used, and is generally line-of-sight.



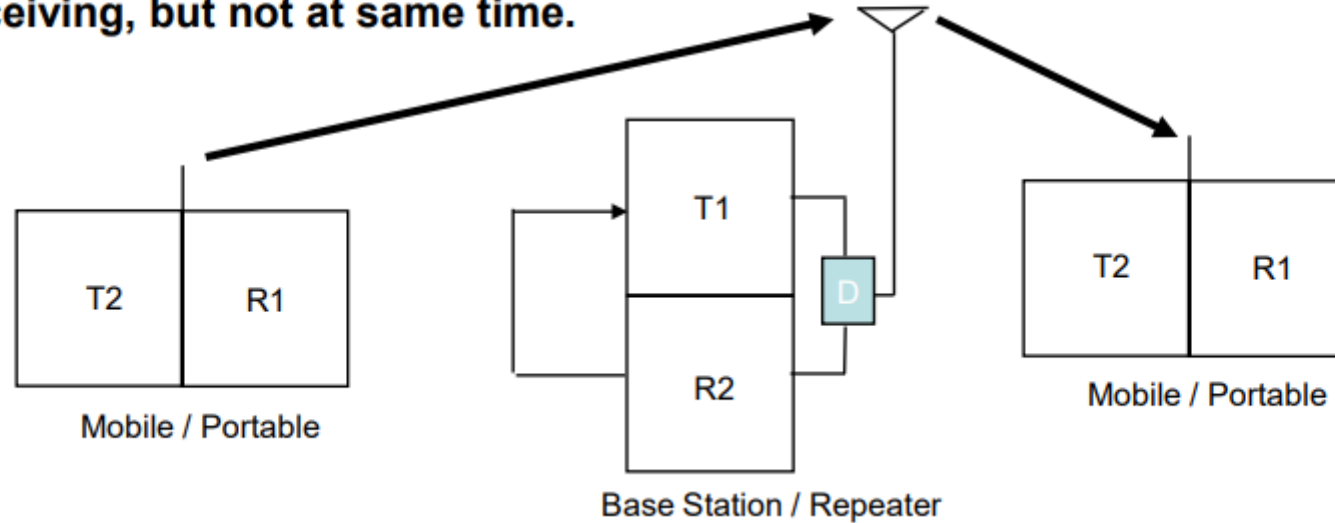
Base Station

Base Station – Uses the same frequency for TX and RX



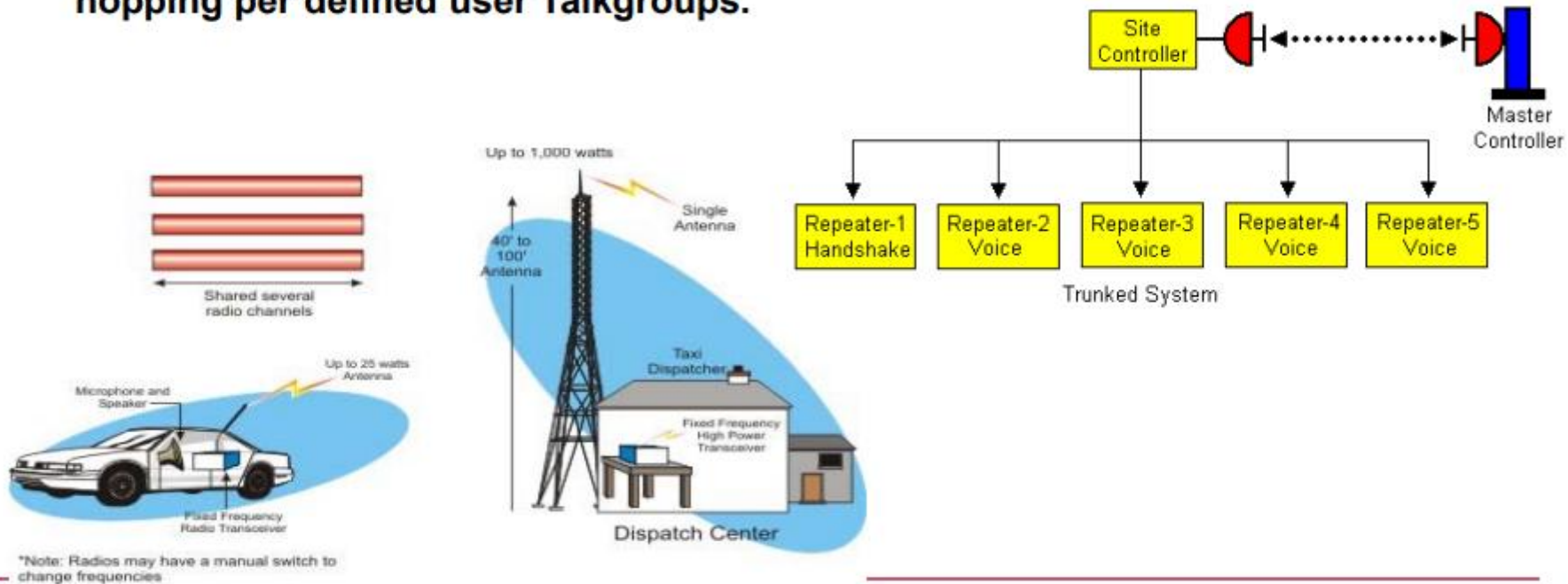
Repeater Station

- **Repeater:** A base station or system that simultaneously retransmits the received signal/audio to other users, thus extending the range of the system (mobile to mobile coverage). Repeater stations operates in full-duplex (both receive and transmit at the same time – identical to mobile cell phone systems). Mobiles/portables operate in half-duplex mode which is either transmitting or receiving, but not at same time.



Trunked Radio System

- **Trunked Radio** – Multiple radios tied together under control of a dedicated digital system control channel, allowing 100 or more subscribers per channel. Uses a fleet map and multiple codes for subscribers. Computer controlled channel hopping per defined user Talkgroups.





Simulcast Radio System

All the cats howl in harmony at the same volume. When spread out, they can be heard over a wide area.

In Building Systems and Problems

- These are commonly called “BDS” or “DAS”
- They extend a radio system into a building (They use a relay cat to howl from outside to inside the building).
- The radio system owner must give permission for a building owner to operate a in building system.
- If not properly designed and installed, they can cause severe interference to a radio system.

Help your Tech

- If your system isn't working properly, you can help the techs more quickly resolve the issue.
- When you notice a problem, note the unit(s) involved and what geographical area did it happen in. Is the problem intermittent (worse kind to track down)
- Does the problem only happen at a certain time of day.
- Don't forget to consider your console, headset and PTT switch might be the problem.

Transport (Audio/Control) To/From Dispatch

- Wireline Transport - This was the most common Transport method. It is simply a special Telephone line between two locations (Dispatch/Radio Site).
- Microwave – Not the cooking kind! This is a very fat cat radio between two locations. It can transport many audio/control channels.
- Routers and Switches (IP) This can use Microwave or Fiber connections

Radio Spectrum For Public Safety

- Hz is for Hertz or cycles per second, M is for Mega or million, and G is for Giga or billion. Radio Band – a portion of the entire radio spectrum. The Radio Spectrum is generally from 50,000 Hz to 300 GHz
- 30 to 50 MHz – Good for covering large areas with fewer Base Station sites. Very hard to use portable radios on this band. CHP uses this band Statewide.
- 150 to 174 MHz (VHF) – This band is used by almost all agencies. It has good coverage for each base station and portable radios work reasonably well. This band is heavily used throughout Southern California. It can be very hard to find additional frequencies for an agency to expand capacity

Radio Spectrum For Public Safety

- 450 to 512 MHz (UHF) This band has similar coverage to the VHF Band and slightly better portable coverage. This band is also heavily used in southern California and like the VHF band, it is hard to find additional frequencies. The frequencies are paired and this makes repeater use easy. The paired frequencies are called channels.
- 851 to 860 MHz (800 Band) Note – 851 to 854 is the NPSPAC band governed by a Regional Plan. The 800 band has lots of frequencies and they are paired. The systems in this band are usually built as a trunked configuration. While not always easy to find additional channels, this band is a good choice for a major expansion and upgrade. This band has good coverage characteristics in Southern California. Portable coverage is very good.

Radio Spectrum For Public Safety

- 769 to 775 MHz (700 Band) This band is also governed by a regional plan. It uses paired channels and is very similar to the 800 band. This band is used mainly by large cities and the counties. Good band to look to for expansion and can be mixed in with 800 Band channels.

Last

Fun Questions

- For Operations Folks – How did Motorola get its name?
- For Technical Folks – Besides Motorola, what 2 very large companies were LMR vendors in the 1960's ?