# Amateur Radio Technician License Training

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# Topics on Exam

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# Amateur Radio Technician License Training

## T-3 Radio Waves and Propagation

Presented by Steve Turner, KJ6EIF

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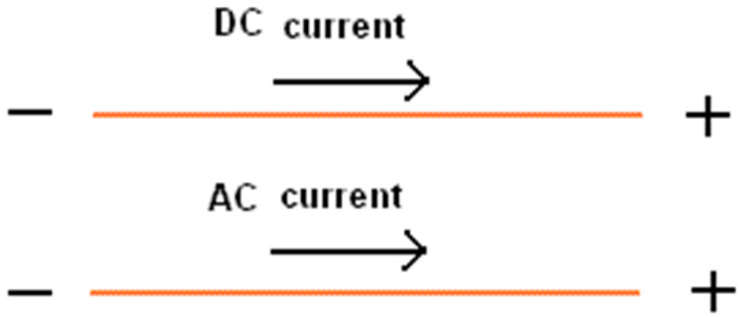
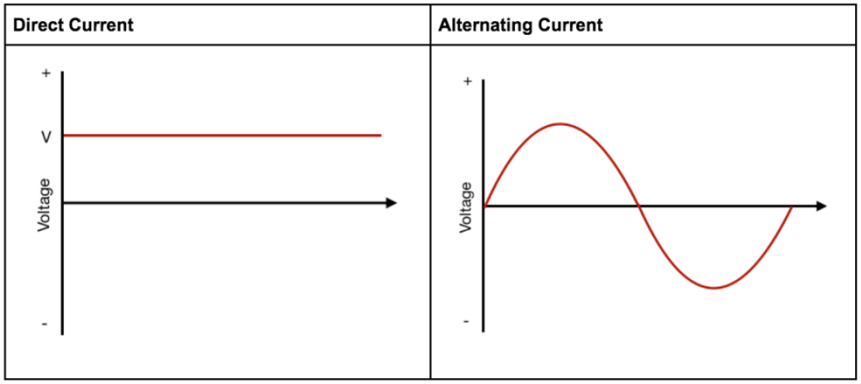
## Electric Current




Direct Current (**DC**) electricity flows in one direction from positive to negative.
Alternating Current (**AC**) switches direction frequently.




If we plot the flow of electricity over a period of time, AC looks like a wave. From zero to positive to zero to negative to zero is a **Complete Cycle**

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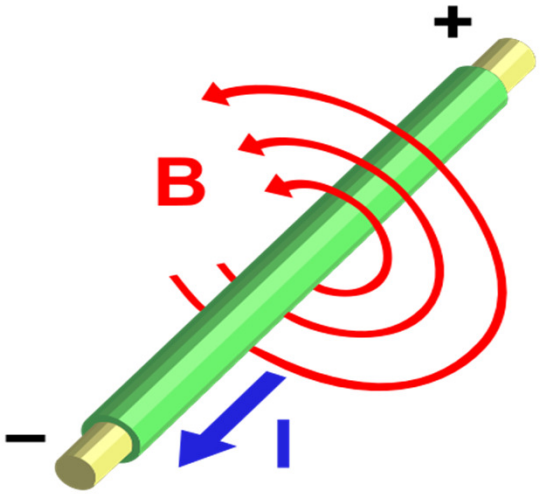
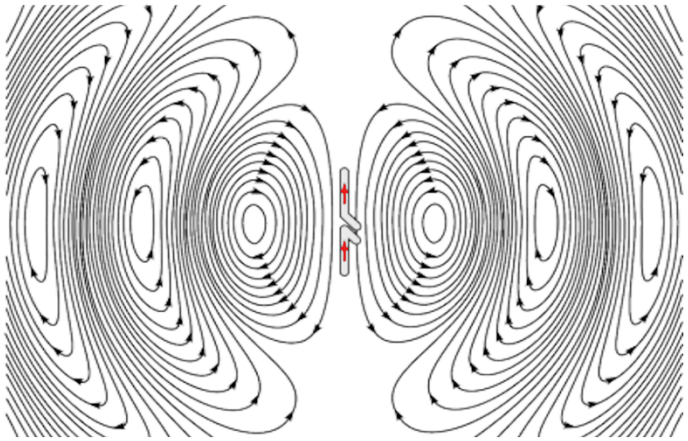



## Electro-magnetism and Electromagnetic Fields



When **DC** flows through a conductor it creates a stationary magnetic field around the conductor.

When **AC** flows through a conductor it creates a pulsating **electromagnetic field** that radiates away from the conductor

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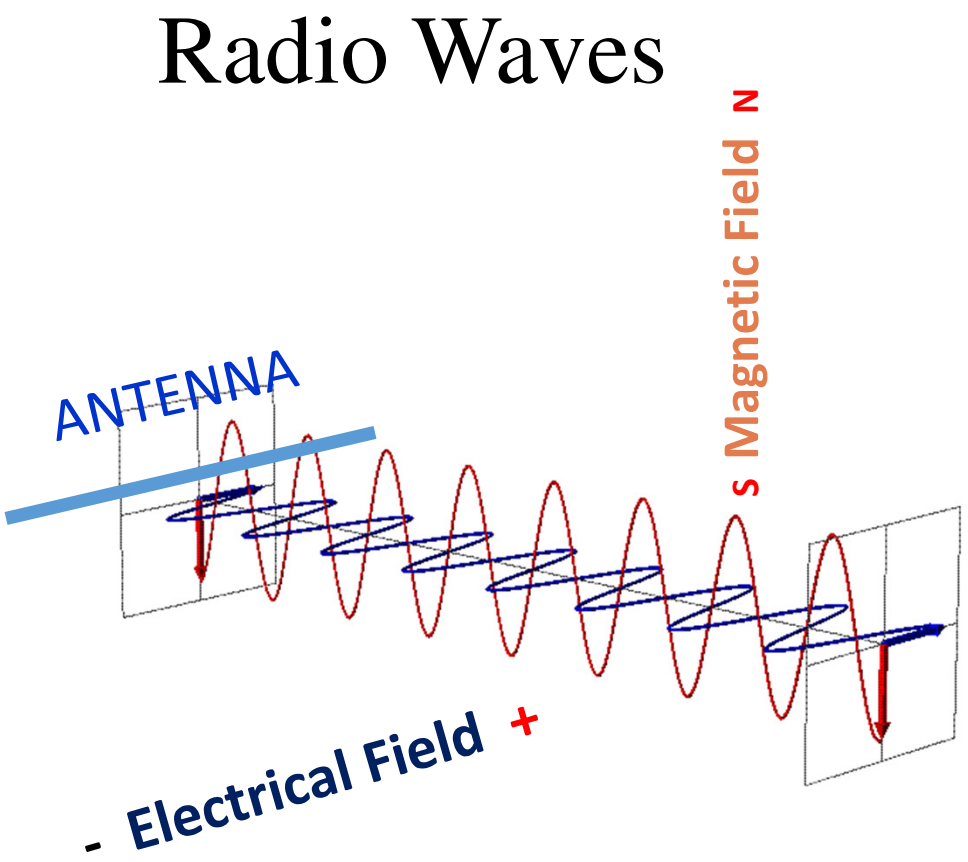
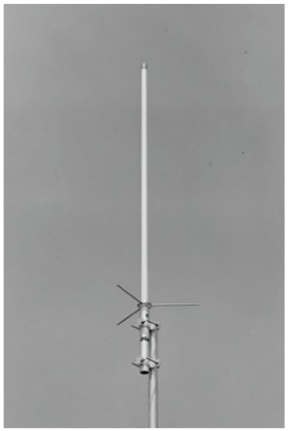
- The **two components** of a radio wave are the Electric and Magnetic fields.
- They are at **right angles** to each other.
- The orientation of the **electrical field defines the radio wave's polarization**.



# Antenna Polarization

- Horizontal polarization is normally used for long-distance CW and SSB contacts on the VHF and UHF bands.



- Vertical polarization is used for local VHF & UHF FM contacts.
- When antennas at opposite ends of a VHF or UHF line-of-sight link are not using the same polarization received signal strength is reduced.

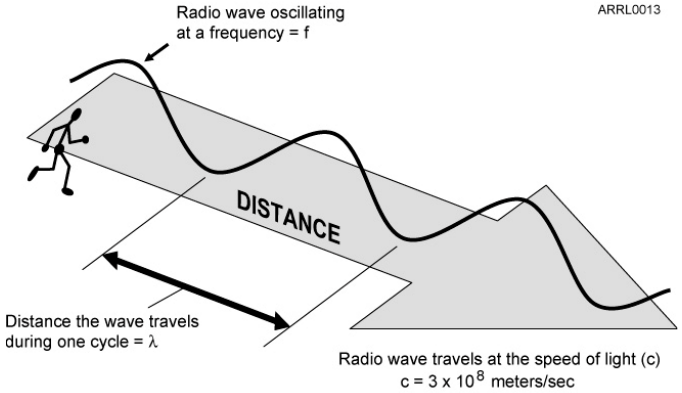
# Wavelength

*Wavelength* is the distance a radio wave travels during one cycle of the wave's electric and magnetic fields.

The velocity of a radio wave traveling through free space is the **Speed of Light.**

The approximate velocity is **300,000,000 meters per second**

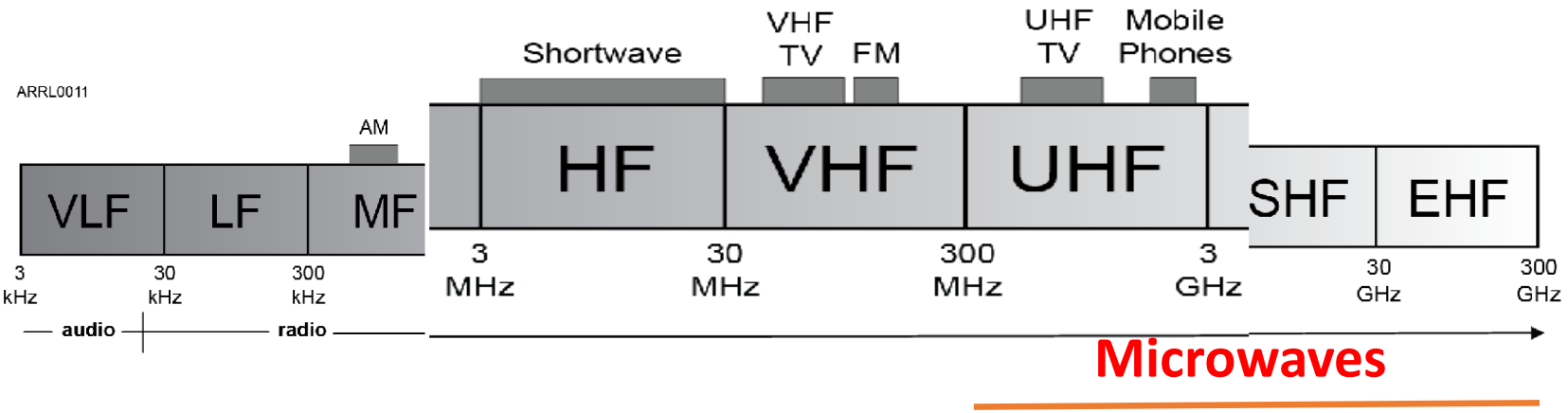
Wavelength gets shorter as frequency increases.




λ= c/f = 300 / f in MHz

# Electromagnetic Spectrum

- The electromagnetic *spectrum* is divided into ranges of frequencies in which electromagnetic waves behave similarly.
- **Wavelength in meters = 300 divided by frequency in Megahertz**
- Memorize the HF, VHF, and UHF ranges. (3GHz = 3,000MHz)



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**In addition to, frequency amateur radio bands are often identified by their approximate wavelength in meters.**

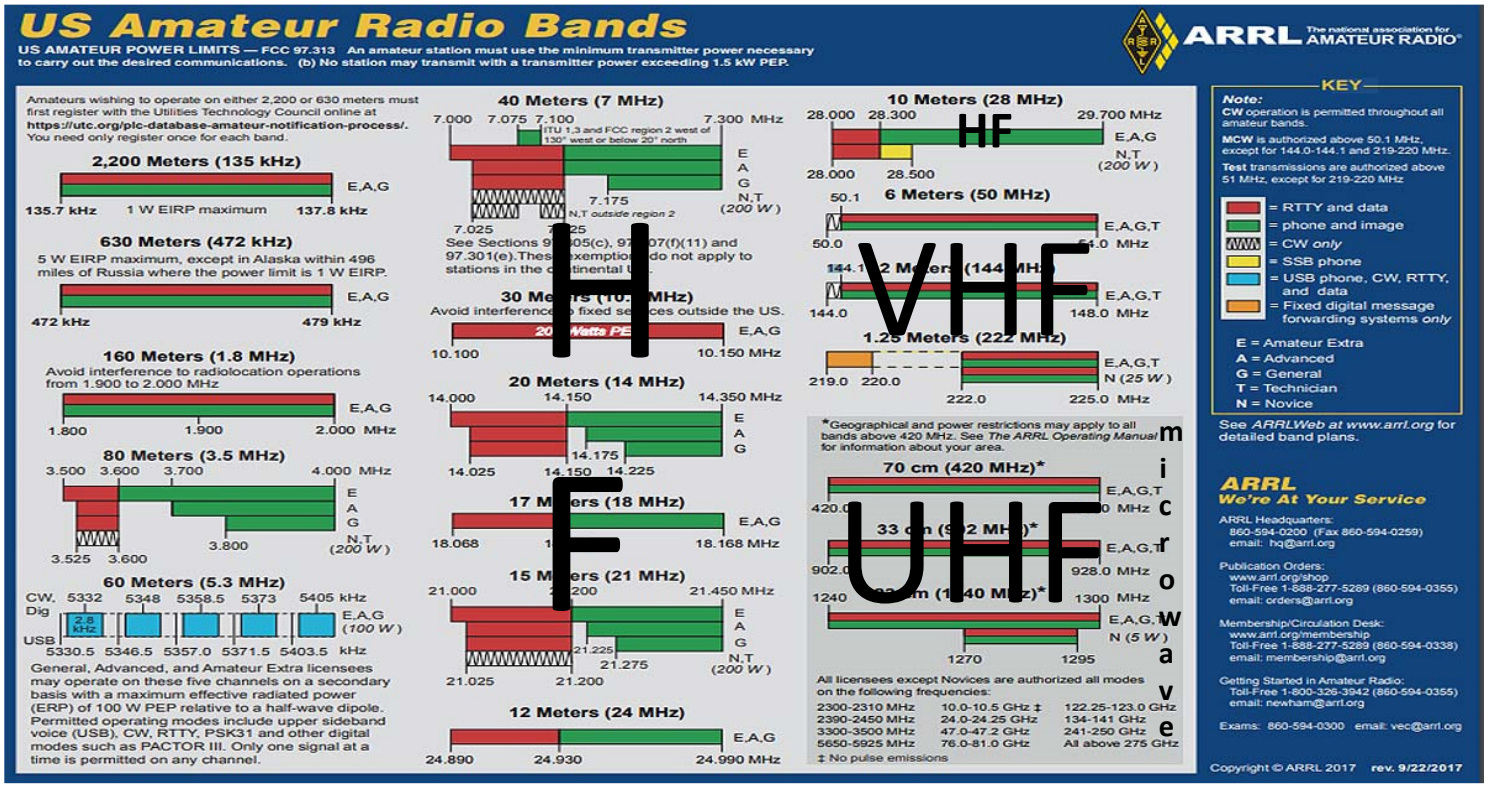
LF

MF

MF

HF

HF



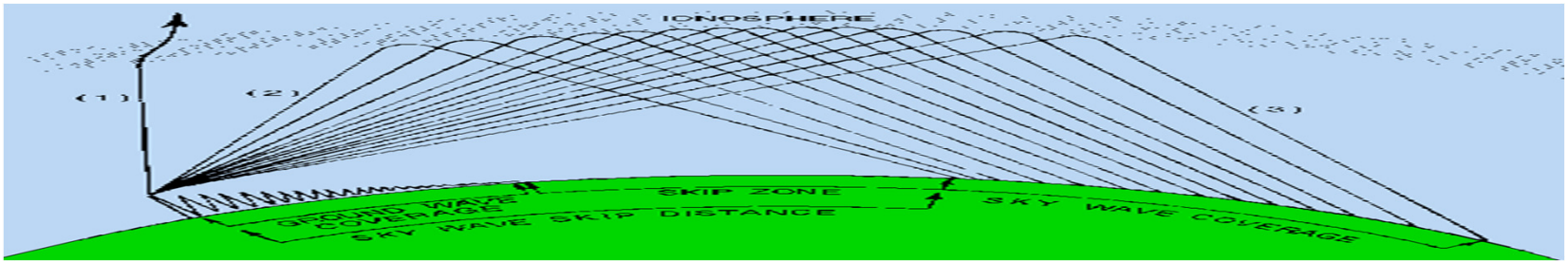
# Radio Wave Propagation:

Getting your signal from Point A to Point B

Radio waves *propagate* in many ways depending on…

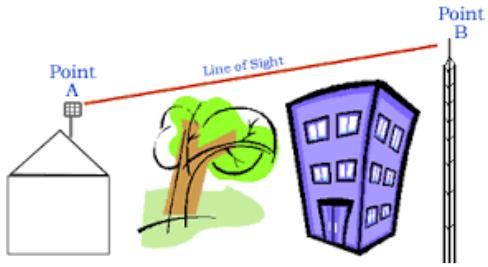
- Frequency of the wave
- Characteristics of the environment

Signal attenuation occurs as the radio wave travels, due to spreading



# Line-of-Sight Propagation

VHF & UHF radio energy travels in a straight line from transmitting antenna to receiving antenna – called the ***direct path***



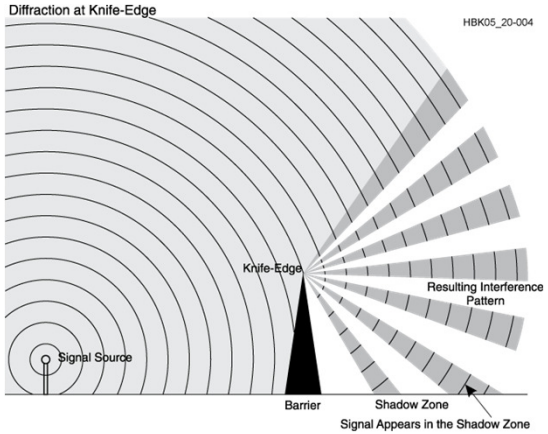

- Simplex UHF signals are rarely heard beyond their radio horizon because UHF signals are usually not propagated by the ionosphere

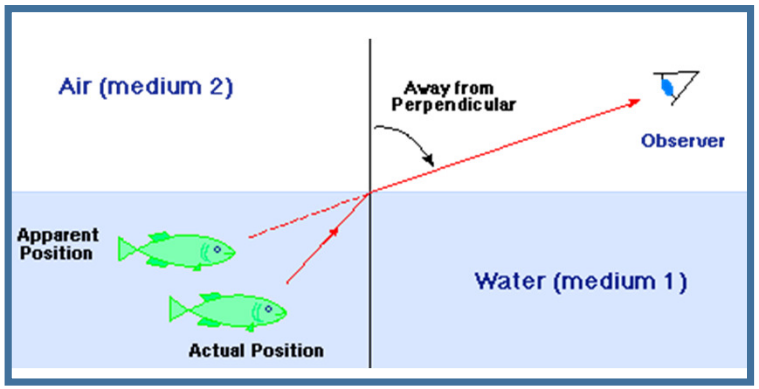
- Fog and rain will have little effect on 10 & 6 m bands but Precipitation will decrease range at microwave frequencies, UHF and up

- Vegetation will also absorb UHF and Microwave signals

# Diffraction and Refraction

*Diffraction* occurs when a wave encounters a sharp edge or corner, causing it to bend around the edge. ie. Knife Edge Propagation




*Refraction:* The direction of waves can be changed at the boundary of two media having different densities.

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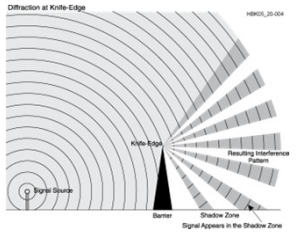
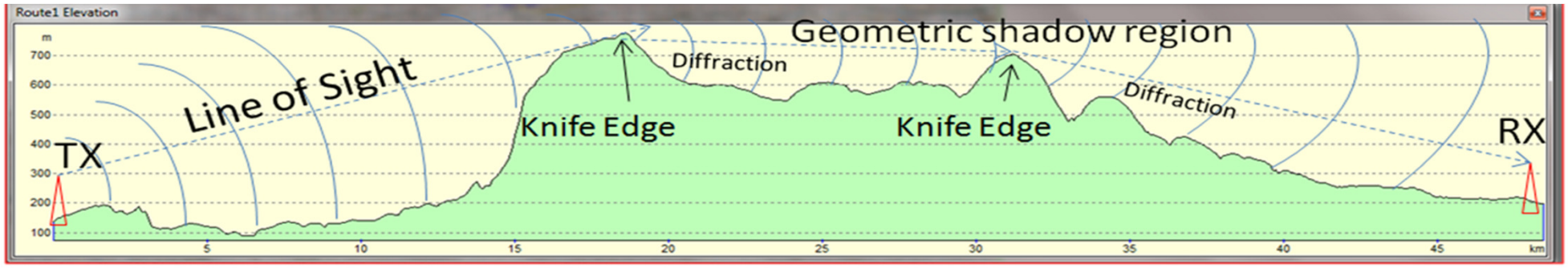



## Knife-edge Propagation

## Ukiah to Mendocino




Ukiah

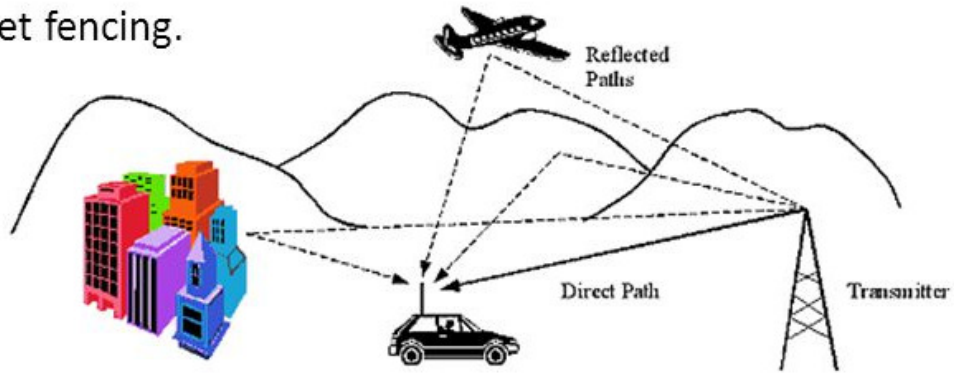
Mendocino

Knife edge **diffraction** may allow radio signals to travel beyond obstructions between the transmitting and receiving stations

# VHF and UHF Propagation

Buildings may block line of sight, but **reflected and diffracted** waves may get around obstructions.

- Picket fencing.

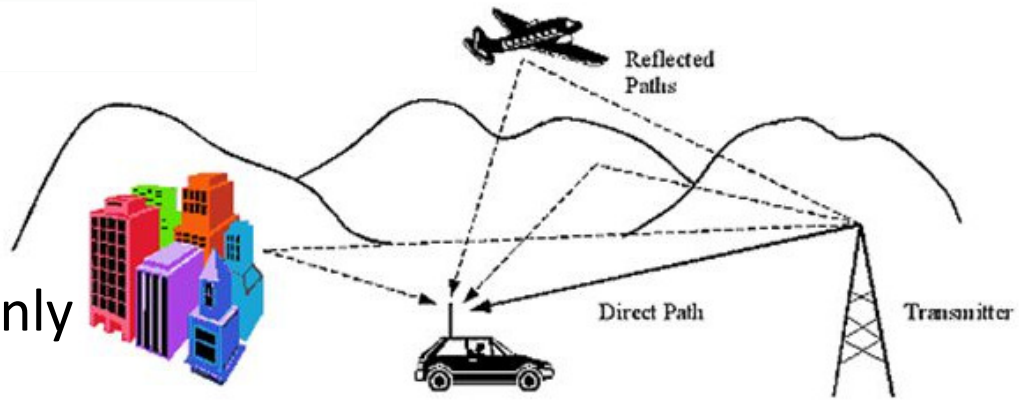



***Multi-path*** results from reflected signals arriving at the receiver by different paths and interfering with each other.

# Reflecting Line-of-Sight Propagation

When using a directional antenna, you may be able to reflect your signal around buildings or obstructions blocking your direct path

VHF signal strengths sometimes vary greatly when the antenna is moved only a few feet because multi-path propagation cancels or reinforces signals

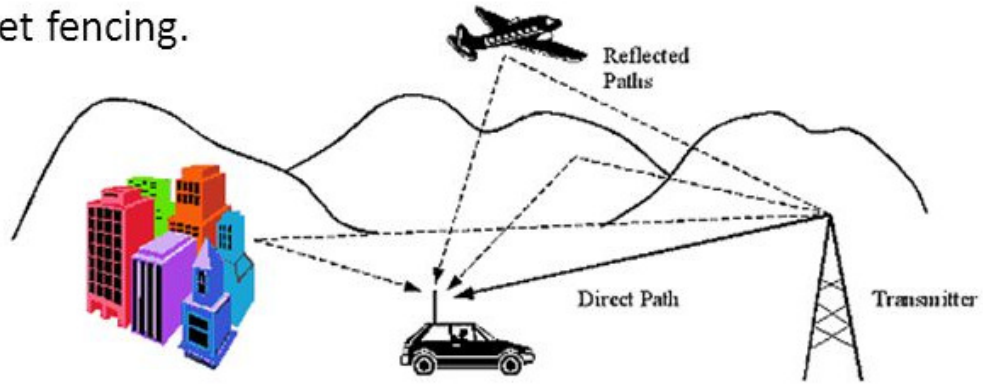


# Reflection Propagation **Problems**

**Error rates are likely to increase if data signals arrive from multiple paths**

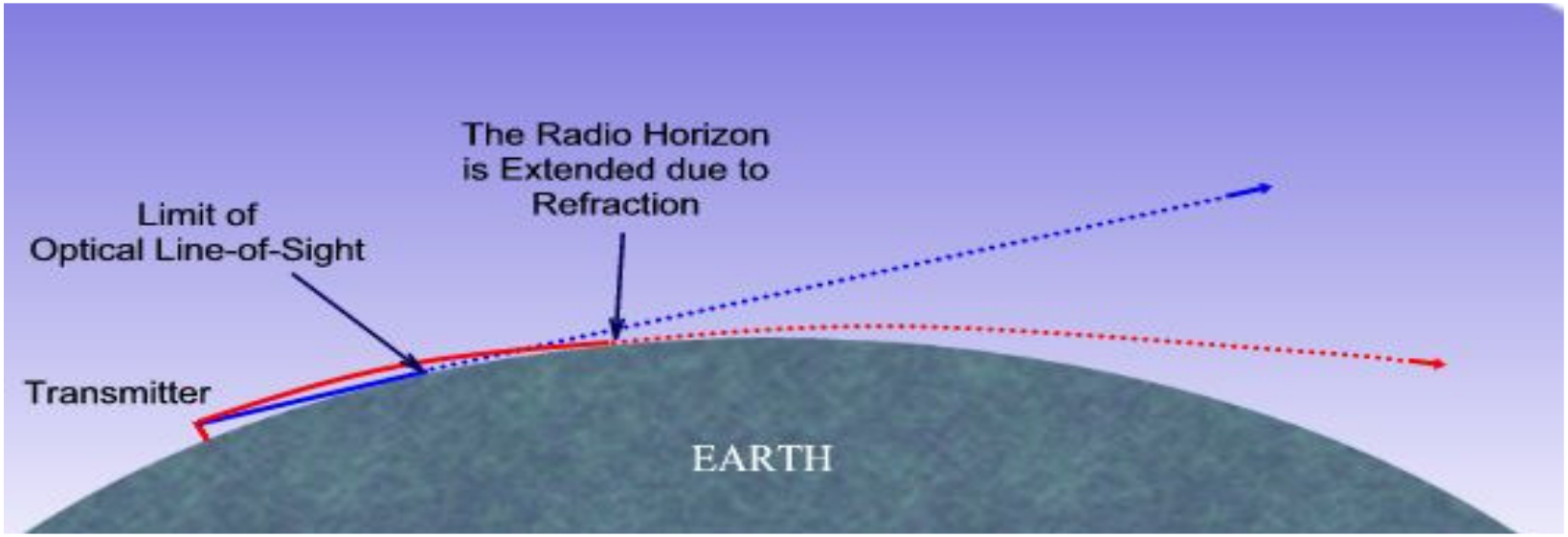
***Picket-fencing*** is the rapid fluttering sound of mobile signals due to **multi-path propagation**

- Picket fencing.



# VHF & UHF Atmospheric Propagation

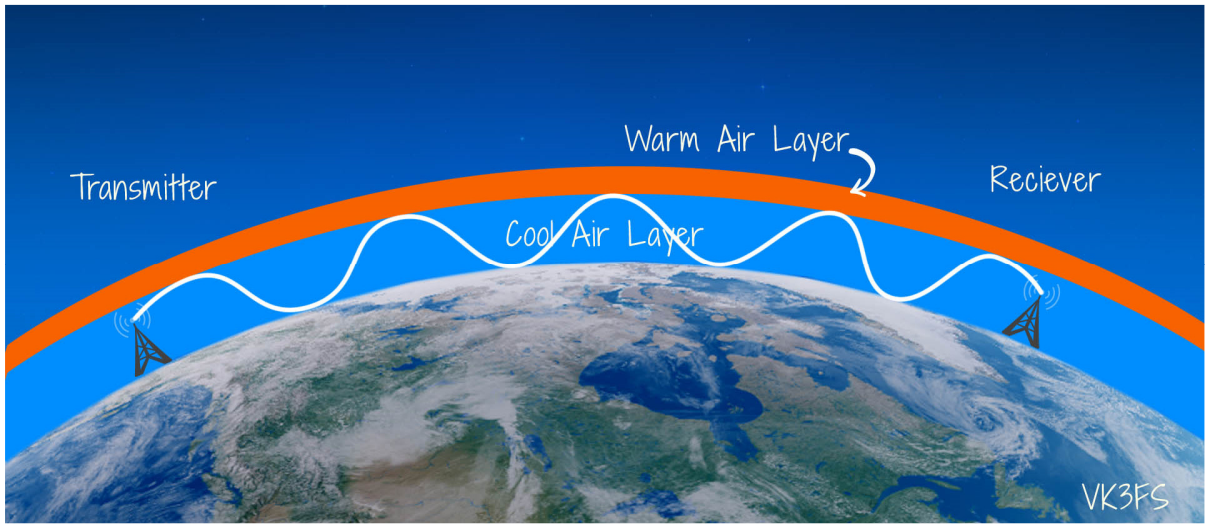
- The Radio Horizon for VHF & UHF signals is more distant than the visual horizon because the atmosphere **refracts** radio waves slightly



# VHF & UHF Atmospheric Propagation

**Tropospheric Ducting** is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis.

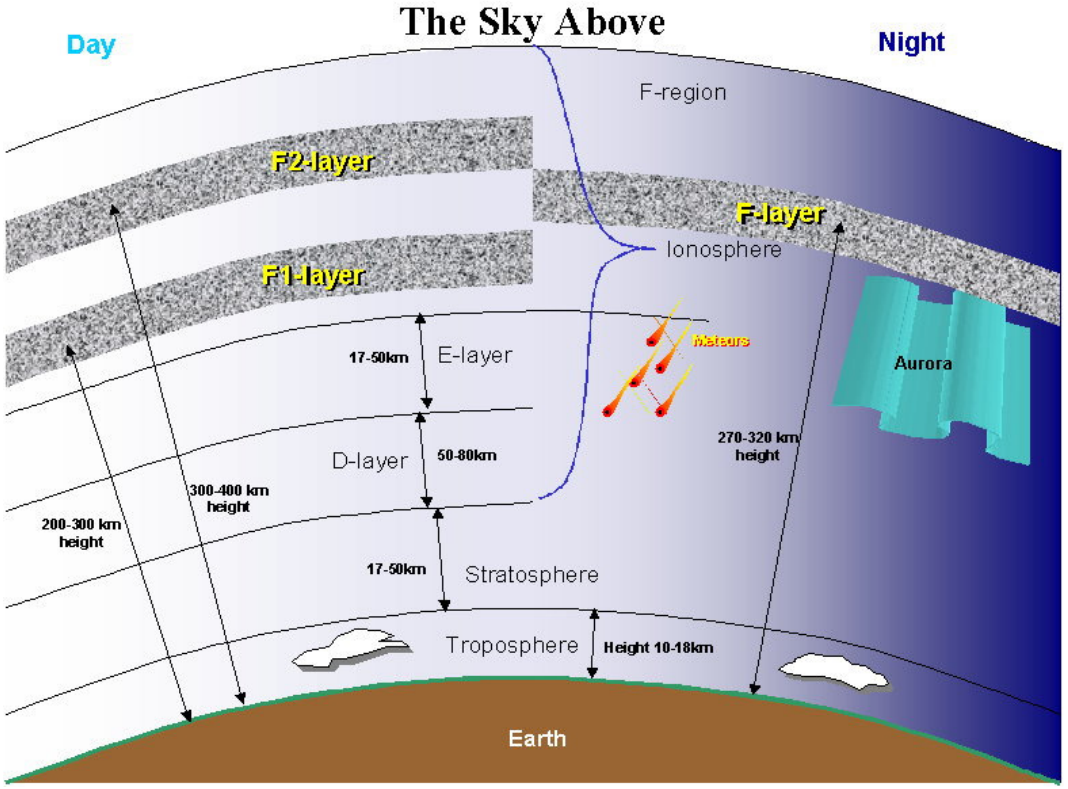
Temperature inversions in the atmosphere cause **refraction of the signal**



# Sporadic E, Aurora

**Sporadic E** is most commonly associated with occasional strong over-the-horizon signals on the 10, 6, and 2 meter bands

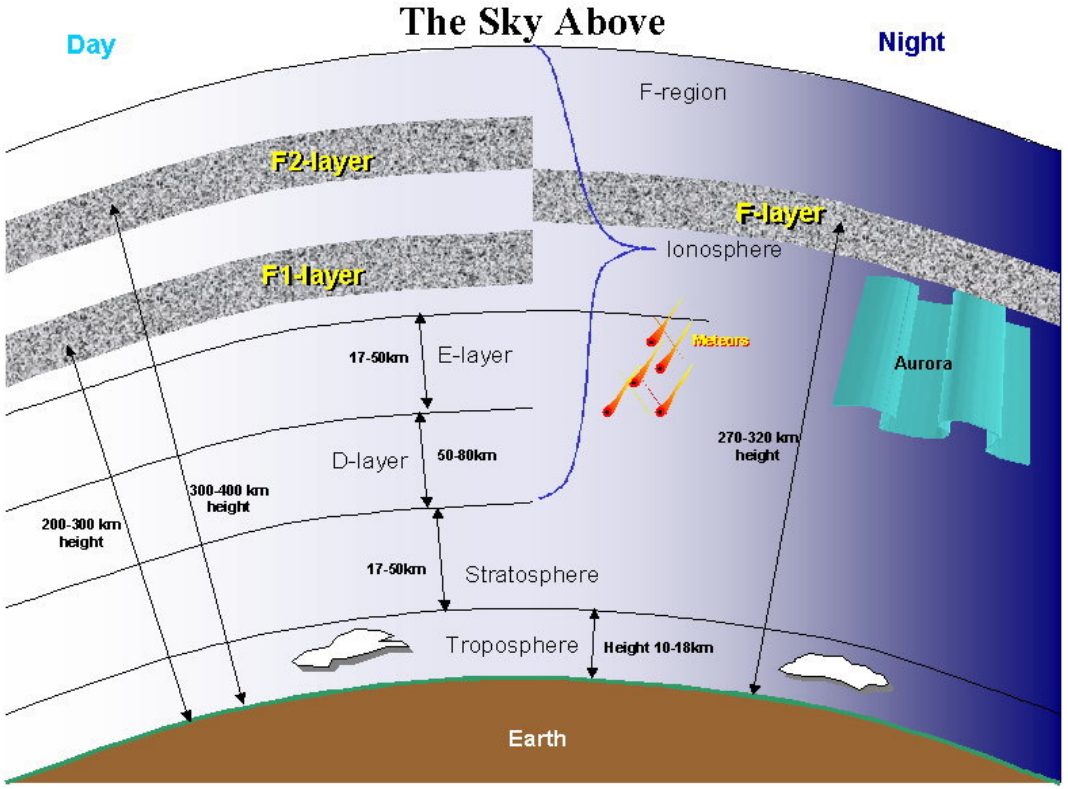
**Aurora** VHF signals received via auroral backscatter are distorted and signal strength varies considerably



# Sporadic E, Aurora, and Meteor Scatter

Thousands of ***meteors*** enter the Earth's atmosphere every day, most quite small, leaving trails of highly ionized gas that last for several seconds. The trails can reflect radio waves – called ***meteor scatter***.

**The best band for this is 6 meters**.



# Ionosphere enables propagation around the world

- Region 30 - 260 mi. above the surface
- Thin atmosphere is ionized (electrically charged) by solar radiation
- Varying density forms layers with different amounts of ionization
- Higher ionization refracts or bends radio waves more strongly and at higher frequencies
- Ionization varies with solar illumination (hour to hour), intensity of solar radiation, and the 11 year sunspot cycle

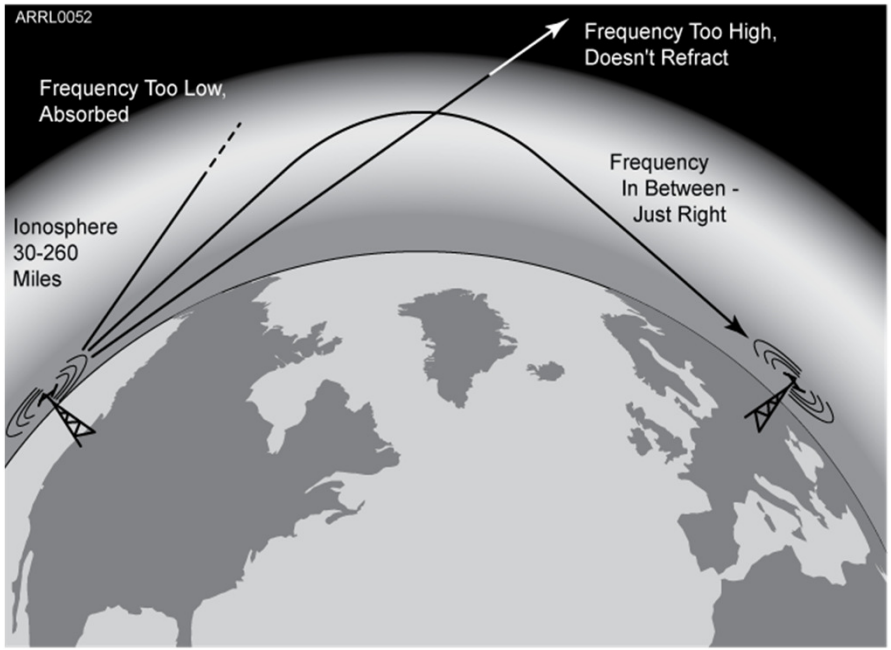
# The Ionosphere – An RF Mirror

Reflection depends on frequency and angle of incidence.

Too high a frequency or angle and the waves are lost to space.

**Ionospheric propagation is far more common on HF than VHF**

**UHF signals are not usually reflected by the ionosphere**



# The Ionosphere – An RF Mirror

**Six or ten meters bands** may provide long distance communications via the F region during the peak of the sunspot cycle.

From dawn to shortly after sunset during periods of high sunspot activity is generally the best time for long-distance 10 meter band propagation via the F region

Skip is very rare on the 144 MHz and higher, UHF bands.

# The Ionosphere – An RF Mirror

Signals can take many paths (multi-path) through the ionosphere, randomly combining at the receiving antenna, signals can partially cancel, creating irregular fading as the ionosphere changes.

Fading causes data errors for digital signals.

Either vertically or horizontally polarized antennas may be used for transmission or reception

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Break time!