Chapter 10
Topics in Radio Propagation

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HF Propagation

- HF signals make their journey between stations by either traveling along the Earth's surface (ground-wave) or by returning to Earth after encountering the layers in the upper ionosphere (sky-wave or skip)

Ground-Wave Propagation

- The direction of radio wave can be changed by both diffraction and refraction.
- **Diffraction** – is created by the construction and reinforcement of wavefronts after the radio wave encounters a reflection surface's corners or edges
- **Refraction** is a gradual bending of the wave because of changes in the velocity of propagation in the medium through which the waves travels.

Ground-Wave Propagation

- Diffraction with Vertical HF Antennas
  - The lower part of the radio wave losing energy because of currents induced in the ground
  - This slows the lower portion of the wave causing the wave to tilt forward slightly, following the curvature of the Earth
  - Tilting results in Ground-Wave propagation allowing low-frequency signals to be heard well beyond line of sight (160 & 80 meter band)
  - Ground-wave propagation is lossy because the vertically polarized portion of the wave's electric field that extends into the ground is mostly absorbed
  - Loss increases with frequency (28 MHz = only a few miles)
  - Ground-wave is most useful during the daytime

Sky-Wave Propagation

- Signals that travel into the ionosphere can be refracted (bent) by ionized gas in the ionosphere's E & F region, returning to Earth some distance away.
- Refraction occurs because the region of ionized gases causes the radio wave to slow down which bends the wave.
- Refraction or Sky-wave is the primary HF mode of propagation
  - One hop skip distance for the F-layer is 2500 miles
  - One hop skip distance for the E-layer is 1500 miles

Sky-wave

- Absorption: D-layer (35-60 miles above Earth) is a relatively dense region where ionized atoms are closer together and recombine quickly
- A great deal of the radio wave energy is dissipated as heat called Ionospheric absorption in the 1.8 to 3.5 MHz bands during the daytime

Sky-Wave

- Long-Path & Gray-Line Propagation
  - The circumference if the Earth is 25,000 miles, short path would be less than 12,500
  - Long-path distance would be 25,000 minus the short path distance
    - Tokyo to Pittsburg is 6619 miles at 328 degrees, long-path would be 18,381 miles bearing 148 degrees
- If you notice an echo on the signal, turn you beam 180 degrees for long-path

Sky-Wave

- 20-meters is the most common band to experience Long-path propagation
- For paths of 6,000 miles or less, the short path usually is best
- Long-path is usually observed either along the gray-line (the terminator between light and darkness) or over the nighttime side of the Earth
- Gray-line propagation can be quite effective because the D-layer disappears rapidly at night (160-30 meters)

VHF/UHF/Microwave Propagation

- For space wave signals that travel essentially in a straight line between the transmitter and the receiver, antennas that are low-angle radiators (concentrate signals toward the horizon) are the best
- Radiation angle decreases as horizontally polarized Yagi antennas are raised above the ground
- Transmitting and Receiving antennas should be in the same polarization (20dB loss cross-polarized)

VHF/UHF/Microwave Propagation

- Radio Horizon – VHF radio waves are bent or scattered in several ways, making communications possible with station beyond the visual or geometric horizon. (plus 15%)
- The farthest point to which radio waves will travel directly, via space-wave propagation, is called the radio horizon

VHF/UHF/Microwave Propagation

- **Multipath**: Several components of the same transmitted signal may arrive at the receiving antenna from different directions.
  - Phase relationship between multiple signals may cause them to cancel or reinforce each other.
  - "Picket Fencing" is a a common example

Tropospheric Propagation

- VHF Big Gun station with high power and big antenna arrays are usually limited to 500 miles
- Weather conditions that create a sharp transition between air layers (ducts) in the troposphere can allow VHF radio waves to follow the curvature of the Earth for hundreds or thousands of miles like a wave guide.
  - Tropospheric Ducting Forecast “Hepburn Report”
  - (http://www.dxinfocentre.com/tropo_eur.html)

Transequatorial Propagation (TE)

- TE is a form of F-layer ionospheric propagation
- TE occurs between mid-latitude station approximately the same distance north and south of the Earth’s magnetic equator (2,500 north and south of the equator)
- TE occurs on 50, 144 MHz and to some extent 432 MHz
- The high-density-ionization regions from approximately between 10 and 15 degrees on either side of the Earth’s magnetic equator
- Best time to look for them is March 21 & Sept 21

Auroral Propagation

- Auroral borealis is caused by the collision of solar-wind particles with oxygen and nitrogen molecules in the upper atmosphere.
  - These collisions partially ionize the molecules by knocking loose some of their outer electrons
- VHF radio waves are reflected from the ionization created by an auroral curtain
- VHF/UHF propagation up to 1,400 miles
- Generally, auroral propagation is available only to stations in the northern states

Meteor Scatter Communications

- Radio waves can be reflected by the ionized trail of a meteor (level of the E-layer, 50-75 miles)
- The ability of a meteor trail to reflect radio signals depends on the electron density
- The best frequency range is between 28 and 148 MHz
- Meteor-scatter communication is best between midnight and noon
- Meteor Showers – are predictable (Perseids in August, Geminids in December)
- FSK441 part of the WSJT software suite, HSCW 800 to 2,000 WPM.

Earth-Moon-Earth Communications

- Stations that can simultaneously see the Moon communicate by reflecting VHF or UHF signals off the lunar surface (Mutual Lunar Window)
- Stations maybe separated by nearly 12,000 miles
- Low-noise receiving setup is essential for successful EME work since most of the signal is close to or in the noise