Atmospheric Transmissions
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Radio signals travel at a speed of 186,000 miles per second, which is the same as the speed of light. The range of most radio signals is line-of-sight, so we have had to develop methods that will allow us to go beyond the natural structures of our planet such as hills, valleys, mountains, trees, bodies of water and the atmosphere in order to communicate. We need methods that will allow us to communicate to submarines under water, space crafts in space, planes in the air, ambulances from different hospitals, police officers in all terrains and more.

There is a mathematical formula that will allow us to calculate the approximate line-of-sight range of an antenna over level ground without any barriers:

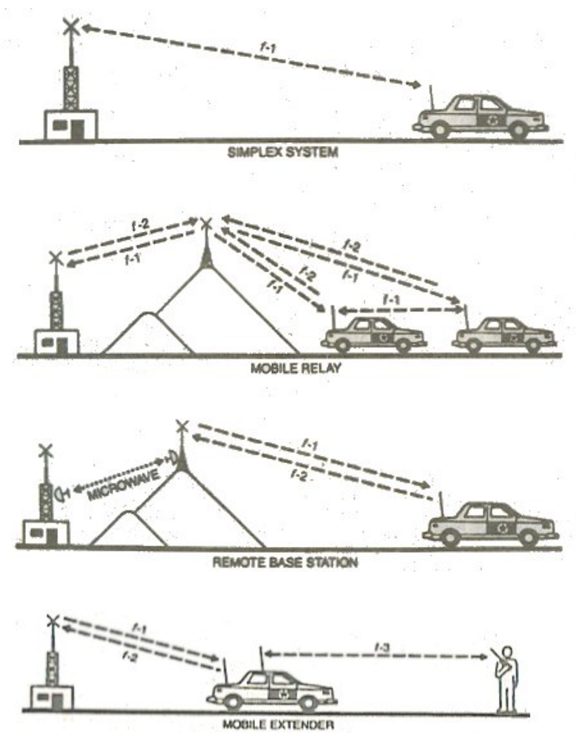
D= sqr(H) x 1.4
D= distance to the horizon, in miles
H= antenna height above ground, in feet

If you want to figure out the distance between two antennae, you need to calculate both line-of-sight distances and then add the two together. For maximum range to vehicles, you can add approximately three miles to your distance, and for boats, 10 miles due to possible atmospheric anomalies.

Small local towns use simplex communications, because their coverage area is not large enough to require spending money on building towers. Citizens band radios are examples of simplex communications, because they take turns sending and receiving signals. Aircraft use simplex, because they do not have the natural barriers blocking their transmissions.

With natural barriers, we use mobile relay systems. County departments tend to use mobile relay systems, because they cover more ground. Mobile relays use duplex communications, which require the receiving and transmitting of signals on separate frequencies so that repeaters can rebroadcast simultaneously without stepping on the station transmitting. Radios are designed to switch frequencies upon keying of the microphone.

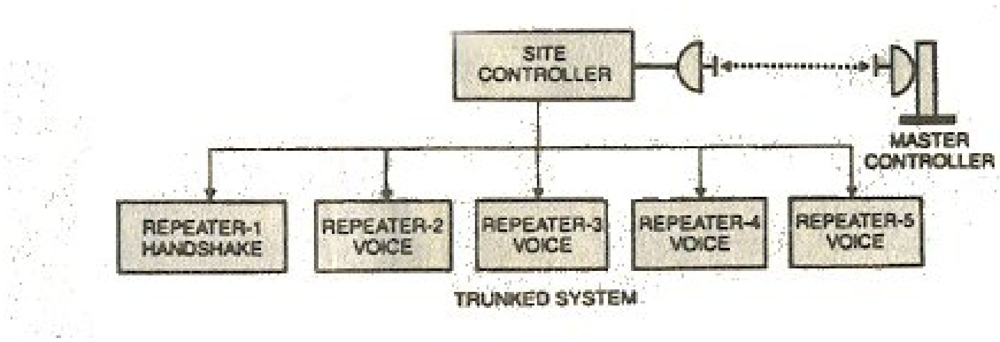
State agencies that cover a large area tend to use base station communications. Dispatches can control the use of multiple towers through the use of microwaves or land lines, but operate very similar to mobile relays. Cellular phone companies use these methods, because they allow for trunking.



In 1882, the first repeater was invented and applied at Auburn, New York. Since then people have invented many repeaters, but Stearns perfected the duplex repeater. The duplex operation has succeeded in innovation to this day. Repeaters didn't become common among amateur radio and public safety stations until around the 1950's.

Today computers use sub-audible tones, or as I like to call them "dog whistle tones," to recognize the difference between transmitting stations and other noise. Some agencies also have digitally encrypted tones. A receiver is sensitive to sounds and can be programmed to not activate until it hears a specific sound which we can't hear. Sub-audible tones may also be used to dispatch different fire departments using the same radio frequency. This can be tried out using Motorola FRS walkie-talkies from Best Buy. There are fourteen frequencies assigned channel names, and there are thirty-eight possible tones to choose from. These tones allow multiple stations to use the same frequency without having to listen to other station traffic.

Trunking is a system of sharing repeaters with multiple agencies. Every station within a group of agencies is tuned into a "handshake" repeater. This repeater will tell every station in the agency what frequency repeater is available for use and will instruct those radios which frequency to switch to. The purpose of this is to be efficient in the use of frequencies. Police may not be busy with the channels during the day, but don't have enough of them at night. Public services are the opposite. Trunking allows the services to share the same frequencies. Cellular phones operate in this manner, because there are thousands of people in range of one tower, and they can't all have their own personal frequency. When one user is done, a new caller is assigned to that frequency.



Signals don't always have to be repeated to reach areas that are out of line-of-sight. There are exceptions to the rule. As the transmitting frequencies decrease, there is more bending of signals through the atmosphere. VHF (very high frequency) transmissions, which range in frequencies around 100 Mhz, will travel beyond the horizon by as much as 30 percent. Above 800 Mhz, in which most cellular phones operate, there is little or no more bending by the atmosphere. This means that lower frequencies get greater range.

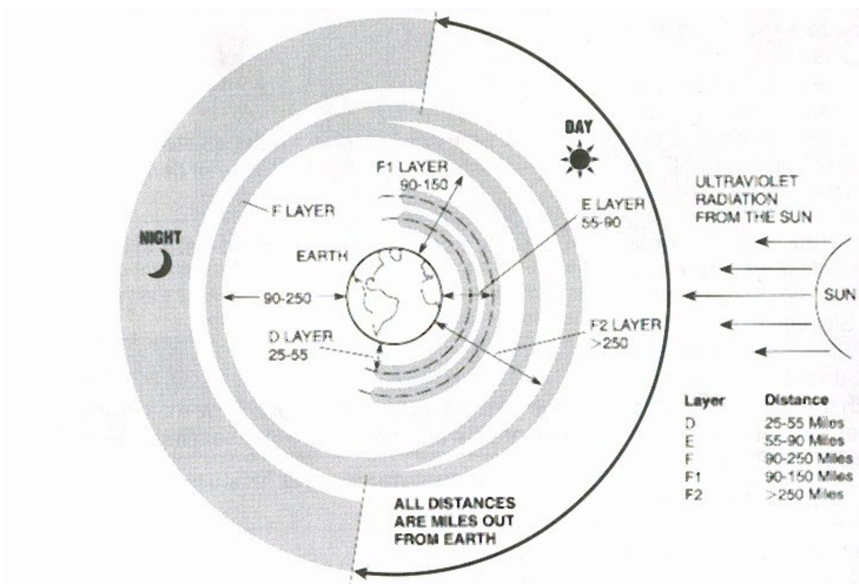
There is a benefit to using UHF (ultra high frequency) and higher frequencies, however. These signals will bounce off of metallic structures better, reaching into large buildings, and are unaffected by electrical noise from power sources, appliances, and machinery.

UHF transmissions are usually chosen in metropolitan areas, and VHF transmissions are usually chosen for more rural areas.

ULF (ultra low frequency) transmissions are used to break the surface of the water, because they don't bounce like higher bands do, but is less capable of carrying voice signal, so Morse code is used.

There are some occurrences on the sun that may affect our radio transmissions. Sunspots are magnetic storms on the sun that increase to a maximum and decrease to a minimum over a period of nine to fourteen years. Through the years 2001-2002, radio signals were experiencing the greatest skip ranges. Usually, frequencies from 500Khz to about 25 Mhz are used to communicate large distances, but sunspots turn the uppermost layer of the atmosphere into a mirror causing VHF-low signals to occasionally reach thousands of miles at the same strength as signals coming from a few miles away.

Skip also occurs more in the spring and fall months, and then mostly during daylight hours. The ionosphere is charged up daily by the sun. When the ionosphere becomes overcharged, we see the Northern Lights. We often here signals from other continents to the east and west in the early morning hours or late evening hours, because they are in their midday peak.



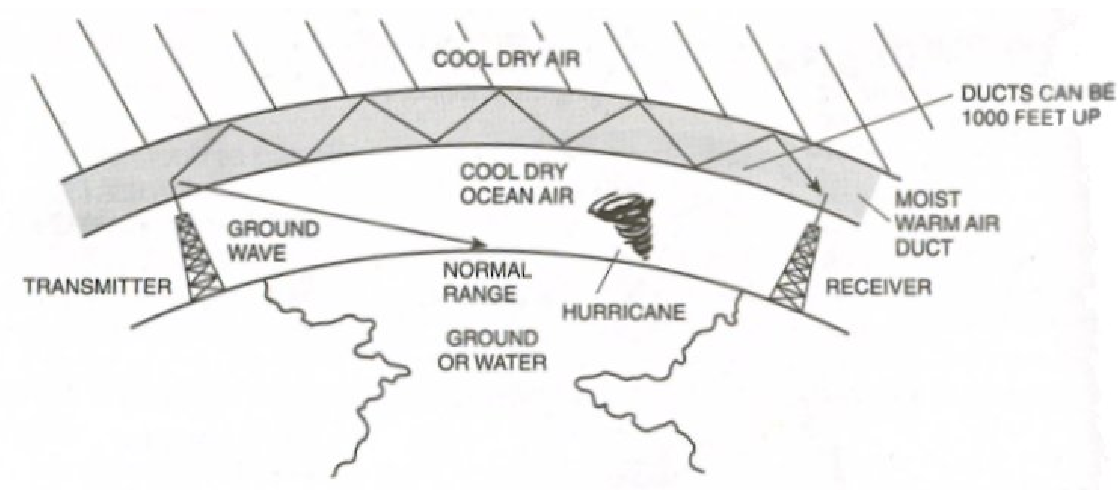
Ionosphere Layers

The D layer of the atmosphere is about 40 miles up. It is considered the daylight layer, and almost disappears at night. It absorbs frequencies between 1Mhz to 7Mhz, which have long wavelengths. All other frequencies will pass through it.

The E layer of the atmosphere is about 70 miles up. It is also considered to be a daylight layer. This layer can cause reflections of HF and VHF frequencies.

The F1 layer of the atmosphere is about 150 miles up, and gives us the far away signals. The F2 layer of the atmosphere is about 250 miles up, and is best for furthest ranges on medium and short waves. At nighttime, the F1 and F2 layers combine to become the F layer at about 180 miles up. The D and E layers disappear and this F layer will bend back signals to the earth between 1Mhz and 15Mhz.

Ducting is another form of skip that sometimes affects VHF-high frequencies. Distances of up to several hundred miles can be reached by signals that bounce between layers below the atmosphere. This usually happens around coastal areas and places with large storms where there is cool dry air on the ground in what we call the ecosphere, warm air above that in the troposphere, and cool dry air above that in the stratosphere. Warm air sandwiched between two cool layers at about a 1000 feet up creates the ducts that will carry signals several hundreds of miles away. Many people try sending signals to Hawaii from California using this phenomenon.



Tropospheric Ducting

Obtaining radio communication distances is a hobby of many licensed amateur radio operators. At one time, there was a fascination in bouncing sound signals off the moon in order to experiment with receiving returned signals with slight delay. We are already in an era that is receiving video and sound from Mars without humans ever leaving the earth. Computer networking at higher speeds over the air waves is also becoming another wave of the future. Regulation, sharing and keeping interference to a minimum is a serious issue that needs to be constantly considered as we add more technology to the band plan, because radio usage is being used more and more by our world.

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