It’s Duct Hunting Season

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We have a little saying around here at the Bird Technologies Site Optimization Services Group — “interference is a growth industry.” This is never truer than in the spring and summer. While atmospheric ducting can occur during any season, and often does, the warmer weather increases the frequency of these events, particularly for those near the coast.

What Is Ducting?

Atmospheric ducting is a phenomena that produces propagation enhancement due to conditions in the atmosphere that cause the radio waves to bend back to earth, extending the range of a communications system sometimes far beyond its predicted service area. This produces unforeseen co-channel interference to another system or systems that share the same frequency.

There are a number of different mechanisms that produce these effects, and in fairness not all of them are truly ducting. However, for the purposes of discussion we tend to lump them all together in the same category.

One of the more common forms of ducting is something known as an “evaporation duct.” This occurs over water and can cause a significant enhancement in propagation between land-based systems that have a large body of water between them. One example on the East Coast of the United States would be the path between Virginia Beach and Long Island, NY (*Figure 1*). The duct forms when the air immediately above the water is saturated with water vapor, while at the same time the barometric pressure is relatively unchanged and the air temperature is either unchanged or increasing (temperature inversion). This causes the radio signals to bend back toward the surface of the ocean. Since salt water has a high degree of conductivity, the wave is reflected back up and the process continues until the duct disappears.

Under these conditions, the duct acts somewhat as a waveguide, keeping the signal within the duct. Since the energy is not allowed to radiate outside the duct and spread, the signal levels tend to be higher than would be expected based on free space loss. The duct will continue as long as the conditions are favorable or until it reaches land, at which time the duct will disappear and the signals contained within the duct will be allowed to radiate in a more normal fashion. Due to the fact that the signal levels have been maintained at a much higher level than expected, the signals from the distant system can often be equal or greater in amplitude than local users, particularly when looking at subscriber talk-in performance.

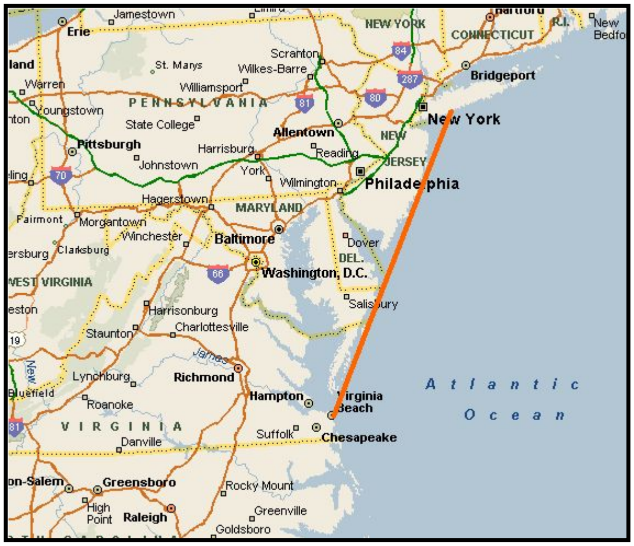

Figure 1: *Path of duct from Virginia Beach to Long Island, NY*

Looking back at our Virginia Beach to Long Island example, we have, on many occasions, witnessed signal levels from subscribers near the ocean in Virginia capturing over subscribers at the infrastructure receivers located in the New York metro area.

There are a couple of other ducting mechanisms, but the common elements in a duct are that they normally occur over water and that they behave like conduits to allow RF signals to travel much further then would normally be expected. There are some additional mechanisms that are not truly ducts but still result in enhanced propagation. These are fronts and inversions.

Normally air temperature decreases as we go higher in altitude. At a frontal boundary (front), two large air masses with different temperatures are colliding. The cold air is generally denser and tends to tunnel under the warm air, pushing it upward. At the point where this occurs, the normal change in temperature with altitude is inverted, and the air actually gets warmer with increasing altitude. When RF passes through this boundary, it can sometimes be bent or refracted downward, causing it to return to the earth far beyond the radio horizon and well outside the predicted coverage area.

Unlike ducts that occur mostly, if not always, over water, propagation enhancements due to fronts and inversions can occur over land or water. Also, the refraction from an inversion normally occurs at only one point along the path, while a duct can exist for hundreds of miles or more when the conditions are right, bringing interference to or from some very remote systems.

Ducting Season

In the beginning we referred to this as "duct hunting season," a play on words based on "duck hunting season" or perhaps the famous scene with Bugs Bunny and Daffy Duck arguing "duck season, rabbit season…." Without question, this is the season for ducting. Since ducts usually require highly saturated air over water, then it is logical that during the warm summer months, when the sun is bright and the water temperature a little warmer, it would be conducive to producing the required conditions for an evaporative duct.

Many systems, especially those on the higher frequencies at 700 MHz and above, can go through nearly three complete seasons totally interference free and then find themselves the victim of some rather severe co-channel interference starting in the late spring or summer.

While there is not much that you can do to prevent ducting, it is good to know when it occurs and how to differentiate between interference caused by ducting and other forms of interference. Ducting can effect either infrastructure receive (talk in) or subscriber receive (talk out). Our experience in New York City primarily involved the infrastructure receiving distant subscriber radios at signal levels competitive with local units. On the other hand, some systems we have investigated in the Southeastern United States involved primarily talk-out problems, where the infrastructure transmitters of the distant co-channel system were competing with the local system's infrastructure.

Figure 2 shows the results of a 24-hour study that was performed on a system infrastructure transmit channel. The higher-level signals are from the local system's transmitters. At approximately 9 a.m. the channel was disabled for local traffic. The signals that are present between 9 a.m. and noon are from a co-channel system located well over the horizon. Other studies for this same frequency show that at most times these signals are not present above the noise, except when conditions for ducting are better. Then these signals are significantly stronger.

In the old days of analog communications, this was a little easier to diagnose. We simply placed our receivers in carrier squelch mode and listened to the co-channel activity. After a while, based on names and addresses transmitted by the co-channel user, we could deduce where the system was located.

With the current digital technology, the identification process is a little harder. If the modulation type is known and co-channel system is not encrypted, we can still listen. However, most of the times we have to rely on signal-level readings from our spectrum analyzer, direction finding techniques, and license information from the FCC database.

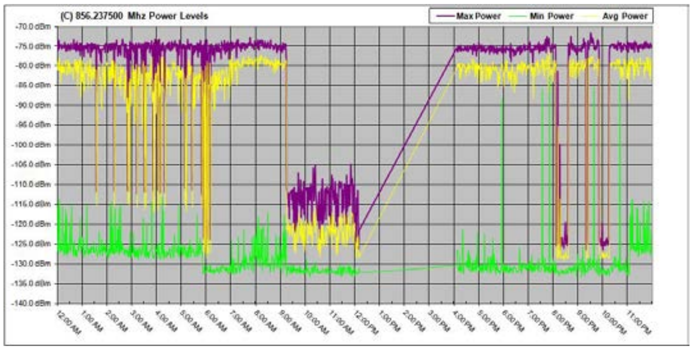

Figure 2: *Co-channel signals arriving via ducting*

Predicting Ducting

Currently, as far as we know, none of the commonly utilized coverage prediction programs take ducting into account when analyzing potential co-channel interference. However, there is a website run by William Hepburn (www.dxinfocentre.com) that publishes daily maps showing the ducting forecast for about a week in advance, like

NOAA's seven-day forecast. Additionally, maps for the previous week are archived, so you can go back and compare your interference events with the ducting forecast for that day, in order to better understand the nature of the problem.

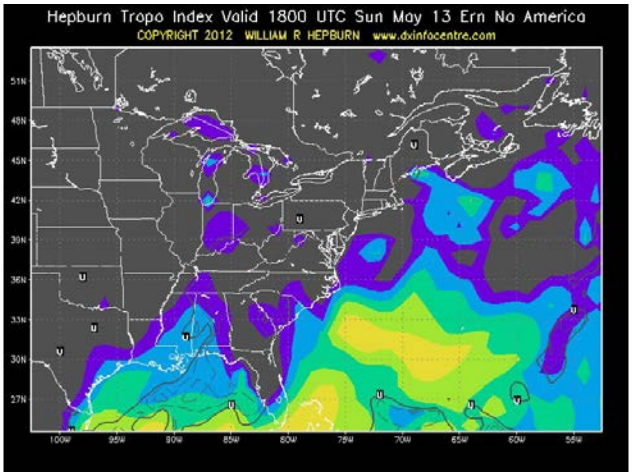

Figure 3: *Ducting Forecast for May 13*

The map shown in *Figure 3* is a ducting forecast map for Sunday, May 13. The map is from the website and is utilized in accordance with William Hepburn's copyright license, which allows limited publication of non-current maps. We must also point out that this is not an exact science and that, other than trying to understand the mechanisms involved in ducting, no other value can be assumed from these maps. The website primarily exists for use by amateur radio operators, short wave listeners, and other radio hobbyists.

In conclusion, while it might be great fun if you are a ham radio operator, ducting and other forms of atmospheric propagation enhancement can be a big problem if, for example, you are running a public safety communications system. Unfortunately, other than limited duct forecasting, there is little you can do about the problem except to understand how it might affect your system.

And that is a Bird's eye view.