Using a Shared Apex Loop Array for DRM Listening

DRM is a great tool for receiving antenna testing. That is my conclusion after several years of development on a new type of receiving antenna that I call the "Shared Apex Loop Array". This array is a member of the true-time-delay family and differs from it's more common phased array cousin in several important aspects. In a true-time-delay antenna, signals from the elements are intentionally delayed (rather than phased) to achieve a desired result. Using this technique, wide bandwidths are realized. For example, my current fifteen foot version of the array provides front-to-back ratio performance (15 - 25 dB) from 1 – 18 MHz and front-to-side ratio (15+ dB) from 1 – 10 MHz. For many HF DRM applications, the fifteen foot version is actually larger than it necessary, and a smaller version would provide better front-to-side ratio at the higher frequencies. There is a downside though – and that is that the gain of the array is increasingly negative as the frequency is lowered, so size is helpful to overcome this limitation. Also, a low noise amplifier is essential.

A four element version of the array is shown in figure 1. It is constructed using four identical loops, positioned in mirrored relation about a mast constructed from 1-3/4" PVC pipe. The mast forms a shared apex for each loop with its associated vertical leg following the pipe as shown.

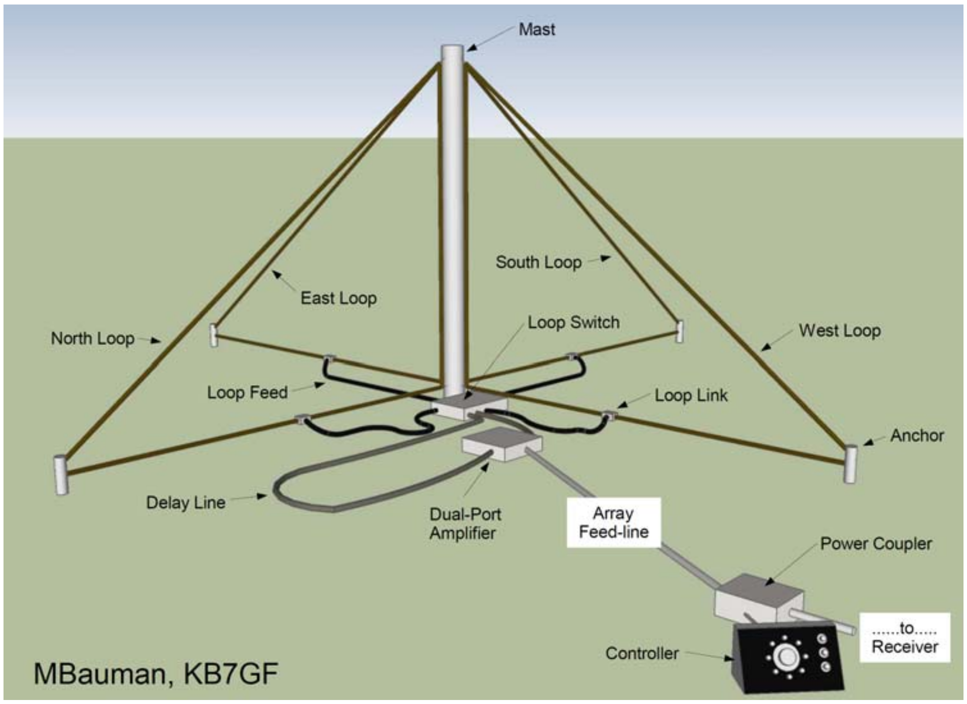

Figure 1: Sketch of a Four Loop Shared Apex Loop Array

Each loop is 14 feet tall, and 15 feet at its base, and is coupled to a 75 ohm coax loop feed line by means of a current transformer. Each loop feed line is connected to a loop switch that is controlled by a remote controller (positioned at the receiver). Depending on the direction selected, signals from appropriate loops are routed through the loop switch to a dual port amplifier via either a delay line or direct coax connection.

As an example of operation, supposed that our desired signal is coming from a northerly direction. In this case, you rotate the controller knob so that it indicates north. Then, a signal is sent from the controller to a power coupler where the data is coupled to an array feed line that is connected to the dual port amplifier. The data signal is then routed from the dual port amplifier to the loop switch via another coax cable (not shown) where it is decoded.

In response, the loop switch routes signals from the north loop through a line connected directly to the dual port amplifier and routes signals from the south loop through a delay line to the dual port amplifier. The time difference between the direct line and the delay line (and group delay difference through the dual port amplifier) is designed so (by installing the proper delay line length) that signals arriving from a southerly direction are delayed by just the right amount so that when they are combined with the signals from the northern loop, they significantly attenuated. In this manner, the time delay is frequency independent, so the appropriate time delay at 2 MHz is the same as that used at 15 MHz. The signal is then amplified and routed through the array feed line where it is decoupled by the power coupler where the signal is routed to a receiver.

In receiving antennas, signal to noise ratio (SNR) trumps signal strength as the paramount performance measurement. On HF, interference sources are ever-present and can be as close as your own fluorescent lamp or a distant as a thunderstorm on the other side of the globe. The tools provided by the DREAM software are invaluable for providing relative measurement of the SNR parameter. In Figure 2, a sample of Radio Canada International's (RCI) DRM broadcast at 2130 UTC on 9,800 KHz is shown using the array and the loop in time-multiplexed fashion. Here, the array provides an improvement of 3 – 5 dB over a single loop (in the array).

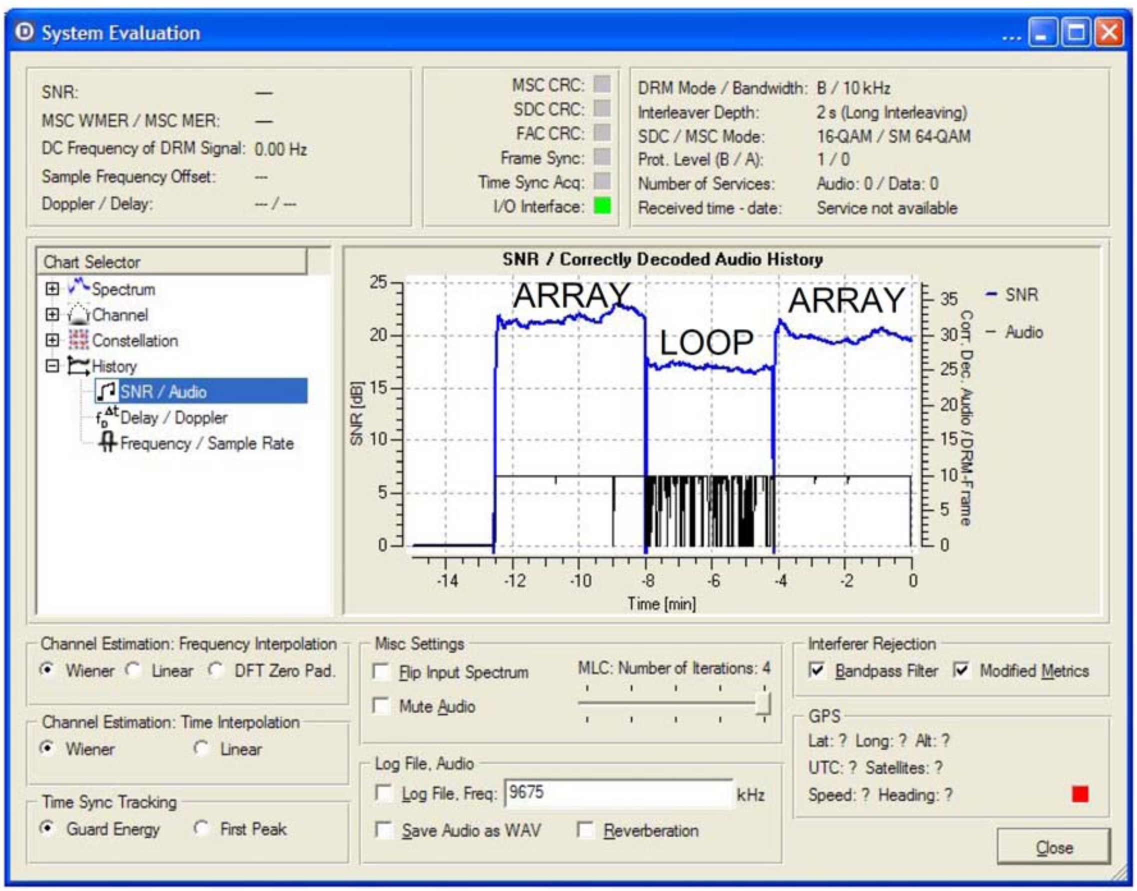

Figure 2: SNR Comparison of Array vs. single Loop

The SNR comparison is also helpful for illustrating the front-to-back and front-to-side ratio as shown in Figure 3. Once again, this RCI at 9,800 KHz. An SNR difference of greater than 10 dB is clearly shown off of the back, with closer to 5 – 7 dB off of the side.

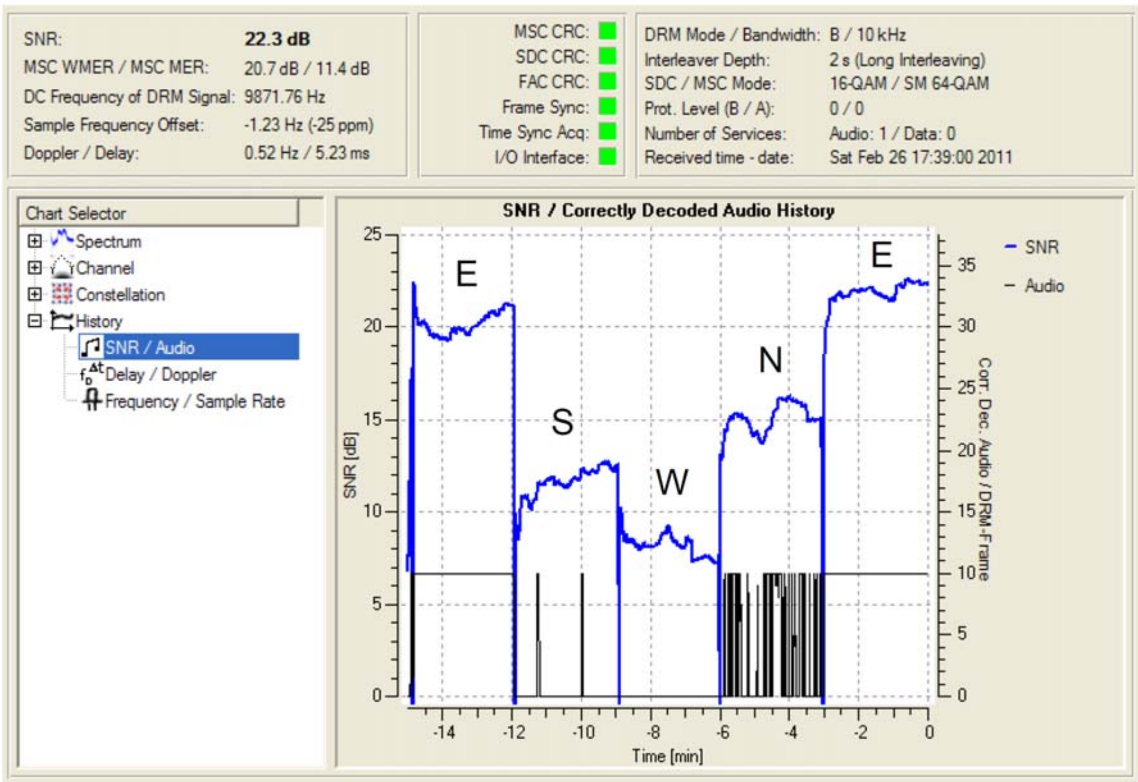

Figure 3: SNR Comparison with Array Pointed in Different Directions

A very vivid picture of the impact of the effect of SNR on the RCI data constellation is shown in figure 4.

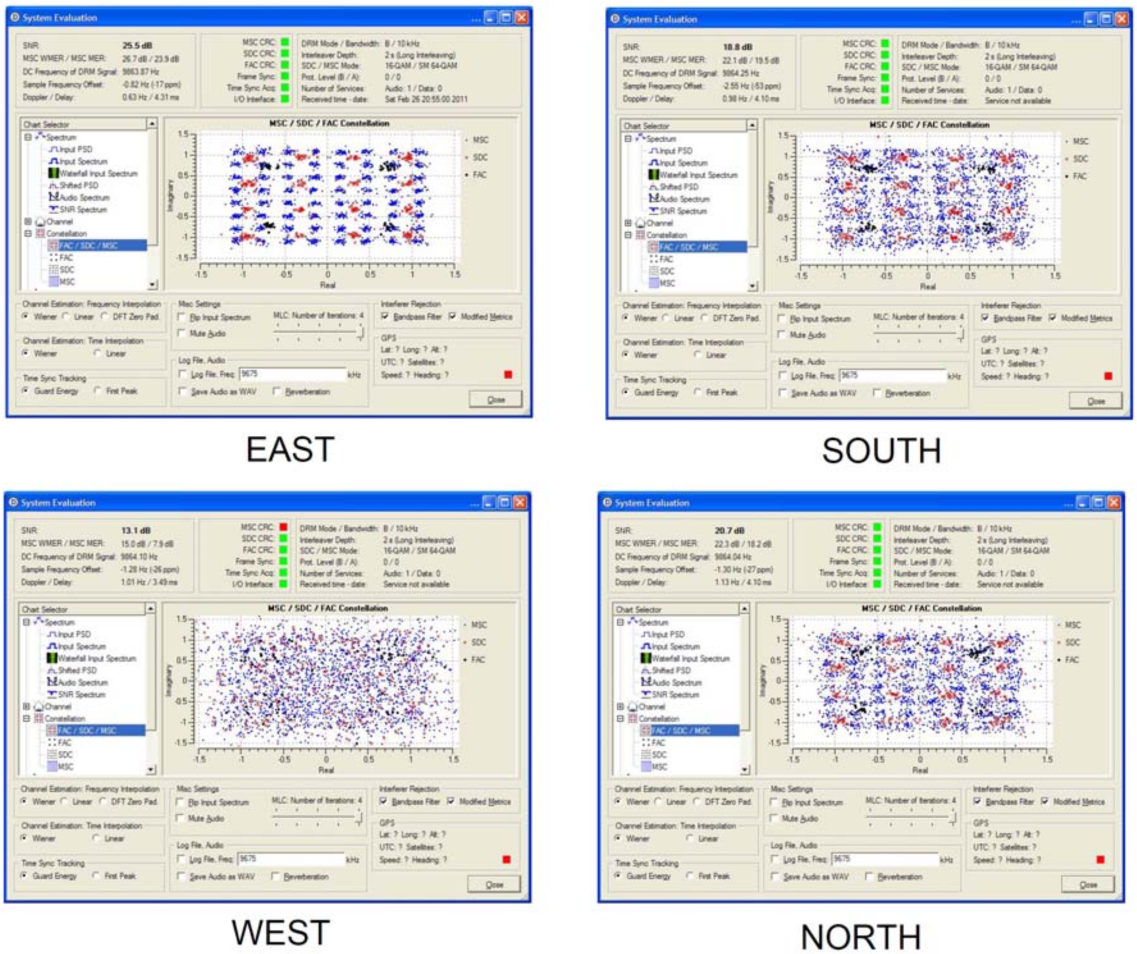

Figure 4: Data Constellation Comparison with Array Pointed in Different Directions

The waterfall input spectrum can also be useful, as a time captured snapshot of the input spectrum as shown in figure 5 for RCI as the antenna is electronically rotated in eight directions.

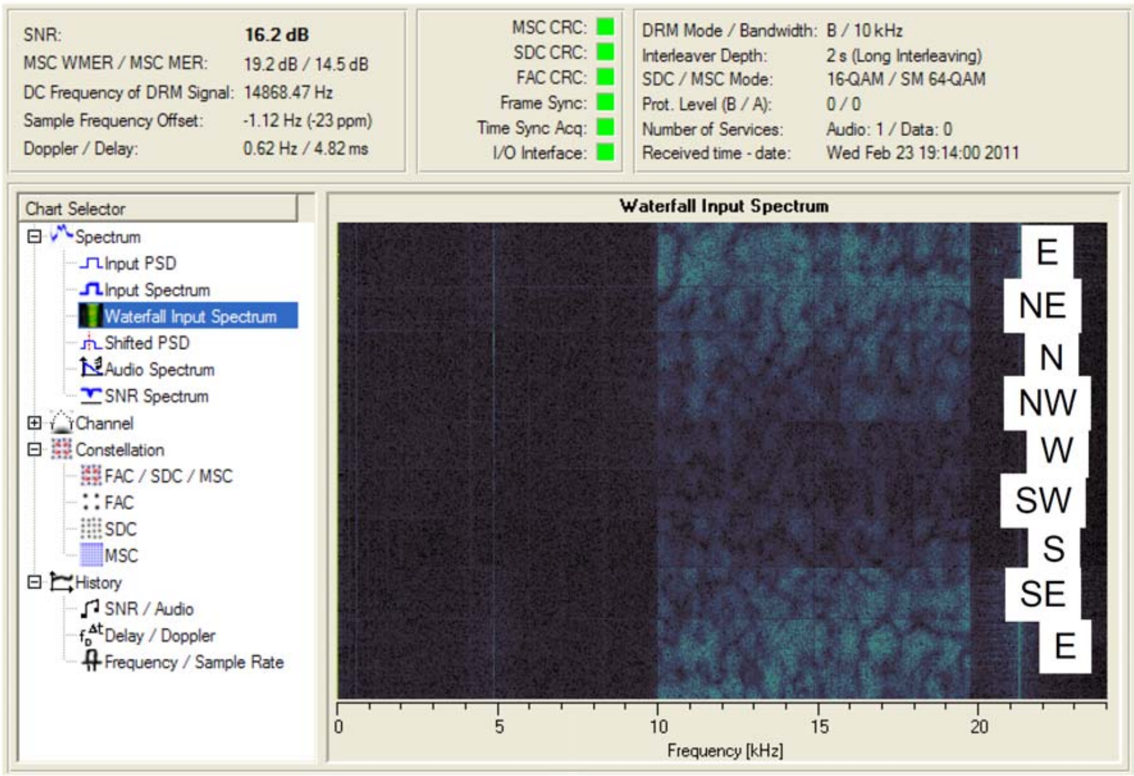

Figure 5: Waterfall of the Array in Various Directions

The remaining figures (6,7,8) illustrate the frequency agility of the Shared Apex Array at 13, 15 and 17 MHz for Radio New Zealand International (RNZI).

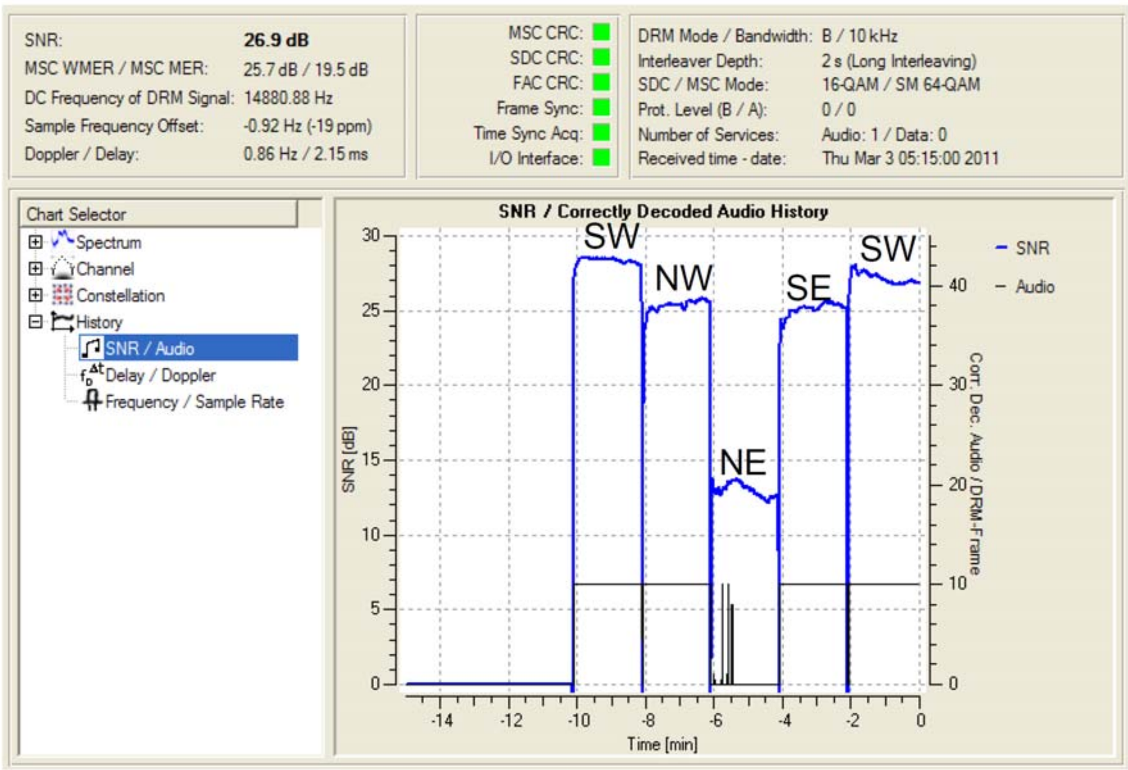

Figure 6: RNZI @0400 UTC 13,730 for Various Directions

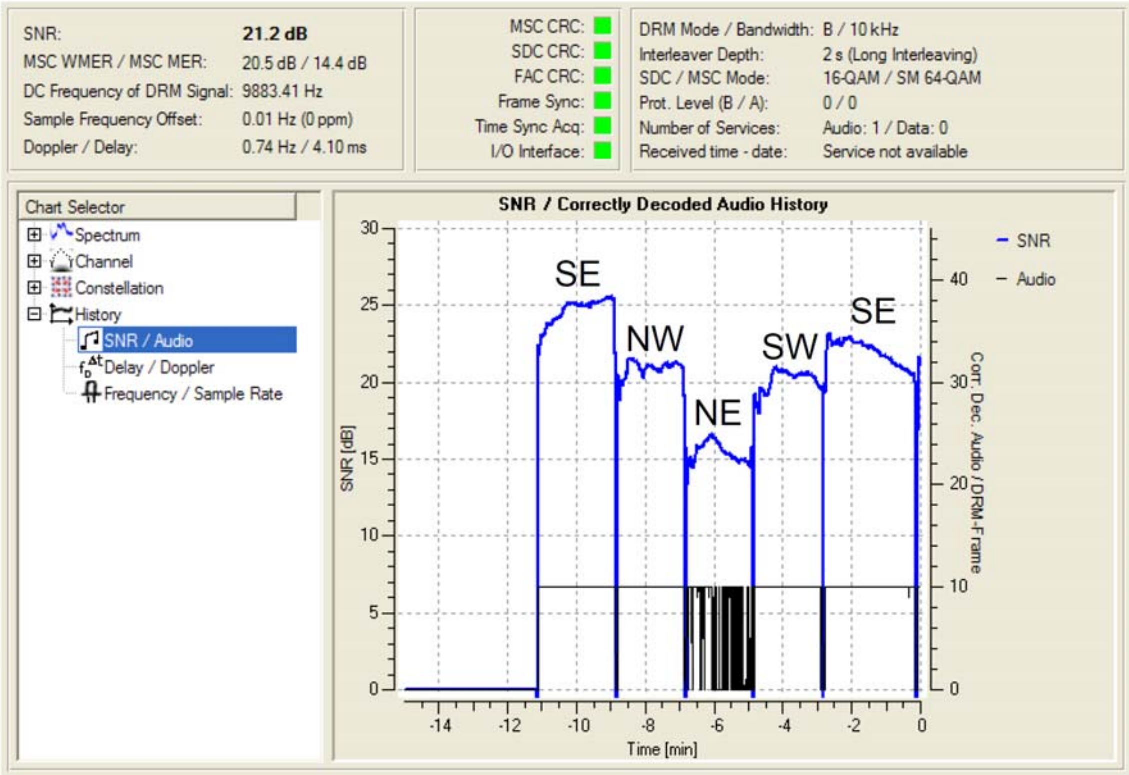

Figure 7: RNZI @2030 UTC 15,720 for Various Directions

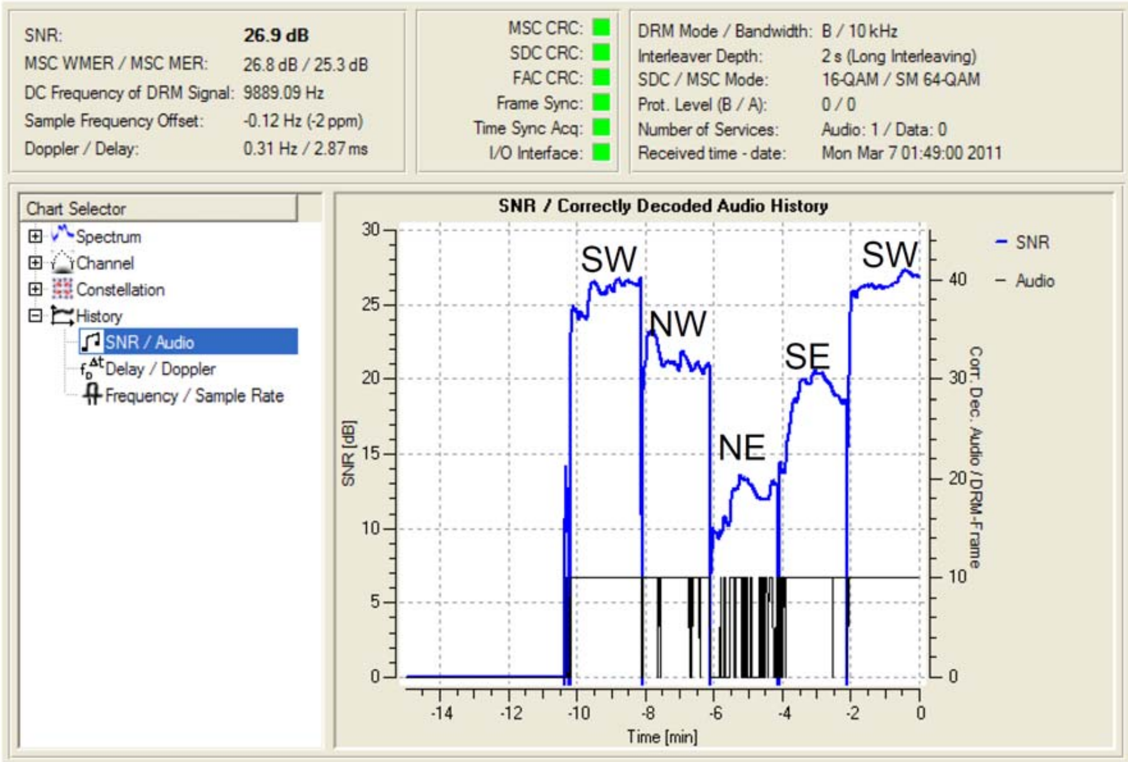

Figure 8: RNZI @0100 UTC 17,795 for Various Directions

In designing the Shared Apex Loop Array I sought to bring a compact, easy to construct, wideband, low noise, and high performance receiving antenna to both amateur and professional users. I have filed a patent on some aspects of the design but encourage amateurs and listeners to experiment with the design. The construction of the loops and mast itself is basic and straight-forward. I can't stress enough, though, the input of the impedance and group delay difference of dual port amplifier - both must be carefully managed to maintain consistent time delay through the delay line over the anticipated operating frequency.

I am currently building a few sets of the modules (controller / coupler / dual port amplifier / loop switch) and expect that these will be available for sale by the end of April. I've also set up a website for further information on the array - widebandloop.com).

73, and happy DRM'ing!

Mark, KB7GF