Extreme DXing

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Back when I was a Novice in northwest Indiana in late 1961, I believed working a W6 or W7 was DX. And when I worked a VO1 in Newfoundland on the old 15-Meter Novice band – wow – a foreign country! Of course as I progressed up the equipment and skills ladder, it was much easier to work what I had considered DX back in my Novice days. That just says that DX is a relative term. This month we'll talk about 'extreme DXing' – in other words, really pushing the limit.

Over the past 54 years I've certainly experienced my share of what I consider 'extreme DX'. For example, my first introduction to 10-Meter long path was in late 1980. In early 1979 I transferred down to the Dallas/Fort Worth area from Chicago with Motorola. By early 1980 I had a 40-Meter inverted-vee and a homebrew duo-band 2-element 15-Meter/10-Meter Yagi on a TV mast, and spent a lot of time on 10-Meters taking advantage of the big peak of Cycle 21.

One evening (very late in the evening, in fact) in the fall of 1980 I heard a very weak signal calling CQ on 10-Meter CW. He was coming from the southwest. It was a DL coming in via long path. But I couldn't work him. At the time I was running a TS-120 barefoot – an amp sure would have helped. The long path from DL to W5 is around 31,810 km. That's about 80% of all the way around the Earth. As a side note, Figure 1 shows 10-Meter long path possibilities for stations in North America.

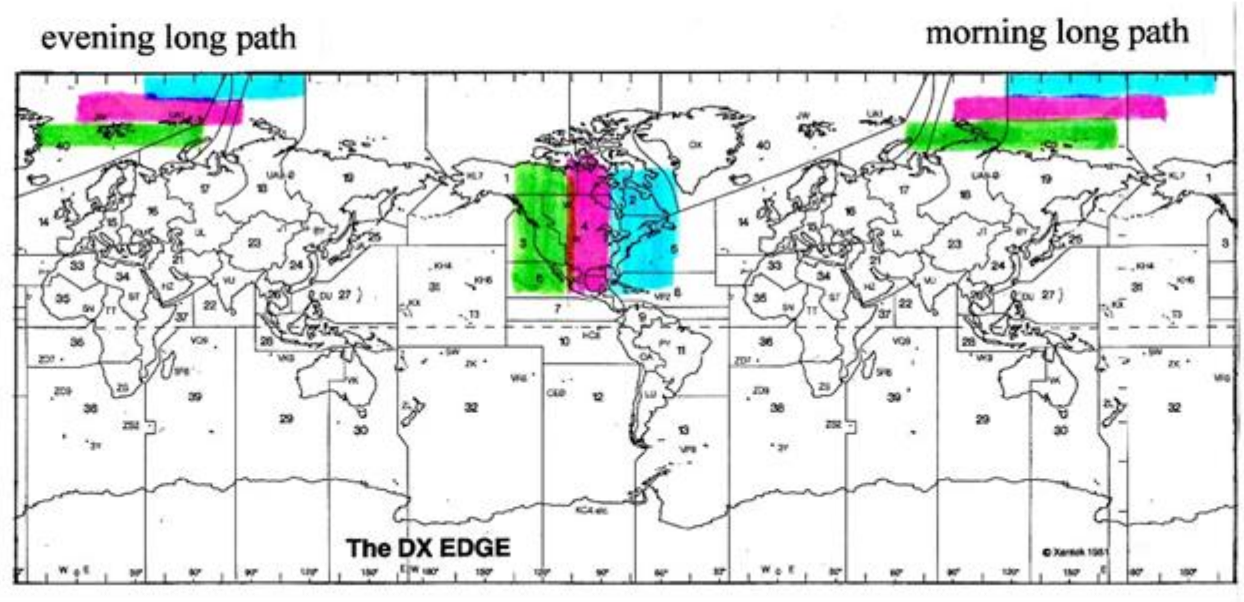

Figure 1 – What You Can Work on 10-Meter Long Path

Stations in the middle of the US (the pink area – where I was in late 1980) could have a morning long path opening to Southeast Asia and the Far East (the pink longitudes on the right). They could also have an evening long path opening to Europe and the Mideast (the pink longitudes on the left). The West Coast and the East Coast have similar openings as indicated by their green and blue shaded longitudes, respectively. Of course this assumes the Sun cooperates with lots of ionizing radiation.

Another example that stands out as ‘extreme DX’ is the 160-Meter QSO between K1FK and JO3JIS that I discussed in the August 2015 Monthly Feature on my web site (http://k9la.us). Although the long path distance is 29,656 km, it was likely a bit shorter due to my belief that the RF cut across the dark ionosphere to minimize ionospheric absorption. Other topbanders have had similar QSOs on 160-Meters, and I know all of these QSOs were tough – QSOs like this don’t happen often and signals are very weak due to ionospheric absorption on 160-Meters.

There is even more ‘extreme DXing’ out there in the Amateur Radio world – EME (moon bounce) comes to mind. Now if we go outside the Amateur Radio world, the most recent example of ‘extreme DXing’ is when the New Horizons spacecraft completed its 9 ½ year journey and made a close pass by Pluto last July. When that happened, Pluto was about 4.7 billion kilometers (about 3 billion miles) from Earth. Aside from the fact that it takes an electromagnetic wave about 4.5 hours to traverse that distance, the extreme distance also attenuates the RF coming from the spacecraft by a huge amount (the free space path loss).

The power received (Pr) on Earth at the frequency of operation (about 7 GHz) can be estimated to a first order with the equation Pr = Pt + Gt + Gr – FSPL, where Pt is the transmitted power from the spacecraft, Gt is the gain of the transmit antenna on the spacecraft, Gr is the gain of the receive antenna on Earth and FSPL is the aforementioned free space path loss [**note 1**]. With Pt = 40.8 dBm (12 Watts), Gt = 43.5 dBi (the 2.1 meter diameter shaped parabolic dish on New Horizons), Gr = 72.2 dBi (the 70 meter diameter dishes in the US, Spain and Australia in the Deep Space Network) and FSPL = 302.8 dB, the received power is -146.3 dBm.

Assuming the Deep Space Network system has a noise figure of about 1 dB, the sensitivity should be -173 dBm in a 1 Hz bandwidth. For the New Horizons signal to be at the DSN sensitivity, a bandwidth no greater than 500 Hz is allowed [**note 2**]. Now the smaller the bandwidth, the slower the data rate. In fact, the actual data rate for the Pluto-to-Earth link is about 1 kilobit per second – which means a typical high-resolution image takes about 50 minutes to transmit. Wow – that reminds me of when I used to have dial-up to get on the Internet!

I think we’d all agree that the Pluto fly-by was ‘extreme DXing’. But there’s another example that’s even more extreme. That would be SETI – the Search for ExtraTerrestrial Intelligence. Instead of talking about distance in terms of billions of kilometers, we’re talking in terms of light years (1 light year is about 9.5 trillion km). That results in even more free space path loss, but at least we have some options to play with in the Pr equation given two paragraphs earlier.

For example, transmit power can be a heck of a lot more than 12 Watts. And the transmit antenna gain can be much greater since it would be land-based and not on a small satellite. But what about frequency? Where would an extraterrestrial transmit? Referring to **note 1**, it’s obvious that as the frequency increases the free space path loss increases. But as the frequency increases, the antenna gain could increase. The initial SETI operation looked at 1420 MHz, which is the spectral line of neutral hydrogen. Picking this ties the frequency to a universal physical constant that all intelligent life should know about. So let's do a quick estimate of receive power using 1420 MHz and Pt = 1 megawatt with 70 meter diameter dishes on both ends.

Our nearest star (other than the Sun, of course) is Alpha Centauri (actually Alpha Centauri is three stars – Alpha Centauri A, Alpha Centauri B and a red dwarf) at about 4.4 light years from Earth. Plugging in the numbers and estimating the antenna gains at 1420 MHz from their area gives Pr = -159.2 dBm. That puts the intelligent life signal about 13 dB below the estimated sensitivity in a 500 Hz bandwidth. Instead of reducing the bandwidth and the data rate, let's try a higher frequency. If we move up to 4461 MHz (1420 MHz times PI – the same frequency multiplied by an additional universal physical constant), Pr = -150.2 dBm. Thus moving up in frequency gives a stronger signal because the gain of the two antennas increases more than the increase in the free space path loss.

To increase our receive sensitivity here on Earth, we could move up a bit higher in frequency and we could build an even bigger receive antenna system. Other than that, all we can hope for is that the extraterrestrial life is transmitting with even more than 1 megawatt with an even bigger antenna than the 70 meter dish I assumed. Of course all of this is for naught if we are alone . . .

In summary, there are several 'extreme DX' scenarios, and they depend on the definition of DX. But an important point to make is that regardless of whether you're doing Amateur Radio DXing or deep space DXing, there is common ground. You must pick the best frequency, maximize your transmit power, maximize your transmit antenna gain, maximize your receive antenna gain (which can also reduce external noise pick-up if designed properly) and use the narrowest bandwidth commensurate with the desired data rate.

Note 1. The free space path loss can be calculated from the equation FSPL (in dB) = 32.5 + 20 log(frequency in MHz) + 20 log(distance in km). At 7 GHz and 4.7 billion km, the FSPL is 302.8 dB.

Note 2. The amount of noise let into a receiver increases as the bandwidth increases, and it is proportional to 10 log(bandwidth in Hz). A 500 Hz bandwidth lets in 27 dB more noise. Thus a sensitivity of -173 dBm in a 1 Hz bandwidth = -146 dBm in a 500 Hz bandwidth.