Different MUFs in Our Prediction Programs

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Last month I attended Pacificon in San Ramon, CA (in the Bay area). On Saturday it's a typical hamfest, with vendors, seminars, kit building, license exams, card checking, a parachute mobile demo (weather permitting) and other activities.

What makes Pacificon so special for many is the ***Antenna Seminar*** on Friday. This is an all-day event with many speakers talking mostly about antennas. Sometimes other topics are discussed. This is held in a very big room, with most of the seats filled. The following was the agenda for this year's ***Antenna Seminar***.

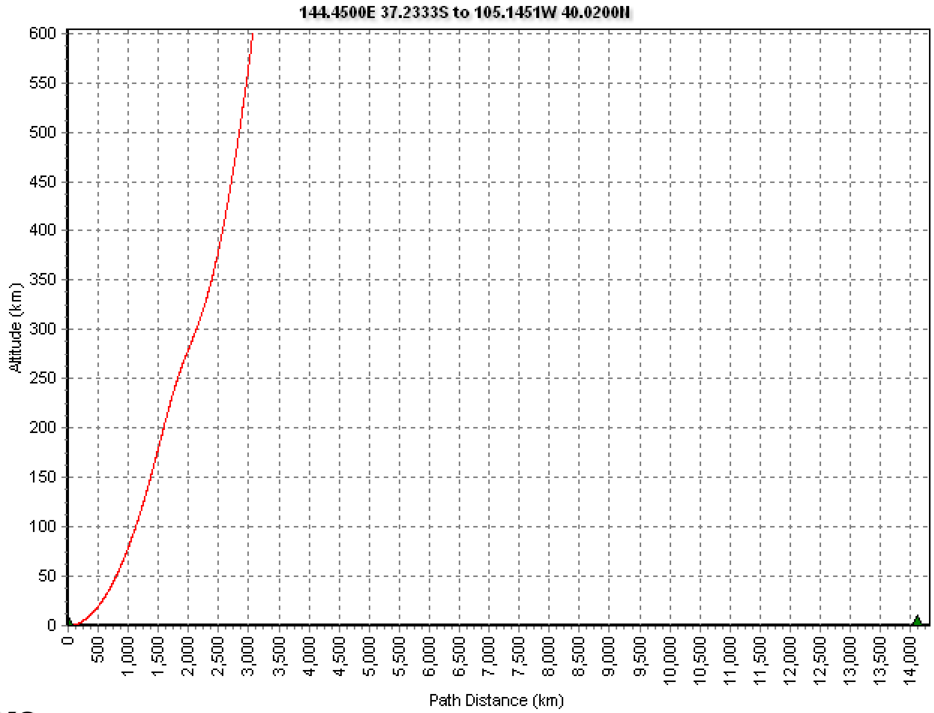
8:00 am - 8:50 am	**So you have antenna challenges? Let's try this…** Tom Schiller, N6BT
9:00 am - 9:50 am	**Understanding Propagation with Respect to Unusual QSOs** Carl Luetzelschwab, K9LA
10:00 am - 10:50 am	**Antennas: The Story from Physics to Computational Electromagnetics** Steve Stearns, K6OIK
11:00 am - 11:50 am	**SimSmith Tools** Ward Harriman, AE6TY
11:50 am - 12:50 pm	Lunch Break Please return promptly for afternoon speaker, as we will start on time.
1:00 pm - 1:50 pm	**A Wire in The Air - What Matters Most** Kristen McIntyre, K6WX
2:00 pm - 2:50 pm	**How to Blow Up Your Balun and Other stuff** Dean Straw, N6BV
3:00 pm - 3:50 pm	**Designing H.F. Loops for Best DX** Ted Algren, KA6W
4:00 pm - 4:45 pm	**Q & A**
4:45 pm - 5:00 pm	**Antenna Drawing**

I especially enjoyed N6BT's presentation (he was a co-founder of Force 12 antennas). Do you remember his article titled "Everything Works" in the July 2000 issue of **QST**? Tom used his TS-850S to a 150 Watt light bulb mounted on a post at his home QTH in an ARRL DX CW contest and worked 28 countries. His article included a "gain vs antenna" chart, with a light bulb at around 18 dB below a dipole and a stack of monoband Yagis at around 10 dB above a dipole.

I was the second speaker on the agenda, and gave a brief update on Cycles 24 and 25 before getting to the meat of the presentation – understanding QSOs that appear to be due to unusual propagation (as the title of my talk indicated). One of the QSOs I focused on in my Pacificon presentation was on 20-Meters between VK3MO in Kyneton, Victoria and KRØE in Boulder. VK3MO was using a four-high stack of 20-Meter monobanders (not bad, huh?), and KRØE was using a 5-element 20-Meter monobander (even that's not bad!).

Using Proplab Pro V3 (from Solar Terrestrial Dispatch), a 2-D (two-dimensional) ray trace [note 1] on 14.2 MHz from VK3MO to KRØE on November 25, 2017 at 1649 UTC gives the following result with a 0º elevation angle [note 2].

November 25, 2017 at 1649 UTC
14.2 MHz, R_{12} = 10



VK3MO **KRØE**

The 0º degree elevation angle goes through the ionosphere. Any higher elevation angle will do the same. This makes sense as November 2017 is for all intents and purposes at solar minimum between Cycles 24 and 25. Additionally, 1649 UTC is 2 hours 12 minutes before VK3 sunrise. Thus the ionosphere on the VK3 end has been in darkness for many hours, and has not yet started to be ionized by solar radiation – thus there’s just not enough ionization on the VK3 end to refract 14.2 MHz back to Earth at 1649 UTC. Proplab Pro V3 suggests that this QSO should never have happened. But it did.

The clue in understanding the Proplab Pro V3 result is what was said in the previous paragraph – VK3 was more than 2 hours before sunrise. Proplab Pro V3 uses the IRI-2007 model of the ionosphere [note 3], so let’s see what the model says about the F2 region MUF (maximum useable frequency) along the VK3MO-to-KRØE path at 1649 UTC.

Making a worldwide F2 region MUF map is easily done in Proplab Pro V3. The MUF we’re interested in is 2000 km from VK3MO. This is the F2 region control point [note 4] for predicting propagation on the VK3 end of the path (there’s also an F2 region control point on the KRØE end of the path). Looking at the contour lines on the map and doing some interpolation indicates the MUF is on the order of 12 MHz. Thus it is obvious why the ray trace went through the ionosphere – the 12 MHz MUF is below the QSO frequency of 14.2 MHz. As a side note, the 12 MHz value from IRI-2007 is a monthly median MUF.

On the other end of the path, the F2 region MUF 2000 km from KRØE is around 22 MHz. This portion of the path is in daylight, and explains why the MUF is so much higher. This also indicates the VK3MO end of the path is the critical end.

Now let's see what VOACAP says. Inputting the same data as used in Proplab Pro V3 gives us a monthly median MUF of 14.1 MHz (which again is the lower of the two MUFs at each control point at each end of the path). Using the antenna gains and VK3MO's output power gives a monthly median signal power of -107 dBm.

Now the question is "why does Proplab Pro V3 predict no propagation while VOACAP predicts propagation?" The answer is two-fold.

First, as stated earlier, the model of the F2 region in Proplab Pro V3 is the IRI-2007 model. The model of the F2 region in VOACAP is a different model. They are both monthly median models, but they are different. Here's a comparison of the MUF along the VK3MO-to-KRØE path using Proplab Pro V3, the latest version of VOACAP and W6ELProp.

Proplab Pro V3	**VOACAP**	**W6ELProp**
12.0 MHz	14.1 MHz	12.3 MHz

To reiterate, they're all monthly median values, but they are slightly different. Remember that approximately 75% of the Earth is water, so having accurate data over the oceans is a challenge – which is where the control point is for the VK3 end of the path.

Second, Proplab Pro V3 does its ray trace at the monthly median MUF (which would be 12.0 MHz). Ray tracing is a "go/no-go" endeavor. If the MUF is higher than the operating frequency, then it's a "go". If the MUF is lower than the operating frequency, then it's "no-go". On the other hand, VOACAP has an above-the-MUF algorithm built-in, and thus may show propagation even if the monthly median MUF is below the operating frequency [note 5].

The bottom line in understanding unusual QSOs is that we don't have one tool that tells all. To understand these QSOs, sometimes we have to look at propagation predictions, ionosonde data, TEC data, worldwide MUF maps, great circle path maps in relation to ionization, space weather and ray tracing to make our best educated guess as to what happened.

Notes

1. A two-dimensional ray trace means only the great circle path is considered. A skewed path is not analyzed. A three-dimensional (3-D) ray trace (which Proplab Pro V3 can do) would look at non-great circle paths. This QSO did not rely on a non-great circle path.

2. Generating sufficient energy at a 0^{o} elevation angle (and at other extremely low elevation angles) is near impossible unless you're over salt water.

3. IRI stand for International Reference Ionosphere, and 2007 means the 2007 version. IRI is constantly being reviewed and updated to include the latest data.

4. To predict propagation over long-distance paths, our propagation programs look at control points 2000 km from each end of the path (to assess the F2 region MUF at each end). Whichever F2 MUF is lowest is the MUF for the entire path. The programs also look at control points 1000 km from each end to evaluate the E region.

5. When the MUF is below the operating frequency, there may be some form of scatter to complete the QSO, but at the expense of additional loss. I believe the above-the-MUF mode is likely responsible for the amazing results using FT8 on 6-Meters when the Es MUF may not be high enough and on 10-Meters around solar minimum. See my Monthly Feature titled "Analysis of an FT8 6-Meter QSO" at https://k9la.us/Mar18_Bonus_-_Analysis_of_an_FT8_6-Meter_QSO_-_revised_Oct_2018.pdf