Software for Contesters – May/June 2007

Precision, Accuracy and Artifacts – Pitfalls for Modeling Accuracy

I've used a lot of modeling software of various sorts – particularly for antennas and propagation. We have an amazing range of capabilities on our desktops today, even as compared with five years ago, thanks to the revolutionary reduction in the cost of high-performance PCs. Many of us now understand a lot more about the effect of terrain on our station performance, why HF stacks are a good thing, and how the seasons and sunspots affect propagation.

At the same time, I think I've probably made most of the mistakes that can be made in the use of this software, so I've pulled together a short list of what I think are the most often violated guidelines, in the hope that you'll be able to avoid stumbling into the same pitfalls I have.

1. **Be aware of known, explicit limitations of the software** – this is one of my personal favorites, or at least you'd think so by the number of times I commit this kind of *faux pas*. For example, the standard antenna modeling engines – MiniNEC, NEC-2 and NEC-4 – each have very specific real-world situations that they handle less than well, or not at all. Knowing what these are, and whether or how you can partially or completely compensate for them, is a key to getting results that will closely approximate reality.

The best reference source I know of on antenna modeling is the books, articles and technical notes of L. B. Cebik, W4RNL (http://www.cebik.com). He covers the strengths and weaknesses of various modeling engines, which commercial programs incorporate which, and the importance of considering which program you should use for a given problem. In one article, for example, he reaches back to MININEC to model an HF T-match design after NEC-4 gave suspicious results (more on this later).

Propagation prediction software, like my favorite VOACAP, is particularly apt to entice you into believing it does more than it does. The other day, when the VU7s were active, I found myself mousing over a prediction map and thinking, "Wow, the MUF to VU7 is close to 28 MHz – maybe we'll get a 10-meter opening." Every time I do that, the computer should go upside my head and tell me, "It's a monthly probability, dummy, not a real-time bulletin from the ionosphere."

IONCAP and VOACAP were made to guide decisions on the placement, design features and broadcasting schedules of short-wave broadcast stations. Their designers would have liked a way to predict radio conditions on a day-by-day basis, but as K9LA put it (in *WorldRadio*, August, 2004), "There is little correlation on a day-to-day basis between what the ionosphere is doing and what the Sun is doing." The best correlation the engineers and scientists could find would only let them predict how signals will be *on average*, a month at a time, using smoothed sunspot numbers. That was good enough for their purposes, and that's why we have what we have.

In my opinion, propagation software has relatively little to offer the contester who wants explicit guidance on what to do, in choosing bands or pointing his antennas, next weekend, from his home QTH. Where it can be very helpful is in speeding up the learning process at a new QTH or on a contest DXpedition, and in designing an antenna system to take advantage of the statistically most probable arrival angles from key areas. Where it's essential is in planning the operating schedule of a two or three-week multiband DXpedition to someplace rare, where the task at hand is to schedule your operations at times and frequencies that match your goals in reaching your target "audience".

There are a couple of good references for this. The entire propagation section at ARRL's TIS web site (http://www.arrl.org/tis/info/propagation.html) is good reading, but particularly K9LA's articles on DXpedition planning (http://www.arrl.org/tis/info/pdf/propplan.pdf) and contest prediction (http://www.arrl.org/tis/info/pdf/propcontest.pdf).

2. "**The map is not the territory" –** this dictum from semantics applies equally well to modeling. Models are just that – mathematical approximations of a physical system. Professional modelers usually don't use models to try to discover a better antenna or other system; instead they use them to explore and verify in detail what is already generally known about the physical system. If a model produces results that are "too good to be true," it's usually because something is wrong.

The degree to which models match the physical reality is importantly influenced by the information that the modeler gives the software to work on. An important example is specifying receiving and transmitting antennas in propagation prediction software. Often, such software defaults to using imaginary constructions called "isotropic radiators", which radiate and receive equally well at all arrival and takeoff angles. Of course, there's no such thing in the real world – a horizontal antenna may have a null 30 dB deep at some takeoff angles. What happens if the best propagation mode between two points at a given time falls in such nulls on one or both ends? The signals can be down by as much as 50-60 dB. Anyone who has worked weak Europeans with the S-meter not even moving, while big stations there are 30 over S-9, knows that this is a common scenario.

Sometimes the mismatch between model and reality can be subtler. For example, while N6BV was developing the HFTA terrain analysis software, several of us who were beta-testing it discovered that certain terrain would produce large peaks in signal at very low elevation angles. The gains were sufficiently pronounced that the signal would seemingly violate the conservation of energy – that is, the total radiated power (in all directions) was larger after reflection and refraction off the terrain than before. This is a great example of a modeling *artifact,* where the model produces results that aren't a reflection of the real world. In the case of HFTA, Dean made some changes and also eventually cut off the calculation below .5 degrees elevation, to avoid having these anomalies influence overall results (such as the figure of merit of a given antenna/terrain combination).

A piece of good advice from N6BV – if you model an antenna 50 feet above terrain, or a stack with 30-foot spacing, take the extra time and rerun the model with 49 and 51-foot height or 29 and 31-foot spacing. If the change in gain and pattern is gradual, that's probably a good sign. If results change suddenly with minor changes in parameters like these, that is probably an indication that the model isn't to be trusted.

A somewhat similar thing can happen with antenna modeling. W4RNL has a good discussion of this issue on his web site. In a simplistic nutshell, any antenna element must be divided into segments (sometimes called "wires" or "pulses" for modeling purposes, and the pattern of the element is derived from the sum of the radiation from each segment. The length of the segments relative to the frequency can have a large effect on the accuracy of the model. Most commercial modeling programs have auto-segmenting routines built in, but you can't be sure, in any given configuration, particularly a complex one like a stacked array, that the recommended number of segments will be enough. The cure is to keep increasing the number of segments until you determine that a further increase doesn't produce a significant change in the results. Achieving "convergence", as this is called, takes time, but without this step your models will not be reliable. Similarly, big improvements in accuracy with close-spaced elements of similar sizes can often be achieved by segmenting the elements so that the segments more or less line up with each other. It takes more time, but the improvement in results can be worth it.

3. Don't Confuse Precision with Accuracy – This last point may seem elementary, but it's very easy to get wrapped up in precision that outruns the accuracy of the methods being used. If a piece of modeling software says that a given antenna has 23 dB front-to-back ratio with one reflector length and 24 dB with another, that probably isn't sufficient reason to rush out, take the antenna down, and whip out your hacksaw. N6BV recommends users of HFTA not give much credence to differences in figure of merit of less than 2 or 3 dB, because of the known limitations of 2-dimensional reflection/refraction analysis over 3-dimensional terrain. On W4RNL's web-site there is a very enlightening article (http://www.cebik.com/model/teea.html) about using NEC-4 to evaluate the effects of different diameters of T-match tubing on the performance of a Yagi. The program said the gain of a 5-element antenna with a .5 inch diameter T-match would be almost .9 dB less than with a 2-inch diameter T-bar. That would be big news if it were true, but after a lot of painstaking effort he determined that it is a modeling error, and that even NEC-4 cannot be fully trusted with close-spaced elements.

This modeling is great stuff – you can save a lot of time and money, and have a lot of fun with it. Just be careful, heed the warnings of the authors about avoiding subtle errors, and take the time to do your modeling right. Apply your real-life experience and the advice of others, as well as modeling results. If it seems too good to be true, it may well be.