An Introductory Tutorial to VOACAP
Running Your Own Propagation Predictions
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This document shows how to download and use VOACAP. Gregory Hand of the Institute for Telecommunication Sciences (ITS) maintains VOACAP on the ITS web site. ITS is under the National Telecommunications and Information Administration (NTIA), which is part of the US Department of Commerce.

To download VOACAP, follow the directions in Table I.

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1. go to http://elbert.its.bldrdoc.gov

2. click on High Frequency (HF) propagation models ICEPAC, VOACAP, REC533

3. click on HFWIN32

4. click on README.txt to download some general information about the software and PC requirements
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5. click on here in the "Technical Manual" line to get the technical manual

6. click on here in the "Original User's Manual" line to get the user's manual

7. click on here in the "install from your hard drive" line to download the software to your PC

Table I Downloading the Software

Instead of going right to the page that downloads the software, I've listed it step-by-step so you can read each page to get a better overall picture of ITS.

I strongly suggest reading the two manuals. Both are many pages long. The Technical manual explains how propagation programs were developed and gives the details on how they work. It is very technical in nature, and you'll learn a lot by reading it. You'll see many of the topics I've discussed in my WorldRadio Propagation columns over the months. The User's manual gives details on how the software is implemented, along with definitions of terms, descriptions of antenna options, and other user-critical topics.

What you've downloaded is itshfbc.exe, which is the 32-bit Windows NT/95/98 version of the software (note the caveat about NT on the page after doing step 3). Download it into a sub-directory (I called mine VOACAP). The file is about 5 Meg, so it may take awhile. When it's downloaded into your sub-directory, execute it and follow the directions. The end result is an icon on your desktop named ITS HF Propagation.

There are also versions for DOS and versions for 16-bit Windows 3.x, but with limitations (as explained on the page after doing step 2). I did not download the DOS or Windows 3.x version, and I have no experience with them.

Assuming everything goes ok in the installation procedure, you should end up with three generic propagation programs: VOACAP, ICEPAC, and REC533. VOACAP is, of course, what we were after. It is the Voice of America's version of IONCAP tailored for

their international short wave broadcasting needs. ICEPAC is a pleasant bonus – it's IONCAP with an allegedly improved model of the high latitude ionosphere – specifically the mid-latitude trough, the auroral zone, and the polar cap as described in my March 1998 WorldRadio Propagation column. Running VOACAP and ICEPAC are very similar, so my comments apply to both. REC533 is the International Telecommunications Union (ITU) international HF planning model, and I will not address it.

VOACAP and ICEPAC also have area coverage versions (VOAAREA and ICEAREA - contour plots of signal strength) and signal-to-interference in point-to-point modes (S_I VOACAP and S_I ICEPAC). I will not address these subsets. Ok, enough introductory information – let's get into running a propagation prediction using VOACAP. We'll run a prediction from K9LA to ZF (Cayman Islands) centered on the middle of January 2001 at 2300 UTC with an assumed smoothed sunspot number of 109.

When you click on the VOACAP icon after opening ITS HF Propagation, the "VOACAP Point-to-Point data input" screen will come up. Here's where we set up all the parameters for the path we want.

For Method, let's go with Method 20 – complete system performance. We'll see later what it gives us. For Year, select 2001. For Coefficients, go with CCIR (Oslo). For Time, input 2300 UTC by selecting 2300 to 2300 in 1 hour increment. For Groups, input 1.00 for monthly median results for January, and input SSN = 109 (our assumed smoothed sunspot number for January 2001). For other dates you can get the smoothed sunspot number at **www.swpc.noaa.gov/products/predicted-sunspot-number-and-radio-flux**. For Transmitter, input 41.00N and 86.00W and name it K9LA. For Receiver, input 19.50N and 80.80W and name it ZF.

Next is Path. Toggle it to Short path. It shows the distances (kilometers, nautical miles, and statute miles) and the heading from the Transmitter (K9LA) to the Receiver (ZF). Toggle it to Long path to run a long path prediction.

For Frequencies, input 24.9MHz and 28.3MHz. Note that there are default frequencies – since this is a Voice of America program, these default frequencies are the SWL bands.

For System, select the default noise (-150dBw at 3MHz in a 1Hz bandwidth, which is about –118dBm at 24.9MHz in a 500Hz bandwidth, and 2dB lower at 28.3MHz), select a 3.0 degree minimum elevation angle (it's hard to generate energy at extremely low elevation angles), select the default 90% required reliability, select the default 3dB multi-path tolerance, and select the default 0.1ms time delay tolerance. For Req SNR (Required Signal to Noise Ratio), input 48dB (which is in a 1Hz bandwidth). Table 2 gives recommended required SNRs for various modes.

mode	Required SNR in 1Hz bandwidth
AM	51
SSB	48
CW	31

Table 2 – Required SNRs for various modes

For Fprob, stick with the default values. Essentially these are fudge factors to vary the monthly median critical frequencies.

For Tx Antenna (which is at K9LA), select Sample.23 (horizontal dipole with .5 wavelength elements at .25 wavelengths above ground) in the TxAnt field, input 7dBi in the Design field (the maximum gain of a horizontal dipole over average ground), and click "at Rx" to point it on the heading to ZF identified in the Path parameters. Set the power to .1kw (100w). Likewise, select Sample.23 for the Rx Antenna (which is at ZF), input 7dBi in the Gain field, and click "at Tx" to point it toward K9LA.

Ok, everything is inputted. Now click on "Run" and then "Circuit" to run the prediction from K9LA to ZF. What you get is a header with all the parameters you selected and the prediction. The actual prediction should look like Figure 1.

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     CCIR Coefficients            ~METHOD 20   VOACAP 05.0119W  PAGE   1

 Jan   2001             SSN = 109.                 Minimum Angle= 3.000 degrees
 K9LA                 ZF                     AZIMUTHS        N. MI.      KM
 41.00 N    86.00 W - 19.50 N   80.80 W   166.79  349.46    1318.0   2440.7
 XMTR  2-30 IONCAP #23[samples\SAMPLE.23    ] Az=166.8 OFFaz=360.0   0.100kW
 RCVR  2-30 IONCAP #23[samples\SAMPLE.23    ] Az=349.5 OFFaz=360.0
 3 MHz NOISE = -150.0 dBW     REQ. REL = 90%    REQ. SNR = 48.0 dB
 MULTIPATH POWER TOLERANCE =  3.0 dB   MULTIPATH DELAY TOLERANCE =  0.100 ms

 23.0 26.1 24.9 28.3  0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0 FREQ
      1F2  1F2  1F2   -     -     -     -     -     -     -     -     -  MODE
      9.8  7.9 11.8   -     -     -     -     -     -     -     -     -  TANGLE
      8.7  8.6  8.8   -     -     -     -     -     -     -     -     -  DELAY
      344  299  392   -     -     -     -     -     -     -     -     -  V HITE
     0.50 0.69 0.17   -     -     -     -     -     -     -     -     -  MUFday
      150  149  166   -     -     -     -     -     -     -     -     -  LOSS
       12   11   -8   -     -     -     -     -     -     -     -     -  DBU
     -127 -128 -146   -     -     -     -     -     -     -     -     -  S DBW
     -176 -175 -177   -     -     -     -     -     -     -     -     -  N DBW
       49   47   30   -     -     -     -     -     -     -     -     -  SNR
       25   19   44   -     -     -     -     -     -     -     -     -  RPWRG
     0.52 0.46 0.16   -     -     -     -     -     -     -     -     -  REL
     0.00 0.00 0.00   -     -     -     -     -     -     -     -     -  MPROB
     0.20 0.21 0.09   -     -     -     -     -     -     -     -     -  S PRB
     24.5 15.5 25.0   -     -     -     -     -     -     -     -     -  SIG LW
      9.3 10.0 21.9   -     -     -     -     -     -     -     -     -  SIG UP
     26.3 18.3 26.8   -     -     -     -     -     -     -     -     -  SNR LW
     10.9 11.4 22.7   -     -     -     -     -     -     -     -     -  SNR UP
     -3.4 -5.0 -2.0   -     -     -     -     -     -     -     -     -  TGAIN
     -3.4 -5.0 -2.0   -     -     -     -     -     -     -     -     -  RGAIN
       23   29    4   -     -     -     -     -     -     -     -     -  SNRxx
 *****END OF RUN*****     VOACAP 05.0119W
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Figure 1 – Sample run

The first column is the time (remember we're only looking at one time). The second column is the predicted monthly median MUF – 26.1MHz for this path. Note that MUFday, which indicates the number of days in the month that the MUF should be at least 26.1MHz, is .50 as it should be, as this is the monthly median. The third column is 24.9MHz and the fourth column is 28.3MHz. Let's focus on the 28.3MHz prediction.

The MODE says it is one hop via the F2 region. The TANGLE says the elevation angle needed out of K9LA for this mode is 11.8 degrees (our assumption of 3 degrees minimum is ok). The DELAY says it takes 8.8 milliseconds for the RF to get from K9LA to ZF via the 1F2 mode. The V HITE is the virtual height of the reflection point in the F2 region. The MUFday of .17 says 10m should be open on about 5 days (.17 times 31) of this January month (unfortunately we don't know which specific days of the month these are) at 2300 UTC with SSN = 109. The MUFday is lower than .50 because 28.3MHz is higher than the 26.1MHz monthly median. Also note that the MUFday for 24.9MHz is .69 – it's higher than .50 because 24.9MHz is lower than the monthly median of 26.1MHz.

The LOSS is the median system loss in dB. The DBU is the predicted median field strength at ZF in dB above 1uv per meter. The S DBW is the median signal power at ZF in dB above 1 watt. Likewise, N DBW is the median noise power at ZF in dB above 1 watt. Table 3 converts dBW to S-units (assuming S9 = 50uv and an S-unit is 5dB, which is about what receivers do nowadays per my measurements on my receivers):

Signal power in dBw	Signal power in dBm	S-units
-93	-63	10dB over S9
-98	-68	5dB over S9
-103	-73	S9
-108	-78	S8
-113	-83	S7
-118	-88	S6
-123	-93	S5
-128	-98	S4
-133	-103	S3
-138	-108	S2
-143	-113	S1

Table 3 – Conversion between power and S-units

The SNR is the difference between S DBW and N DBW. The REL is the probability that the predicted monthly median SNR (30dB) exceeds the required SNR (we went with 48dB). Since 30 is less than 48, we'd expect the REL to be less than 0.5 – indeed it is, and it says the required SNR is predicted to be met on only 5 days of the month (.16 times 31). There are some more parameters listed, but I'll let you dig into the User's manual (section 4.3 starting on page 26) to decipher them.

I hope you enjoy VOACAP. Add more frequencies, change the dates and times, change the smoothed sunspot number, change the method, etc. Pretty soon you'll be running predictions to help with your specific Amateur Radio activities. One last thing – if you're doing predictions on paths that go through high latitudes, you may want to try ICEPAC. ICEPAC only requires one more input parameter than VOACAP – the q index. Check out Figure 52 in the User's manual to convert the Boulder k index to the q index. A caveat, though – predictions using ICEPAC are not as well validated as predictions using VOACAP.