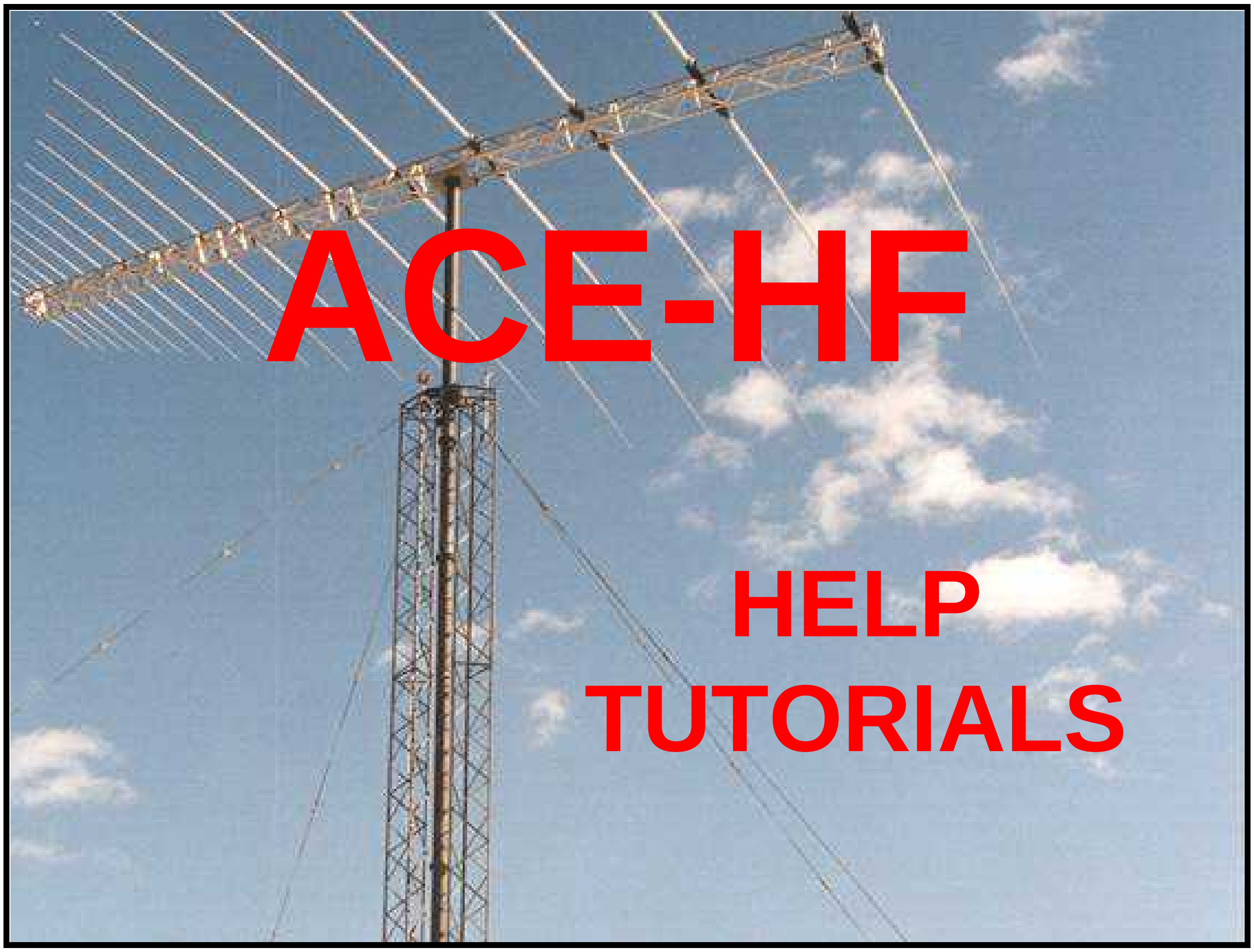

ACE-HF System Simulation and Visualization Software

User Guide and Reference Manual
Version 2.06

ACE-HF
HELP TUTORIALS

User's Guide and Reference Manual
for
ACE-HF System Simulation and Visualization Software for Ham Radio & Shortwave Listening Applications

Version 2.06

ACE-HF
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Dedication

The work of ACE-HF is dedicated to the memory of Arthur A. Collins, founder and President of Collins Radio Company. Arthur Collins was personally responsible for outstanding innovations in HF radio communications, starting with the amateur radio transmitter designs that made him famous and which became industry high-end standards for decades.

Collins Radio was the first to perfect Single Sideband HF radio, giving the U. S. Strategic Air Command reliable worldwide command and control for the first time. Thereafter, Collins HF SSB radios became the *Cadillacs* of the radio industry in both military and amateur HF service.

Arthur Collins' personal vision led to a 250-kW HF transmitter design for international broadcasting that included innovative computer control systems that were decades in advance of other concepts. That transmitter development of the 1960s was perhaps the last in which Arthur took a direct personal interest. It was the author's good fortune to have worked directly with Mr. Collins during the design as it took shape in the laboratory. As did most others at Collins Radio, I found Mr. Collins to be friendly and courteous, and always ready to lead the way toward new and challenging adventures in radio engineering.

Arthur Collins became a hero to many young engineers at his company, and will be remembered with admiration by all who touched the company's products. Arthur's dedication to quality and technical excellence is perhaps best characterized by this quotation:

> *"The real thrill in radio work comes not from talking to stations in distant lands, but from knowing that by careful and painstaking work and by diligent and systematic study you have been able to accomplish some feat or establish some fact that is a new step toward more perfect communication."*
>
> *by Arthur Collins, 9CXX*
> *1926, at age 16.*

RPB

GETTING STARTED WITH ACE-HF

Welcome to ACE-HF. Learning ACE-HF is easy-just follow these steps:

(Use Help, Getting Started on the Main Screen or Circuit Analysis Screen to see this panel again. You can also print all the Help screens from the HELP.PDF file from the installed folder or from the CD.)

HINT: Some users shrink from reading the ACE-HF Help Tutorials because they are quite detailed. But don't worry. ACE-HF is designed to be intuitive and you can operate the software by reading just this page. The tutorials may be used as reference documents. Just use the Table of Contents to find a topic of interest.

If you are reading this Help file before starting the program, be aware that you can load new Station Location key files (the original key file comes on the CD) from your download folder or from any hard drive folder. If you need another key file, call or write ACE-HF for a duplicate or alternate location file to be delivered via e-mail.

1. What's New? If you are a previous ACE-HF user, you may want to begin by reading about the new features in Version 2.06 of the software. Please go to the "What's New?" Help Tutorial. Also, you may find a listing of program revisions in the file \ACE-HF\ACEHF_History.PDF that was installed from the CD.

2. Initial Setup.
A. User Mode. The program first appears in the Ham User Mode by default. Using the Main Screen menu, File, User Options, select either Ham Operator or Shortwave Listener. Please go to the SWL Help Tutorial to learn more about the SWL User Mode.

B. Path Units. Using File, User Options, set path distance units to your preference.

C. Clock Offset. Using Main Screen File, Set the Clock Offset so PC time is shown as Coordinated Universal Time (UTC) within ACE-HF.

3. Initial Run. ACE-HF automatically runs the predictions for the default circuit shown on the Inputs, Circuits panel. To see the predictions, click on the Main Screen top-row menu Circuit Analysis item. The Circuit Analysis Screen will appear with a graph of SNR vs. time-of-day for the default circuit. (See the Circuit Analysis Charts Help Tutorial.)

4. Saving Circuit Defaults. Go to the Inputs, Circuit panel and click on Save Circuit. Initial settings are already saved in a Default file and appear automatically on startup.

5. Changing Settings. On the Inputs, Circuit panel, try changing one of the blue circuit functions. Note that the comment line changes automatically. Then click on the Run Circuit Predictions button. The Circuit Analysis screen will have data for the new input selection. Use the top-row menu to return to the Inputs Screen. You can restore the default parameters by recalling the file HamDefault.ckh or SWLDefault.cks.

6. Setting the SSN Number. The Smoothed Sunspot Number (SSN) is set for 100 on the CD. If you are connected to the Internet, use the Inputs, Circuit panel, *Get New SSN* function to update the SSN.

7. Station Defaults. In the Ham mode, the red transmitter parameters have been customized for your station, but you can change your transmitter power and antenna type. See the Antennas Help Tutorial for more information about the antenna file selections.

8. New Circuits. Returning to the Inputs screen, a new circuit may be specified by selecting a new station location from the database, by using the keyboard, or by changing the station dot location on the Circuit Analysis screen. (See the Hidden Features Help Tutorial.) The comment line and path values will change automatically. Then click Run Circuit Predictions to see data for the new location.

9. Circuit Options. Change to the Inputs, Circuit Options panel to see the program defaults. Each may be changed and the defaults may be restored. Run the predictions again if you change something.

We'll discuss Area Coverage and Antenna Options settings in separate Help Tutorials. You may read about the ACE development by clicking on the Main Screen Help Tutorials, and select Basis, What's ACE?

Now read the Features, Hidden Features Help Tutorial. Have fun with ACE-HF!

WHAT'S NEW IN VERSION 2.06?

This section provides a brief overview of new features introduced in ACE-HF Version 2.06. More extensive discussions of these features are provided in the other Help Tutorials (see the Table of Contents).

1. Antenna Central. A new antenna modeling capability called *Antenna Central* is now included. Antenna Central includes 1650 new antenna models by L. B. Cebik, W4RNL (SK).

2. Expanded MCS. The new Multi-Channel Schedule panel now permits separate antennas and transmit powers to be specified for all ten frequency channels. The new MCS panel permits automatic predictions with any schedule of user-specified antennas.

3. New Maps. *S*election from thirty-four new maps is now possible, and a selected map appears on both the Main and Circuit Analysis screens.

4. Better Map Selection. A new map may be selected from either the Main or Circuit Analysis screen.

5. Lat/Lon Readouts. Latitude-Longitude readings now appear on the Circuit Analysis Screen when the user left-clicks on the selected map.

6. Improved Prediction Accuracy. Area Coverage, as well as Point-to-Point Circuit and Circuit Group predictions may now utilize different antennas for each channel by specifying an MCS file.

7. Easier Station Relocation. The Main Chart is now hidden when moving the transmit or receive dot.

8. Better DXCC Database. The DXCC Database has been updated.

All the new features introduced in Version 2.05 have been retained:

9. SWL User Mode. The new *User Mode* control permits ACE-HF to be used in a new Shortwave Listener mode as well as the normal Ham Operator mode. Please see the *SWL* Help Tutorial.

10. New Antenna Analysis Capability. Two interesting new charts permit the user to analyze antennas selected for both the transmit and receive ends of circuits. The new Antenna Analysis chart shows the vertical pattern of any selected antenna as well as the computed elevation angle of the most reliable propagation mode. This comparison is especially useful when NVIS circuit operation is needed. The second analysis capability charts both azimuthal and vertical patterns for VOACAP Type 13 antenna models and animates them through their frequency range. This interesting chart is augmented by a three-dimensional display of the entire antenna pattern, which itself may be animated through the frequency range.

11. Absorption Model Selection. Either the *NORMAL* (VOACAP Standard) or the *IONCAP* signal absorption model may now be selected. The IONCAP model yields an increased signal level in the predictions of low-frequency, nighttime circuits and may be used experimentally.

12. HFCC Antennas. More than 660 International Broadcasting antenna models have been added. These are useful in the simulation of shortwave circuits.

13. HFCC Station Database. More than 640 International Broadcasting transmit station locations may be called from the HFCC Database.

14. CIRAF Zones. Users may show International Broadcasting CIRAF Zones and numbers when displaying area coverage maps.

15. New Service Types. Seven new service type settings may now be selected for popular HF data modes. In addition, a new AM service type for International Broadcasting has been added.

16. ALE Simulation. Automatic Link Establishment (ALE) circuits, as well as conventional HF circuits may now be simulated.

17. Improved Clock Offset. The Clock Offset function may now be set for fractional hours, to accommodate users in Australia and elsewhere.

18. Improved Screen Resolution Scaling. The user may now preset the software to display all screens in full-screen or normal 800x600-pixel mode, and all user screen resolutions will scale automatically. A single ACE-HF program now supports normal (small) and large screen fonts, and dual-screen and wide-screen displays are supported.

19. Automatic MOVIE Displays. The animated area coverage display program, *MOVIE*, now appears for the current hour and automatically advances every hour when 24-hour displays are created.

SWL OPERATION

1. Two Programs in One. Beginning with Version 2.05, ACE-HF has become two programs in one. All the Ham features are retained, and the software can be configured for ShortWave Listener (SWL) use as well. Operation is switched between the HAM and SWL modes by using the Main Screen, *File, User Options* panel. Click on *Ham Operator* to use ACE-HF in the normal Ham User Mode. Click on *Shortwave Listener* to switch to the SWL User Mode. The custom callsign or station name that appears in the upper left corner of the Main Screen and Circuit Analysis Screen carries a *Ham* or *SWL* prefix to show the selected mode.

2. Ham or SWL Mode? Whether you have purchased ACE-HF for Ham or SWL operation, the software has been customized for your station through the use of a key file. When you first install ACE-HF the key file load from the CD. Regardless of the intended use, all users may use the software in either mode by switching user modes at any time. In fact, Ham users will benefit from some of the new SWL features, and SWL users will enjoy some of the new Ham capabilities. Some new features, such as the new antenna models and analysis charts, will be of interest to both Hams and shortwave enthusiasts.

3. SWL Simulations. New features of interest to SWL users include the HFCC database, which permits the selection of worldwide International Broadcasting transmitter locations. By selecting a station from the HFCC database, the SWL user may quickly configure point-to-point circuits, or circuit groups, to his receive location. Used in conjunction with shortwave published schedules from the Internet, which list the station's transmit power level and frequency as well as the antenna azimuth for different broadcasts, accurate simulations of each shortwave transmission may be made. Unique frequency schedules for each station may be created and saved by using the frequency list on the Inputs, Circuit Options panel.

HINT: If you regularly listen to several broadcast stations, make a note of the several frequencies used by each. Although most stations will have unique frequencies (to avoid interference), many of their channel assignments will be similar, so a common broadcasting frequency list can accommodate several different stations. Usually, frequencies within 100 kHz or so will yield similar propagation predictions.

Another feature for SWL users is the addition of many HFCC antenna models, found in the HFCC folder of the Select Antenna screen. Some SWL enthusiasts search for exact antenna definitions contacting their favorite station for technical information. But if you don't know the station's exact antenna configuration, you can begin by using the CONST17.VOA antenna model that is at the end of the HFCC antenna listing. The CONST17.VOA model was created by the Voice of America to approximate the large curtain arrays used by HF broadcasters, and some such antennas have high directional gains of up to nearly 30 dBi. The generic VOA antenna has a gain of 17 dBi, with curtailed radiation at the low take-off angles, and is omnidirectional.

For better simulations, you can use one of the curtain arrays that have high directional gain. The HFCC BC003S00.S00 antenna is a good nominal choice. This model has a directivity gain of 21.2 dBi with an excellent front-to-back ratio. You can view its patterns using HFANT or the Type 13 Antenna Analysis Charts. (See section 4 of the Antennas Help Tutorial for a more detailed description of the HFCC antennas.)

4. CIRAF Zones. You will want to use ACE-HF's area coverage displays to better define the coverage from International Broadcast stations. When you create area coverage displays, you can invoke the *CIRAF Target Zones* feature to superimpose the zones over your area coverage displays. *CIRAF* stands for *Conferencia Internacional de Radiodifusión por Altas Frequencias* and was a conference first held in Mexico City in the 1940s to define areas to be served by each shortwave broadcaster. Continuing HFCC meetings are held to refine such agreements. Each CIRAF target zone has a number, and the Internet schedules list those zones, along with frequencies, times-of-day and antenna azimuth angles used for each broadcast. You can use this information to better simulate such broadcasts.

5. Simulating Shortwave Broadcasts. In summary, here are the procedures the shortwave enthusiast might follow for simulating shortwave broadcasts:

A. Specify your receive station parameters. First, set up your station in ACE-HF. If you have purchased the software for SWL purposes, you probably chose a station name, or you own name, and that name will appear in the green Inputs, Circuit *SWL Receiver* panel. Now you must chose a model that most nearly simulates your station's receiving antenna. It might be a simple dipole wire antenna, and you can use the HFANT program to create a custom model by starting with the DIPOLE23.23 file in the \antennas\UserAnt folder. (Read the *Antennas* Help Tutorial for more detail.) Set the dipole's physical length and height above ground and chose ground conductivity and dielectric constant values that approximate those of your location. Pay particular attention to the angular orientation of the dipole. ACE-HF assumes that the zero azimuth angle points to true North, and for dipoles that angle is the broadside emission of the antenna. You can set the antenna azimuth angle to compensate for the physical orientation of your antenna.

Or you might wish to select another generic antenna from the \UserAnt folder or from the new Antenna Central collections. You can even specify the SWWHIP.VOA antenna from the HFCC antenna folder if you have a simple receiver with a whip. Or, you may wish to select the default Isotropic antenna that is often used for unknown Ham stations.

Then, set the manmade noise level on the Inputs, Circuit panel. Use the default *Rural* level if you are in a suburban or rural area away from electrical transmission lines and other electrical equipment. If you are in a noisy environment (you can tell by simply listening to background noise on your HF radio), you might want to select the *City* or *Industrial* noise level.

B. Specify the transmit station parameters. Select a shortwave station you want to listen to and use the HFCC database to find its location. Use the station's published schedules to find the transmit power, antenna azimuth (main beam) angle and CIRAF Zones to be covered by the broadcast. The schedules will also list the frequencies and times-of-day for each broadcast. Two good sources for this rapidly changing data are www.hfcc.org and www.ilgradio.com/ilgradio.htm. In the Inputs, Circuit panel set the station's transmit power value. Set the transmit antenna azimuth if you have selected an HFCC directional antenna.

C. Set the service type. On the Inputs, Circuit panel, select the *IB (AM)* service type. This specifies the required signal-to-noise (SNR) threshold sensitivity for AM International Broadcast service. The default Required SNR (RSN) value is 67 dB-Hz, but can be changed on the Inputs, Circuit Options panel. You can read more about service types in the *Circuit Quality* section of the *Basis for the Predictions* Help Tutorial.

D. Specify broadcast frequencies. You can specify ten broadcast frequency channels using the list in the Inputs, Circuit Options panel. The software assumes the Ham User Mode to start with, so after you have changed to the SWL User Mode, move to the Inputs, Circuit Options panel and recall the *SWLExample.frq* list. Then edit that list to better represent the various frequencies used by a given broadcast station. You can save a different frequency list for each broadcaster, or you can make a generic frequency list as was explained in section 3, above.

E. Making a trial prediction. To see predictions for the point-to-point circuit that you have defined, just click the *Run Circuit Predictions* button on the Inputs screen, or the *Circuit Analysis* menu item on Main Screen. You can then use the various analysis charts to understand when your shortwave program can be heard.

F. Making reception area predictions. Most shortwave enthusiasts will want to use ACE-HF's powerful area coverage displays to better see how broadcast station coverage varies with frequency and time-of-day. You can make *Normal* transmission area coverage predictions to see the coverage of a particular station, or you can make *Reversed* reception area coverage predictions to see the coverage around your receive station. In the latter case, the software moves the transmitter all over the world to see its coverage limits to your station. Read more about area coverage displays in the *Area Coverage* Help Tutorial.

G. Making Circuit Group predictions. You can also make predictions for transmissions from as many as 18 broadcast stations by using the *Circuit Group* capability, following the *Circuit Group* Help Tutorial.

WHAT'S ACE?

This Help Tutorial describes the development of the ACE area coverage animation displays. It won't help much with learning ACE-HF, so if you're not interested, go on to *Hidden Features* Help Tutorial. The term ACE refers to the display technique. All ACE-HF predictions are made with the VOACAP program.

The ACE (Animated Communications Effectiveness) concept was developed for the U.S. Navy and first applied to VLF submarine communications. VLF signaling is the preferred method for such applications because the signals can be heard over great distances and can penetrate sea water, thus permitting the submarine to remain hidden below the surface. For many decades, propagation models using waveguide theory (where waves are assumed to propagate between the D-region of the ionosphere and the earth's surface) have been conceived and fine-tuned. Today, validated and accurate models for under-sea VLF reception exist.

As the VLF models grew more complex, so did the problem of depicting the result. For years, it was common practice to plot area coverage curves on paper. But at VLF, such plots varied greatly with transmit power, signaling mode and other factors, and particularly with time-of-day. An oft-used simplification was to assume an all-daytime scenario because daytime coverage was easier to understand and, in general, was worse than nighttime coverage. But in fact, nighttime signal fading often causes severe signal drop-outs in many areas, and those effects were missed when only a simple coverage prediction at one time-of-day was made.

To understand these effects, the authors (of the ACE programs) began to produce hourly area coverage curves and hang the papers on the wall. But soon, the walls were totally covered because every revelation suggested changing another system variable and producing another set of paper. Eventually, the solution was to show the curves on a computer screen one after the other—the ACE concept was born.

The ACE method shows a sequential series of coverage maps, with multiple curves as needed to describe the effect of changing system variables. When showing the maps one after the other, a movie-like display is produced. In fact, the program that displays the sequential coverage maps is called *MOVIE*. The images may be shown one at a time, or repeated rapidly at various speeds.

At HF, propagation anomalies are even more complex than with VLF. The great advantage of ACE-HF is that the effects—sometimes astonishing effects—of the day's passage may be easily understood. With ACE-HF maps, one can see at a glance when the HF bands will be open in different parts of the world. Then, the point-to-point analysis charts may be used to see the details of transmissions to particular locations. In ACE-HF, the effect of time is always emphasized.

HIDDEN FEATURES

1. Some definitions. The graph that appears at the bottom of the Circuit Analysis Screen is called the *Main Chart*. There are three other charts on this screen, the *MUF Chart*, the *Best Frequency Chart,* and four types of *Summary Charts*. The Main Chart appears automatically, as described in the Help tutorials, while the other charts are invoked from the Circuit Analysis Screen top-row menu. Read more about these specialty charts in the Cha*rts* and *Antennas* Help Tutorials. And remember, in ACE-HF *all* charts are animated.

When you have selected the SWL Mode, selected frequencies are called *Channels*. When in the Ham Mode, they are called *Bands*. In either case, you can always set a new group of ten frequencies by using the Inputs, Circuit Options screen

2. Analysis Screen Pop-Up Menu. Perhaps the most useful ACE-HF feature is the Circuit Analysis Screen Pop-Up menu. Right click anywhere on the Circuit Analysis Screen. Then left click on the parameter you want to change. Current selections are marked. New predictions replace previous chart data in a few seconds, so it's easy to see the effect of a parameter change without returning to the Inputs screen. Note that you must terminate chart animation before you can access the Pop-Up menu.

You may choose a different chart type from the top list in the left column. Selections from other lists will automatically re-run the predictions. Try a new parameter. For example, changing the Required Reliability value from 50% to 90% is instructive.

The Pop-Up menu also permits a quick return to the Inputs Circuit or other screens by using the items in the right-hand column. Also, you can temporarily *Hide* the Main Chart and the other charts then re-*show* them if you wish. You can also *Hide* and *Show* the Open Bands boxes using this Pop-Up.

3. Open Bands Boxes. The boxes in the upper right corner show bands that are *open* at the current time. A hint defining the box colors appears when you pass the mouse cursor over the Open Bands area. The colors track any circuit changes you make. For example, a band that is Open (green) with the default Isotropic antenna may be Closed (red) if you change to an antenna having less gain. The color changes track those of the Main Chart. Normally, all ten bands are shown. But if you select *Contest Bands* in the Main Screen, *File, User Options* panel, only six bands will appear in the Open Bands boxes, making Contest Band status easy to see at a glance.

4. Circuit Path Dots. The point-to-point circuit and its two terminal dots are *active* in the Circuit Analysis Screen. If you are in the Ham Mode and want to select a new receive location, left click the green receive-site dot. Then move the cursor to a new position and left click again. A yellow panel will appear after the first click to show the cursor's pixel position and Lat-Lon values. After the second click, predictions for the new circuit are computed automatically, and the new location is shown on the Inputs screen and in the Main Chart title. New circuit locations are also repeated to the Main Screen.

If you have selected the SWL Mode, then the red transmit-site dot will be active. The same procedure applies. Just left click the red dot, move it to a new position and left click again. A new circuit from the relocated transmit site will be established.

With this feature, you can quickly examine other locations to see when your favorite band is currently open, observing the Open Bands Boxes after you move a dot. And the Main Chart will show when the bands might open up in the future. Remember that you can use the Pop-Up menu to *Hide* the Main Chart if you need to move one of the dots to an area under the chart. Then use the Pop-Up again to *Show* the chart.

On either screen, you can place the mouse cursor over the dots to see a hint giving call sign, location, path distance and azimuth from both ends. The hint also identifies the circuit as *Long* if Long Path was selected.

5. Main Chart Values. You can see exact values by passing the cursor over the graph. A hint will appear with a value for each time-of-day or band. Since the *Time* chart is interpolated to five-minute intervals, intermediate values between the hourly predictions also appear.

6. Propagation Modes. When *Modes* is selected on the Main Chart, the value hints are replaced with mode hints showing the principal propagation mode at each time-of-day. (See *Circuit Analysis Charts* tutorial.)

7. Main Chart Zoom. An area of the Main Chart time graphs (and the MUF chart) can be expanded by opening the area with the mouse. Left-click and hold the mouse button down over the time-of-day graph and drag the mouse cursor down and to the right. When the mouse button is released, a smaller area of the chart will appear. Restore the chart to normal by left clicking and dragging the mouse cursor up and to the left. The Zoom function will also work on the Type 13 Antenna Analysis 3D chart, and you can right click to move a portion of the 3D-chart image. Restore the 3D chart by left clicking and dragging the mouse cursor up and to the left.

8. Output. When you click on *Output* on the Main Screen or Circuit Analysis screen top-row menu, a sub-menu will appear naming the types of output files you can view. Click on *Point-to-Point Run* to view the output file made by VOACAP for the last circuit prediction. The Windows WordPad program is used for this function, and files shown in WordPad may be printed. Both input and output data are shown together in the point-to-point run file. Separate sub-menu items are provided for normal and reversed area coverage runs. On the Circuit Group screen, you can click on the Output menu time to see the VOACAP output for the last circuit run in the group.

9. Screen Hints. Many screen objects have hints that appear when the mouse cursor is placed over the object. For example, the hint for the Open Bands bars defines the colors and notes that the bars are for current time. In another example, the Inputs Panels include hints that define acceptable ranges of each parameter. In the Inputs, Area Coverage panel, hints are provided for each of the principal functions.

There are hints on each of the two main circuit dots that appear on the Main Screen and the Circuit Analysis Screen. The red transmitter dot hint shows the transmitter call sign, location, the great circle path distance (in the units selected in the File, Options panel) and the azimuth angle in degrees from the transmitter to the receiver. The azimuth, or bearing, is defined as the angle from the North Pole measured clockwise around the horizon. In ACE-HF, azimuth angles progress from 1° through 360°. (Thus 360° = 0°.)

The green receiver dot hint shows the receiver location, the path distance and the azimuth angle from the receiver back to the transmitter. The two azimuth angles may be used to set directional antennas to the angles of the propagation path. (See the *Inputs* Help Tutorial.) All path data is shown on the Inputs, Circuit panel.

There is a hidden hint on the Main Chart when the S-units time graph is displayed. This graph also carries an Elevation Angle curve, and you can find its value by placing the tip of the cursor on the curve. The hint will give both time-of-day and elevation angle values.

10. ID Timer. It is assumed that Ham operators will likely display the ACE-HF Circuit Analysis Screen during on-the-air contacts, in order to continuously monitor the status of open bands on various circuits. As an operational aid, ACE-HF includes an ID Timer to assist during on-the-air operations by reminding the operator of the need to identify his transmission every ten minutes. Use the Circuit Analysis Screen Pop-Up menu and click on *Start ID Timer*. A small digital clock will appear to the left of the Open Bands Boxes. At every ten-minute interval the clock background turns red. Click on the clock object to reset the alarm for the next ten-minute interval. The timer will continue to count total time from the time it was first invoked. To stop the timer entirely, use the Pop-Up menu again and click on *Stop ID Timer*. The ID Timer is repeated on the Main Screen and may be reset from that screen, but can only be started and stopped entirely by using the Circuit Analysis Screen Pop-Up menu.

11. Main Screen Pop-Up Menu. The Main Screen also has a Pop-Up menu, invoked by right clicking anywhere on the map. This Pop-Up permits the user to *Show* or *Hide* various screen features that may have been created using the Main Screen *Screen Features* menu item. To learn more about the Main Screen features, read the *Screen Features* Help Tutorial. The Main Screen Pop-Up is also used to *Show* or *Hide* the Open Bands boxes, and starting with V2.06 the pop-up may be used to change maps.

12. Print Screen. A copy of the *PrintKey 2000* freeware program was copied to the \ace-hf folder during the installation. PrintKey 2000 may be used to print a screen image when the Print Screen key is pressed. If you want to use this feature, click the Main Screen, *File, User Options* menu item and click the *Install PrintKey 2000 Print Screen Utility* checkbox. The PrintKey 2000 program will be automatically installed now and whenever you next re-start ACE-HF. When you then look in the Windows system tray (in the right-hand part of the Windows task bar) you will see a “hand” icon, confirming that PrintKey 2000 has been installed. Right click on the PrintKey 2000 icon to be sure it is set for *No Dialog*. You can always remove PrintKey 2000 from your PC by clicking *Exit* in the icon menu and unchecking the User Options checkbox. For a more comprehensive print utility, see http://www.warecentral.com.

13. Analysis Charts. More details of the Circuit Analysis charts are discussed in the *Circuit Analysis Charts* Help Tutorial, and chart parameters are discussed in the *Basis for the Predictions* Help Tutorial.

14. Saving Scenarios. ACE-HF user settings are saved automatically when you close the program, and are recalled when the program restarts. You can place a number of Screen Features on the Main Screen (see the *Screen Features* Help Tutorial), and sets of these features may be saved and recalled as **.scn* files using the *Save/Recall Screen Features* items on the Main Screen *File* menu. For example, suppose you have a favorite HF network you have defined with a set of screen features. You may save and recall the features using this function.

15. Installing a New Station Location File. If you move, or if you plan to temporarily operate your station at a new site (at a DXpedition location, for example) and wish to make ACE-HF predictions for that location, you can obtain an additional station location file from http://www.acehf.com. In most cases, the new file will be E-mailed to the user.

For new location files where the original call sign is used but a different location is specified, the new station location file will come with a (fictitious) suffix appended to the call sign, or you can specify your own station name when you order the file. ACE-HF will accommodate up to 20 characters in the name. This station name will appear in the upper left corner of the Main Screen and Circuit Analysis screen, and will also show in the area coverage predictions list when you run predictions for the new location. The list can then contain predictions from the new as well as the original location, and you can select files of either type.

To change the ACE-HF station location, start ACE-HF and use the *Install New Station Location File* function in the Main Screen top-row File menu. You may install from your download folder if you have received the new file via E-mail. You no longer need to exit and re-start ACE-HF for the new location to become effective. When you return home, use the same process to reinstall the original station location file that was distributed with the ACE-HF CD.

16. ACE-HF and GeoClock. If you have GeoClock installed on your PC, you probably use it to watch the day-night terminator as it approaches your station. This is particularly useful during contests, when the higher-frequency bands often open at the onset of the daylight hours. Also, you can use GeoClock to quickly find the local time at a distant receive location.

ACE-HF and GeoClock can be used together so you can watch the Open Bands Boxes and the circuit prediction charts while you keep an eye on the GeoClock terminator display. One handy screen arrangement is to call GeoClock from the ACE-HF Circuit Analysis Screen top-row menu, and then use the GeoClock Window Controls to reduce its window size while maintaining the 4 x 3 aspect ratio. Put GeoClock in the upper-left corner of the screen and reduce its size so that its lower edge is about even with the equator of the ACE-HF map. (In GeoClock, type C and then NOCITY to remove the GeoClock city labels.)

If you have called the ACE-HF Summary Chart, you can now watch the summary predictions—and even the ID Timer if you have started it—as well as the Main Chart predictions while you note the terminator’s passage in the GeoClock window. You can switch back and forth between ACE-HF and GeoClock by using the Windows ALT + TAB function.

17. ACE-HF and Logging Software. In the same manner, you can use ACE-HF and your favorite logging program simultaneously. One of the popular logging programs can be installed on your computer and called in a separate window. Use the ALT + TAB keys to switch between the applications.

In fact, you can call all three programs—ACE-HF, GeoClock and your logging software and switch between them at will. Windows multi-tasking is a great capability for this purpose.

18. Dual-Screen Operation. ACE-HF now supports dual-screen operation. You can start ACE-HF and drag it over to a secondary monitor while you view another program on the primary monitor. Or, you can use your dual monitors to simultaneously display different ACE-HF screens. For instance, you can start ACE-HF on the primary monitor, invoke the Inputs screen and drag it to the secondary monitor. Then, run the circuit prediction and show the Circuit Analysis screen and the Inputs screen simultaneously.
HINT: If you do use dual (or more) screens, it is best to set both monitors to the same resolution.

19. Full Screen Setting. From the File, User Options panel, you can set ACE-HF to operate in the *Full Screen* mode regardless of the PC's current resolution setting. Or, you can select *Normal Screen* mode, where the ACE-HF screens remain in their native 800x600-pixel size. This Normal setting is useful when multi-tasking on a monitor that has been set at a higher resolution. Then, ACE-HF can be dragged to a convenient corner of the monitor screen and other programs can be shown elsewhere on the monitor.

If you have a monitor capable of displaying a very high resolution, say 1600x1200 pixels, another useful arrangement is to set ACE-HF in the *Normal Screen* mode and drag its screens around until you fill all four corners. You might have the Inputs screen in the upper-left corner, the Circuit Analysis screen in the upper-right corner, the Circuit Group screen in the lower right and GeoClock in the lower-left corner. At this time, due to map-drawing limitations, it is not possible to further change the size of the ACE-HF screens.

20. Selecting Maps. Click the *Maps* item on the Main Screen top-row menu to see a preview window and selections for other maps. Four world maps and 24 quarter-world maps are included, as well as several close-up maps. When world or quarter-world maps are shown, click on the arrow controls to the left and under the preview window to select the desired map. Click *Accept* to install the map on the both the Main and Circuit Analysis screens. The map selection panel may be invoked from either the Main or the Circuit Analysis screen, and a map selected from either screen will be automatically echoed to the other screen. You may also select the principal maps from the Main Screen pop-up menu.

21. Lat-Lon Locations. When you are on the Circuit Analysis screen, left click on any location to readout latitude and longitude at the cursor location. Hold the left button down and move the mouse cursor around the map to read lat-lon at other locations.

INPUTS

HINT: If your printer is connected and on and you have enabled PrintKey 2000, press the *Print Screen* key to make prints of the four ACE-HF Inputs panels. Refer to the prints as you read this tutorial.

1. Circuit Input Panel. Click on the *Inputs* top-row menu item on the Main Screen, the Circuit Analysis screen or the Circuit Group screen to access the Inputs Screen. The four tabs at the top provide access to the four principal panels. Use the Circuit panel to specify parameters for a point-to-point circuit.

The Circuit panel is divided into three sections. The top section deals with the transmitter parameters, where you specify transmit power and transmit antenna characteristics. The station location has been customized for your station, but you can install alternate locations if you have acquired them. (See section 15 of the *Hidden Features* Help Tutorial.) In the Ham Mode, your transmit station location is fixed and the database button is used to select a receive location. In the SWL mode, your receive station location is fixed and you can use the database to select any transmit location.

In either case, the transmit power entry should be the power delivered to the antenna, not the transmitter output power. Be sure to reduce the transmitter output power by any transmission line and mismatch losses. Selecting antennas is discussed in the next section of this tutorial. Although the transmitter and receiver nomenclature of this panel implies a one-way circuit, it is recognized that most circuits are bi-directional and it is assumed that a common antenna is used for transmit and receive at each terminal. So antenna settings in the transmitter section are for both transmission and reception at that location.

The Receiver section of the panel permits the user to specify parameters for the distant end of the circuit in the Ham mode. You can specify a distant receiver's location in three ways. You can access the locations database, as is explained in the *Database* Help Tutorial. Or, you can move to the Circuit Analysis Screen and change the location by moving the receive dot on the screen, as was discussed in the *Hidden Features* Help Tutorial. Or you can manually type in the information, including latitude and longitude using the keyboard. Either way, when the selection is made the path parameters shown in the System Parameters section of the panel are automatically updated. In the SWL Mode, you can specify parameters in the transmit panel. Note that you always specify the man-made noise level on the receiver panel, regardless of the user mode you have selected.

Path distance is shown in the units that were selected on the Main Screen, File, *User Options* panel. The great-circle azimuths at both ends of the circuit are computed for both short and long paths. The path type may be changed between *Short* and *Long* using the buttons at the right of the Systems Parameters section. Try this and see how the path graphic changes on the Main Screen and Circuit Analysis screen. But be careful to return to the default Short Path setting unless you really want to use Long Path calculations.

Other controls of the System Parameters section permit you to change Smoothed Sunspot Number (SSN), Month, Service Type and Required Reliability for the circuit computation. (See *ALE Simulations* in the *Basis for the Predictions* Help Tutorial.) The Month setting automatically defaults to the current month and each of the others has default selections as well. The Service Type selections refer to the Required SNR (RSN) levels that may be specified in the Circuit Options panel. Man-made Noise values may be specified in that panel, also. You should always re-run the predictions after changing any of the circuit parameters.

2. Selecting Antennas. ACE-HF now has an improved antenna selection capability, permitting the user to specify and select an unlimited number of antenna models. The various selections are described in detail in the *Antennas* Help Tutorial. Here, we will simply define the controls.

To choose an antenna for either end of the circuit, click on the *Select Antenna* button in the respective panels. The Select Antenna screen will appear, with buttons for the various antenna categories. The *User* category appears by default. To select an antenna from the UserAnt folder, click on the line you want and then click the *Accept* button. The Inputs screen will reappear, showing the selected antenna in the right-hand antenna panel. Note that you can click on *Default* in either antenna panel to select an Isotropic antenna. When an Isotropic antenna is selected, the gain of that antenna will be set to the value that is specified in the Inputs, Antenna Options panel.

3. Setting Antenna Azimuths. Both antenna panels of the Circuit panel permit the user to set antenna azimuth in two ways. You can use the arrow control to specify an exact azimuth in degrees (or you can edit the azimuth box directly from the keyboard), or you can click the *Point at* box. When you click the two *Point at* boxes, the antenna azimuths will be automatically pointed at the other ends of the circuit, along the great-circle path. You can check this by noting the computed great-circle azimuths in the System Parameters panel. Usually, one should check the *Point at* boxes unless you have a directional antenna that is fixed in one direction. In that case, different paths will produce off-azimuth antenna gains that vary in accordance with their patterns. The azimuth angles are saved automatically when you leave ACE-HF.

4. Retrieving New SSN Values. You should update your Smoothed Sunspot Number estimate every month by using this function. Click the *Get New SSN* button to automatically access the Internet and retrieve the current month's estimate. Or, you can select a different month and year from the SSN Retrieval panel to explore SSN variations at future (or past) dates. Once selected, click on *Accept* to install the new estimate in the User SSN box on the Inputs, Circuit panel. The *User* SSN box can also be edited manually if you have no Internet access and wish to enter the estimate yourself. The source of and basis for the SSN estimates are discussed in the Solar Effects section of the *Basis for the Predictions* Help Tutorial.

5. Calculating Magnetic Declinations. ACE-HF permits the user to compute magnetic declinations for both circuit terminal locations. Click on the *Calc Mag Dec* button in the System Parameters section of the Circuit panel to update the values. Both Magnetic Declinations and Magnetic Azimuths are computed by this function, and should be updated by the user whenever a new location is selected, if they are needed.

Magnetic azimuth values are useful for positioning a directional antenna in the field by using a compass. Compass headings may be taken directly from the magnetic azimuth computations and will help to optimize system performance at locations when declinations are unknown. ACE-HF magnetic declination and azimuth computations are made using the MAGPOINT software, derived from the U. S. Department of Defense World Magnetic Model (WMM). You can read about the WMM at:
http://www.ngdc.noaa.gov/geomag/

6. The Circuit Comment Line. The Circuit Comment Line repeats all the point-to-point circuit parameters in abbreviated notation. It's a good idea to routinely check this line before running your predictions, to be sure the selected parameters are what you really want. The comment line is repeated as a title line on the Main Chart of the Circuit Analysis Screen. The Comment Line updates automatically each time you change a setting on the Circuit panel or on the Circuit Options or Antenna Options panels.

7. Saving and Recalling Circuits. You may save all the Circuit panel settings by using the *Save/Recall Circuit* buttons. (These functions are repeated under the Main Screen *File* menu item.) For example, if you have a regular schedule with a ham friend in Italy and you know his antenna type, you can save and recall the details of that circuit for later use. You can always restore the circuit defaults by recalling the a Default file. The current circuit is shown above the Save Circuit button. The circuit files save only the terminal information and receive-site noise setting, so you can use the same file when you change a system parameter, such as *month, service type*, or *SSN*.

If you select the Ham Mode, circuit files are saved with the extension *.ckh*. In the SWL Mode, circuit files have the extension *.cks*. Thus, you can save two types of circuit files depending on the user mode selected.

8. Circuit Groups Inputs. Change to the Inputs, Circuit Groups panel to see the parameters for defining groups of circuits. In the Ham Mode, this function permits you to define terminals at the distant end of up to eighteen circuits, with each using your station as the local transmit terminal. In this case, the circuit groups use the transmit power, antenna selection and antenna azimuth settings from the Transmitter section of the Inputs, Circuit panel. In the SWL Mode, you can define the transmit terminals of up to eighteen circuits, and the receive terminal settings are taken from the Receive section of the Inputs, Circuit panel.

In the Ham Mode, to specify a new group circuit, select a distant location using the Ham Receiver section of the Circuit Groups panel. You can select the location by using the database, by typing in the data, or by moving the Rx Dot on the Circuit Analysis Screen. In either case, the resulting path parameters are shown in the Ham Receiver section and you can calculate new magnetic declination and azimuth values for each location selected. The antenna azimuth settings for the distant terminal may be set here as well, using the Circuit panel methods. You can use the *Point At* method, or you can set the azimuth at a fixed angle if you want all receive locations to have a common fixed azimuth setting.

In the SWL Mode, the Circuit Groups panel label will change to SWL Transmitter, but the method is the same as described above.

Once you have specified the parameters of a circuit, you can *define* that circuit as one of the group by clicking the *Define Circuit* button. The circuit's terminal parameters will appear in the list. You can continue to define different circuits and enter them in the list until as many as eighteen circuits have been defined. You can edit the list using the Insert and Clear buttons.

HINT: If you wish the Circuit Group antenna to point at the other terminal, be sure to check the *Point At* checkbox on the Circuit Group antenna panel before you start defining circuits. The usefulness of *Circuit Groups* is discussed in the Circuit Groups Help Tutorial.

9. Automatic Circuit Group Definitions. If you click the *Auto Define* checkbox on the Inputs, Circuit Groups panel, you can then go to the Circuit Analysis Screen and automatically add circuits to the Defined Circuits list. Each time you move the green or red dot to a new location, you will have the opportunity to name the distant end of the circuit. When you then click on *Accept*, a circuit by that name will be added to the list.

This feature is useful in contest situations, where you want to quickly set up circuits to various target areas in order to make predictions of when the bands might open to those countries. The default Isotropic antenna is often used in these cases. Each group of eighteen target areas may then be saved for future reference.

10. Changing System and Frequency Settings. Note that the defined circuit list includes only the terminal parameters of the circuit. This is done purposely in order to permit changes in system parameters without the need to re-define the circuits. Suppose, for example, that you have defined circuits for eighteen contest areas and have set the system parameters to exclude the Sporadic-E calculation. You can go to the Inputs, Circuit Options panel and activate Sporadic-E predictions without changing the group list. Or perhaps you have been working CW in your contest and want to see what the target area predictions might be for SSB voice operation. Just go to the Inputs, Circuit panel, select the SSB Service Type, click the *Circuit Group* tab and re-run the group predictions. Current system settings, as well as the current frequency selections for the ten bands, are summarized on the Inputs, Circuit Groups panel.

11. Saving and Recalling Circuit Groups. Groups of up to eighteen circuits may be saved under user-denoted filenames by clicking on *Save Group*. A previously saved group may be recalled using the *Recall Group* button. These functions are repeated under the Main Screen *File* menu. You can also recall a saved group directly from the Circuit Group Screen. The same filename extension, *.grp,* is used for either the Ham or SWL Mode, so it helps to describe the group by a unique name in the filename.

12. Area Coverage Inputs. Change to the Inputs, Area Coverage panel to see the controls for making area coverage predictions and for creating displays. The controls for these functions are described in the *Area Coverage* Help Tutorial.

13. Circuit Options Inputs. Change to the Inputs, Circuit Options panel to see other controls for setting system values. Here you can vary frequency settings, can specify different values for Required SNR (RSN) and Bandwidths of each Service Type, and can change the Man-made Noise Levels. You can also control whether the Sporadic-E model is to be included in the prediction computations and whether the *NORMAL* or the *IONCAP* Absorption Model is to be used (see Inputs section 14, below).

Each numerical parameter has a default value, which can be recalled by clicking on the appropriate checkbox. Because these parameters are controlled and used in many locations within the program, an indirect method is used to change the values on this panel. Just type the desired new value in the white box, and then click on the target box. As is true throughout the program, the general rule is that only white boxes can be edited.

There are two overall defaults for the RSN and Bandwidth values. The standard settings are for standard Ham service, where the more conservative RSNs recommended by VOACAP for operator-to-operator service are given. A second default group, labeled *DX/Contest Defaults,* are for less conservative RSNs that an experienced Ham operator might use in contest situations. The latter defaults should be used with caution however, and are discussed more thoroughly in Section 15 of the *Basis for the Predictions* Help Tutorial, under "How to Manage DX and Contest Situations". For SWL users, the same RSN values may be used, but the AM service type for International Broadcasting should usually be selected.

When you pass the mouse cursor over a value box, a hint will give the range of permissible values. The program has various error traps that will disallow inappropriate entries. For example, entries must be made in ascending order as you move from top to bottom of the frequency list. You can select different frequencies within that limitation. For example, you may wish to specify a 75-m frequency for the 80-m Ham channel.

14. Using the Absorption Models. In 1999, VOACAP was changed to include a more conservative model of nighttime signal absorption for frequencies below about 4 MHz. The previous IONCAP absorption algorithm was replaced because it was feared to be in error, since very little measured data supported the low-frequency predictions.

Since then, however, anecdotal experiences by Hams and other HF operators have reported nighttime signal reception where the VOACAP model computed no connectivity. Recent tests show that for some circuits, the IONCAP model results in higher signal predictions. ACE-HF now permits the original IONCAP absorption model to be invoked if the user wishes to experiment with this different computation. The absorption model selection is found on the Inputs, Circuit Options screen. Initially, ACE-HF defaults to select the NORMAL absorption model setting to emphasize that those desiring more conservative predictions should always use the standard VOACAP absorption model.

WARNING: Please observe the hints that appear when the mouse is placed over the Absorption Model controls and read the warnings shown there about the use of the IONCAP model.

15. Saving and Recalling Frequency Lists. If you make changes to the default frequency list, you can save those frequencies and recall them later using the *Save* and *Recall Frequency List* buttons. The CD contains a *Hambands.frq* file and an *SWLexample.frq* file that were included during installation. You can also restore default values for the total list by clicking on the *All Ham Bands* checkbox.

16. Antenna Options Inputs. Change to the Inputs, Antenna Options panel to see other controls that change antenna parameters. If you have specified one of the Isotropic antennas using the Select Antenna function, you can specify its gain here. Separate controls are provided for both terminals of point-to-point circuits. These same gain values are used when defining circuit groups and making area coverage runs.

HINT: If you change one or both of the Isotropic antenna gains after defining a circuit groups list, you must redefine the list before running Circuit Group predictions.

The Elevation Angle panel lets the user specify a minimum take-off angle for the transmit antenna. Three degrees is the default. Three degrees prevents unrealistic low-angle gains from being used by the program, and permits the simulation of obstructions in the near field of the antenna. [Lane, April 2001, pp 9-3, 9-4].

Creating Multi-Channel Antenna Schedules is discussed in the *Antennas* Help Tutorial.

CIRCUIT ANALYSIS CHARTS

ACE-HF includes many analysis charts. Those of the Main Chart may be graphed as a function of time-of-day or frequency. To change the chart style, select *Time* or *Bands* (*Chans.* in the SWR mode) using the controls at the left of the chart. (The Values and Modes controls are described below.) Use the Analysis Screen Pop-Up menu or the Analysis Screen *Chart* menu item to select one of the following parameters:

1. SNR. The default chart graphs signal-to-noise ratio for the specified circuit and input parameters vs. time-of-day. The controls on the right select the band (channel) or time-of-day to be graphed, depending on the chart style selected on the left. Try animating the charts, using the indicated controls.

The charts show two values for SNR. The black curve at the top of the time-of-day chart is SNR in dB-Hz and its values show in the cursor hints. (dB-Hz is the ratio in dB between the signal power and the *noise density*, expressed as the amount of noise power per Hertz.) The lower black curve is SNR in dB for the bandwidth specified in the Inputs, Circuit Options panel. In the Bands (Chans.) chart, the taller bars are for SNR in dB-Hz, while the shorter bars show SNR in dB at the specified bandwidth. (The use of bandwidth settings is further discussed in the *Basis for the Predictions* Help Tutorial.)

SNR is the primary measure of circuit quality and is used to define whether each band is *Open* or *Closed*. In the time-of-day chart, SNR predictions are interpolated to show values at five-minute intervals, and the blue flashing bar shows current time. The solid horizontal line repeats the Required SNR level in dB-Hz for the selected service type, and the dashed line shows a level 10 dB below the solid line. Both lines move automatically as the Service Type is changed. Chart colors are green, yellow or red, depending on the value of predicted SNR with respect to the two lines.

The chart's title—derived from the Inputs, Circuit comment line—summarizes the circuit being graphed, and changes automatically when a new parameter is selected. The SNR chart's left axis label also reflects the reliability level specified for the circuit.

Predicted SNR levels are related to the Required Reliability specified for the circuit. Since Required Reliability is equivalent to Time Availability, if we specify, for example, a Required Reliability of 90%, the predicted SNR levels of the chart will be those that can be achieved 90% of the time, or during 27 days of a 30-day month.

Most charts of the *Time* style include *terminator bars* at the bottom of the graph. These bars show the condition of the circuit at each time-of-day. A light blue bar means that both ends of the circuit are in daylight; a dark blue bar indicates an all-nighttime path. Medium blue means that the day-night or night-day terminator (the twilight zone, or gray line) is passing over some portion of the path. The terminator bars are based on an approximation of the time sunlight encounters the F2 ionospheric layer at either end of the path in defining whether twilight conditions exist in the path, and are set for an ionospheric height of 420 km. The terminator bars, together with the predicted SNR levels, can help to explain why a particular circuit may be open or closed. (Moving terminator zones are also included in the Area Coverage displays.)

Terminator Bar colors are computed for Short Paths only. Further discussions of terminator bars and of circuit quality may be found in the *Basis for the Predictions* Help Tutorial.

2. Values and Modes. When the default *Values* control is selected in the Hints box, the chart hints show the value of the top line at each point on the graph. When *Modes* is selected, chart hints show the Most Reliable Mode (MRM) of the propagation prediction. The mode hints identify the number of hops and ionospheric layer for the MRM. For example, a mode hint of 2F2 indicates that the MRM has undergone two hops from the F2 layer over the circuit path.

In the long-path model, the hint gives the ionospheric layer that reflects the optimum ray from the transmitter followed by the layer that reflects the optimum ray to the receiver, e.g. F2F2, or F1E. (See the *Basis for the Predictions* Help Tutorial for a discussion of the Short and Long Path models.)

The MRM hints are computed for each hour, but since it is impossible to interpolate alphabetic strings the mode hint for each hour is held constant for subsequent values until the next hour is encountered. Thus, the MRM hints are only accurate at the hourly values.

3. Required Power Gain. This chart graphs the additional power gain needed to meet the specified Required SNR level at the Required Reliability. When the values are negative the chart is green, showing that excess power exists to meet the circuit SNR criteria. When the chart shows red values, more power is needed for the specified circuit.

Required Power Gain is related to the predicted SNR (at the specified reliability level) and to the Required SNR value. Levels in the red region of the chart show the amount of power increase (in decibels) required for the communication system to reach an SNR level that achieves the Required SNR and Reliability. Required Power Gain is computed as the Required SNR minus the predicted SNR at the specified reliability.

Power gain is the combination of antenna gain (at both ends of the circuit) and transmit power level. For example, if a station operated with a 100-watt transmitter and Required Power Gain at the current time indicated a deficiency (red) of 10 dB, adding an amplifier to transmit 1000 watts would restore the circuit to the required SNR level. Required Power Gain charts are useful to see how circuit power needs vary as different bands, antennas or reliability settings are selected.

One can lower Required Power Gain by using a less demanding Service Type—changing from Single Sideband to CW transmission, for example. Or, one might accept assured operation during fewer days of the month (by changing to a lower Required Reliability). For example, if a circuit prediction shows an excess power gain of 13 dB—in the green area of the chart—transmit power could be lowered from 1000 watts to only 50 watts.

4. Reliability. In ACE-HF, *Reliability* means the predicted monthly *Time Availability* for each hourly computation. For example, 50% Reliability is a monthly median level and means that the circuit would be available as predicted only 15 days of a 30-day month. 90% Reliability means that the circuit would be available 27 days of the month. As Required Reliability values increase, the prediction becomes more conservative. Most commercial HF circuits are specified for a Required Reliability level of 90% because good connectivity is required most of the time.

The *Required Reliability* setting affects the SNR and Required Power Gain predictions, but has no effect on the predicted reliability of the circuit. Reliability charts show predicted reliability for the specified Required SNR value. The reliability charts have a black line at the Required Reliability level, and the predicted values are colored green above and red below that line.

5. Elevation Angle. This chart shows the *elevation angle*, or takeoff angle, of the predicted MRM at the transmit end of the circuit. If the transmit antenna's vertical pattern is known, the chart can be used to see if the antenna's *acceptance angle* includes that of the predicted elevation angle. The chart's color changes from green to yellow if the predicted elevation angle falls below the Minimum Angle value entered on the Inputs, Antenna Options screen. Click the *Grid Lines* control to more easily read this chart. (See the discussion of ACE-HF's additional Antenna Analysis Charts in the *Antennas* Help Tutorial.)

For path lengths of 7000 km or less, the receive-site reception angle is the same as the takeoff angle. For longer paths, different takeoff and arrival angles may occur when the Long Path model prevails.

The principal propagation mode changes when the predicted elevation angle shows a strong peak. Such changes indicate a discontinuity in the MRM, which can occur very quickly. One should use caution in choosing a *best frequency* at a time-of-day when such propagation discontinuities occur.

6. Signal (dB microvolts). The signal chart shows signal strength as it would be measured at an assumed 50-ohm receiver input. Predicted signal strength is graphed in dB with respect to one microvolt across 50 ohms. Each curve of the *Time* style Signal chart may be turned on or off using the controls at the right.

Signal strength is computed directly from the VOACAP-predicted *S DBW* parameter, which is median signal power expected at the receiver input terminals in dBW. Median means that actual signal levels may be higher or lower than the values predicted for 15 out of 30 days in a month. To convert to signal strength as shown on the chart, *Signal (dB microvolts) = S DBW + 137.*

The signal predictions are interesting as one band is compared with the other, but only the SNR predictions should be used to determine circuit quality. The signal values are merely hypothetical levels that assume the arriving signal has been transferred to the receiver without loss. Since the receive antenna, the transmission line insertion loss and other losses peculiar to each station are not considered, the data should only be used for relative comparisons. The signal and noise levels used for SNR predictions are much more reliable, because they are treated as a ratio that remains unchanged by individual station factors.

Users will sometimes note that signal graphs appear to reach a constant minimum in the higher bands. The lower bands are controlled by the program's absorption model, which can reduce signals to very low levels. But the upper bands are controlled by the *Above-the-MUF* model, which has a limit of no more than 25 dB loss. For this reason, upper-band signals often have limited negative value ranges.

7. Signal (S-units)/Elevation Angle. Signal levels in dB microvolts are converted to signal-units (S-units) in this final graph of the Main Chart. Again, these are median signal levels. Median means that actual signal levels may be higher or lower than the values predicted for 15 out of 30 days in a month. Signal levels are broken into ranges for each S-unit. For example, any signal level from 3.2 to 5 microvolts is evaluated as *S4*.

In an attempt to emulate the S-meter of a typical HF receiver, the S-unit graph is purposely made non-linear. In the middle of the scale, each S-unit represents about a 4-dB range. The scale tapers to about 10 dB per S-unit at S1 and at S9, and is calibrated at S9 where *S9 = 50 microvolts.*

The S-unit vs. time-of-day chart also includes a graph of the predicted elevation angle, or takeoff angle, of the predicted MRM at the transmit end of the circuit, repeating the curve from the Main Chart Elevation Angle graph. Elevation angle data alone is hard to evaluate because VOACAP will present such data for any circuit, even when predicted signal levels are well below those of noise. This combined graph helps to evaluate when bands are truly open or closed.

When the S-units chart is selected, and the Hints box *Values* function is chosen, cursor hints appear over the S-unit curves in the normal manner. When the *Elevation Angle* curve is selected, additional hints also appear over the elevation angle curve, giving values at hourly intervals.

To read an exact elevation angle value, place the cursor tip on the curve. The resulting hint gives the time-of-day value followed by the elevation angle value for that time.

8. MUF Chart. ACE-HF presents a traditional HF MUF chart in a separate panel, called from the Circuit Analysis Screen top-row menu. The MUF chart updates automatically whenever a circuit change is made, and may be hidden by again clicking on the top-row menu item, on the chart's "X" symbol, or on the pop-up menu.

The MUF curves give Maximum Usable Frequency predictions vs. time-of-day. The blue curve is the median of the daily MOFs (Maximum Observed Frequencies) over all days of the month at a given hour. The HPF (Highest Possible Frequency) red curve gives values expected only 10% of the time. The FOT (from the French: *Frequence Optimum de Travail*) green values are defined as the frequencies where the MOFs will be higher on at least 90% of the days of the month at that hour. FOT is sometimes called OWF (Optimum Working Frequency).

The MUF chart also has a blue flashing line to indicate current time, and horizontal lines showing the frequencies of each band. The band lines change automatically if a frequency change is made in the Inputs, Circuit Options screen.

MUF predictions give a measure of ionospheric conditions but do not account for other circuit variables such as atmospheric and man-made noise or antenna gain. MUF values are best compared with SNR predictions when the latter use the 90% reliability setting. SNR predictions at 50% reliability often show a good circuit quality at frequencies above even the HPF curve, which merely reveals that the statistical calculations of MUF and of median SNR are different. The MUF curves are another tool for predicting *best frequency* operation, but the SNR Summary Chart remains as the most accurate measure of circuit quality and is best used at the higher reliability levels.

9. Best Frequency Chart. SNR is again graphed for each band in the chart of this separate panel, called from the top-row menu of the Circuit Analysis Screen. The graph is similar to those of the *Bands* style Main

Chart except that here values are interpolated to five-minute intervals. Bar colors are the same as those of the Main Chart *Bands* graphs and change with respect to the Required SNR lines.

The Best Frequency chart updates automatically every five minutes and whenever a circuit parameter is changed. The *Best Frequency* at the current time is that of the flashing bar. The chart may be hidden by again clicking on the top-row menu item, on the chart's "X" symbol, or on the pop-up menu.

For short circuits, the bars of Best Frequency chart sometimes exceed the normal scale height. An Auto-Range control is provided to reduce the bar height to a readable value.

10. SNR Summary Chart. The SNR Summary Chart provides perhaps the best overview of circuit quality, because it presents a simultaneous summary of predicted SNR at all frequencies and all times-of-day for the specified circuit, service grade and specified reliability. The SNR Summary Chart is called from the Circuit Analysis Screen top-row *Summary Charts* menu and is updated automatically when a new prediction is run.

In this chart, SNR data for each band and each hourly time-of-day has been interpolated to form a 300 x 288-point grid. Each grid point is then colored green, yellow or red in accordance with the Required SNR value, and a legend is given at the top of the chart. You can move the mouse pointer over the chart to position the chart crosshairs over the current time-of-day and more accurately read the chart data.

The chart is best used for a Required Reliability of 90%, where the green area is then bounded by the 90% contour and represents the *Operational Working Area*. The upper-frequency bound of the green area is then the Frequency of Optimum Traffic (FOT) *for the Required SNR and grade of service*, and the lower-frequency bound is the Lowest Usable Frequency (LUF). Assured contacts will most likely result when the frequencies and times-of-day of the green area are used as a guide.

The SNR Summary Chart curves are similar in shape to those of the MUF chart but are more useful, since they are based on all parameters of the circuit. The curves of the MUF chart summarize only the ionospheric conditions of the given path, month, sunspot number and time-of-day, whereas the SNR Summary is based on all the parameters of the circuit and its environment. The chart may be hidden by again clicking on the top-row menu item, on the chart's "X" symbol, or on the pop-up menu.

11. REL Summary Chart. The REL Summary Chart is similar to the SNR Summary Chart except that here the predicted reliability (time availability) of the circuit is presented. In this case, the three colors represent areas where predicted reliability is >90%, >50% and <50%. The chart may be hidden by again clicking on the top-row menu item, on the chart's "X" symbol, or on the pop-up menu.

12. Selected Antenna Analysis Chart. A special antenna chart for analyzing any operational antenna that has been selected may be invoked from the Circuit Analysis Screen *Summary Charts* menu item. This chart is discussed in more detail in the *Antennas Analysis* Help Tutorial.

13. Type 13 Antenna Analysis Chart. Any VOACAP Type 13 antenna model may be analyzed by invoking the chart from the Circuit Analysis Screen *Summary Charts* menu item. An interesting three-dimensional chart is included in this capability. The Type 13 charts are discussed in more detail in the *Type 13 Antenna Analysis* Help Tutorial.

AREA COVERAGE

You can make animated ACE-HF area coverage displays to your own specifications, as described here.

HINT: If your printer is connected and on and you have enabled PrintKey 2000, press the *Print Screen* key to make a print of the Area Coverage Inputs panel. Refer to the print as you read this tutorial.

1. Making Coverage Displays. Making ACE-HF area coverage displays is a two-step process. You must first make the coverage predictions. Then, you must create an ACE display to show the results. Click on the Main Screen *Area Coverage* menu item to see the Area Coverage Inputs panel.

When you run area coverage predictions, a separate ACE Grid (AG) file is automatically made and saved on the hard drive. Each AG file contains a comment line that can be viewed by clicking on the Predictions List button. The AG file list also appears when clicking the Create Display button.

2. Coverage Predictions Trial Run. Try making a trial run for one time-of-day using the default settings in the Coverage Predictions panel. Click on *Run Predictions* on the Coverage Predictions panel. (A panel giving an estimate of run time and the required hard drive storage space will appear. Just click *Yes* for now.) The run may take from seconds to a minute or so, depending on the speed of your PC. A small VOACAP window helps to keep track of the run. Also, note that the *Run Predictions* button is replaced by an *Abort Run* button, which is removed when the run is completed.

3. Coverage Prediction Parameters. The top portion of the Coverage Predictions panel provides settings for SSNs, Channels and Times-of-Day. Predictions may be made for ranges of these principal parameters. The time-of-day may be set to current time—the time that is closest to present PC time as adjusted by the Clock Offset setting. However, you may select another (or several) times-of-day by clicking on the checkboxes. Or, you may select *All* TODs to create predictions for each hour of the 24-hour day. Click on C*lear* to uncheck all the boxes. ACE-HF will remember the area coverage selections when re-starting.

By default, the Channels selection is set for Chan. 6 (20 m), but you can select any channel or groups of channels by clicking on the checkboxes. Clicking on *All* will select all channels. Click on *Clear* to uncheck all the boxes.

In the SSN panel, you can select your estimate (the *User* value) for the current smoothed sunspot number for running predictions. The *User* value is entered on the Circuit Inputs panel (see the *Basis for the Predictions* Help Tutorial). Or, you can select a preset value or click on *All* to specify a range of five SSN levels. Click on *Clear* to uncheck all boxes.

Area coverage predictions are also specified by other settings on the Circuit Inputs panel. For example, predictions will be made for the current month unless you change to some other month on that panel. Area coverage runs will also be made automatically for the Antenna Types, Service Type and other parameters selected on the Circuit panel. (An exception is the Circuit Reliability setting—all area coverage runs are made for 50% and other reliabilities can be selected when creating the displays.) All selections are repeated in the Area Predictions Comment Line.

4. Reception Area Predictions. When the Coverage Predictions controls are set for *Normal* predictions, and when ACE-HF has been set for the *Ham* User Mode, conventional *transmission area* coverage predictions centered on the user's transmit station are made. (Please see the *SWL* Help Tutorial for differences when the *SWL* User Mode has been set.) But when *Reversed* is selected, *reception area* predictions are made instead. In the Reversed mode, the area coverage prediction is centered on the receiver location that has been selected on the Inputs, Circuit panel. The receiver location may be selected by choosing a location from the database, by entering a location manually using the keyboard, or by simply moving the Rx Dot on the Circuit Analysis Screen. Thus, an unlimited number of receive locations may be selected for creation of AG files.

The Reception Area prediction is a powerful feature of ACE-HF, in that it permits the user to generate area coverage predictions for the center of any target area in the world. Although the transmit location is at a fixed location, the reception areas are not. Creating a group of reception area predictions for each world target area is an excellent way of predicting when the bands will be open to those targets during contest situations.

Note that reception area predictions permit the user to specify the power level of the theoretical transmitters within the area. That power level is set in the Inputs, Circuit Transmitter panel as Tx Pwr. When in the *Ham* mode, reception area predictions also utilize the transmit antenna in the Inputs, Circuit Transmitter panel, but an omni-directional transmit antenna should always specified for Reversed predictions.

In the *SWL* mode, Normal area predictions may be created for *any* transmitter specified in the Inputs, Circuit Transmitter panel. In the SWL mode, when Reversed predictions are specified, the user's fixed receive station location is used. All these differences are clearly shown in the area coverage comment line.

5. Area Predictions Comment Line. All parameters of the area predictions are automatically listed in the *Area Predictions Comment Line* as the parameters are changed. You should check the comment line to be sure you have the desired combination of parameters before running the predictions. The Area Predictions Comment Line also appears as an ID line at the bottom of the coverage displays.

Spend some time understanding the nuances of the comment line. First, note that a ">" or a "<" sign appears between the two groups of parameters to indicate the direction of transmission. In the *Ham* mode, the ">" sign shows a normal transmission from the user's station to all receive points of the area grid. In the reversed case, the "<" sign shows that the receive station location and antenna configuration—given at the left of the "<" sign—are receiving signals from area transmitters characterized at the right of the sign. Also, antenna types and their current azimuth settings are now listed in the comment line.

In the *SWL* mode, when Normal predictions are made, the ">" sign shows a prediction from *any* transmitter that has been selected in the Inputs, Circuit panel. In the Reversed setting, the "<" shows that a prediction can be made from transmitters in the grid to the user's receive station.

In either case, system parameters are then listed on the comment line. Some of these are now abbreviated (for example SSN is now shortened to S) in order to assure a proper appearance in the MOVIE ID lines.

When both Normal and Reversed AG files have been made in an arbitrary order, the predictions list will list the files in the order in which they were made. Careful attention to the >, < and RV marks will help to sort out the differences. In creating a multi-frame display, when you select one file of either type ACE-HF will select only similar files of the same type (normal or reversed) when you select *All Times* or *All Channels*.

With the addition of the Absorption Model selection (see the Inputs Help Tutorial, section 14), an "N" for NORMAL or an "I" for IONCAP has been added at the end of the comment line. All times are in Universal Coordinated Time (UTC) but the hour of the run is shown as hhZ, where *Z* means Zulu (military) time.

6. Antenna Azimuth Settings. Both transmit and receive antenna azimuths may be set in area coverage predictions. If a directional antenna has been specified for the transmit station, the Inputs, Area Coverage panel provides for setting the azimuth for the antenna's main beam when running Normal predictions. Once set, the antenna azimuth is presumed to remain fixed for all bearings of the area coverage predictions. (If you want to predict equal power emissions at all azimuths, select an Isotropic Antenna on the Circuit Inputs panel, or choose some other omni-directional radiator.) It is interesting to compare the areas covered with omni and beam antennas. In the latter case, a fixed azimuth will clearly show a concentration of emission in that direction.

For Normal predictions, an omni-directional receive antenna should be specified. If directional receive antennas are used, the same azimuth setting will be applied to each grid-point location. Using a fixed azimuth directional antenna is rare, but could be found. One example might be an aircraft with a directional antenna flying through the area.

For Reversed predictions, only the receive antenna may be set, and it is assumed that an omni-directional antenna has been specified for the grid transmit locations. If a directional receive antenna has been specified, the azimuth may be set to a fixed direction.

7. Run Silent Mode. When you run area coverage predictions in the default mode, a small VOAAREA window appears for each run at the top of the screen. The repeated appearance of the window helps to keep track of each run's progress, but can be distracting when long unattended runs are desired.

By clicking the *Run Silent* checkbox, subsequent runs will be made with the VOAAREA window hidden. With Run Silent checked, ACE-HF automatically switches back to the Main Screen where run progress messages then appear. ACE-HF can then be minimized and other Windows applications may be used while the area coverage runs continue in the background. You can switch immediately to other applications without minimizing ACE-HF by pressing the Windows keyboard button, or by using the ALT+TAB keys.

You can abort a run at any time by clicking the Main Screen *Abort Run* button after the run has been started in the silent mode.

8. Runtime Considerations. When you make a coverage prediction run for one time-of-day, the program makes repeated runs of point-to-point circuit predictions along paths from the transmitter to a grid of worldwide receive points. ACE-HF always runs a grid of 61 x 61 receive points at a spacing of 3 x 6 degrees in latitude and longitude. After you start a run, a small window appears at the top of the screen listing the time-of-day of the run and other principal parameters. You can watch the run tick off 61 rows of calculations, each of which has 61 receive points. Or, you can *Run Silent*, as explained above.

When you select *All* TODs, for example, ACE-HF will automatically repeat the process 24 times, once for each time-of-day. If your PC requires, say, 5 seconds to make a single run, then an *All TOD* run will require 2 minutes. That sounds like a long time, until you realize that VOACAP is running 61x61x24 = 89,304 circuits for each case!

Each time you click on *Run Predictions* the run-time estimate panel appears, summarizing the number of runs you have specified and giving an estimate of the total run-time required for the set. For the first run, you should use your watch to measure a single run and enter the number of seconds required for that run in the white box. Then, whenever you specify an array of runs, the program will predict the approximate run-time for the set. The program will save your single run-time estimate.

If you have specified the maximum range of SSNs, Channels and Times-of-Day, the program will make 1200 sequential runs automatically. If you are satisfied with the predicted runtime and space requirements for the specified set, then click on *Yes* to start the procedure. If you feel that the total runtime is too long for now, click on *No* and select a more modest set of runs.

After you start a set of runs, the *Run Predictions* button will change to an *Abort Run* button. If you start a run and then notice something wrong in the run window or in the comment line, just click on *Abort Run* and start over. If you have allowed a bad run to complete, use the Predictions List *Delete Item* function to delete the bad run.

HINT: Take the time to build a database of area coverage predictions. If you create monthly 24-hour predictions for each channel (and for a range of SSNs), you only have to do so once a month. If you have a large hard drive, the predictions you make may then be used year after year, unless the SSN value has changed significantly. (PCs are great things: they can run ACE-HF while you sleep!)

9. Building a Predictions Database. Each time you run an area coverage prediction, whether it is for a single time-of-day or for a selection of parameter ranges, the resulting *ACE Grid* (AG) files are saved automatically. The program permits up to 99,999 such files to be saved. You can review the database by using the *Predictions List* button. A list of file numbers with their time-of-day extensions and their area prediction comment lines will appear. You can then delete any file to remove duplicate or erroneous runs. If you manually delete one or more files outside the program, you should use the *Rebuild List* function to update the list index. The index is rebuilt automatically each time the program starts and after each internal delete.

When you run ranges of SSNs, Channels and TODs, the program will first run all specified channels for the first time-of-day and SSN, then repeat the Channel range for the next time-of-day. When all time-of-day selections have been completed, the program will move to the next SSN value and repeat the set. This process will be continued until all specified runs have been made. When you review the list of predictions, you will see the Channels grouped together for the first time-of-day and SSN, followed by the next time group, and so on.

10. Saving and Moving Prediction Files. ACE-HF includes a *Move AG Files* function that permits you to save sets of AG files in specialized folders of your choosing. A common method is to make monthly files for all channels and all times-of-day, and for the current SSN value, and then save them when the month has passed. Empty folders for the various scenarios are created during the installation for this purpose. Or, you may select or create another folder as desired using this function. For example, you might wish to save your normal and reversed predictions in separate folders. You could even create a series of folders in advance of an important contest and save groups of reverse area reception files in designated folders.

When files from the CD are installed, a series of empty folders under the \ACE-HF\AREADATA folder named *Scenario01, Scenario02, . . . , Scenario12* are made. Using the Move AG Files button, you can rename those folders to anything you wish.

You can only create displays from files that appear in the \ACE-HF\AREADATA folder, however. If you wish to make displays for specialized runs that have been saved elsewhere, those AG files must first be moved back to the \AREADATA folder.

One precaution should be noted. All AG files are automatically numbered sequentially as they are made, and those numbers start over if files from the \AREADATA folder have been moved elsewhere. The numbers appear in the filenames and are easily identified in the predictions list, along with their extensions that show the time-of-day of the run. If you wish to move files from a storage folder back to the \AREADATA folder and use them along with existing files, the stored files should be renamed with different numbers to avoid overwriting files with the same names and extensions.

11. Creating Coverage Displays. Use the lower Display Options panel to create an ACE coverage display. When you click on *Create Display*, the area coverage predictions list will again appear. Click on a single line to highlight the prediction to be used and click on *Make Display* to create and show a coverage map for one SSN, Channel and Time-of-day. Because the displays are created quickly and because the map files are rather large, displays are saved only for the current *Make Display* sequence. When you select a new prediction and start a new *Create Display* sequence, previous display files are overwritten. Remember you can make a print of the MOVIE display screen at any time by pressing the *Print Screen* key on the keyboard if you have loaded PrintKey 2000.

After viewing and exiting a display, you can show it again by clicking on *Run Selection*. Or, if you have displayed an SNR map and want to see a different parameter, select either *ALE or SNR 50, Select Rel, Select Rel & 50%* or *Required Power Gain* and again click *Create Display*. The Run Selection function is only available for recalling a MOVIE display right after it has been shown. If you change a parameter or select a different map, the Run Selection button will be disabled until you have again created a display.

12. Coverage Map Types. Four types of coverage maps may be displayed, depending on the parameter selected in the lower panel. Selecting the default *ALE or SNR 50* parameter will produce a coverage map with a single curve at the dB level of the specified service type and for 50% reliability. (The 50% reliability level has been found to best simulate ALE operation. See the *ALE Simulation* Help Tutorial.) Areas in which the signal can be received at SNR levels at or above the specified value are shown by open spaces. Areas beyond the curve are shaded red to indicate locations where lower SNRs prevail. (Every other pixel is colored red—over blue ocean areas the red shading appears as a purple color.)

When the *Select Rel* parameter is selected, a single curve at the selected reliability level will appear. When *Select Rel & 50%* is chosen, two curves appear—one at 50% and one at the selected reliability level, and the map is shaded between the curves.

When *Required Power Gain* is selected, three curves appear. The center, white, curve is the same as that of the SNR 50 display and shows the limits of coverage at zero additional power gain. The other two curves are for power gains of plus and minus 10 dB with respect to the center curve. The red curve defines the further areas that could be covered if 10 dB of transmitter power or antenna gain could be added. The green curve shows the smaller coverage area that would result if the combined power gain of the transmitter and/or antennas was reduced by 10 dB.

In each display, an identification (ID) line appears below the map. The ID line repeats all details of the area predictions comment line. An added label in the lower left corner identifies the display as one for SNR, Reliability, or Required Power Gain.

13. Coverage Displays Parametric in Time. Most animated displays are parametric in time-of-day. To create such a display, click on *Create Display* and highlight one file on the list. If you have created predictions for *All* TODs, there will be 24 such files in the listing, all having similar comment lines except that their TOD value will be different. You may hold down the Control key and click on each in turn to highlight all 24 files, but there is an easier way. After highlighting one of the files, simply click on the *Select all Times* button. All 24 files having identical comment lines will then be highlighted. The number of files selected appears in the title line. Then, click on *Make Display* to create the coverage display.

If you have more than 24 highlighted files, you can hold down the CTRL key and left click on the one(s) you want to exclude. Or, you can use the *Delete* button to delete the unwanted files from the area database.

When you create a display with 24 time-of-day files, the area coverage display will appear for the hour that is near the PC's time as corrected by the Clock Offset function. The display will then advance automatically every hour on the half-hour before the hour. This feature is handy in contest situations, when you wish to watch how coverage changes as time progresses.

14. Coverage Displays Parametric in Frequency. Once you have created predictions for all times-of-day and for all channels, it's easy to create animated displays that are parametric in frequency. Just highlight one of the listed files and click on *Select All Channels*. All the files at the selected time-of-day and for all channels of that comment line's parameters will be selected. Then, click on *Make Display* to create the coverage display.

If you have more than ten highlighted files, you can hold down the CTRL key and left click on the one(s) you want to exclude. Or, you can use the *Delete* button to delete the unwanted files from the area database.

15. Custom Displays. You can *mix and match* your grid files to create a custom animated display. For example, suppose you wish to examine the effects of sunspot numbers on area coverage from your station on your favorite channel. First, use the *Run Predictions* function to specify a time-of-day and channel of interest and build prediction grid files for all SSN values by selecting *Range* in the SSN panel. After the predictions have been made, you can then select the resulting grid files when you create a new display by using *Control + Click* to *gang* the selections so that groups of coverage maps for the five SSN values appear in sequence. Click on *Make Display* and a single animated display parametric in SSN and frequency will be created.

There is no limit to the number of frames (display screens) in one display file. You could, for example, generate a display parametric in both SSN and Channels. Another interesting example is to make an AG file with the Absorption Model set for NORMAL, then repeat the run with the model set for IONCAP. You can then display the two runs with animation to quickly see the effect on coverage.

16. Selecting Maps. Displays should be created for the default world map area the first time. But you can shift the world map to the right, 90 degrees at a time, by using the arrow keys under the map preview window. Then create the display or click *Run Selection* if you have already created a display. (*Run Selection* is disabled after each parameter or map change.)

If you want to see a more detailed coverage area, you can select the Quarter-World option and move the map area up and down and from side to side using the arrow keys to the left and under the map preview window. Any quarter-world area can be so specified, and you can create a new display. Twenty-four quarter-world maps are available. The preview image may be moved 30 degrees at a time in latitude or 60 degrees in longitude in any direction.

There are also six special-area maps that may be selected from the area coverage Map Type panel.

17. Using the Area Coverage Displays. The area coverage displays are great for quickly finding the transmission or reception areas where the bands are open. However, at the edges of coverage those displays should not be interpreted too literally.

A proper procedure is to use the area displays to get a quick overview of a circuit's effectiveness, and then run a point-to-point prediction to "zero in" on circuit conditions. You can then watch the Main Chart change as you vary various parameters to study system sensitivities. For example, if you find that a circuit is to operate at frequencies that are close to being "above the MUF" at one time-of-day, you may wish to change to another channel where the propagation path is more stable.

18. Using .MCS Files for Area Coverage. Starting with V2.06, you may use Multi-Channel Antenna Schedule (.MCS) files when you make area coverage predictions. This means that an .MCS file may be created, saved and then specified on the Inputs, Circuit panel. The same or different .MCS file(s) may be specified for the transmitter and receive antenna entries. (See the Antennas help tutorial for creating .MCS files.)

When an .MCS file is created, a different antenna and a different transmit power level may be specified for each frequency channel. (For example, you may wish to specify 50 watts for the power-restricted 60-m band, and say, 1000 watts, for the other bands.) When a sequence of, say, ten area coverage predictions at different frequencies are then created, the correct antenna and transmit power will be automatically applied for each AG file.

When you specify an .MCS file on the Inputs, Circuit panel, or on the Inputs, Circuit Groups panel, only the .MCS filename is needed. But when the area coverage runs are made, the comment line automatically changes to show the specific antenna and transmit power for each channel from within the .MCS file. Then, when an area display is created and animated, the MOVIE ID line will show the changing antennas and powers during the animation.

WARNING: When an .MCS file is made, it is common to utilize antenna models that were made for a specific frequency. For example, you might specify ten Type 13 antenna models, each of which is unique to a given frequency. One must be careful to use only .MCS files that were made for a particular frequency list. If the run uses an .MCS file that was made for frequency list "A", but the user has since changed to frequency list "B", the resulting predictions will be wrong, but the program will not trap that error.

HINT: Although only eight characters are permitted when naming and saving an .MCS file, try to choose a name that indicates an antenna group as well as the frequency list used. For example, name the file as *TF50HamF.MCS* for a group of 50-meter long Terminated Folded Dipole antennas that were selected for the ten ham frequencies. (The example TF50 Type 13 files may be found in the *TF50.G#* antenna folder.)

COVERAGE DISPLAY ANIMATION

Map Animation. When a 24-hour display (or a display parametric in another parameter) is made, progress messages and screens are shown as the display is created. The display then switches automatically to the *MOVIE* program to show the area coverage prediction. The Movie display starts on the hour nearest to the PC's time as modified by the Clock Offset function. The display will then advance automatically every hour on the half-hour before the hour.

You can animate the display by using the controls below the Movie window or by pressing the 0 through 9 numeral keys (not the function keys) on the keyboard. However, the animation keys will not work initially until you first *Pause* the display. (This is because the automatic hourly advance is itself an animation, which must be interrupted before you can start a faster animation.) If you have made a display for a single hour, channel or SSN, only one map frame is shown, and the automatic advance and the animation controls will not function.

Each ACE-HF time-of-day display file typically contains 24 full-color coverage displays (frames) repeated at hourly intervals. Other display files may contain multiple channel or multiple SSN displays.

Animation Controls. Once an ACE display has been created, the display may be shown in movie-like fashion using the animation controls below the MOVIE window. After pausing the automatic animation, clicking one of the numbered keys starts the animation and sets the speed. The VCR-like controls at the left may be used to fast forward or run backwards at the previously selected speed. The center button pauses the display, and the arrow keys may be used to single-step backward or forward. Click on the X button to close the Movie and quit the window.

In previous ACE-HF versions, keyboard controls were used to control the animation. Those keyboard controls are retained and are described below:

P	Pause display. (You must Pause the display before setting animation speed.)
0 – 9	Set animation speed (9=fastest). (Both top-row number keys or keys on the numerical keypad may be used, but not the function keys)
+	Single step forward.
–	Single step backward.
X or Escape	Exit back to the Area Coverage Inputs screen.

ANTENNAS

Specifying transmit and receive antennas is perhaps the most difficult task in any HF circuit simulation. And yet antenna type, siting and gain variations can influence prediction integrity more than most other parameters. For this reason, ACE-HF includes several aids to antenna selection, as discussed below.

1. Selecting Antennas. You may select from an unlimited number of antenna types for both ends of the point-to-point circuits, for circuit groups, and for area coverage predictions. You may add your own antenna models in any one of several antenna folders or modify antenna models that were provided during the installation. You may also select from the 1650 new *Antenna Central* models that were added in Version 2.06. You may analyze your antenna choices using several new analysis screens. This Help section describes the controls for selecting antennas. Subsequent sections discuss how the antennas may be used.

When you click on one of the *Select Antenna* buttons, the Select Antenna screen appears with numerous selection controls. When ACE-HF was installed, various sub-folders were created to contain antenna files of various categories. The contents of each sub-folder may be accessed by clicking on one of the antenna model buttons at the bottom of the screen. The available antenna models in that sub-folder will then appear in the list. (See section 5 of this tutorial to learn about the special methods used to select Antenna Central models.) Highlight one of the files in the list and click on *Accept* to install that antenna in the circuit. The software will remember which Select Antenna button was clicked to get to this screen, and will install the antenna in that panel. You can check this when the Inputs screen reappears after you click *Accept*. If you have selected a directional antenna, remember to set the azimuth when you return to the Inputs screen.

2. User Antennas. An initial set of antenna models was installed from the CD into the \UserAnt sub-folder. This is a good place to add any new models you might create, or they can be added in one of the specialty sub-folders, or in both places. Or you can modify the antennas as noted below. The initial user antennas were taken from the VOACAP Samples folder and re-named here. They are briefly described below:

BNTWHP38.38. This 20-foot whip antenna is based on the VOACAP Type 38 Inverted-L model, and is an approximation of vertical whip antennas where the top portion is bent over to form a horizontal section. In this case, the horizontal end is 1.5 meters long and the lower vertical section is 4.6 meters in height. (Those dimensions may be modified by using the HFANT program, by clicking on the Main Screen HFANT menu item). Such bent whips are often used for short-distance circuits where NVIS (Near-Vertical Incidence Skywave) radiation is required. (Note that the model does not approximate the curve of a conventional tied-down whip, but treats the two sections as being at right angles to each other.)

DIPOLE23.23. This common horizontal dipole antenna has the same radiation characteristics as the VOACAP SAMPLE.23 antenna, but may be modified by the user as explained in the *Modifying Antennas* section below. Unmodified, the antenna is assumed to be a half-wavelength long and a quarter-wavelength above ground at all frequencies. Note that these filenames repeat the VOACAP extension number within the filename itself in order to shorten the designations in the comment lines while preserving the identification.

INVL28.28. This is another Inverted-L model, based on the VOACAP Type 28 Inverted-L model. In this case, it approximates a vertical whip where the top portion is bent over to form a horizontal section. This example is 15 meters long, with the vertical section being 1.4 meters long. Again, the model does not approximate the curve of a vertical whip that has been bent gradually, but treats the two sections as being at right angles to each other.

ISOT.000. A theoretical Isotropic point-source antenna that radiates equally well in all directions. It has equal gain at all azimuthal and elevation angles and is often called a perfect omni-directional radiator. In the Inputs, Antenna Options panel, ACE-HF provides for adding gain to both the Transmit and Receive Isotropic antennas. Default gains of +6 dB approximate the gain of many amateur antennas, but the model should be used with caution, as it is impossible to create a real antenna that radiates equally in all directions. This ACE-HF Isotropic antenna is the same as VOACAP CCIR.000. (NOTE: Do not attempt to vary gain by changing the ISOT.000 antenna's gain using HFANT. Instead, use the Inputs, Antenna Options panel. Isotropic antenna gain may be varied from –90 to +90 dBi, but this adjustment affects predicted signal power only. Predicted noise power will not be modified by the adjustment.)

LOGPER05.05. The Log Periodic is a good directional antenna choice – an all-band antenna with a main beam that can be pointed in any horizontal direction. This choice is similar to the VOACAP SAMPLE.05 antenna, and has 29 elements. You will probably want to modify this specification to better describe a more practical ham antenna. Note that this file has set all element heights at 19.2 meters above ground to simulate a rotatable LP. The SAMPLE.05 model assumes a conventional sloping log periodic element arrangement.

NONE.999. An Isotropic antenna with gain set at –40 dB. Used with multi-channel antenna schedules to simulate the fact that no practical antenna is available for the designated channels. Its use effectively takes those channels out of the calculation.

SWWHIP.VOA. This Short Whip selection is based on the VOACAP SWWHIP.VOA design. You might want to select this choice for the receive end of your circuit, but your transmit station probably has a better antenna. A better choice for an unknown receive station might be the Isotropic antenna with +6 dB gain. The Short Whip has the same gain as a 0-dB gain Isotropic antenna and is omni-directional in the horizontal direction. But it does have a varying radiation pattern in elevation.

VERT22.22. The vertical antenna selection assumes a quarter-wavelength mast height at all frequencies with a gain of 0 dB with respect to that of a half-wave dipole antenna. This selection is equivalent to the VOACAP SAMPLE.22 antenna and radiates omni-directionally in the horizontal plane.

YAGI34.34. The Yagi selection is another directional antenna that concentrates its radiation in one horizontal direction. It is equivalent to VOACAP SAMPLE.34. A Yagi antenna is usually designed for a fixed frequency and dimensioned in feet (or meters). However, this model is dimensioned in wavelengths as may be seen by using the HFANT program. Applying a single Yagi such as this to all bands implies that you have a whole forest of Yagis, each cut for one band.

You can make your own antenna models with NEC programs like EZNEC, which can be called from within ACE-HF if it has been installed. You can install new files in the \UserAnt sub-folder or in any of the other antenna sub-folders.

3. VOACAP Antennas. The Select Antenna screen provides access to all antennas of the original VOACAP list. However, most have been re-named for use in ACE-HF by including the filename extensions within the filename. Also, some of the description lines have been enhanced to better describe the models. Click on the *Default* and *Samples* buttons to see the available models. Please note that many of these models depict antennas designed for HF shortwave broadcast use, and may be impractical for ham operation.

4. HFCC Antennas. The HFCC (High Frequency Coordination Conference) antenna folder includes 661 antenna models used by International Broadcasters. They are included in ACE-HF to support simulation of shortwave circuits when using the SWL mode. Most of these antennas are VOACAP Type 01 models that are large curtain dipole arrays with various numbers of rows and stacks of elements and reflectors. The Type 01 variations include different heights above ground and are also shown with specified *slew* angles. By changing the phase shift of currents fed to adjacent collinear arrays of elements, an azimuthal slew of the antenna's main beam may be achieved by the broadcaster. In this way, a common physical construction may be made to serve different target areas. It is quite interesting to examine the azimuthal patterns of the various Type 01 antennas.

As with all directional antenna models, when Type 01 antennas are used by ACE-HF, the main beam is assumed to point at zero degrees azimuth (toward North on the compass). The ACE-HF azimuth controls may then be used to point the antenna in a different direction, in order to focus the main beam on the desired target. Once the azimuth control has been set (analogous to physically constructing a curtain antenna to point in a fixed direction) different models with various slew angles may be selected to show how the azimuthal pattern may be made to change direction. It is instructive to make area coverage displays with models having different slew angles and show them sequentially. The animated patterns of these high-gain antennas will flick across the map, simulating what really happens at a broadcast station.

Several other antenna types are included in the HFCC folder. These include the Type 02 and 03 curtain arrays, and the Type 04 Tropical arrays. (Tropical arrays are curtain antennas especially designed to service the *Tropical* regions of the world—like in Africa—from stations in northern countries.) There are also some

Log Periodic models, Rhombic antennas, and Dipole Quadrant arrays of various types. All these models are described further in Recommendation ITU-R BS.705-1, which may be obtained from the ITU web site. (See References.)

In many of the HFCC Recommendation 705 antenna models, such as the curtain arrays, the designs are for fixed frequencies, but the antennas will work over a limited frequency range around the design frequency. For example, for the typical HF 4/4/.5 curtain array (file BC003S00.S00) the design frequency is 7 MHz and the usable operating range is from 5 to 9 MHz. Beyond those frequencies, the model's gain is set to –30 dBi to indicate that the frequency is outside the design range.

The design frequency is a setting you can make in HFANT and then save the file under a unique filename or by overwriting the original file. If you do not specify the design frequency, then the antenna will be valid for all frequencies and the design frequency will be set equal to the operating frequency. However, such changes can result in hypothetical and unreasonable antenna designs. For REAL, existing, antennas set the design frequency to the model's default in HFANT. Then, the resulting real antenna will not be valid outside its stated range, and gains at other frequencies will be set to –30 dBi.

You can examine such models using the Selected Antenna Analysis Chart, where gains may be seen to drop to –30 dBi except for certain permitted frequencies. This means that you cannot apply such antennas with abandon, since ACE-HF will then blindly apply the model to all ten frequencies and predictions for frequencies outside the antenna's range will be incorrect. Such limited-bandwidth antennas should be used within an MCS schedule, as described in section 9 of this tutorial, or should be restricted to limited frequencies.

5. Antenna Model Types. It is useful to understand how ACE-HF employs antenna model types. Because the program uses VOACAP as the computational engine, it must adhere to VOACAP standards for reading model files. In general, VOACAP reads the second numbered file record in order to determine the file type, and internal code switches to various subroutines to create vertical and azimuthal radiation patterns unique to each type. If you modify a file manually, you can rewrite the first line comment, but do not modify the number in the [2] Antenna Type record or the second line showing how many parameters are to be read.

Most of the VOACAP antenna model types carry other records that permit the user to modify the antenna using the included HFANT program. For example, the DIPOLE23.23 file allows the user to modify the ground conductivity and dielectric constant, and to change the antenna length and height. The rest of the pattern-making details are handled internally by the VOACAP program. There are exceptions, however:

Type 13 files are gain-table files where 360 tables (for 360 horizontal degrees) containing gains at each of 91 vertical degrees are listed. The VOACAP code uses these gain tables directly to determine antenna radiation in each vertical and horizontal direction. The files are unique to a particular antenna and frequency. All the files included in Antenna Central are Type 13 files.

Many Type 13 files are provided on the ACE-HF CD. If you make your own files using EZNEC V5 or some other NEC software package that outputs VOACAP-compatible formats, they will be Type 13 files. Type 13 files may be used in ACE-HF for either point-to-point, group or area coverage predictions.

Type 14 files are also gain-table files, but are for special cases. These files include 30 tables of 91 elevation angles for 30 frequencies, but are for a single calculated azimuth. They can be used for point-to-point predictions only, and are not really suitable for general ACE-HF predictions.

If you create or modify your own Type 13 antenna model files, remember these ground-rules:

A. Each filename must have eight characters maximum, and internal decimal points are not allowed. (a VOACAP DOS constraint).
B. The filename extension must always be *.13* for use within ACE-HF.
C. The first line of the file is an arbitrary comment line, but must be limited to 75 characters in length.
D. The file can be placed in any \ANTENNAS sub-folder.

6. Examining Antennas. One great advantage of ACE-HF is the ability to evaluate different antenna models in terms of their potential effect on coverage. Without the labor and cost of erecting a complex array, one can "try it on for size" if a suitable antenna model is available. Try the process by making some trial comparisons. Choose, for example, a simple horizontal dipole antenna and make an area coverage prediction for your favorite band. Then select one of the higher-gain antenna models and again make a prediction. When you create the coverage display, you can place the two predictions in adjacent frames and move back and forth between frames to see the difference. Different antennas you may be considering may be compared in the same manner. The process is quite instructive and is great fun. More importantly, this capability to correctly model antennas and show their effects underscores the importance of a correct HF system simulation.

Any of the antennas may be examined by using HFANT. And all the Antenna Central Type 13 models may be understood by using the Type 13 Antenna Analysis chart, called from the Inputs, Circuit Analysis menu.

7. Practical Limitations. When you select an antenna type, ACE-HF applies that antenna to all frequencies of the circuit simulation (unless you have created and called a Multi-Channel Antenna Schedule). That's acceptable if you use the default Isotropic antennas at each end, but it may be an impractical model for all channels. For example, you may be unlikely to erect a 160-m vertical antenna, which at a quarter-wavelength would be more than 100-feet tall! Also, the default antenna specifications are set in fixed wavelengths, and it's physically impossible for a single antenna to have a fixed wavelength at all frequencies. For these reasons, ACE-HF provides for further customizing your antennas.

8. Modifying Antenna Models with HFANT. When you select *HFANT* on the Main Screen top-row menu, ACE-HF opens the VOACAP HFANT program, which permits the user to customize most of his antenna models. (The Type 13 gain-table models are exceptions. However, HFANT can still be used to view the patterns of Type 13 models.) In HFANT, click on the *File, Open* menu item and select one of the antennas in any of the antenna sub-folders. For example, open the \UserAnt\DIPOLE23.23 file to examine the specifications for the Horizontal Dipole antenna. (NOTE: Do *not* use the HFANT File, *New Type* function, as those antenna filenames are renamed in ACE-HF. Instead, open the desired antenna file using the File, *Open* function.)

Most antenna files permit you to change the ground conductivity and dielectric constant values. You should begin your customization by setting those values to better describe your transmit site, for each of the antenna choices where ground parameters are given in the files. (Note that such settings will then also apply to the antenna choices for the receive site. So if you want different site conditions for a receive site that uses the same basic antenna, you should copy and re-name the file for that condition using HFANT.)

In the horizontal dipole antenna file, you may set the physical length and height above ground in meters. The program will then use those dimensions for all the bands. Or you can create a generic file by setting the dimensions in wavelengths, but its use across the bands implies a family of dipoles.

One should use caution in specifying and using antenna models. When antennas are called by ACE-HF, the program assumes the station has a lossless matching network that transfers all transmit power to the antenna in each band. Known mismatch losses should be accounted for by modifying the transmitter's power in the *Circuit Inputs* panel.

The HFANT program also permits you to plot the vertical and horizontal radiation patterns of each antenna at a specified frequency. Look at the patterns for your modified horizontal dipole to understand this feature.

After you have modified an antenna, you must then save the modified file. Save the file using a filename of your choice in any antenna sub-folder.

9. Creating Multi-Channel Antenna Schedules. HF antennas are seldom designed for all-band usage. A Ham station might have one all-purpose antenna, such as a half-wave horizontal dipole or a vertical, or it might have multiple antennas with each covering one or more bands.

ACE-HF now permits the user to specify up to ten different antennas at either end of a circuit, each assigned to an individual channel. In the Inputs, Antenna Options panel you may select a different antenna for each of ten antennas—the antennas you have customized using the HFANT program or any of those in the antenna sub-folders. MCS files are particularly useful when using Type 13 antenna models.

You may also specify the transmit power for each range of bands. This is useful for automatically reducing transmit power in the 60-meter Ham band to the restriction of 50 watts ERP. Remember that in ACE-HF, the transmit power level entered in the program is the transmitter output power reduced by any coupler or transmission line losses as it is fed into the antenna. The 60-meter ERP restriction means that you must work backwards and determine the equivalent transmit power level at the antenna input that will result from the 50-watt ERP constraint. The equivalent transmit power level will thus vary depending on the gain of the antenna to be used for 60-meter operation.

You may specify a particular antenna for one channel or for multiple channels. For example, in the Ham Mode, you might specify a horizontal dipole for the 160-meter band only Channel 01 using the Dipole23.23 model from the \UserAnt folder. (Channel frequencies are defined in the Inputs, Circuit Options panel.) You might then specify the same horizontal dipole for 80 meters, etc. But remember that the dipole model is an example of VOACAP *mathematical* models, which exist as sets of algorithms (equations) within the VOACAP code. Thus, you may use such models for multiple frequencies and the program will automatically apply the correct gains for each particular frequency. But that is not true for VOACAP Type 13 models, which have each been made for a set frequency and cannot be changed. (See the Antenna Central section of this tutorial.)

If you have other antennas for which mathematical models exist, such as the Vert22.22 model, you might specify that vertical for 60 through 30 m, switching to a log periodic for 20 through 10 meters. However, a more accurate simulation will exist if you specify a unique Type 13 antenna model for each channel. These may be NEC models that you have made yourself, or examples you have selected from Antenna Central.

If you have one Ham antenna that is designed for, say, 40 through 20 meters and no other antenna is available, you could select the *None.999* model for 160 through 60 meters and *None.999* for 17 through 10 meters. When *None* is selected, the program specifies an Isotropic antenna with –40-dB gain, which effectively takes that channel out of the picture. That action prevents the program from finding *Best Frequencies* that are outside the range of the station's hardware.

After creating a Multi-Channel Antenna Schedule, you must then save it as an *.mcs* file by clicking on the *Save Antenna Schedule* button. Saved schedules may be recalled by clicking on the *Recall Antenna Schedule* button. Take care in naming your .mcs files so that the filenames will be meaningful when using the schedule. Each filename must be limited to a maximum of eight characters, with an .MCS extension.

To apply a Multi-Channel Antenna Schedule, use one of the *Select Antenna* buttons to invoke the Select Antenna screen. Then click on the *Multi-Chan* button to bring up the list of .mcs files. Highlight the desired file and click *Accept* to install the file. Each .mcs file shown in the list carries a program-made comment line showing the antenna model name and transmit power level for each of the ten selections.

10. Antenna Central.

10.1 The Collections. In section 5, we learned that Type 13 models are gain-table files made by NEC. Many collections of Type 13 antenna models have been added in ACE-HF V2.06. The word *collection* emphasizes that, unlike the antenna math models, each Type 13 model must be generated for a specific frequency. Thus, there will be many files in a collection. For example, with an eight-element Yagi antenna with many variations, there are 28 Type 13 files. For this Yagi antenna, files are grouped together in a separate folder.

For the ham bands, L. B. Cebik has created 1650 Type 13 antenna models and has organized them into separate folders by type for use within Antenna Central. Each collection has many files for different variations as well as frequencies. For example, the *\ANTENNAS\y-8s.A#* folder includes a collection of 28 three-element, short-beam Yagi models for the 80-10 meter band, with variations for different heights above ground. See section 11 of this tutorial for Dr. Cebik's detailed antenna descriptions.

10.2 Navigating the Screens. Given the large file quantities, managing and selecting Type 13 antenna models could be a complex task, but ACE-HF has devised a simple method for organizing the process. Within Antenna Central, separate Folder Management and File Management screens have been added to make model selection simple. To select an antenna, or a group of antennas, one follows this sequence:

1) From the *Inputs Circuit*, *Inputs Circuit Groups*, or *Inputs Antenna Options* panel, click on one of the *Select Antenna* buttons. The Select Antenna screen will appear.
2) In Antenna Central, click on the *Folder Management* button. After extracting files from folder(s), return to Antenna Central.
3) In Antenna Central, click on the *File Management* button. Here you may view files from within each folder and select a file for a circuit or circuit group, or to create a new Multi-Channel Schedule. Return to Antenna Central or select a single antenna model to install it.

10.3 Folder Management Screen. Because many Antenna Central files are now available and the size of the files is large (about 270 kb each), ACE-HF has compressed the files into a single self-extracting ZIP file within each folder. The folder and its self-extracting file have the same name in each case. For example, the *\ANTENNAS\y-8s.A#* folder has a single *y-8s.exe* file, which contains, in this case, 28 Type 13 files.

Within each folder, there is also a Contents.TXT and a Help.TXT file. The Contents file contains a one-line explanation of the folder's contents, and shows as a screen comment alongside its folder name. Click the Help button to read details about the folder's content.

At the bottom of the Folder Management screen are buttons that access antenna models placed into six categories. The *ham-band* categories are:

- ***Horizontal Polarization:***
  A. Rotatable Arrays
  B. Multi-band Fixed Wire
  C. Multi-band Wire Arrays
- ***Vertical Polarization:***
  D. Basic Monopoles & Dipoles
  E. Self-contained Phased Arrays
  F. Vertical-element Phased Arrays

The ***Custom*** button accesses general models that might not fit the first six categories.

To help with the bookkeeping, each Antenna Central folder has a two-character extension. The first character corresponds to the category button letter, while the second character — a # symbol — denotes that the file is for the ham bands.

The purpose of the Folder Management screen is to extract files from the compressed folders. When the folder list appears, the number of files that have been extracted, initially zero on the CD, follows each folder name. To extract files, highlight the desired folder and click *Extract Files*. Then click *Refresh File Count* to confirm the number of files extracted. You may also delete previously extracted files from any folder.

You may, of course, extract all the files from all the folders if you wish. Once you have extracted files for the antennas of interest, cancel this screen, return to Antenna Central and click the File Management button.

10.4 File Management Screen. When it first appears, the File Management screen looks like the Folder Management screen except that the controls are different. To use this screen, first click on a folder line. The screen list will then show all the Type 13 files in the selected folder. If there are no files shown, return to the Folder Management screen and extract the files.

Once you have extracted all the files you wish to use in your application, you will routinely use only the File Management screen. Click on a folder name and the screen will change to show the files contained in that folder. You can use this screen to select a particular Type 13 file for a point-to-point or group circuit, or to populate the MCS panel, by clicking the *Accept* button.

WARNING: Remember that each Type 13 file was created for only one frequency. If you assign it to, say, a circuit transmitter, ACE-HF will use it for all ten frequencies and the resulting computation will be wrong except at one frequency. It is better to use the MCS panel and apply a different Type 13 file to each channel. Go to the Inputs, Antenna Options screen and select an antenna for each channel from the Antenna Central File Management screen. That screen includes a list of current frequencies to aid your selection.

HINT: Be sure to make and save a new .MCS file on the Inputs, Antenna Options panel after you make a new frequency list (for example if you are in the SWL mode and have selected an SWL list of frequencies. Try to choose an .MCS filename that denotes the basic antenna types (if possible) and the frequency category. For example, save a DiplHamF.MCS file to designate that the file contains a group of dipole models specified for the ham-band frequencies. The MCS filename as well as the Type 13 filenames must be limited to eight characters. (A VOACAP constraint.)

10.5 Adding New Collections. New collections of Type 13 antenna models may be created by using one of the NEC programs. (EZNEC Pro V5.0 or later is recommended.) Usually, a single NEC model may be made for each antenna type and Type 13 files can then be created for each frequency without leaving NEC. If you make the NEC files yourself, be sure to check the Type 13 file for correct format.

A new antenna collection can be saved in a new sub-folder placed under the *\ANTENNAS* folder. Use existing folder and filename conventions as a guide. The folder name may have as many as five characters, but the folder extension must be limited to two characters where the first character is A through G and the second character is #. If the extension is different, ACE-HF will not find it in the Antenna Central collection. Folder names should be based on the filenames within the folder.

New antenna filenames must follow strict rules. The first four characters denote the antenna type, and could even be a serial number referring to an external list in the case a large antenna farm. The next three characters should be numerals recording the frequency of the model in tenths of MHz. The last character will denote the assumed ground conditions for the model. (See below.) Using an example from the CD, a collection for a Terminated Folded Dipole antenna 50 meters long, in folder *t050.G#*, would have a filename format of TF50fffC, where *fff* might be *187* for 18.7-MHz and where *C* indicates average ground conditions. For the ham-band Antenna Central folders and files, you may depart from this convention. Using ACE-HF, review the folders and Type 13 file collections made by L. B. Cebik for guidance, and read the section 11.

ACE-HF has adopted these filename codes to denote different ground conditions [Cebik 2006]:

Filename Code	Soil Description	Conductivity in S/m, σ	Permittivity (Dielectric Constant), ε
A	Very Poor	0.001	5
B	Moderate	0.003	4
C	Average	0.005	13
D	Good	0.01	4
E	Dry, sandy, coastal	0.001	10
F	Pastoral hills, rich soil	0.007	17
G	Pastoral medium hills and forestation	0.004	13
H	Fertile land	0.002	10
I	Rich agricultural land, low hills	0.01	15
J	Rocky, steep hills	0.002	15
K	Marshy land, densely wooded	0.0075	12
L	Marshy, forested, flat	0.008	12
M	Mountainous, hilly (up to about 1000 m)	0.002	5
N	Highly moist ground	0.005	30
O	City industrial of average attenuation	0.001	5
P	City industrial of maximal attenuation	0.0004	3
Q	City industrial area	0.0001	3
R	Fresh water	0.001	80
S	Sea water	5.0	81
T	Sea ice	0.001	4
U	Polar ice	0.0003	3
V	Polar ice cap	0.0001	1
W	Arctic land	0.0005	3
X	Custom	user entered	
Y	Custom	user entered	
Z	Perfect Ground	--	--

WARNING: The above values for *Poor, Moderate, Average, Good, etc.* may not agree with the values that appear in HFANT for these soil conditions. Table values are drawn from many more recent sources and are used in the Nittany Scientific NEC programs [Cebik 2006]. Users may enter custom values wherever information on actual soil conditions is available, and may then enter *X* or Y as the filename code.

10.6 Making Self-Extracting Files. If you have the WinZip Self-extractor program, you may make your own self-extracting folders. The self-extracting .EXE files of the Antenna Central folders on the CD were made with WinZip Self Extractor V3.1 using the command line: *WZIPSE32 d044 -y -auto -runasadmin -d.* (The *d044* notation is an example of the .ZIP file to be compiled.) Note that this command must be made by calling WZIPSE32 from its installed Program Files location and the Type 13 files you wish to include into a new folder must first be compressed into a .ZIP file using WinZip. The .ZIP file must then be moved temporarily to that directory where WZIPSE32 resides.

You may then create a new sub-folder under the installed *\ANTENNA* folder. The new folder's name usually corresponds with the filename of the .ZIP file, and the folder's two-character extension must be as discussed in section 10.5.

11. Antenna Central Models by L. B. Cebik.

11.1 Introduction. Dr. L. B. Cebik, W4RNL (SK), wrote the following informal notes during the development of *Antenna Central* for ACE-HF. The Antenna Central files, and his notes, are included in ACE-HF V2.06 as a memorial to LB, who passed away unexpectedly on April 23, 2008. The Antenna Central Type 13 models are included as an addition to ACE-HF without extra charge for the benefit of all radio operators, in keeping with LB's wishes.

"Amateur interest in propagation software is growing. The best way to obtain the most accurate propagation forecasts and analyses for a given HF installation is to use within ACE-HF an antenna that closely resembles the actual station antenna at each frequency of operation. The resemblance need not be physical, but needs only to have a radiation pattern that closely fits the *performance* of the station antenna.

"ACE-HF provides for using a special VOACAP Type 13 file, which includes the radiation pattern in all azimuth directions and for all elevation angles, in 1-degree increments. At each operating frequency, a Type 13 model is an ASCII file of about 270 kb in size that includes all elements of the pattern in the proper format. The file uses the compass rose (clockwise) convention and counts elevation from the horizon.

"In addition, each antenna must be over ground, and for many types of antennas, performance may vary with ground quality. In the models, both rotatable and fixed directional antennas are oriented to place the main lobe (or one of the two main lobes for bi-directional arrays) pointing due North (0 degrees azimuth). ACE-HF controls may then be used to re-aim the antenna at a desired target communications region.

"Fixed antennas present different challenges for the user, and individual *Help* files that accompany each Antenna Central collection make suggestions on how to best use the models. All fixed-element arrays place the elements on an east-west line so that the broadside radiation is north-south. In ACE-HF, the antenna model must be rotated to match the physical installation.

"Users versed in the use of NEC or MININEC can create custom models of their actual antennas. Since NEC and MININEC generally use phi and theta conventions to produce the radiation pattern report, conversion is tedious at best. The latest version of EZNEC (V5) at its Plus and Pro levels can produce the desired Type-13 files by use of the three-dimension plot option.

"Users who are unfamiliar with antenna modeling may not have access to radiation patterns of typical amateur station antennas. Therefore, in Antenna Central, I have begun a process of producing Type 13 files for monoband antennas that cover most of the HF amateur bands. The files are arranged in collections as the ACE-HF screens indicate.

"Each compressed collection contains a considerable number of Type 13 files, and each collection contains example models for each band. Where relevant — for horizontal antennas especially — there are also variations for different heights above ground. The heights used for the upper HF region (20 through 10 meters) are 35, 55, 75 and 95 feet, corresponding generally to typical amateur tower heights. For the lower HF bands (80 through 30 meters), example files exist for heights of 75 and 100 feet. For vertical antennas, especially those using a ground or near-ground mounting, there are variations for ground qualities known as very good, average, and very poor. (See the Antenna Central section of this tutorial.) Where relevant, there are also variations for different sizes of radial fields, namely, 4, 16, and 64 buried radials.

"A Help file, describing the specific file-name coding used for that group accompanies each collection. (VOACAP restricts Type 13 filenames to eight characters, requiring careful coding to provide key file data.) Since all amateur antenna models are monoband antennas, the Help file also specifies any key features. For example, the Yagi collections include the free-space gain and boom length of the model to allow the user to select an antenna whose performance most closely matches the station antenna, even if the station antenna is a multi-band array. A number of directional antenna types can be omitted for similar reasons. For example, those who use quagis, log-periodic dipole arrays, and similar antennas may select the Yagi or the quad pattern shape and gain that most closely matches the performance of the actual station antenna.

"The collections do not attempt to model commercially built (or even home built) multi-band antennas. With the facilities available to most antenna makers, developing Type 13 files for each antenna in their line at each operating frequency should become standard practice, and would allow the maker to classify the file as authorized. However, until makers take this step, most amateurs will have to estimate the performance of their antennas and select from the collections the model that is closest in performance and other variables to the station antenna.

"Despite the relative ease of constructing an individual Type 13 file using the latest modeling software, the development of generally usable file collections is a long-term task. For example, the Yagi file collection contains 28 separate Type 13 files for 80 through 10 meters. File collections can include from 15 to 45 individual Type 13 files.

11.2 Horizontally Polarized Antennas.

A. Horizontal Rotatable Arrays. (Letters A through F refer to the Antenna Central category buttons.) "All rotatable arrays in the following list have separate versions for each HF band from 80 through 10 meters. The free-space E-plane (azimuthal) pattern and performance level are the same within a collection to very small limits of variation. Each antenna has a Type 13 file for each band at a specified height above average ground. (Horizontal antennas are generally less sensitive to ground quality variations than ground-mounted vertical antennas.) The heights for the upper HF region (20 through 10 meters) are 35, 55, 75 and 95 feet, corresponding generally to typical amateur tower heights. For the lower HF bands (80 through 30 meters), different files exist for heights of 75 and 100 feet. Selecting a file is a matter of determining the user's installation height and the performance level that most closely matches an available file. Some multi-band Yagi and quad designs might require selections from different collections on different amateur bands. The goal is to match performance levels and height, not to match the exact number of elements and boom length.

"All horizontal rotatable arrays use elements oriented east-to-west so that the model's main lobe points toward zero-degrees azimuth. Use ACE-HF controls to change the direction of the main lobe. One might change the orientation of the main lobe of a truly rotatable array to point at different sections of the world. If the user's directional array is fixed, then a single orientation setting is required to reflect the actual orientation of the array. The following Antenna Central collections are provided:

1. ***Monoband Yagi Antennas:***

   "2-element driver-reflector Yagis (6.2 dBi free-space gain)
   3-element short-boom Yagis (7.1 dBi free-space gain)
   3-element long-boom Yagis (8.2 dBi free-space gain)
   4-element Yagis (8.8 dBi free-space gain)
   5-element Yagis (10.1 dBi free-space gain)
   6-element Yagis (11.5 dBi free-space gain)
   7-element Yagis (12.4 dBi free-space gain)
   8-element Yagis (13.3 dBi free-space gain)

2. Monoband Quad Beams:

"The quad collection includes versions using two through six elements, with a wider-band and a higher-gain version of the three-element quad.

2-element quads (7.0 dBi free-space gain)

3-element wider-band quads (8.6 dBi free-space gain)

3-element higher-gain quads (9.2 dBi free-space gain)

4-element quads (10.4 dBi free-space gain)

5-element quads (11.1 dBi free-space gain)

6-element quads (11.7 dBi free-space gain)

3. Other Rotatable Horizontal Arrays:

"The element wires run east-to-west so that the main lobes are north-south.

2-element Moxon rectangle (6.0 dBi free-space gain)

2-element phased array (or 2-element driver-director Yagi) (6.7 dBi free-space gain)

2-element Bi-Dir. W8JK Flat-Top with 1-λ elements and ½-λ spacing (6.0 dBi free-space gain)

2-element Bi-Dir. W8JK Flat-Top with 1-λ elements and ¼-λ spacing (7.0 dBi free-space gain)

Collinear, 2-wavelengths with phasing sections (20-10-meters only)

Bi-Square with 1/2-wavelength legs (20-10-meters only)

B. Horizontal Multi-Band Fixed Wire Arrays.

"Many amateur stations employ fixed-wire antennas, such as a center-fed doublet or a large horizontal loop, for all HF amateur bands. The following Type 13 file collections provide samples of popular configurations, but by no means all configurations. All linear wire models are oriented east-to-west so that one of the two main lobes on the lowest band will project due north (zero-degrees azimuth). The user must use ACE-HF controls to re-orient the antenna to reflect the actual station installation.

"Horizontal loops come in too many variations to sample adequately. The small collections provided here are square loops with the feedpoint located at the center of the south side. Using these files requires reorientation so that the model's feedpoint is on the opposite side of the loop from the aiming direction.

"End-fed wires have their feedpoint on the west end (270 degrees) of the array. Using the end-fed models requires careful re-orientation within ACE-HF to ensure both wire alignment and feedpoint position relative to the actual installation.

"All fixed wire antennas and arrays are evaluated at heights of 35, 55, 75 and 95 feet on all bands within the normal coverage range of the antenna. For example, the 135-foot doublet (dipole) collection has files for 80 through 10 meters, but the 44-foot doublet has files for only 40 through 10 meters. All such Type 13 models use AWG #12 wire. The files show only the performance and pattern data; they do not include limitations and possible losses relative to various methods of feeding them. Note that the filename coding system for these antennas differs from the one used for rotatable horizontal beams. See the individual Help files that accompany each collection for details.

1. Linear Center-Fed Multi-Band Doublets:

"The collections contain center-fed doublets with lengths from 270 feet (lowest band = 160 meters) down to 44 feet (lowest band = 40 meters). The elements are oriented east-west so that the broadside emission is north-south.

270' doublet for 160-10 meters
135' doublet for 80-10 meters
102' doublet for 80-10 meters
88' doublet for 80-10 meters
67' doublet for 40-10 meters
44' doublet for 40-10 meters

2. End-Fed Linear Multi-Band Wire Antennas:

“The end-fed collections include un-terminated wires that are 270 and 135-feet long. The elements are oriented east-west so that the broadside emission is north-south. *NOTE:* Above the band on which an end-fed un-terminated wire is 1/2-wavelength long, its pattern will differ from patterns for a center-fed wire of the same physical length. The feedpoint is assumed to be at the west end of the wire.

270' doublet for 160-10 meters
135' doublet for 80-10 meters

3. 30-Degree Inverted Vs:

“The inverted-V collection consists of center-fed wires that slope 30 degrees from the horizontal on each side of the center point. Wires extend east-to-west. The heights listed in the files represent the feedpoint heights. Due to the 30° angle of the wires, some versions are not available at the lowest heights.

270' inverted-V
135' inverted-V
102' inverted-V
67' inverted-V

4. Horizontal Square Mid-Side-Fed Loops:

“Horizontal loops range from a circumference of 288 feet (about 1-wavelength at 80 meters) to 1152 feet (about 2-wavelengths at 160 meters). Wires extend north-south and east-west, with the feedpoint at the middle of the south wire. *NOTE:* Due to variations in the feedpoint locations and the shapes of actual installations, the samples are less certain guides to actual lobe formation and strength.

1152' circumference for 160-10m
576' circumference for 160-10m
288' circumference for 80-10m

5. Terminated Folded Dipoles:

“Each antenna is terminated with a 900-Ohm resistance at the point opposite the center feedpoint. Wires extend east-west.

165' terminated folded dipole for 160-10m
90' terminated folded dipole for 160-10m

C. Multi-Band Wire Arrays:

W8JK with 88' elements spaced 44' apart (40-20 meters)
W8JK with 44' elements spaced 22' apart (20-10 meters)
Lazy-H with 88' elements spaced 44' apart (40-20 meters)
Lazy-H with 44' elements spaced 22' apart (20-10 meters)

11.3 Vertically Polarized Antennas:

General Note: “The collections of Type13 files for vertically polarized HF antennas have several distinctive features relative to the collections for horizontally polarized HF antennas.

“1. They are generally used on the lower amateur bands from 160 through 30 meters. With some exceptions, file collections are restricted to these bands.

“2. Vertically polarized antennas are more sensitive in performance to differences in the ground quality beneath the antenna. Therefore, model collections use samples over three different soil qualities: very good (0.0303 S/m, 20), average (0.005 S/m, 13), and very poor (0.001 S/m, 5). Over the bands covered, performance differentials due to ground quality tend to be larger at lower frequencies. Other differences may be specific to the type of antenna in question. Although amateur antennas employ a wide variety of materials, all models assume the use of AWG #12 copper wire.

D. Basic Monopoles and Dipoles.

"Basic vertical antennas include ground-mounted vertical monopoles with buried radials, elevated vertical monopoles with attached radials, vertical dipoles, and multi-band vertical doublets. The ground-mounted vertical monopoles include 1/4-wavelength and 1/2-wavelength versions using models with buried radials in field sizes of 4, 16, and 64 total radials. The other antennas in this group do not use buried radials. Unless otherwise indicated, patterns are available for 160-30 meters. Patterns are available for very good, average, and very poor ground.

Ground-mounted 1/4-wl monopoles

Ground-mounted 1/2-wl monopoles

Elevated monopoles with 4 attached radials at 20' (80-10 meters)

Vertical dipoles with 0.05-wl base heights (160-10 meters)

Multi-band vertical doublet, center-fed, 44', 5' above ground (30-10 meters)

E. Self-Contained Phased Arrays (SCVs).

"SCVs are 2- or 3-element vertical broadside arrays with in-phase feeding of each vertical using a single feedpoint. They do not require ground radial systems. Feedpoint placement determines the polarization of these antennas. Patterns are available for very good, average, and very poor ground.

Half-square arrays

Bobtail curtains

Equilateral delta loops

Right-angle delta arrays

Side-fed rectangular loops

5-element Bruce array

F. Vertical-Element Phased Arrays.

"The collection of representative basic phased arrays contains both monopole and dipole versions of many types. Because of the complexity of the arrays and because any array in the collection will only approximate an actual installation, the monopole models in NEC-4 employ a MININEC ground, which is roughly equivalent to a radial field of between 32 and 64 elements. All dipole arrays set the base of the dipole at 0.05-wavelength above a high-accuracy ground system with no radial system. The collection includes monopole and dipole versions of triangular arrays that use a fed driver vertical element and two parasitic reflector elements. All arrays are situated so that a main lobe (or the main lobe) points due North (zero-degrees azimuth). Hence, broadside arrays have elements on an east-west line, while in-line phased arrays have elements on a north-south line. The 4-square array forms a diamond with the elements at 0, 90, 180, and 270 degrees. In all cases, users must reorient the models within ACE-HF to coincide with the actual installation. Patterns are available for very good, average, and very poor ground.

2 In-Phase Monopoles, Broadside Pattern

3 In-Phase Monopoles, Broadside Pattern

2 Phased In-Line Monopoles

2 In-Phase Dipoles, Broadside Pattern

3 In-Phase Dipoles, Broadside Pattern

2 Phased In-Line Dipoles

Triangle of 3 Monopoles with 2 Parasitic Reflectors

Triangle of 3 Dipoles with 2 Parasitic Reflectors

4-Square Arrays

11.4 Summary. "The total Antenna Central collection has many omissions relative to antennas and systems used by radio amateurs. Some omissions, such as the inverted-L, have too many variations for any one version to capture its specific behavior. Other omissions, such as stacks of Yagi antennas, are too variable from one installation to another for inclusion. However, despite the present size of the Type 13 collections (61 folders, with 1650 individual Type 13 files), an unlimited number of files may be user added.

"When selecting a Type 13 file, remember that the pattern shape, the forward gain, and the elevation angle are more important factors to consider than the name applied to the model. The goal is to match the Type 13 file to your best estimate of the performance of your own array or antenna. If a closer approximation is required by a specific application, then you should consider modeling your actual antenna or array using NEC.

"These notes are no substitute for mastering your own collection of amateur Type 13 antenna models. These collections are made available without warranty. Use of the files is solely the responsibility of the user."

-- L. B. Cebik

12. Running NEC Programs. If you have acquired the EZNEC or other NEC software to create your own antenna models, you can call the program from within ACE-HF. Just click on the Main Screen *NEC* top-row menu item. When you are finished creating the file, save it as a VOACAP-format Type 13 file. (Previous NEC-Win PLUS editions saved the VOACAP-format file with an .ANT extension. If you have that edition, re-name the file to a .13 file.) You will probably want to edit the file's comment line to make it more explanatory, using the other Antenna Central Type 13 files as examples. Remember the 75-character limit.

13. Managing Fixed Directional Antennas. Directional antennas are defined as those that concentrate energy in one azimuthal direction, as opposed to omni-directional antennas that emit equally in all horizontal directions. (Antennas can also focus energy at certain angles of elevation, but such emissions in the vertical plane are not considered in this definition of *directional* antennas.)

Usually, one thinks of directional antennas as those that may be rotated and pointed along a particular azimuth angle. Examples are rotatable Yagis (often called *beams*) and Log Periodics that are mounted atop a tower and rotated by a remotely controlled motor. However, there are many other antenna types that yield directional patterns in the azimuthal plane, but are fixed in position. Examples of such fixed directional antennas are Rhombic and non-rotatable horizontal Log Periodic designs, or arrays of vertical antennas.

When considering azimuthal patterns of directional antennas, ACE-HF assumes that all such antenna models have their main horizontal energy pointed at zero degrees azimuth (north). This is a VOACAP convention and has become an industry-standard rule. For a rotatable antenna, such as a Yagi or Rotatable Log Periodic (RLP), the ACE-HF user simply chooses the physical azimuth angle by adjusting a "spinner" that can be set from 1 to 360 degrees. This action points the antenna toward a distant target along a great circle line, just as an operator would point his rotatable antenna. To simplify the setting, there is a *Point At* control, which when checked automatically points the antenna toward the distant station along a predetermined path. There are independent *Point At* controls for antennas at both ends of the circuit.

For the case where a station uses a rotatable directional antenna but leaves it at a fixed setting, e.g. where the station might be unattended, the user sets the azimuth to his/her preferred direction and does not use the *Point At* control. This means that stations not on the predetermined great circle path will receive radiation off the side of the antenna's main beam, and will be so simulated by ACE-HF.

But fixed directional antennas are erected to focus their main beam toward a certain distant station. Or, a small station might install a fixed directional antenna in order to achieve gain, but may be constrained by property limitations. An example is a ham operator who erects a horizontal dipole, but installs it diagonally across his small lot.

When simulating circuits with fixed directional antennas, the ACE-HF user must know the physical direction in which his antenna's main beam is facing. (For example, a horizontal dipole emits most energy broadside to the end-to-end wire's direction.) He then merely sets the azimuth control to that fixed angle and avoids the Point At control. As before, such fixed angles are always measured with respect to true north, as they would appear on a compass (corrected by magnetic declination).

For fixed high-gain directionals like the curtain dipole arrays used in International Broadcasting, the same azimuth control may be used to simulate the use of phased feeds to create slew angles. In that case, the slew angles are usually expressed with respect to the main beam's nominal angle, so they must be added (or subtracted) from that angle. (It is an approximation to slew such models by varying the azimuth setting in this manner. For better accuracy, separate mathematical models are given for most slew angles, and there are dozens of such models included in ACE-HF.)

Many ACE-HF users employ antenna models made with a NEC program. The output of such programs is the standard Type 13 gain-table antenna model, and the user must assure that such files have been made with their principal emission pointed toward zero degrees. (Use the ACE-HF Type 13 Antenna Analysis charting capability to check such files.) This zero-degree main beam convention is used in the NEC-Win Plus and GNEC programs. The EZNEC programs permit the user to set the main beam to zero-degrees or to a designated physical angle, however. The latter adjustment will cause an error when used for ACE-HF predictions unless it is set to zero degrees.

SELECTED ANTENNA ANALYSIS

1. Selected Antenna Analysis Chart. ACE-HF includes two specialized antenna analysis charts that may be invoked through the Circuit Analysis Screen *Summary Charts* menu item. Click on *Selected Antenna Analysis* to view the chart for any antenna specified using the Select Antenna function.

This polar chart compares the selected antenna's computed vertical pattern with predicted elevation angles of the Most Reliable Mode (MRM) of propagation. One of the most difficult problems in HF station operation is matching the best vertical acceptance (take-off) pattern, and thus the best antenna, with the needs of a given circuit. The problem is particularly difficult when short circuits that rely on NVIS propagation must utilize antennas with high take-off angles. Some antennas, such as vertical monopoles, are simply not appropriate for such circuits because their vertical radiation is near zero at the zenith angle. This chart permits you to match the antenna's major lobe of radiation (the red curve) with the range of computed MRM elevation angles (the green curve). Pattern data is taken from the GAINxx.DAT files produced during point-to-point runs. These files provide elevation gains for the single azimuth settings of the Inputs, Circuit panel.

2. Creating Different Circuit Distances. With the chart showing — drag it to the side if needed — you can move the green or red station dot on the circuit analysis screen to examine different circuit distances. The chart will immediately recalculate to show the new comparison, and the range of elevation angles will be shown by the green curve with the maximum and minimum angles listed on the chart.

The chart lists both terminals of the presently selected circuit, and shows the azimuth settings for both antennas, as well as the circuit distance. If you have set one or both azimuths to fixed angles, those angles will remain fixed as you change the terminal locations. This permits you to examine the side patterns of those antennas as you move the dots around the screen. Or, as is more normally the case, you can cause the antennas to face each other by clicking the *Point At* button without leaving the chart. The azimuth values are red when the antennas point at each other. Otherwise they are black.

3. Comparing Antenna Models. This is a handy chart for examining different antenna models, which you can also do without leaving the chart. Right click on the chart to show the Circuit Analysis Screen Pop-Up menu, where you can change either the transmit or receive antenna. Antennas from any of the Antenna Central sub-folders may be selected. The chart will immediately recalculate and the different vertical pattern will be shown. The chart may be computed for either the Tx or Rx antenna, using the control at the bottom, and the selected antenna filenames will be shown in the upper left corner.

The chart also shows the Directivity Gain of the antenna. This is the maximum gain (G_{max}) at the combined azimuthal and vertical patterns of the antenna.

HINT: Even Type 13 antenna models may be examined with this chart, but when one is shown the pattern will remain fixed as you vary frequency. The green line prediction will vary, but the fixed elevation pattern reminds us that each Type 13 file is for a specific frequency only.

4. Frequency Animation. Each antenna pattern is for a specific frequency, shown below the chart, and is taken from the computed gains for each *integer* frequency. Patterns for each of ten channel frequencies (shown above in the Open Bands Boxes) may be selected by the control below the chart, and the chart may be animated through the frequency range. The ten frequencies are taken from the specified frequencies of the Inputs, Circuit Options panel, except that each is rounded to the closest integer frequency before making the chart patterns.

As each frequency is selected the directivity gain is shown, but the pattern charted has gain relative to the maximum gain at each frequency. This treatment is consistent with patterns shown in the HFANT figures. Note that for some antennas and frequencies, directivity gains are shown as –30 dBi and the patterns are uniform circles at zero relative gain. (See the discussion in section 4 of the *Antennas* Help Tutorial.) This shows that the antenna pattern is being shown at a frequency outside the design frequency range and simply indicates that the model would be unsuitable for those channels. The LOGPER05.05 model is an example, where at selected frequencies of 2 through 5 MHz directional gains are –30 dBi.

TYPE 13 ANTENNA ANALYSIS

1. Type 13 Antenna Analysis Chart.

This chart shows two polar plots of any VOACAP Type 13 antenna model, or of groups of such files. Both azimuthal and vertical patterns are shown simultaneously, and the chart may be animated through sequential files. As each pair of patterns is shown, the directivity gain (G_{max}) value is displayed along with the azimuth and elevation angles at which the maximum gain occurs. Again, as with the Selected Antenna Analysis Chart, the displays show relative gain.

This display is for Type 13 files only, and each such file must be created for only one frequency. Antenna modeling programs such as EZNEC are used outside the ACE-HF program to create the files, and users often produce libraries of Type 13 files for all antennas at their station.

2. Selecting and Animating Files. A special *\ace-hf\antennas\TP13Grps* folder has been providing during the installation of ACE-HF, but it is up to the user to create files and populate the folder. However, any Type 13 file in the ACE-HF antenna folders, including the Antenna Central sub-folders, can be imported into the \TP13Grps folder by using the *Import Models* function on the Type 13 Select Antennas screen.

As an example to get you started, another copy of the Sample13.13 file has been placed into the \TP13Grps folder. The patterns from this file can be shown separately. It was made from the HFCC antenna list and is the same as the \ace-hf\antennas\HFCC\BC003S00.S00 HR 4/4/.5 file, which can be selected for use with circuit or area coverage predictions. This example is a typical curtain antenna model with four elements per row and four elements per stack mounted 0.5 wavelengths high with a zero degree slew angle. The model has an unusually high directivity gain, yielding 21.2 dBi at 11.85 MHz, with very little backward radiation.

The BC003S00.S00 file is a VOACAP Type 01 file and can be selected for a circuit and used over a frequency range. (See the discussion in section 4 of the *Antennas* Help Tutorial.) The Sample13.13 file is for the same antenna, but is for only one frequency.

HINT: If you want to view the elevation (vertical) pattern of this antenna over a frequency range, you examine the BC003S00.S00 file using the Selected Antenna Analysis Chart. Or, you can always use HFANT to view the patterns at other frequencies.

ACE-HF asked L. B. Cebik to create a group of 29 Type 13 files for a Terminated Folded Dipole antenna, and these will also be found in the installed \TP13Grps folder. When you click on the Select Antennas button of this chart, a list of antennas found in the \TP13Grps folder appear. You can select one or more of these files just as you would the AG files of the Predictions List, then click *Accept*. Or you can simply click the *Accept All* button to select all files in the list. Click *Delete Models* to delete highlighted files.

Patterns of the 29 files, or any group of more than one file, can then be viewed manually or animated automatically through the group using the controls at the bottom of the chart. As patterns for each file are shown, the definition of the file is shown in the chart's comment line.

The example terminated folded dipole is 50 meters long and is mounted 15 meters above average ground. It is designed to have reasonable omni-directional gain above 2 MHz, but the azimuthal pattern begins to break up at 7 MHz and becomes seriously multi-lobed as 30 MHz is approached. The example was chosen to illustrate how the chart may be used to examine the effectiveness of a wide-band antenna. It also shows how such wide-band antennas, sometimes chosen for NVIS circuits, can produce rather low elevation angles when operated well beyond their design frequency range.

HINT: When the Type 13 analysis chart first appears, it remembers the last antenna file selected when the software was previously operated. To display patterns from a group of files, you must again select the desired group.

3. 3D Antenna Chart. Although standard azimuthal and elevation pattern curves are informative, they are usually made for the angles where maximum gain appears and thus tend to mask the overall shape of the antenna's emission. To view such overall patterns, you can click on *Show 3D Chart* to see a three-dimensional view of a selected antenna.

Operating the 3D chart is lots of fun, and there are many chart controls to play with. All the files previously selected for the Type 13 chart may be shown on the 3D chart, beginning with the Sample13.13 file, which has a high-gain central lobe and little backward emission. The 3D chart may be manipulated using the following controls:

A. Pattern. Click on the *Forward* and *Backward* pattern buttons to reverse the antenna 3D pattern shown.

B. View Angle. Move the *View Angle* sliders. The right-hand slider rotates the angle from right to left. The left-hand slider lowers the figure as if the viewer were to look down into the pattern from above. Click on the number above either slider to reset the figure to its default position.

HINT: It's sometimes informative to move the view angles until the pattern is seen from one plane of the figure. For example, with the Sample13.13 file, move the view angle to *Right 274* and *Up 365* to see the pattern's structure from the side. Reset the figure when you are done.

C. 2D Azimuthal View. Clicking the *2D Az. View* button will cause the 3D format to be replaced with a two-dimensional view seen from the zero-elevation plane. It's easier to read the peak values of the pattern elements in this view. Uncheck the 2D checkbox to return to the 3D view.

D. Ortho View. Click the *Ortho View* checkbox to view the pattern in a 3D orthographic format, where the three axes are orthogonal to each other. Uncheck the checkbox to return to the normal 3D view.

E. Gain Scale. The chart's gain scale can be adjusted using the buttons in the lower left corner. This is useful when low-gain antennas, such as the Terminated Folded Dipole example, are shown.

F. Single Curves. You can create curves of maximum gain that move from left to right along the azimuth or elevation scale by clicking the Single Curves *Animate* checkbox. As the curve moves, the maximum gain at that angle of the pattern is shown along with the angle being displayed. Without *Animate* checked, you can move the single curve manually using the *Az. Angle* arrows. Try clicking the *Elevation* button to animate or move the curve manually through the elevation angle planes. Viewing the pattern from the right end can help with this analysis. (The View Angle controls remain active during single-curve animation.)

HINT: These single curves are useful to examine the gain (or lack thereof) at an antenna's null-point when the path setting is off the maximum azimuth point.

G. Select Files. The controls discussed above may be used to examine any of the Type 13 files in the group list. When a group of files parametric in frequency, such as the 29 Folded Dipole files, have been selected, any one of those files may be chosen for display in the 3D chart. Just adjust the Select Antenna Files up-down control and the selected antenna filename along with its maximum gain will appear in the boxes below the up-down control. You can animate all the selected files, or you can manually examine one at a time. All the chart controls remain active during file animation.

H. Chart Zoom. If you wish to examine a particular area of the 3D pattern, you can zoom in by left clicking just to the left of the area and drag the mouse down and to the right. The chart will redraw to expand the area you have chosen. To reset the chart to normal, left click anywhere on the figure and drag the mouse up and to the left.

4. Using the Type 13 and 3D Charts. By now, you are probably wondering about your own antenna farm. What will the antennas look like for your cases? Do their patterns cover your intended contact areas without any "holes"? These charts may provide the incentive to make your own Type 13 files, or at least to take time to review the Antenna Central models. (Import them into the \TP13Grps folder before you try to view them with these charts.)

The Type 13 and 3D charts, as well as the Selected Antenna Chart were designed to support the continuing desire to properly simulate and visualize your HF circuits. They are part of the analysis capability of the software, and are useful whether you are designing a new system or determining why a particular circuit seems to be performing poorly. In the latter case, chances are that antenna choices are at fault or are perhaps unsuitable for the intended circuit. These charts, and the Antenna Central models, help one to understand antennas and to apply them wisely.

CIRCUIT GROUPS

1. The Circuit Group Display. Click on *Circuit Group* in the Main Screen or Circuit Analysis Screen top-row menu to invoke the Circuit Group screen. The display shows a table of predictions for as many as eighteen circuits that were defined using the Inputs, Circuit Groups panel. (This tutorial assumes that the reader has already read the procedures for defining circuit groups in the *Inputs* Help Tutorial.)

Each of the eighteen possible circuits is listed on the left, and the table provides for predictions at the ten frequencies specified in the Inputs, Circuit Options panel. When the *Run Predictions* button is clicked, successive computations are automatically made for each frequency and for 24 times-of-day for each circuit. The table cells will change color and receive computed values as the predictions are made. Predictions are first shown for the current time, but other times-of-day can be selected, and the display can be animated.

In the Inputs, Circuit Groups panel, different groups of eighteen circuits may be defined and saved. Each saved group may be recalled directly from the Circuit Group screen and the predictions may be re-run for that group. SNR predictions for the current time will appear in the table at the end of each computation sequence. The computed values may be changed to reliability predictions by clicking on *Reliability*.

2. Prediction Thresholds. Each cell of the table is colored in response to the RSN level for the selected Service Type as set in the Inputs, Circuit Options panel. When the predicted SNR level at the required reliability is equal to or greater than the RSN threshold, the cell is colored green. When the predicted SNR is less than but within 10 dB of the threshold, the cell is colored yellow. Below that range, the cell is colored red. Computed SNR predictions are shown by the numbers of each cell. When Reliability is selected, the cell colors are green if above the required reliability setting and red if below that value.

3. Best Frequencies. The predictions are also evaluated for best frequency. If several frequencies have yielded green predictions, the best of those cells is changed to a blue color. Also, the best frequency for the circuit group as a whole is shown by changing the top-row frequency cell from white to blue.

The Circuit Group screen can be used to good effect during contests. A group of as many as eighteen circuits can be set up in advance from the user's location to selected target areas. Each circuit can be customized for typical stations in the target area. For example, if a desired target area is in Japan and one knows that a target station uses a certain type of Log Periodic antenna, that antenna can be specified for the circuit. If the user also employs a directional antenna, the antenna azimuth can be specified for each circuit to optimize the simulation. Multi-channel antenna schedules for both ends of the circuit may be specified and defined in each different circuit as necessary. If more than eighteen target areas are anticipated, several circuit groups can be defined, saved, and recalled as needed.

Note that each circuit group is defined without regard to system parameter settings. During a contest, the same circuit group may be instantly changed, for example from SSB to CW, without re-defining the circuits.

One objective of the circuit group technique is to see, in advance, when various target areas will open up during contest operation. The Circuit Group screen chart can be advanced to any time of day and future band openings can be easily understood.

4. Short and Long Paths. A *Short* path setting is normally used for Circuit Group predictions, and the path setting is shown in the Inputs, Circuit Group *Current System Settings* panel. But if you have defined a circuit for a short path and are using directional antennas for which the "Point at" azimuths have been defined, you will obtain wrong predictions if you then change the system path setting to *Long* (and vice versa). If you truly want predictions for a group of long paths, you should define a new Circuit Group for that purpose.

BEACONS

1. The NCDXF/IARU Beacon Network. The Northern California DX Foundation and the International Amateur Radio Union have created a network of eighteen beacon transmitters around the world. These sites are a popular source of HF transmissions, used by hams everywhere for estimates of real-time propagation conditions. ACE-HF includes predictions of these eighteen beacon signals as received at the user's site.

Each of the NCDXF/IARU beacons transmits every three minutes day and night, with successive emissions on 14.100, 18.110, 21.150, 24.930 and 28.200 MHz. A clever schedule has been devised whereby the transmissions are rotated by frequency between the eighteen beacons with each frequency transmission lasting for ten seconds. (Please see http://www.ncdxf.org/beacon/beaconSchedule.htm.) The entire cycle of eighteen beacons and five frequencies per beacon can be repeated in three minutes. All transmissions are CW sent at 22 words per minute.

Each transmission consists of the beacon call sign followed by four one-second dashes. The call sign and the first dash are sent at 100 watts, with the remaining dashes sent at 10 watts, 1 watt and 100 milliwatts successively. In the ACE-HF beacon simulations, only the 100-watt transmissions are emulated.

2. Active Beacon Display. When a ham listens on one of the beacon frequencies, his or her usual purpose is to determine whether that band is suitable for receiving signals from the beacon's home country. But unless the beacon call sign can be heard clearly and unless the beacon transmission schedule is at hand, it may be difficult to distinguish which beacon is transmitting. ACE-HF solves that problem by presenting an active beacon display. The display appears by clicking the top-row Beacon menu item from the Main Screen or the Circuit Analysis Screen.

Every ten seconds, the display highlights the beacon that is transmitting on each of the five frequencies by white cells in the table. Ten seconds later the highlighted cells move down the table, following the beacon schedule. If the user's PC clock is synchronized to UTC, the active beacon display will exactly follow the beacon transmissions. A handy tool for setting PC time is to use the NIST server and client interface software available from http://www.boulder.nist.gov/timefreq. (Newer Windows PCs reset time automatically.)

3. Beacon Predictions. Click on *Run Predictions* in the beacon display to automatically run predictions for each beacon circuit to the user's receiver. SNR predictions for the current time will appear in the table at the end of each computation sequence. The computed values may be changed to reliability predictions by clicking on *Reliability*. Predictions are run automatically for all five frequencies and for 24 times-of-day. Other times-of-day may be selected, and the chart may be animated.

The predictions may be customized for your station by selecting a preferred transmit antenna on the Inputs, Circuit Transmitter panel. The selected antenna is automatically pointed at each beacon when the circuits are run. Assumed conditions at the receive end (the user's location) of each circuit may be changed by selecting a different SSN value, month, manmade noise level or required reliability. The Sporadic-E calculation may or may not be invoked. However, the signaling mode is always set to CW, at the required SNR level for that service type as set in the Inputs, Circuit Options panel.

The predictions are always run for an assumed 100-watt transmit power level and utilize a common Beacon.22 antenna model that is based on the VOACAP Sample.22 vertical monopole model that has been adjusted for an approximate gain of 0.1 dBi. The Beacon.22 antenna model is in the \ACE-HF\ANTENNAS \VERTICAL folder and may be examined using the HFANT program, called from the Main Screen menu.

4. Prediction Thresholds. Each cell color responds to the CW RSN level set in the Inputs, Circuit Options panel. When the predicted SNR level at the required reliability is equal to or greater than the RSN threshold, the cell is colored green. When the predicted SNR is less than but within 10 dB of the threshold, the cell is colored yellow. Below that range, the cell is colored red. Computed SNR predictions are shown by the numbers of each cell. When Reliability is selected, the cell colors are green if above the required reliability setting and red if below that value.

The beacon predictions are also evaluated for best frequency at the user's location. If several frequencies have yielded green predictions, the best of those cells is changed to a blue color. Also, the best frequency for the beacon network as a whole is shown by changing the top-row frequency cell from white to blue.

5. Some Precautions. The ACE-HF beacon display assumes that all eighteen beacons are transmitting on all five frequencies with good integrity. However, that is not always the case. For example, at the time of this writing (April 2003), the beacon schedule shows that the station in Hawaii does not transmit on 18.110 and 24.930 MHz, transmissions from the station in Russia are garbled and that the beacons in Finland and Peru are off-the-air. The user should occasionally check the published schedule to validate the predictions. A current schedule may be found at http://www.ncdxf.org/beacon/beaconSchedule.htm.

Remember that all beacon predictions assume 100 watts at the source. If you wish to evaluate beacon reception at the lower transmitted powers of 10 watts, 1 watt, or 100 milliwatts, the CW Required SNR level may be artificially increased in 10-dB steps. The actual predictions will still be made with 100-watt sources, but the increased RSN levels have the effect of reducing effective power.

If you are using a directional antenna at your station, the program will automatically point the antenna at each beacon station as the successive calculations are made. Thus, to match the predictions when you are listening to a beacon on-the-air, it is assumed that your directional antenna has also been pointed at each beacon station.

6. Using .MCS Antenna Schedules with Beacons. If you wish to use a Multi-Channel Antenna Schedule with Beacon predictions, be sure you have properly defined antennas for the higher five bands – the frequencies that are used by the beacons. Those frequencies are shown at the top of the Beacons Chart, and correspond to the 20m, 17m, 15m, 12m and 10m ham bands.

An example antenna schedule file, BEACON.MCS, is supplied with ACE-HF, and may be called from the Select Antenna screen in the Multi-Chan folder. You should make a similar file for the antennas of your station and install it as the transmitter antenna on the Inputs, Circuit screen for greatest accuracy in making Beacon predictions. Note that ACE-HF permits you to specify a different antenna model for each of the five beacon frequencies using the Multi-Channel Schedule in the Inputs, Circuit Options screen.

Although Beacon predictions are usually made for short paths only, ACE-HF can obtain long-path Beacon predictions by simply setting the Inputs, Circuit Path control to *Long*. If you are using a directional antenna, this setting automatically reverses the azimuth setting of your station's antenna as each successive path to a Beacon station is specified by the program.

DATABASE

There are three ways to specify a station location on the Inputs, Circuit or Circuit Group screens. You can 1) use the ACE-HF Database, 2) enter station information using the keyboard, or 3) move the station dot on the Circuit Analysis Screen.

1. Database Selection. When you click on *Database* on the *Inputs, Circuit* screen, a separate form will appear with a default listing of *DXCC* Locations, if you are in the Ham User Mode. If you are in the SWL User Mode, the *HFCC* database will appear by default. You can switch to one of the other six databases by clicking on a button at the top of the form. Try it and examine the various databases.

2. Selecting a Record. For this tutorial, change to *U.S. Locations*. You can move through the list by using the buttons below the list, or by using the keyboard arrow, page up, page down, home and end keys.

You can move more quickly to a record by using the *Speed Select* feature. When the database first appears, type the first few letters of the desired city name. The list will jump to a city name that begins with the letters you have typed. There is no need to click on the Speed Select box—just start typing.

For example, type the first few letters of JOPLIN. The list will jump to the first JOPLIN entry.

3. Filtering Records. Selections may be found more quickly by using the *Filter* feature. For example, let's find the record for JOPLIN, MO. Use Speed Select to find a MO item in the State field. Then click on the *Filter by State* button to exclude all entries except those in MO. Now, use the Speed Select feature to find JOPLIN, MO by clicking on the City field and typing the first three letters of JOPLIN.

To again show all records in the list, just click on the *U.S. Locations* button.

The Filter and Speed Select functions may be used in any order. For example, you can Speed Select JOPLIN from the City field, then click on *Filter on City* to exclude all but the JOPLIN entries. Then, click on MO in the State Field to select JOPLIN, MO.

4. Registering a Selection. Once a record has been selected, click on *ACCEPT* to enter the location on the Inputs panel and to return to that panel. Then, click *Run Predictions* to create data for the selected circuit.

You can also register a selection while typing in the Speed Select box. If the database list has jumped to the location you want, just press the keyboard *Enter* key to register the selection without clicking *ACCEPT*.

The other databases have similar listings that can be filtered and selected in the same way.

5. User Locations Database. You may also compile your own listing of favorite stations by using the *User Locations* database. After you call the User Locations list, the selection buttons group under the list will be expanded. Click on the + button to add a record, or on the – button to delete a record.

When you add a record, be sure to fill out each field. If you don't know the state, for example, enter an “X” or “N/A” for Not Applicable. But be careful to enter only real numbers in the Latitude and Longitude fields.

Latitudes and Longitudes should be entered in degrees and minutes. The program will convert the numbers to decimal degrees when entered on the Inputs panel.

After a new entry is completed, click on the Checkmark button to post the entry into the User Locations database.

Note that the user database permits you to save the station name, place name and latitude and longitude of each location. If you want to save other details of a favorite circuit, use the *Save/Recall Circuit* functions on the Inputs, Circuit panel. Once a receive location name (or DXCC call area) has been selected, the station name will appear in the Main Screen and Circuit Analysis screen circuit dot hints.

SCREEN FEATURES

ACE-HF includes other screen features, some derived from the ACE-VLF software, as described below.

1. Main Screen Controls. Use the Main Screen *Screen Features* top-row menu item to create each new screen feature. Click on an item to cause a special input form to appear. Use the Main Screen Pop-Up menu to Show or Hide the features you have created.

2. Circuit Paths. Click the Main Screen *Screen Features* top-row menu to invoke the *Circuit Path* input form. Up to nine circuit paths may be specified by using the spinner at the top of the form. These circuits are in addition to the *main circuit* of the ACE-HF predictions, and serve only as markers to examine distances and azimuths between circuit terminals. They might be used to depict various circuits in an HF network, for example.

Using the Circuit Path input form, each of the circuits may be named and their path colors and widths may be set. Specify the Latitude and Longitude of each end of a circuit, then click *OK*. After each circuit is installed, and the Pop-Up menu is set to *Show Circuit Paths*, you may pass the cursor over the path dot to see the circuit name, latitude and longitude of each end, path distance and azimuth from each terminal.

3. Range Curves. Invoke the *Range Curve* input form by clicking on the *Screen Features* top-row menu. Here you may specify up to nine curves of constant distance around selected points. The *Place on Map* feature may be used to set the center of the range. Use the other controls as described above and set the features to *Show* or *Hide* using the Pop-Up menu. If you prefer to enter range distances in another unit, you must change to Main Screen *File, Options* and click on another unit.

4. LOS Curves. The line-of-sight limits around up to nine selected locations may be created by clicking on the Screen Features *LOS Curves* menu item. These controls permit both the transmit and receiver altitudes above ground to be set and assume a spherical Earth. They are most useful in airborne applications, but are interesting if only to show that the line-of-sight from a location near the surface is indeed quite small on a world map. A curve may also show a geo-synchronous satellite footprint above a given position if so set (use the equator for satellite footprint latitudes).

5. Labels. Up to nine custom labels may be positioned on the screen using the Screen Features *Labels* item. Font color and background color may be specified.

6. Symbols. Up to nine copies each of a number of special symbols may be added to the screen using the Screen Features *Symbols* control. An intermediate form appears with a number of choices. Each selection invokes another form with controls for naming, sizing and coloring the symbols. Screen hints appear when passing the mouse cursor over any symbol so created and named.

7. Example Screen Features File. You may save and recall files that record the Main Screen Features using the Main Screen, *File, Save/Recall Main Screen Features* functions. An *EXAMPLE.SCN* file is provided to show how the features might be set. In this file, a single *circuit path* from London to Capetown is given. You can position your cursor over the dot at the end of this path to see the name and statistics of the path example. The file also contains a group of *range curves* centering on London and spaced at 2500-km intervals. There are *labels* alongside the London and Capetown locations, and a *flag* symbol at Pearl Harbor, Hawaii. Finally, a *line-of-sight curve* has been drawn around the location of W1AW at Newington, CT, showing the limit from the ground station to receivers placed at an altitude of 100,000 feet. (The example shows how quickly LOS area limits diminish as altitude decreases. The area around W1AW is relatively small even with the receiver at great height!)

FREQUENTLY ASKED QUESTIONS

1. "Is ACE-HF only for DX operation?"

No! ACE-HF may be used for any HF circuit. ACE-HF predictions will help DX contest users to quickly find open bands to distant locations, but ACE-HF is also valuable for short-range HF circuits. And QRP operators especially can find both local and DX-circuit open bands. No more calling in the blind!

2. "Does ACE-HF work under Windows Vista?"

Yes. Earlier problems seem to have been corrected by Vista Service Pack 1. In some earlier editions of Vista it was necessary to set ACE-HF for Windows XP compatibility. If the program didn't appear when called from the desktop icon, or if the database didn't appear when called, one could use Windows Explorer and go to the \ACE-HFN folder. Right-click on the ACEHFN.EXE file and set it to "Run as Administrator". Then, open the Compatibility tab and set the program for Windows XP SP2 emulation.

3. "Does ACE-HF work at other screen resolutions?"

Yes. ACE-HF's native design is for 800x600 pixel resolution, but it will display properly at higher resolutions. Most font sizes for the screen labels and objects scale automatically, but the font sizes for menus and hints will grow increasingly smaller as higher resolutions are used (a Windows constraint) unless you adjust the menu font setting (Control Panel, Display, Appearance, Item, Menu, Size). Higher resolutions are more commonly used with larger monitors, where the objects will remain readable.

However, ACE-HF will not scale down to 640x480 pixels, and some of the screen features will be lost.

4. "Why can't I expose the Windows Task Bar when I move the cursor to the bottom of the screen?"

ACE-HF is designed to show the maps best with the task bar hidden. To show the hidden task bar, simply press the Windows-logo key on the keyboard. The task bar and the start menu will then appear. Or, if you don't have the Windows-logo key on your keyboard, pressing CTRL + ESC will do the same thing. It is recommended that the ACE-HF screens occupy their maximum screen areas. Right click on the task bar at the bottom of the screen and set Properties to *Always on Top* and *Autohide* to avoid map distortion.

5. "The MOVIE area coverage displays don't fill the entire screen."

At the present time, the MOVIE displays are designed for VGA (640x480 pixel) resolution, while the other ACE-HF screens are scaled automatically for the PC's display resolution setting. The smaller MOVIE displays are intended.

6. "The top-row menu occupies two lines. I would prefer a one-line menu."

ACE-HF top-row menus are designed to occupy only one line. Go to the Windows Control Panel, Display, Appearance, and select Item, Menu. The Menu Font should be set to MS Sans Serif Size 8, either Normal or Bold. (Normal is the default font.) Click *Apply* and *OK*. In the higher display resolutions, a larger Menu Font size can be used.

7. "The chart background colors are checkered and the charts are hard to read."

This can happen when the display is set for 256 colors. Go to the Windows Control Panel, Display, Settings, and select *High Color (16 bit)* or better.

8. "I received an 'Access Violation' error when changing graphs on Main Chart."

On slower PC's this sometimes occurs due to timing issues in redrawing the charts. Acknowledge the error and continue on. There will be no effect on the chart's accuracy.

9. "I received an 'Exception EinOutError … invalid Numeric Input' error and ACE-HF won't start."

The *acehf.ini* file has somehow been corrupted. Use Windows Explorer to delete the file in the *\ace-hf* folder. Start ACE-HF again and then close it. The *acehf.ini* file will be re-made on program exit.

10. "When I run Area Predictions, I sometimes get an 'VOACAPW did not make output file' error."

This can happen on slow PCs when multiple programs are running under Windows. Exit and re-start ACE-HF. Review the Predictions List and re-start the run from where the error occurred. Before starting an extensive multiple area coverage run on such PCs, it is best to close programs running in the background.

11. "I can increase animation speed from 0 to 4, but beyond 4 the speed doesn't increase much."

The Windows version of MOVIE requires longer to change frames than does the DOS version. On slow PCs, the frame-change time becomes the limiting factor. On fast PCs, animation speed increases through 9.

12. "When I press 'Print Screen', a PrintKey window appears. What do I do?"

Go to the Windows task bar and right click on the PrintKey *Hand* icon. Then check the *No Dialogue* item. When you next press the Print Screen key, the screen image will be sent directly to the printer.

13. "On the Circuit Analysis Screen, I can't get the station location dot to move by only a degree or two."

The relatively large dot hides the area under it, preventing the mouse cursor from finding new locations only a degree or so from its current position. A workaround is to move the dot substantially away from its first position, then move it back to the desired location, using the yellow *coordinates* panel as a guide.

14. "When I move the station location dot, the point of the mouse cursor seems off a bit."

This is an artifact of offsetting the dot to center on the desired location. Use the yellow panel to set the new location more accurately.

15. "Why don't my keyboard cursor controls work when using the Predictions List?"

You must give the list *focus* by clicking on it, which usually happens by default. The Home, End, Page Up, Page Down and Up/Down and Right/Left arrow keys will then work as expected.

16. "Why don't the Main Chart Channels bars and the Best Frequency bars have the same values?"

The Main Chart Channels bars show hourly values, but the values of the Best Frequency bars are interpolated to the nearest five-minute interval. The values of the Main Chart *Time* graphs, which are also interpolated to the nearest five-minute time, and the *Best Frequency* bar values, should agree.

17. "What version of VOACAP is used by ACE-HF?"

The latest VOACAP program is always used for each ACE-HF version issued. The VOACAP version number may be seen by running a point-to-point prediction and, from the Circuit Analysis screen, click on the *Output, Point-to-Point Run* menu item. The VOACAP Version number is given at the top of the data listing.

18. "Why is VOACAP Method 30 used instead of Method 16 or some other method?"

ACE-HF runs VOACAP Method 30 because it is considered to be more accurate. Method 30 includes a smoothing function for reception in the 7,000-10,000 km ranges. Programs not using VOACAP Method 30 may exhibit prediction discontinuities near 10,000 km. The smoothing function eliminates such discontinuities. Method 16 has not been checked and verified by the VOACAP design. [Lane, April 2001]

19. "Why was VOACAP selected as the computational engine instead of ICEPAC?"

VOACAP is preferred because of its extensive validation during years of field reception reports and because it provides a smoothing function between the hop and forward-scatter regions, a feature that is lacking in ICEPAC. Comparisons show that ICEPAC sometimes exhibits a discontinuity of nearly 10 dB at mid-path, causing artificial SNR losses of 20 dB or more further out.

20. "Will I lose the files I have created if I re-install ACE-HF?"

No. If you re-install and select the "Repair" option, any files you have generated since the original installation will be preserved. These included the ACE Grid (AG) files, new antenna files you have added, and the circuit, group, scenario and frequency definition files. Or, if you simply remove the old version and then install the new version of ACE-HF, the previously generated user files will remain.

21. "Get New SSN reports that the NOAA site is unavailable. Why?"

This may occur if a Firewall has been installed on your PC. Disable the Firewall and try again, or work with the Firewall connection warning messages to "Permit Internet access from within ACE-HF". You may also obtain current SSN values by using the Internet directly. See "Basis for the Predictions" Help Tutorial, Section 7, for the URL address.

22. "Should I use Daily Sunspot Numbers?"

No. VOACAP has been calibrated and validated against Smoothed Sunspot Numbers (SSN) only. Using daily values will cause errors in the predictions.

23. "Sometimes I enjoy solid contacts, but ACE-HF predicts no connectivity. Also, sometimes ACE-HF predicts a good circuit, but I can't make contact? Why is this?"

ACE-HF predictions are for undisturbed conditions. Sometimes the ionosphere supports exceptional or inferior connectivity for brief periods. This phenomenon is discussed in more detail in the *Basis for the Predictions* Help Tutorial.

24. "Do ACE-HF Predictions Include Effects of the Aurora?"

No. VOACAP is not designed for automatic modeling of such reflective phenomena. Sometimes HF operators at high latitudes where the northern lights are often visible will point their antennas toward them and will experience enhanced propagation to other locations. Sometimes the ionospheric electron density becomes so great and extends to such high altitudes that it acts like a copper wall. Radio signals reflect from that wall and are bent along paths that are off-azimuth for tremendous distances. Layer heights may be as high as 1,000 km, and the MUF is often well above 30 MHz. [Lane, April 2003].

George Lane tells an interesting story from the 1950s about "the Russians winning the dB cold war". A broadcast from Siberia, intended for Mexico, was found to be booming into Washington, D.C. with signal levels 10 to 20 dB greater than anticipated. Later, Mr. Lane modeled the various paths using VOACAP and concluded that the Siberian broadcast was a grazing shot right along the auroral oval that was being bent so that it accidentally focused on Washington and probably missed Mexico City! [Lane, April 2003]. Such incidents are described in Mr. Lane's interesting book on VOACAP. [Lane, April 2001].

25. "How do I find the local time at distant receive locations?"

The best way is to use GeoClock. If you have GeoClock on your PC, you can call it from the Circuit Analysis Screen top-row menu. Then click on GeoClock's world map to zoom down to the area of interest.

26. "Can I use the HFANT New Type function?"

No. Starting with ACE-HF Version 2, the HFANT *File, New Type* function should not be used, as those antenna filenames have now been renamed in ACE-HF. Instead, Open the desired antenna file by using the HFANT *File, Open* function.

27. "Can ACE-HF use dual monitors?"

Yes. The program works best if all monitors are set to the same resolution.

28. "It takes a long time to start the program. Why?"

At startup, ACE-HF must index and read into memory all the AG files you have made. With a large number of files, it takes longer. After the first indexing, subsequent program re-starts will be faster until the PC is restarted because the files are retained in memory.

29. "I can no longer make area coverage displays. Why?"

As you continue to accumulate AG files, the program requires more and more physical memory (RAM) to store the files. Eventually, if the size of available RAM is exceeded, the operating system will call for virtual memory from the hard drive and the program will slow excessively. The general rule is that the total size of all the AG files should be less than the available RAM. For example, if 4000 AG files have been made on a PC with 512 Mb of total RAM, *available* RAM, as shown on the Task Manager Performance panel, might be, say, only 265 Mb, but the total AG file size will be about 304 Mb. (Each AG file is 75,136 bytes in size.) There are two solutions: 1) Increase the PC's RAM size, or 2) Move some of the AG files to one of the Scenario sub-folders. Also when many AG files exist, it is best to close all other programs.

30. "Does ACE-HF work on Apple's MAC computers?"

ACE-HF is designed for operation on Windows PCs. However, the program has been shown to run perfectly under MAC OS X using Boot Camp and also using the program from VMWare called Fusion. Both these methods entail loading a full version of Windows in a protected environment.

ALE SIMULATION

1. ALE Simulation with ACE-HF. Recent ALE system measurements have shown that predictions at 50% reliability approximate ALE field performance. Thus, one should use SNR 50 settings for ALE and should use 90% Reliability settings for non-ALE systems.

Automatic Link Establishment (ALE) HF radios have been successfully deployed for the past several decades. Frequently, these frequency-versatile systems can outperform convention HF radios by an estimated 20 dB. This enhanced performance results from the ALE system searching out ionospheric conditions where the instantaneous Maximum Observed Frequency (MOF) can be 10 to 15% higher than the monthly median Maximum Usable Frequency (MUF). The use of the higher frequencies, when available, allows the ALE system to perform at higher reliabilities and often at lower powers than conventional systems.

On the other hand, there are occasions when the ALE system will not find any useful frequencies and no traffic can be passed over the link until the system finally locks up on a useful frequency, perhaps after several hours of unsuccessful attempts.

At present there is no prescribed methodology for predicting the exact SNR values yielded by an ALE system, as there is for the conventional HF radio circuits. The ionosphere has a known and predictable range of hourly MOF values over the days of the month, but with present models we can't predict the particular day when the MOFs will be high or low. Nevertheless, VOACAP has been recognized as the program of choice for HF-ALE predictions by the U.S. Department of Defense Air Land Sea Application Center [ALSA Center, September 2003].

For conventional HF radio circuits, one commonly uses predictions to find the best operating frequency as a function of time-of-day for a given month. The predictions are of hourly circuit reliability, and find the frequency within the assigned channels that has the highest reliability.

Once the monthly predictions are made, circuit performance may be viewed in terms of the fraction of the days of the month at each hour that is predicted to have a median SNR that equals or exceeds the user-defined Required Signal-to-Noise ratio (RSN). ACE-HF frequency planning provides a high degree of assurance that the conventional HF radio system will perform at its best under current conditions. Furthermore, the communicator is aware in advance as to when a circuit will perform as required and when a link may suffer from poor propagation conditions.

For ALE radio circuits, although a similarly precise methodology is not yet available, ACE-HF *can* approximate ALE performance. Although VOACAP continues to be recommended for HF-ALE, no guidance yet exists for using VOACAP for the planning, design and operation of an HF-ALE circuit. This tutorial provides insight as to how ACE-HF is used for ALE planning, and describes prediction techniques that may be used.

2. ALE Methodology. ALE systems automatically check the link quality on each of a pre-set list of frequencies and set the best frequency for each link in the net by finding the frequency yielding the lowest bit error rate (BER). The result is a network operating on a *push-to-talk* basis without human intervention to make frequency selections, provided that *listen-before-talk* procedures are used to avoid interference. As a result of periodic channel evaluations and determination of best frequencies having the lowest BER (i.e. highest signal-to-noise ratio), the ALE system tends to operate on the highest propagating frequency of the prescribed list. The reason for this is that the signal power is usually strongest near the MOF, or near the daily MUF at that instant in time. Furthermore, the external noise power (atmospheric and man-made radio noise) is lower at the higher frequencies. (Noise power drops off at about 28 dB per decade in the HF band.) Thus the SNR for the highest usable frequency will be the highest when operating at or just below the MOF.

When one looks at the actual monthly frequency usage for a particular ALE link, one will see a distribution of selected frequencies over each time-of-day during the month. This best-frequency pattern is different than that of a conventional HF radio circuit where the same frequency will be used at a given hour over all days of the month. Typically, the conventional HF operator will specify the highest frequency that yields at least 90% predicted circuit reliability for the month. This generally occurs at the Frequency of Optimum Traffic (FOT), which is approximately 10 to 15% below the monthly Maximum Usable Frequency (MUF) for that time-of-day. In contrast, one will find that the ALE frequency usage distribution is generally above the FOT and often even above the MUF using standard VOACAP predictions.

3. ALE Operation with ACE-HF. The frequency plan for an ALE system is just as important as the one used for conventional HF circuits, but it is very different. First of all, it is a list of frequencies that will be tried over and over again until the Link Quality Assessment (LQA), based on BER, indicates that the link can carry traffic. Some ALE systems use one set of three to five scanning frequencies all day long. Other more dispersed networks may require two to three frequencies to be used all day, plus another set of two to three frequencies to be used during daytime hours with a different two or three frequencies to be used during the nighttime. Very large HF systems may have over a dozen frequencies available.

Without the use of propagation predictions, ALE systems tend to be just “thrown up”, since it is widely believed that the radios will automatically seek out the best frequency and nothing else needs to be done. The result is often many terminals sounding at once, with the result that self-jamming occurs. Add to that the attempts to automatically connect on circuits where propagation simply doesn’t support the paths at any frequency, with consequent repeated sounding. Not only does self-jamming occur, but connect times are greatly lengthened. With prior planning using ACE-HF propagation models, more intelligent channel selection is possible. ALE operation is more assured, connect times are shortened, and interference is reduced.

One major problem occurs when frequency managers assign the scanning frequencies as one would do when planning conventional HF radio circuits. For ALE frequency planning, one does *not* use the predicted circuit reliability, as that value has no meaning for a frequency adaptive HF radio system. This is because an ALE LQA responds to the instantaneous ionospheric condition, and is not representative of such hourly conditions over the month. Instead, the manager must also consider the expected variation in the hourly MUF values (i.e. the distribution of the daily MOF values over the days of the month at that hour). ACE-HF predicts this distribution by time-of-day as follows:

HPF ***Highest Possible Frequency:***
This frequency should only be equaled or exceeded on three days out of the month.

MUF ***Maximum Usable Frequency:***
This frequency should be equaled or exceeded on 15 days out of the month.

FOT ***Frequency of Optimum Traffic:***
This frequency should be equaled or exceeded on 27 days out of the month.

Ideally, ALE prediction models would utilize these parameters directly in making circuit predictions. Until such models become available, the ALE Frequency Manager should use the ACE-HF 50% Reliability predictions, and should moderate his selections of best frequencies by reviewing MUF chart predictions from the ACE-HF Circuit Analysis screen. For each ALE HF radio link, the scanning frequencies should be established such that there are more frequencies near or above the hourly MUF values than at or below the FOT. For best insight into ALE operation, ACE-HF SNR predictions should be augmented by a circuit-by-circuit review of the MUF and FOT predictions shown on the Circuit Analysis screen.

BASIS FOR THE PREDICTIONS

1. ACE-HF Prediction Model. ACE-HF is based on ACE-VLF simulation models developed for Navy agencies and used to predict VLF transmitter coverage to submerged submarines. The HF analysis methods are similar to those of the VLF application and include the ACE (Animated Communications Effectiveness) techniques for area coverage displays. Unlike ACE-VLF, which displays data from computational models that can require hours to run, ACE-HF includes its own prediction model, which may be run in seconds for a specified point-to-point circuit. Area coverage predictions require longer run-times, but can still be produced by the user.

2. Model History. ACE-HF predictions are based on the VOACAP model, a widely used HF prediction program created by the U.S. Department of Commerce Institute for Telecommunication Sciences (ITS) for the Voice of America. VOACAP resulted from a VOA review of the earlier IONCAP model in which a number of calculation errors were discovered and corrected. This effort was funded and directed by George Lane of VOA and implemented by Frank Rhodes of NRL. Further changes were made by Don Lucas at ITS under VOA sponsorship, and the result became a far more accurate HF predictions model. VOACAP and HFANT were programmed and are maintained by Greg Hand, formerly of ITS.

ITS later undertook a parallel development in which different algorithms for high-latitude effects such as the auroral zone and polar-cap phenomena of interest in Air Force circuits to bombers flying polar routes were included. However, VOACAP remains the more completely validated of the two models, having been corrected to agree with worldwide VOA listener reports accumulated during many years.

VOACAP is considered to be the most accurate HF prediction model now available and remains the most widely used HF prediction program. VOACAP represents the culmination of nearly 60 years of ionospheric research and simulation by the HF community and is the de facto standard for HF commercial broadcast use.

The ACE-HF software was developed under the guidance of George Lane, Consultant, who for many years was the senior HF propagation engineer for the Voice of America. Mr. Lane was responsible for the conversion of IONCAP to the VOACAP model and devised several enhancements for the program, and serves as a technical advisor to several U. S. Government committees on high frequency propagation and systems design. Mr. Lane has authored a book on the use of VOACAP [Lane, April 2001].

ACE-HF and ACE-VLF were designed by Richard P. Buckner and Sue M. Buckner and were programmed by Stephen Biro and Jerry McCollom, W0MC. The ACE display software was programmed by Joe Ahlgren of GeoClock.

3. Circuit Quality. ACE-HF circuit quality predictions are based on the Required SNR levels for each service type shown on the Inputs, Circuit Options screen. The default settings for each type are as follows:

SSB. AM Single-Sideband suppressed-carrier modulation is assumed in this service type. The standard default setting of 48 dB-Hz reflects standard SSB voice operation in a 3000-Hz bandwidth. The dB-Hz value is for signal reception in an occupied bandwidth relative to noise in a one-Hertz bandwidth. An Operator-to-Operator grade of service resulting in 90% intelligibility of related words for trained operators when the subject matter is known [Akima et al, 1969] is assumed, without diversity reception, signal processing enhancements or noise reducing circuitry. The 48 dB-Hz level is the same as recommended for Operator-to-Operator service without diversity in the VOACAP program. The SNR charts also show dB-BW data, which are the predicted SNR levels in the specified bandwidths of the Inputs, Circuit Options screen. Please see section 15 of this tutorial for a discussion of DX/Contest Default levels.

AM. AM Double Sideband operation is assumed for this setting, again for an Operator-to-Operator service grade without receiver enhancements. The default setting of 51 dB-Hz assumes a 6000-Hz bandwidth with 90% sentence intelligibility for 50% of shortwave listeners [Lane, 1975]. The 51 dB-Hz level is the same as recommended for Operator-to-Operator service without diversity in the VOACAP program. Both the SSB and AM Required SNR values represent usable reception in amateur service. HF commercial-grade service would require higher quality levels. Please see section 15 of this tutorial for a discussion of DX/Contest Default levels.

IB (AM). This AM service type is similar to the previous AM setting, except that the need for higher quality reception is assumed. The setting is used most frequently in the ACE-HF SWL User Mode. The default setting is 67 dB-Hz, which is a value employed by the Voice of America when simulating VOA listener circuits. This default level is less than the usually recognized setting of 75 dB-Hz for good commercial broadcast service.

RTTY. The standard default setting for radio teletype circuits is set at 55 dB-Hz, and assumes FSK modulation at 60 words per minute (Baudot) with reception at a character error rate of one percent (one character per 100) [Lane, 2003]. This character error rate is ten times that of commercial RTTY service. For DX/Contest use, the default level has been lowered to 50 dB-Hz, which might result in adequate reception during contests but with character errors of perhaps one character in ten. Please see section 15 of this tutorial for a discussion of DX/Contest Default levels.

Mil-Std-188. The RSN standard default setting for this service type is 55 dB-Hz and is taken from the Mil-Std-188-110B appendix C specification, paragraph C.6.1. The data mode assumes the use of a 64 QAM (Quadrature AM) waveform that is typical of that used in modern HF e-mail systems. (However, many HF e-mail systems utilize ARQ and forward error correction protocols that are not addressed by this data mode example. The ACE-HF Mil-Std-188-110B standard default setting of 55 dB-Hz is for a user data rate of 4800 b/s when measured in an ITU-R Poor Channel at a 10^{-5} bit error rate. The DX/Contest default setting is 50 dB-Hz and corresponds to a data rate of 3200 b/s when measured under the same channel conditions.

AMTOR and PACTOR.. Estimates for the PACTOR and the older AMTOR modes are from the SCS-PTC Company's published test results [Helfert, 2003]. The Standard Required SNR (RSN) default settings for AMTOR, PACTOR I and PACTOR II (shown on the Inputs, Circuit Options panel) assume that SNRs at the test bandwidths are equal to the values where throughput rates fall to approximately 50% of their maximum rates. For PACTOR II, in poor channel conditions, the default RSN is 39 dB-Hz at about half the maximum throughput rate of 320 b/s. For PACTOR III, SCS-PTC suggested a more conservative RSN value of 44 dB-Hz, but the maximum throughput rate is estimated to be 1600 b/s under good channel conditions.

In addition to ACE-HF's *Standard* RSN defaults established for each of the data modes, the user may also change to *DX/Contest* RSN defaults for those cases where emergency distress or minimal service may be required. At the DX/Contest RSN levels—with throughput rates as low as, say, 30 b/s—the channel conditions are assumed to have degraded below the *CCIR Poor Channel* level, and throughput rates have degraded accordingly. Some data may get through, but message delivery times will be much longer. When DX/Contest defaults have been selected, only the RSN levels at which ACE-HF chart colors change from green to yellow or red are modified.

CLOVER. This ARQ data mode is for the CLOVER-2000 data protocol by HAL Communications Corp. This operation automatically switches between six available modulation modes as a function of circuit SNR level. Thus, as circuit conditions worsen, throughput rates diminish through six stair-step like plateaus where the throughput rate is maintained at a maximum. CLOVER-2000 achieves a maximum throughput rate of about 1650 b/s in this mode when operating in a circuit bandwidth of 2000 Hz. The ACE-HF standard RSN default is set at 54 dB-Hz for a rate of 1100 b/s. The DX/Contest default is set at 33 dB-Hz, which yields a throughput rate of about 120 b/s.

CW. The CW Required SNR standard default setting of 27 dB-Hz is an assumed value for skilled amateur CW operation. This SNR level is a recommended value for 500-Hz bandwidth (see 4, below). Beginning amateur operators should perhaps change the Required SNR level to a higher value – perhaps to 42 dB-Hz in a bandwidth of 1100 to 1500 Hz [Lane, 2003]. Please see section 15 of this tutorial for a discussion of DX/Contest Default levels.

CUSTOM. The Custom 24 dB-Hz default settings represent another CW level that assumes a skilled amateur at the key. A more narrow bandwidth is assumed. This Service Type is provided so the user can set both the Required SNR and bandwidth values after experience with his particular receiver. Or, he can use the Custom type for other signaling types not listed.

4. Bandwidth. VOACAP does not treat receiver bandwidth as an input. All VOACAP SNR data is in dB-Hz, and the effect of narrowing bandwidth (a more narrow bandwidth will reduce broadband noise) is handled by reducing the Required SNR level for a particular service type. ACE-HF shows SNR in both dB-Hz and dB at a specified bandwidth and permits the user to set Required SNR bandwidth independently on the Circuit Options screen for each service type. The conversion is: dB-BW = dB-Hz – 10 $\log_{10}$(BW in Hz).

HF receivers have changed markedly since the 1940's practice of using 3000 Hz as a typical bandwidth. By the 1970's, military CW operators used narrow-band filters of 1100 Hz once initial contact was made and today, 500-Hz filters are typically used when copying CW transmissions. For a 500-Hz bandwidth, a 27 dB-Hz Required SNR setting might be specified as a minimum value for a skilled operator, which would result in a zero-dB SNR in 500 Hz. [Lane, December 2001]

5. Noise. ACE-HF SNR predictions include a power sum of atmospheric, galactic and man-made noise levels. (The model does *not* include the thermal noise of the receiver.) Atmospheric noise models are derived from those of CCIR Report 322-3, which is based on worldwide noise measurements made in the 1960s [CCIR, 1988]. Atmospheric noise results mainly from worldwide lightning flashes, and such noise levels vary with location, time-of-day, season and frequency. Atmospheric noise levels at a given receive site are the accumulated noise powers from local and distant thunderstorm centers, and these powers are propagated to the receive site just as are signals.

Because the attenuation of propagation channels generally increases with frequency, atmospheric noise levels decrease as frequencies rise. In the HF bands, man-made noise levels can thus dominate the SNR computation, and several such levels may be selected in ACE-HF.

Four man-made noise categories are given, each with a default noise value, which can be changed on the Inputs, Circuit Options panel. The default *Rural* category was set on the basis of worldwide VOA measurements showing that -155 dBW-Hz was not excessively high for rural or suburban residential areas. [Lane, April 2001]

6. ACE-HF Solar Effects. ACE-HF models the effect of different solar conditions by using the VOACAP preference of Smoothed Sunspot Numbers (SSNs), which are averages of thirteen monthly means and are the values most often used for HF propagation predictions. Each monthly mean is the sum of daily International Sunspot Numbers (ISNs) for the month divided by the number of days in that month.

VOACAP actually bases its SSN calculations on smoothed solar flux equivalents. For user interest, ACE-HF computes smoothed 2800-MHz solar radio flux values using an algorithm suggested by the ARRL, and equivalent solar flux is shown on the Inputs, Circuit panel.

The program accepts user entry of SSNs in the range of 0 to 300. A SSN of 10 is typical of very low solar activity while an SSN of 130 is typical of very active solar conditions. The ACE-HF default SSN is 100.

Current SSN predictions may be obtained from NOAA via the Internet site:
ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SUNSPOT_NUMBERS/sunspot.predict
ACE-HF permits users with Internet access to interrogate the NOAA site directly from within the program.

In the NOAA-site table, the predicted sunspot numbers for the 12^{th} month after the latest observation are computed using the method of A. G. McNish and J. V. Lincoln [Transactions of the American Geophy. Union, 30, 673-685, 1949] and modified using regression coefficients and mean cycle values computed for Cycles 8 through 20. The 90% confidence interval is shown by parentheses for each month of predictions. This indicates the uncertainty above and below the predicted number. The predictions are always based on the latest observed data available and will change each month as a new observation is included in the calculations. Final International Sunspot numbers, as they become available, are used in deriving the smoothed data. [Lane, July 2003].

In the table of the NOAA site, computed values are averages where the current-month SSN is not accurately computed until six months in the future. Therefore, the table gives estimates for current and future months where the accuracy of the table is refined as time passes. The number in parentheses under each prediction is the ± range of SSN uncertainty estimated with 90% confidence. The user is cautioned that entry of daily sunspot numbers for the ACE-HF calculations may result in erroneous predictions. It is better to use the predicted smoothed sunspot numbers of the reference above, and even then such numbers should not be changed outside of the 90% confidence range.

VOACAP accounts for solar effects on the earth's magnetic field indirectly. The program factors in the effects of expected deviations of instantaneous sunspot numbers and geomagnetic disturbances and accounts for such factors in the calibrations against HF reception reports that were made during a range of solar conditions. Thus, user entry of the effective geomagnetic activity index, Q_e, or of the planetary magnetic index, K_p, is not required. [Lane, April 2001].

7. Short and Long Path Models. ACE-HF runs VOACAP Method 30 for all circuit path computations. In this method, VOACAP switches from a quasi-ray trace model for multiple ionospheric reflections, to a ducted or forward scatter model at 10,000-km path distances. Method 30 also includes a smoothing function for reception in the 7,000-10,000 km ranges that was devised by George Lane. Programs not using VOACAP Method 30 may be expected to exhibit prediction discontinuities near 10,000 km, which are artifacts of the parent IONCAP program. The smoothing function eliminates such discontinuities. [Lane and Vo, 1995]

The VOACAP short path model is considered to be more rigorous. Its values are used at all distances where the long path model provides lower signal power values. The predictions are more accurate at the lower decile of the signal power distribution than at the median values. Consequently, predictions made at the 90% reliability level are considered to be more accurate.

The Short or Long path selection controls should not be confused with the short and long path computation models. The path selections on the Inputs, Circuit panel determine whether predictions are made for the shortest great circle distance between the transmitter and receiver, or the longer way (through the antipode) around the Earth. In either case, when the path exceeds 7000 km, the change to forward scatter computations is made automatically and the smoothing function is used.

8. Propagation Models. ACE-HF uses the default VOACAP FPROB settings for the ionospheric E and F layers. FPROB multipliers used to adjust the predicted critical frequency for the associated layers are foE = 1, foF1 = 1 and foF2 = 1.

ACE-HF permits the user to decide whether the Sporadic-E layer model is to be included in the propagation calculation. By default, the Sporadic-E model multiplier is foEs = 0.7 and the Es model is included. When turned off, foEs = 0. Using the Es model can increase SNR at the receiver by 2 to 4 dB in some cases, depending on circuit distance, season and sunspot number. Shutting off the Es calculation will therefore result in more conservative predictions [Lane, April 2001].

9. Elevation Angle Settings. The setting for Minimum Transmitter Elevation Angle, as entered in the Inputs, Circuit Options screen, has a significant impact on prediction quality. When the transmit antenna is accurately modeled at the low angles, the best minimum angle setting is 0.1 degrees. But when the antenna pattern and/or the terrain are unknown, a more reasonable elevation angle is 3 degrees (the default setting).

The minimum elevation angle can be increased to account for known horizon obstructions, but as the setting exceeds 3 degrees, the program's ionospheric predictions will be modified, and may become unrealistic. Values above 3 degrees should be used with caution. [Lane, April 2001]

10. Skip Zones and Near Vertical Incidence Skywave (NVIS) Coverage. VOACAP is a skywave propagation model. At some frequencies, areas close to the transmitter exhibit a *skip zone* where there is no ionospheric support for the circuit. Such areas are often seen in the ACE-HF area coverage displays where filled (no coverage) areas exist near the source, and coverage is not found until the paths are extended to where the first skywave coverage begins.

When high angle-of-fire antennas are used however, NVIS propagation is possible at the lower frequencies and is predicted by VOACAP. In such cases, skip zones may be diminished or eliminated at very short distances by NVIS. Such reception requires antennas (such as a bent whip with a portion set parallel to the ground) that may not be included in the VOACAP sample antenna list. [Lane, April 2001]

11. Terminators. ACE-HF shows the rotation of the Earth in two ways. Firstly, all area coverage maps have superimposed twilight zones that move across the map as time progresses. The map features are shown in darker colors in the nighttime regions, and the features within the twilight zones are shaded.

The *terminator* is defined as the line between day and night at the Earth's surface and describes a line of points where observers at the surface of a spherical Earth would note the appearance (or disappearance) of the Sun. The twilight zone is defined as the area where sunlight reflected from the atmosphere provides partial light. The two curves on the map show the limits of the dawn and dusk twilight zones.

If you have GeoClock on your PC, the default setting for the twilight zones shows the civil definition of twilight: the time when it is so dark that you must use your headlights. In ACE-HF, however, the twilight zones are much wider because the upper limit is set to show the approximate height of the F2 layer in the ionosphere. The F layer is that region where radio waves may be reflected back to Earth and is the highest such region considered by HF propagation theory. During the day, the F region may split into the F1 and F2 layers. ACE-HF assumes a typical reflection height of 420 km for the F2 layer and treats that height as a constant when constructing the twilight zones of the maps. The program computes the solar zenith angle (the angle from the Earth to the Sun, where the Sun directly overhead is at zero degrees) at each point on the map and defines the F2-layer solar zenith angle as about 110°.

On the maps, the line between the all-daytime region and the twilight zone marks where the terminator at the Earth's surface is found. The line between the all-nighttime region and the twilight zone shows where sunlight encounters the F layer of the ionosphere. Taken together, the two lines define the area between the Earth and the ionosphere where HF radio wave propagation occurs.

The same solar zenith angle computations are made to determine the *terminator bar* colors in the Main Chart. In this case, a bar is colored light or dark blue to indicate when both ends of the path (at the ground and at the F2 layer) are in an all-daytime or all-nighttime condition at the indicated time. A medium blue color shows that the dawn or dusk terminator is present in some portion of the path at that time. The bar colors change at points corresponding roughly to those where the line between daytime and the twilight zone, or the line between nighttime and the twilight zone, crosses the two terminals of the circuit.

There are 48 terminator bars on the charts, one for each half-hour. Although a typical terminator bar is centered on an hour or half-hour mark and extends to the sides, the colors are only accurate at the hour and half-hour marks. Terminator Bar colors are computed for Short Paths only.

NOTE: When finding terminator bar colors, ACE-HF assumes that both circuit terminals are either in daytime or nighttime conditions, with a mix of the two denoting a terminator in the path. This simplistic assumption ignores high-latitude cases where both terminals might be in day or night, but a terminator still might cross the path.

12. Transmit Power Setting. In keeping with VOACAP practice, the transmit power level entered on the Inputs, Circuits screen is the transmit power delivered to the antenna. Antenna radiated power will then be determined as a function of azimuth and elevation angles of the selected antenna model, just as is done in VOACAP. The transmit power you enter should first be reduced by known losses of the antenna tuner and transmission line, and mismatch losses, for more accurate predictions.

For single-sideband (SSB) voice operation, one should enter the peak envelope power (PEP) of the transmitter, reduced by known losses. For AM (double-sideband) with carrier, the transmitter's average power output should be entered.

13. Precautions. One should use care when interpreting ACE-HF predictions of *SNR, Best Frequency and Area Coverage*. While ACE-HF faithfully presents VOACAP predicted data, those predictions do not account for receiver sensitivity limitations that may further limit reception. To fully evaluate a circuit, particularly at the higher frequencies, one should also review the VOACAP output data [Lane, Dec 2001].

For long distance circuits—for example, in a November 17 UTC 10-meter circuit from the U.S. East Coast (41.7N 72.7W) to Indonesia (2N 100E)—the predicted signal power (S DBW in the output data) may seem reasonable, but the noise power (N DBW in the output data) at this high frequency is extremely low. A median noise power of –182 dBW is typical. For the same circuit, VOACAP predicts a median signal power of –133 dBW, so the computed SNR for average (50%) reliability is –133 – (–182) = +49 dB, which is just above the 48 dB Required SNR level for SSB service. Thus, the prediction seems to assure a good circuit, and ACE-HF reports a *green* open band at that hour.

However, if we assume that the signal power appears directly at the receiver's input terminals (in this case, we assume a transmission line with zero insertion loss and a receiver input impedance of 50 ohms to make the calculation simpler), the signal voltage is seen to be rather low. The –133 dBW signal power prediction translates to a voltage of 4 dBu (4 dB with reference to one microvolt) at the receiver input, or an input voltage of only 1.6 microvolts.

Modern HF receivers typically require input levels of 0.1 to 1 microvolt with a signal-to-noise ratio of 10 dB to overcome internal thermal noise [Lane, Dec 2001]. So the 10-meter prediction just discussed is seen to be close to the receiver's sensitivity limit, and the SNR prediction at 50% reliability may be too optimistic. The addition of a few dB of transmission-line loss, for example, could disconnect this marginal circuit.

It is for this reason that SNR predictions at higher reliabilities are always recommended. When 90% reliability is selected, VOACAP includes a factor for the lower decile value of the predicted signal range and the SNR prediction is then more conservative. In the above example, the signal lower decile value (SIG LW in the output data) is 25 dB so the predicted signal power at 90% reliability is –133 + (–25) = –158 dB. SNR at 90% reliability is then –158 – (–182) = +24 dB, which is much less than the 50% value. The result is that predicted coverage limits at the required SNR value occur at closer distances, where signal power is increased above the receiver's sensitivity threshold. In the area coverage predictions, marginal *islands* of coverage that sometimes appear in the 50% map often disappear at 90% reliability.

Every HF receiver has a different sensitivity however, and every station's antenna and transmission line design is unique. The user should make his or her own estimates of receiver threshold sensitivity in each operating band. For critical circuits where connectivity must absolutely be assured, predictions should be made for 90% reliability, and the VOACAP output data for S DBW and SIG LW should be reviewed.

ACE-HF reliability settings of 95%, which are now provided, should be used with caution because the original data from which VOACAP was calibrated were limited to the 90% range. 95% predictions can be made, but should be considered to be estimates.

ACE-HF permits the user to specify frequencies down to 1.8 MHz, but the VOACAP program has a 2.0-MHz lower limit. For this reason, frequencies below 2.0 MHz are rounded to 2.0 when the program is executed.

In using HFANT, one should recognize that it cannot accurately model horizontal antennas that are close to the ground with consequent unaccounted-for resistive losses in the ground. Very low horizontal dipoles that are sometimes quickly erected in the field to serve as NVIS antennas are examples where HFANT produces inaccurate patterns. HFANT models are closed form solutions that assume a pure sine-wave current distribution in the elements of the antenna. Such solutions become inaccurate when the antenna wires are within about 0.16 wavelength of the ground.

One final caveat: When looking at VOACAP output files, you might notice that predicted SNRxx values can go down to very low negative numbers. In ACE-HF such numbers are truncated at –50 dB to avoid graphics problems.

14. Chart Precision. ACE-HF employs cubic spline interpolation to produce chart values at five-minute intervals, in an attempt to better describe what happens in the real world—real parameters don't just jump from one hourly value to the next. However, such intermediate values should be taken with a grain of salt, since they imply a degree of precision that isn't really there in the VOACAP data. In particular, when intermediate values are greatly different than the hourly values on either side they should be considered to be less accurate. In the Main Chart *Channels* graphs each column is for an even hour, and each hourly prediction should be understood to be typical of the hour's period but only accurate for the exact hour.

In the Elevation Angle *Time* chart, the interpolated curve values between the hourly values can sometimes show negative angles (a physical impossibility). Such negative values should be disregarded. When the reported Most Reliable Mode changes, elevation angles usually change abruptly, and the smooth cubic spline interpolation between hourly values is particularly suspect.

15. Predictions vs. On-air Experiences. HF operators sometimes experience good reception on circuits where ACE-HF predicts poor connectivity. The question naturally arises, "Is ACE-HF under-predicting?" Conversely, there may be cases where ACE-HF predicts solid contacts, but the band in question seems dead. Why are these on-air experiences different from the predictions? This section will discuss how simulation errors can sometimes cause erroneous predictions, and at the end will describe how to change ACE-HF parameters to better match operating conditions.

- ***VOACAP Basis.*** [Lane, April 2003]. The first thing to recognize is that VOACAP (and thus ACE-HF) predictions are for *undisturbed* conditions. *Undisturbed* is defined as an *Ap* index of no higher than 27 or a *Kp* index no higher than 4. These geomagnetic field indices are a function of the Sun's solar wind and rise when geomagnetic storms occur. [Luetzelschwab, April 2002]. Such relatively high indices are rare and can occur within hours or days of when visible aurora effects are present. VOACAP has been calibrated against long-term measurements of both signal and atmospheric noise, both of which are highly variable in nature, and also responds to varying solar conditions. VOACAP accounts for this variability be determining SNR distribution functions and by computing statistical factors for both signal and noise. VOACAP predictions vary as a function of Smoothed Sunspot Number (SSN) and require the user to input monthly SSN estimates.

- ***Reliability.*** When we speak of VOACAP average coverage predictions, we are referring to median values of functions that vary over time. The computed *Reliability* value of an HF circuit is defined as *Time Availability*, and in VOACAP is computed for a typical 30-day month. Thus, for a designated circuit, SSN level and month, a reliability prediction of 50% means that the received SNR level will be as predicted *or better* during 15 days of the 30-day month. 50% reliability also means that the predicted SNR could be worse during 15 days of the month.

  To reduce the variability of the prediction, one can specify a higher reliability. For example, a 90% reliability means that SNR will be as predicted or better during 27 days of a 30-day month. Thus, the ACE-HF prediction becomes more conservative — more *accurate* — at the higher reliability levels. That is why military and commercial HF systems are commonly designed for 90% or higher reliability.

  One can visualize the effect of reliability by making area coverage displays that show two reliability levels. Make a display for 50% and 90% reliability, and then for 50% and 10% reliability to see the differences.

- ***Correct Simulations.*** In general, actual on-air performance *should* be better than the predictions when the system is accurately specified in the program's input. [Lane, April 2001]. The conservative degree of the prediction is a big factor in matching predictions to real-world experiences. Equally important is making a correct simulation, and that is why ACE-HF now places a stronger emphasis on simulation. HF systems are complex, and there are many factors that influence the integrity of the simulation. When the predictions don't match field experience, it is often because the system hasn't been correctly simulated.

  One should start by considering the transmit station. Has the specified transmit power been properly reduced to account for transmission line and mismatch losses? How about frequency effects — does the transmit power require adjustment from one band to the other? And what about the Required SNR level of the signaling mode? The levels given in ACE-HF are conservative standards, but they can be adjusted if the operator feels that a different Required SNR value is more appropriate. Please also see the discussion of practical receiver sensitivity limits in section 13 of this tutorial. Also see how the required SNR specification may be adjusted for DX and contesting situations, later in this section.

  Correctly simulating the distant end of the circuit is more difficult, because the ham operator often has little knowledge of the distant station. But more accurate predictions will result if he or she properly selects the appropriate manmade noise level at the station when it is known, and carefully specifies the antenna at the receive station. For sustained and repeated QSOs, the distant antenna type can usually be determined and the circuit specification can be saved for future use.

What about antenna azimuth settings? A directional antenna may be in use at each end of a circuit, but the main beam may be *off-azimuth* with respect to the true circuit bearings. In addition, one must pay attention to the predicted takeoff angle of the most reliable mode with respect to the acceptance angle of the antenna is use. On a long path that demands low radiation angles at both ends, for example, the use of an NVIS antenna (like a horizontal dipole) that directs most emission straight up is a poor simulation. And it is not enough to select accurate antenna models and set their azimuth correctly. One should also consider the ground conductivity and dielectric constant of the Earth under each antenna. Finally, terrain should be considered — an antenna placed at the edge of a cliff overlooking the ocean will have different radiation characteristics than an antenna in the prairie.

Even setting the antenna's azimuth can be a source of error. Antenna azimuth should be referenced to True North, and not to a compass reading based on Magnetic North. ACE-HF includes computations of Magnetic Declination and Magnetic Azimuth for both ends of the circuit to help in avoiding this error.

One should also consider atmospheric noise conditions at the receive location. If that location is in the midst of a giant thunderstorm, or even nearby such a storm, atmospheric noise levels may be much higher than the nominal levels predicted by the model. Conversely, if you are in an unusually quiet period with no storms even close to your area, even on a July afternoon when such storms, on average, usually arise then you may enjoy solid contacts when the predictions show the channel in question to be marginal. [CCIR 322-3, 1988.]

Remember that atmospheric noise predictions are used in the calculation of SNR levels at the *receive* end of a circuit. If you are interested in the predicted noise levels at your own station, you may want to run ACE-HF reception area predictions, which center on your station. Or, you can change to the SWL User Mode, which permits you to simulate circuits from distant transmitters to your receive station.

Also, if the received SNR is greater than predicted, Sporadic-E propagation modes may be present and the prediction should be re-run with the Es mode switched on. George Lane provides additional discussions about correct system simulation in his excellent book. [Lane, April 2001].

- ***The Disturbed Ionosphere.*** If we are using conservative reliability settings and have exhaustively checked our system simulation, yet the field contacts are still better (or worse) than predicted, what then? The answer lies with the ionosphere. The ionosphere is highly variable itself, and solar effects perturb it and the Earth's magnetic field. The most regular of these changes is the diurnal cycle, where the upper atmosphere is more heavily ionized during the day and even separates into multiple layers, and at night the lower limit of ionization rises as sunlight disappears. Those changes are properly accounted for in the VOACAP model.

  But when greater solar storms occur, the ionosphere is further perturbed and the magnetic indices can rise beyond the normal limits for which VOACAP has been calibrated. Such *disturbed* conditions can be caused by solar flares and by particle storms. These perturbations may be local or may be distributed over wide areas. They may last for a few hours or may persist for days.

  One can track solar conditions by noting the variations in daily sunspot numbers. The Sun makes a full rotation every 27 days, so the number of sunspots affecting HF communications is ever changing over the days of the month. This is the cause of rather large differences in signal power at a given hour during the month.

  Here is where adaptive HF systems come into play. In military applications, certain methods like ALE (Automatic Link Establishment) have been invented to take advantage of ionospheric variations where abnormal propagation paths can exist for a short time. (Please see the ALE SIMULATION tutorial to understand how ACE-HF simulates ALE systems.) With ALE radios at each end of a circuit, each equipped with computer algorithms that enable testing and hand shaking, the path can be subjected to a Link Quality Analysis to determine the best operating frequency. The process involves sending sample tones in both directions on a number of channels, and often an ionospheric anomaly is identified that permits abnormally good propagation to exist. Indeed, it is not unusual to achieve circuit quality improvements of 20 dB by using ALE. The disadvantages are that the radios are expensive, the method results in heavy interference and ALE operation is not covert.

So when the ham operator or shortwave listener experiences unexpectedly good contacts — better than those predicted — and he or she has done a proper simulation, the chances are that the ionosphere has bestowed one of its blessings and the propagation channel is much better than the undisturbed standard. Enjoy it when it happens, because it may not last long. For undisturbed conditions and in the long term, VOACAP and ACE-HF predictions are correct.

- ***How to Manage DX and Contest Situations.*** [Lane, April 2003]. SNR predictions can be less than what occurs during disturbed ionospheric conditions or when the predictions are being applied to only one or two days of the month. The predicted SNR distributions themselves are usually correct, but a period of only a few days can fall at the upper and lower limits of the distributions.

  Ham DX Contests are often concentrated into only a few days of time — perhaps over a weekend of intense calling activity. A sample size of only a few days is too small to be properly predicted since it is less than ten percent of the month. In these situations, selecting a median reliability setting of 50% is a better predictor, because it yields the best estimate for a given hour and day of the month. Generally, the actual SNR values for a given hour will cluster around the median, with only a few days falling at the extremes of the SNR distribution.

  During a contest, calls to a target area are often repeated over and over. Repeated calls are an advantage because the redundancy tends to negate noise bursts and one can wait for the constructive up-swing of the minute-to-minute fade cycle, which can add about 5 dB to the received SNR when it occurs every minute or so. Repeating call signs, phonetically spelling words or using Q-words of the ham vocabulary puts signal processing diversity to work. The operator tends to remember part of what he or she hears, and can fill in the blanks with successive repeats. Such effects are real and can be simulated by changing the ACE-HF Required SNR setting.

  Let's take an example: Assume SSB signaling and that the receiver is probably set to a narrow bandwidth—perhaps 2000 Hz. To hear a normal voice transmission, we would usually require a SNR of 15 dB in the bandwidth of the receiver, or 15 + 33 = 48 dB-Hz as a Required SNR (RSN) level. (48 dB-Hz is the ACE-HF default for the SSB service type using the default 3000 Hz bandwidth.) If we can wait for the constructive fade in a Rayleigh distribution, we would have a 5 dB enhancement every minute or so. The RSN value could then be reduced to 48 – 5 = 43 dB-Hz. If we can remember what we heard on each repeat during a successful DX contact, then we can expect an additional 3 to 6 dB of enhancement, depending on the skill and experience of the operator. Thus, for DX contesting, it is practical to select an RSN level of 37 to 40 dB-Hz. The reduction is equivalent to increasing transmit power by a factor of 10 or more!

  Good operators can sometimes make DX SSB contacts at RSN levels closer to those of CW (24 to 27 dB-Hz) than those of a normal voice RSN having 90% sentence intelligibility. Adjusting the ACE-HF RSN levels until the predictions better match the on-air experience is an acceptable way to "trap" those illusive ionospheric conditions where the propagation paths are enhanced.

  As an aid to DX contesters, a second group of *DX/Contest Defaults* is given on the Inputs, *Circuit Options* panel. However, these values are merely examples that may be used as guides for more closely simulating actual operating conditions one might find during short DX sessions. Over time, you may wish to adjust your RSN levels for predictions that better duplicate the experience from your station.

  Such adjustments should not be used routinely, however. For nightly SSB contacts with a distant friend where good reception is to be assured, it is better to use the 48 dB-Hz RSN level and set the reliability requirement at 90%, in order to find the best band and hour for consistent contact over the month.

16. Low-Frequency Accuracy. As stated in section 13, 160-m frequencies are rounded to 2.0 MHz to conform to VOACAP's lower frequency limit. VOACAP 2-MHz predictions are reasonably accurate for NVIS and short-range predictions out to about 1500 km. But when path distances are very long, VOACAP becomes less accurate at night. At night, a residual E-layer exists with a MUF usually above 2 MHz. It is this phenomenon that permits AM broadcasts in the medium-wave bands to propagate thousands of kilometers during nighttime hours. VOACAP, however, is based on data that was collected at frequencies of 4 MHz and higher. Extrapolation was used to cover the lower frequencies, but funding limitations prevented the collection of further data to support those extrapolations. Unfortunately, when using the VOACAP *NORMAL* Absorption Model, computed absorption values are excessive in the extrapolations and the nighttime predictions thus become excessively attenuated as path distance increases. [Lane, April 2003].

In 1999, VOACAP was changed to include the more conservative model of nighttime signal reception for frequencies below about 4 MHz as discussed above. The previous IONCAP absorption algorithm was replaced because it was feared to be in error, since very little measured data supported the low-frequency predictions. Without a strong database, it was thought best to err toward the conservative, if at all.

Since then, however, anecdotal experiences by Hams and other HF operators have reported nighttime signal reception where the VOACAP model computed no connectivity. For that reason, ACE-HF now permits the original IONCAP absorption model to be invoked if the user wishes to experiment with this different computation. The model selection, found on the Inputs, Circuit Options panel, defaults to the NORMAL setting to emphasize that those desiring more conservative predictions should always use the standard VOACAP absorption model. Users who wish to experiment with the IONCAP setting should observe the warning that appears in a hint on the IONCAP button.

17. References.

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19. ACE-HF Support. Questions about ACE-HF NETWORK software and bug reports are welcomed. You may contact *acesupport@acehf.com* via e-mail.