
18 CALCULATIONS: HF HF PLANNING

18.1 INTRODUCTION

Planning of HF systems employing ionospheric propagation in the frequency range of 2 - 30 MHz can be performed in WRAP through the integration with a family of software codes developed by the Institute for Telecommunication Sciences in the USA. Properties of stations with definitions according to WRAP standards can be used by automatically transferring the important data to the inputs of the ITS codes. The following ITS programs can be used:

Point-to-point calculations

- VOACAP
- ICEPAC
- REC233

Point-to-area calculations

- VOAAREA
- ICEAREA
- RECAREA

Antenna handling

- HFAnt

The programs can be downloaded from <http://elbert.its.blrdoc.gov/hf.html>, and they should be installed in accordance with the instructions available at that web site. The software is also included on the WRAP CD-ROM. Detailed documentation on the theory and use of the programs is also available to download and is also included on the WRAP CD-ROM.

It should be noted that these programs are in wide-spread use and are considered to be among the very best codes available for the prediction of HF circuits. However, due to the free-ware nature of the programs there are no guarantees against errors or malfunctions. The following text is taken from the *ReadMe* file:

Disclaimer:

The software contained within was developed by an agency of the U.S. Government. NTIA/ITS has no objection to the use of this software for any purpose since it is not subject to copyright protection in the U.S. No warranty, expressed or implied, is made by NTIA/ITS or the U.S. Government as to the accuracy, suitability and functioning of the program and related material, nor shall the fact of distribution constitute any endorsement by the U.S. Government.

Before using the HF software together with WRAP it must be installed on the computer and the search path to the **itshfbc** directory must be set using the **ChangeDB** (*Other paths*) utility of WRAP.

The instructions on how to use the HF programs are not repeated in the WRAP User's Manual. Instead refer to the specific HF documentation. In particular the following two documents are useful:

- **Ionospheric Communications Enhanced Profile Analysis & Circuit (ICEPAC) Prediction Program User's Manual** (178 pages, [B09])
- **Ionospheric Communications Enhanced Profile Analysis & Circuit (ICEPAC) Prediction Program Technical Manual** (94 pages, [B10])

The following information on WRAP stations is used to give input data to the HF calculations:

- Geographical coordinates of transmitting and receiving stations
- Transmitter antenna, receiver antenna (selected from the HF antenna library. Antennas are edited and created with the HFAnt program.
- Frequency (can be a single frequency or a table of frequencies)
- Required signal-to-interference ratio and receiver necessary bandwidth. This is used to calculate the required signal-to-noise ratio.
- Transmitter power. Note that it is the transmitter output power, not the EIRP.
- For point-to-point calculations a *Link* should be formed in WRAP, using two HF stations of Class *Fixed station* (only this class can be used to form link pairs).
- For point-to-point: The transmitter antenna is taken from the transmitting station and the receiving antenna is taken from the linked receiving station.
- For point-to-area: The transmitting antenna is taken from the transmitting station and the receiving antenna is taken from the receiver of the transmitting station (if a receiver is defined), otherwise the receiving antenna will be the same as the transmitting antenna.

Note that all this data can be changed using the editing functions of the ITS software.

The selection of the specific HF antennas is only available for stations with a frequency in the range of 2 – 30 MHz, which are the valid limits for the ITS software. This antenna is only used for the ionospheric calculations performed by the ITS software. Other calculations in WRAP use the antenna defined in accordance with the WRAP format.

Examples of results are presented in the following figures.

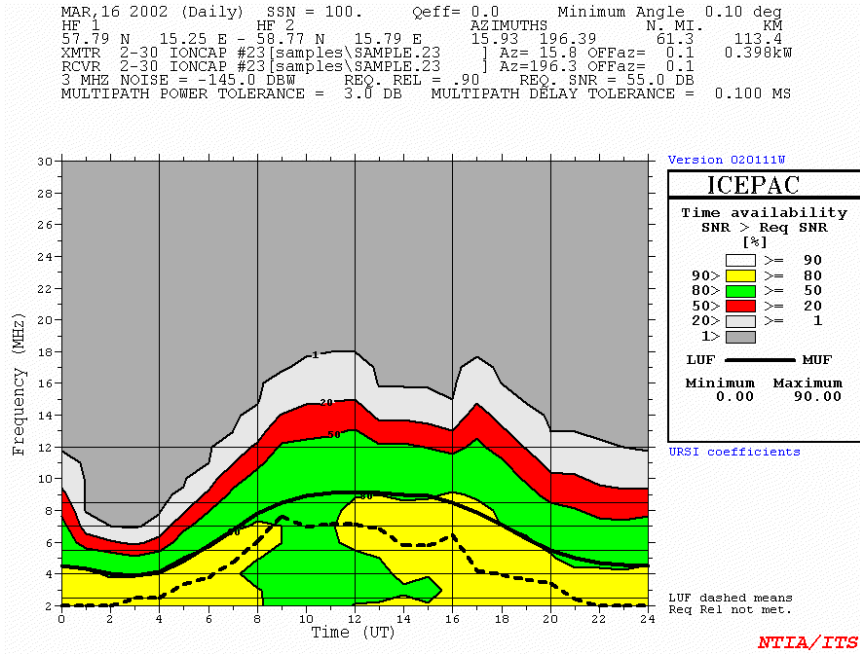


Figure 18.1: Reliability as a function of time for a 113 km HF link (ICEPAC).

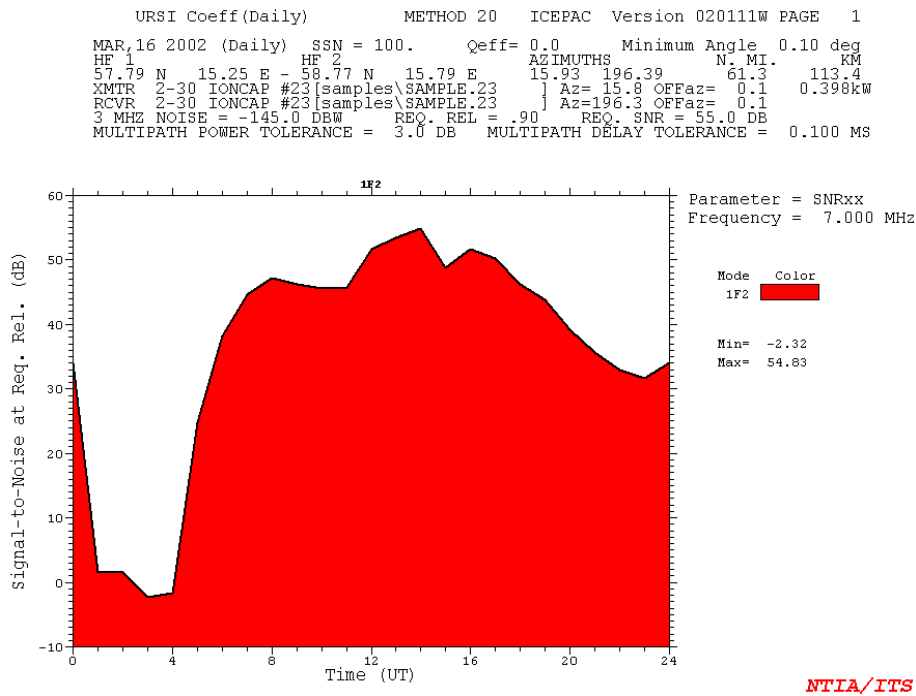


Figure 18.2: Signal-to-noise ratio for 90% required reliability (ICEPAC).

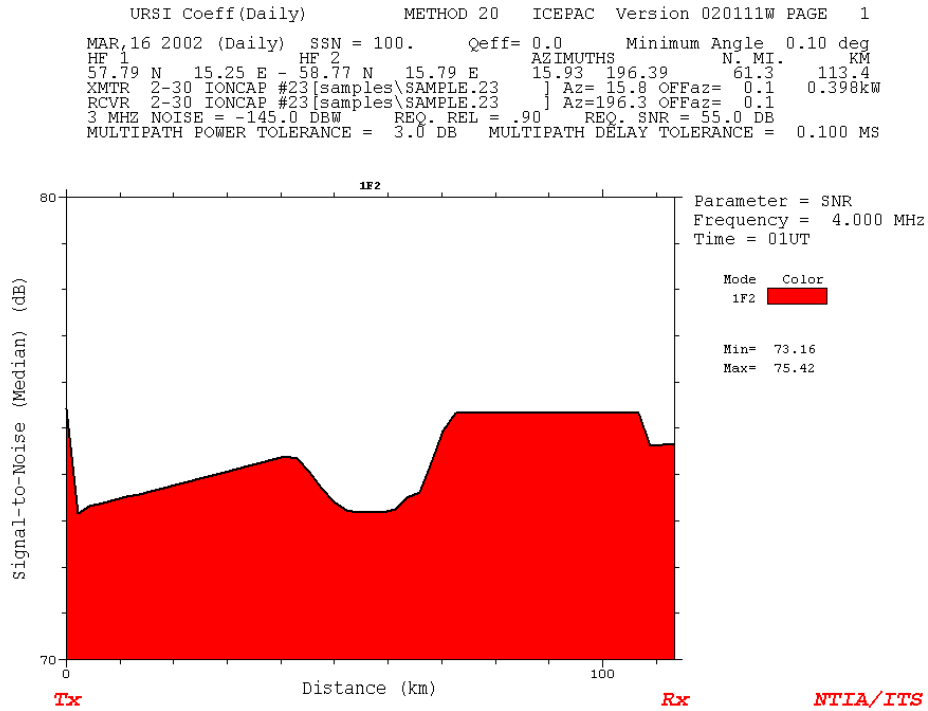


Figure 18.3: Median signal-to-noise ratio as a function of distance (ICEPAC).

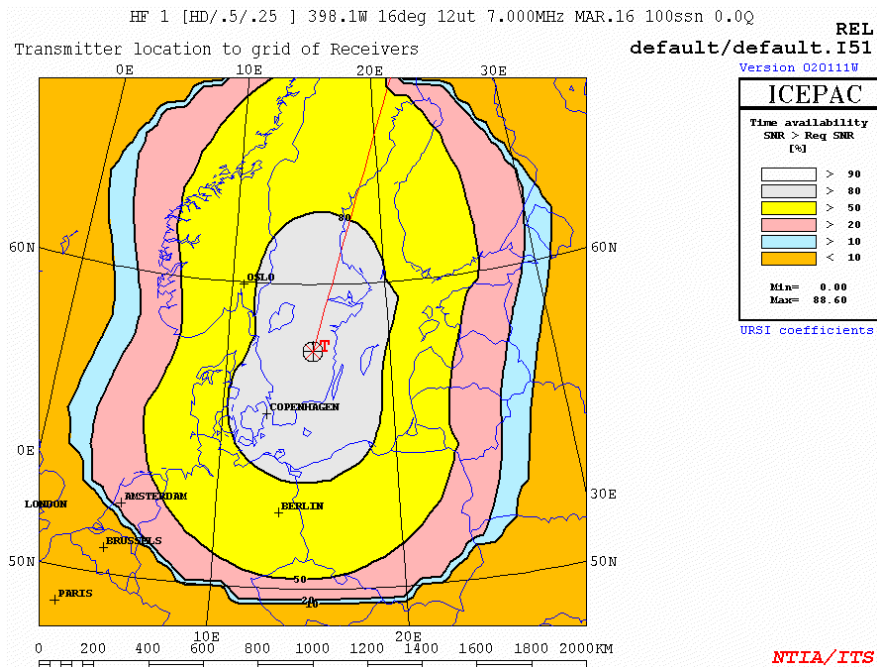


Figure 18.4: Probability that SNR > Required SNR (ICEAREA).

18.2 COMMUNICATION WITH THE ITS HF SOFTWARE

WRAP communicates with the ITS HF software through files as defined in the following. It is important to understand how this works to be able to utilise the full benefits of the integration of the two software systems. In order to allow the preparation of preferences for calculations WRAP produces the files as described here: One which is read by default by the ITS HF software and one which is used as the preferences file.

18.2.1 Point-to-point calculations

The following two files are used:

- X:\itshfbc\saved\default\default.voa/ice/rec*
Data used by the ITS VOACAP/ICEPAC/REC533 software to generate the initial input data display AND to be used for calculations, unless the user makes a specific selection of another file.
- X:\itshfbc\saved\WRAPDef\wrapdefp.voa/ice/rec*
Data read by WRAP upon starting either of VOACAP/ICEPAC/REC533 to be modified by the specific data of the marked station to create a new *default.voa/ice/rec* file and a new *wrapdefp.voa/ice/rec* file. Note that WRAP only writes specific data as defined later in the text. Other data is unchanged, and is prepared using the input data forms of the ITS HF software.

If the directory and file *\WRAPDef\wrapdefp.voa/ice/rec* does not exist, WRAP generates relevant information using default data together with the station-specific data. This information is used to create the *\saved\default\default.voa/ice/rec* file and also creates the *\WRAPDef\wrapdefp.voa/ice/rec* directory and file.

WRAP writes the following data into the *wrapdefp.voa/ice/rec* and saves as a new *wrapdefp.voa/ice/rec* and *default.voa/ice/rec* file. All other data as read from the existing *wrapdefp.voa/ice/rec* file is left unchanged when writing to the two files.

Table 18.1: Data generated by WRAP as input to the ITS HF software (point-to-point calculations).

Data in ITS HF	Data in WRAP	Comment
Year, month, day	Computer clock	Only if the <i>wrapdefp.voa/ice/rec</i> does not exist
Transmitter coordinates	Edit Station – Main: Position	From marked station
Receiver coordinates	Edit Station – Main: Position	From linked station. If no linked station exists – same coordinates as marked station.
Transmitter name	Edit Station – Main: Name	From marked station

Data in ITS HF	Data in WRAP	Comment
Receiver name	Edit Station – Main: Name	From linked station. If no linked station exists – same name as marked station.
Frequencies	Edit Station – Frequencies: List of frequencies (first 11)	From marked station. The indicated <i>Calculation frequency</i> is listed first and is always included.
System, Required S/N	Calculated from Edit Receiver – Required S/I and Necessary Bandwidth (NBW): Req S/I + 10logNBW _[Hz]	From receiver of linked station. If no linked station exists – from receiver of marked station. If no receiver exists – set to 0 dB. For simplified receiver: Required S/I is set to 10 dB.
Tx Antenna	Edit Station – Tx Equipment: HF Antenna	From marked station. Selected from the ITS HF Antenna files.
Tx Antenna, MainBeam	Edit Station – Tx Equipment: Azimuth	From marked station
Tx Antenna, Power	Calculated from Edit Transmitter – Main: Power [dBW] to [W].	From marked station.
Rx Antenna	Edit Station – Rx Equipment: HF Antenna	From linked station. If no linked station exists – from marked station. If no receiver antenna exists – same as transmitter antenna Selected from the ITS HF Antenna files.
Rx Antenna, Receiver Bearing	Edit Station – Rx Equipment: Azimuth	From linked station. If no linked station exists – from marked station Rx azimuth, reverse direction by 180 degrees. If no receiver exists – set to 0 degrees.

Important note: *If antenna files are edited and saved, or new antenna files are created, they MUST conform to the DOS standard of naming, i. e. a maximum of 8 alphanumeric characters followed by a 3-character extension.*

Calculation preferences are created using the input data forms of VOACAP/ICEPAC/REC533 and saving the preferences files under directory and name *X:\itshfbc\saved\WRAPDef\wrapdefp.voa/ice/rec*.

18.2.2 Point-to-area calculations

The following two files are used:

- *X:\itshfbc\areadata\default\default.voa/ice/rec*
Data used by the VOAAREA/ICEAREA/RECAREA software to generate the initial input data display.
- *X:\itshfbc\areadata\WRAPDef\wrapdefa.voa/ice/rec*
Data read by WRAP upon starting VOAAREA/ICEAREA/RECAREA to be modified by the specific data of the marked station to create a new *default.voa/ice/rec* file and a new *wrapdefa.voa/ice/rec* file. Note that WRAP only writes specific data as defined later in the text. Other data is unchanged, and is prepared using the input data forms of the ITS HF software.

If the directory and file *\WRAPDef\wrapdefa.voa/ice/rec* does not exist, WRAP generates relevant information using default data together with the station-specific data. This information is used to create the *\areadata\default\default.voa/ice/rec* file and also creates the *\WRAPDef\wrapdefa.voa/ice/rec* directory and file.

WRAP writes the following data into the *wrapdefa.voa/ice/rec* and saves as a new *wrapdefa.voa/ice/rec* and *default.voa/ice/rec* file. All other data as read from the existing *wrapdefa.voa/ice/rec* file is left unchanged when writing to the two files.

Table 18.2: Data generated by WRAP as input to the ITS HF software (point-to-area calculations).

Data in ITS HF	Data in WRAP	Comment
Month, day	Computer clock	Only if the <i>wrapdefa.voa/ice/rec</i> file does not exist.
Transmitter coordinates	Edit Station – Main: Position	From marked station
Transmitter name	Edit Station – Main: Name	From marked station
Plot Center	Edit Station – Main: Position	The plot centre for the map display is defined as the coordinates of the marked station. The operator can change this before starting the AREA calculation.
Frequency	Edit Station – Frequencies: Calculation frequency	From marked station.
System, Required S/N	Calculated from Edit Receiver – Required S/I and Necessary Bandwidth (NBW): Req S/I + 10logNBW _[Hz]	From receiver of marked station. If no receiver exists – set to 0 dB. For simplified receiver: Required S/I is set to 10 dB.
Tx Antenna	Edit Station – Tx Equipment: HF Antenna	From marked station. Selected from the ITS HF Antenna files.
Tx Antenna, MainBeam	Edit Station – Tx Equipment: Azimuth	From marked station
Tx Antenna, Power	Calculated from Edit Transmitter – Main: Power [dBW] to [W].	From marked station.
Rx Antenna	Edit Station – Rx Equipment: HF Antenna	From marked station. If no receiver antenna exists – same as transmitter antenna Selected from the ITS HF Antenna files.
Rx Antenna, Receiver Bearing	Edit Station – Rx Equipment: Azimuth Value is ignored by current version of ITS HF software.	Planned function: From marked station Rx azimuth, reverse direction by 180 degrees. If no receiver exists – set to 0 degrees. The current version of the ITS software seems to assume that the receiver antenna always is directed towards the transmitter.

Important note: *If antenna files are edited and saved, or new antenna files are created, they MUST conform to the DOS standard of naming, i. e. a maximum of 8 alphanumerical characters followed by a 3-character extension.*

Calculation preferences are created using the input data forms of VOAAREA/ICEAREA/RECAREA and saving the preferences files under directory and name *X:\itshfbc\areadata\WRAPDef\wrapdefp.voa/ice/rec*.

18.2.3 Calculate Propagating Frequencies function

Note that this function will only be available if there is at least one HF link (with frequency in the range 2 – 30 MHz) in the project and that the HF Planning function is included in the licence for the licensed version of WRAP.

A function is available where WRAP in addition to feeding input data to the ICEPAC software also reads the output result from the ionospheric prediction. In this case the following additional data entered by the user in WRAP is written to the ICEPAC input data file:

- Date
- Sunspot number
- Required reliability

WRAP reads the output data file *X:\itshfbc\RUN\icepacg.out* created when running the ICEPAC calculation type *Graph* and determines the low and high frequency limits of propagation for the selected combination of time-of-day interval and the FOT/MUF/HPF/HPF+20% parameter selection made by the operator.

18.2.4 File summary

The ITS software reads the data files indicated by the **first** line in each row in the second column of **Table 18.3** to generate the initial display of data in the input data forms and for **point-to-point** calculations uses the same file as input data to the calculations.

For **point-to-area** calculations the user is prompted to select a desired input data file. The selection should be either the *default.voa/ice/rec* file or the *wrapdefa.voa/ice/rec* file or some other file that can be based on the either of these files.

WRAP reads the data files indicated by the **second** line in each row in the second column to complement that file with the specific station data from WRAP and write a new *default.voa/ice/rec* file.

WRAP reads the output data file indicated by the **third** line in the ICEPAC row in the second column to retrieve the propagating frequency range.

Table 18.3: Summary of files read by ITS HF and by WRAP, respectively.

Tool	1st line: Initial file read by ITS HF 2nd line: Initial file read by WRAP 3rd line: Output file read by WRAP
VOACAP	X:\itshfbc\saved\default\default.voa X:\itshfbc\saved\wrapdef\wrapdefp.voa
ICEPAC	X:\itshfbc\saved\default\default.ice X:\itshfbc\saved\wrapdef\wrapdefp.ice X:\itshfbc\RUN\icepacg.out
REC533	X:\itshfbc\saved\default\default.rec X:\itshfbc\saved\wrapdef\wrapdefp.rec
VOAAREA	X:\itshfbc\areadata\default\default.voa X:\itshfbc\areadata\wrapdef\wrapdefa.voa
ICEAREA	X:\itshfbc\areadata\default\default.ice X:\itshfbc\areadata\wrapdef\wrapdefa.ice
RECARA	X:\itshfbc\areadata\default\default.rec X:\itshfbc\areadata\wrapdef\wrapdefa.rec

18.3 USING THE HF PLANNING FUNCTION

Station data available in the project files and station database(s) in WRAP can be used to provide input data to the ITS HF calculations. This allows the following basic functions of WRAP to be utilised for the handling of HF stations and networks:

- Database storage and retrieval of stations, networks etc. Frequencies, locations, equipment etc. are all stored.
- Assigning frequencies to stations and networks by the operator. Propagation consideration is taken automatically by executing the ITS HF software to find the suitable frequency ranges for ionospheric propagation.
- Display in the Map Viewer of stations, networks, groups, sites etc. incorporating HF stations
- Generation of highest level frequency allotments (frequency tables, channelling plans), with administrative consideration to other utilisation of the spectrum as stored in the databases as stations or allotments. Propagation consideration is taken

automatically by executing the ITS HF software to find the suitable frequency ranges for ionospheric propagation.

- Generation of divided allotments with selections of frequencies from a higher-level allotment. Propagation consideration is taken automatically by executing the ITS HF software to find the suitable frequency ranges for ionospheric propagation.
- Importing, exporting allotments as text files.
- Point-to-Point and Point-to-Area calculations involving the specific ionospheric propagation models are performed by the ITS HF software.

When running this function for a network of HF stations it is possible to determine the propagating frequency range considering

- All point-to-point links in the network
- All point-to-point links from a selected station (normally the master station) to the other stations
- A single point-to-point link (if it has been formed in advance).

The following examples demonstrate some of these capabilities.

Important note: Before being able to run the HF Planning function you should make sure that the ITS HF software is installed, and that the **ChangeDB** utility of WRAP has been used to set the search path properly. Refer to **Figure 18.5**. ITS HF software is available on the WRAP main CD-ROM. The latest version can be downloaded from <http://elbert.its.blrdoc.gov/hf.html>

There is a chance that later versions may be incompatible with WRAP, if ITS changes the file structure that is used for communication with the software. In that case the installation should be made from the WRAP main CD-ROM. Also note that a comprehensive User's Manual for ICEPAC exists as reference [B09].

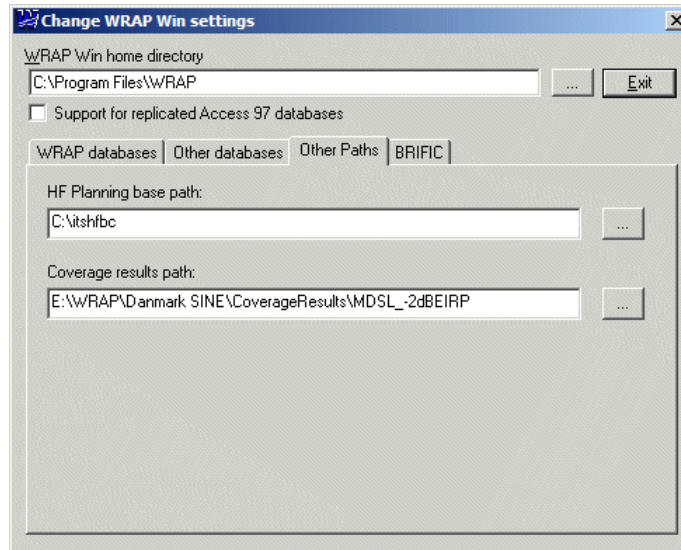


Figure 18.5: Setting the search path to the ITS HF software to enable the HF Planning function in WRAP.

18.3.1 Example: Antennas, point-to-point links

Point-to-point links for HF by definition includes two stations at fixed locations. This is naturally similar to the point-to-point concept of microwave links in WRAP. This is used to provide the relevant input data to the point-to-point tools in the ITS HF software, i. e. VOACAP/ICEPAC/REC533.

Point-to-point links in WRAP can be formed only between stations defined by the class *Fixed station* (FX in ITU terminology). The *Link/Unlink* function available in the project list view (right-click on two marked stations) is used to form a point-to-point link between two unlinked stations. Conversely, two linked stations may be released from each other by this function.

A prepared project exists to allow a quick-start and demonstration of the HF planning function. This project contains two linked stations. Perform the following.

- Open the project **HFDemo.wpe** in the samples folder. Open the **Stations in Project** folder to list the stations in the list view.
- Double-click on one of the stations. Select the **Transmitter** tab and notice that there are two antennas:
 - **Antenna: WSTD Omni**
 - **HF Antenna: samples\SAMPLE.23**

“Antenna” is used for all calculations in WRAP EXCEPT for the HF Planning function, and as such needs to be fully compatible with the WRAP software. “HF Antenna” is used ONLY for the HF Planning function, and as such needs to be fully compatible with the ITS HF software.

WRAP antennas are handled as normal with their data stored in WRAPdB.

HF Antennas are selected from the ITS HF antenna library, which has the search path *X:\itshfbc\antennas* if the ITS HF software was installed in its default directory. Three sub-directories exist in the standard ITS HF installation. The following two contains antenna definitions that can be selected for the HF Planning function:

- default
- samples.

The **Select...** button opens a standard Windows file select dialogue. The **Edit...** button starts the **HFAnt** software, which is part of the ITS HF package. This is used to display numerical properties of the selected antennas, edit some properties and to plot the antenna pattern.

Now continue as follows:

- Click on **Edit...**. This starts the HFANT software with its main window displaying its default start antenna data. Perform the following to display the data for the antenna selected in WRAP:
 - Select **File - Open** and browse to the *\itshfbc\antennas\samples* folder
 - Select **SAMPLE.23** and click on **Open**.
 The data is shown for this antenna, which is a half-wave dipole at $\frac{1}{4}$ wavelength above ground. See **Figure 18.6**.

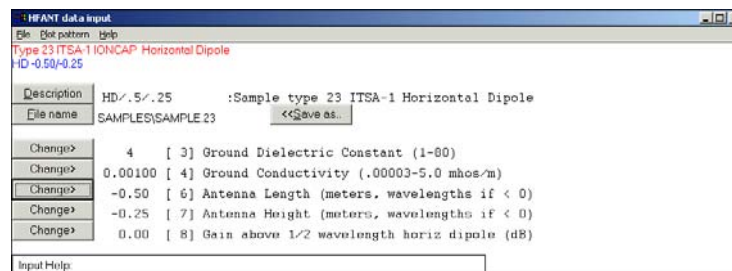


Figure 18.6: Antenna parameters for half-wave dipole at $\frac{1}{4}$ wavelengths above ground.

The data can be edited if desired and the antenna can be saved under a new name (DOS 8.3 character format of file name). Note that if the edited antenna is to be used on the station in WRAP you must select this new antenna in the **Edit Station – Transmitter** (or **Receiver**) tab.

- Select **Plot pattern - Vertical** and **Azimuthal**. This results in the display of the respective pattern. See **Figure 18.7**.

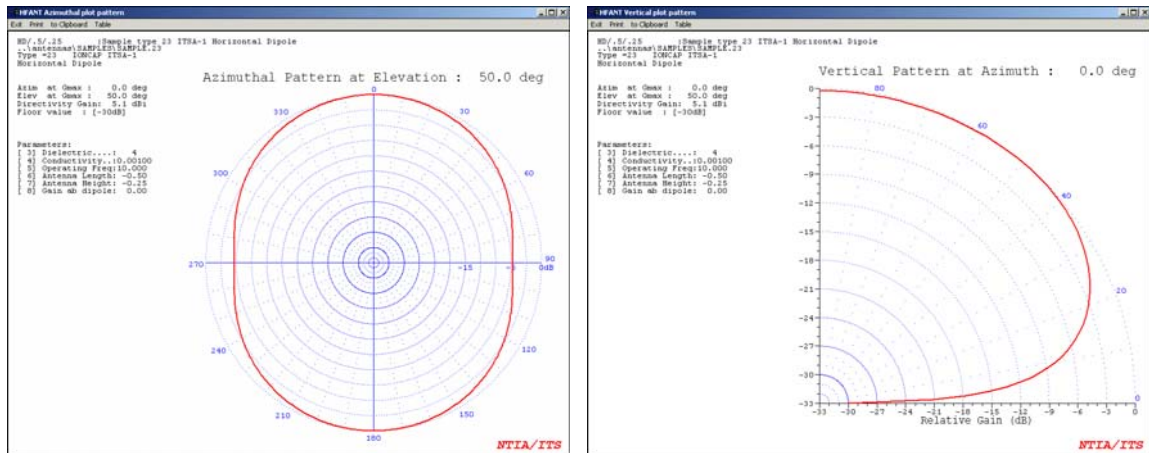


Figure 18.7: Vertical and horizontal plane radiation patterns for half-wave dipole at $\frac{1}{4}$ wavelength above ground as calculated by HFANT.

You may also explore the other options in the antenna pattern window, such as the tabular representation, print options and using the clipboard functions which allows exporting the displayed pattern and legends using Windows clipboard feature to paste it into for instance a Word document.

Now close the **HFANT** window to return to WRAP.

Perform the following:

- Double-click on the **HF 1** station in the list view (or in the Map Viewer, if you have displayed the stations there). Go to the **Frequencies** tab. Notice that the station has six assigned frequencies, with 7.0 MHz marked as the calculation frequency. Calculations will be performed for all frequencies in the list (a maximum of 11 though, as this is a limitation in the ITS HF software).
- Mark the **HF 1** station in the list view. Click on the drop-down arrow at the **HF** icon in the menu bar. Select the **VOACAP...** function.
- The following data window will appear, with data as shown *if no preferences have been set before*. Previous preferences settings in the VOACAP settings file for WRAP (*WRAPDefP.voa*) may give a different display.

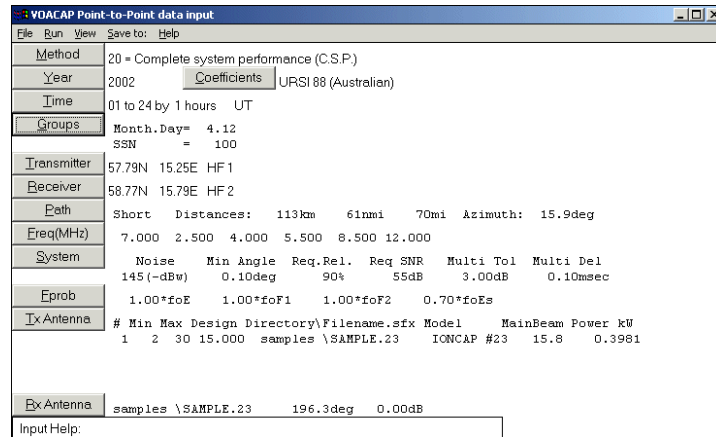


Figure 18.8: Data input for VOACAP HF calculation.

Notice that some data comes from the WRAP stations **HF 1** and **HF 2**, and some data only exists in VOACAP.

- Select **Run - Graph** and then **REL** in the window **Select PARAMETER to plot from**. This plots the reliability of the link as a function of the time of day. See **Figure 18.9**.

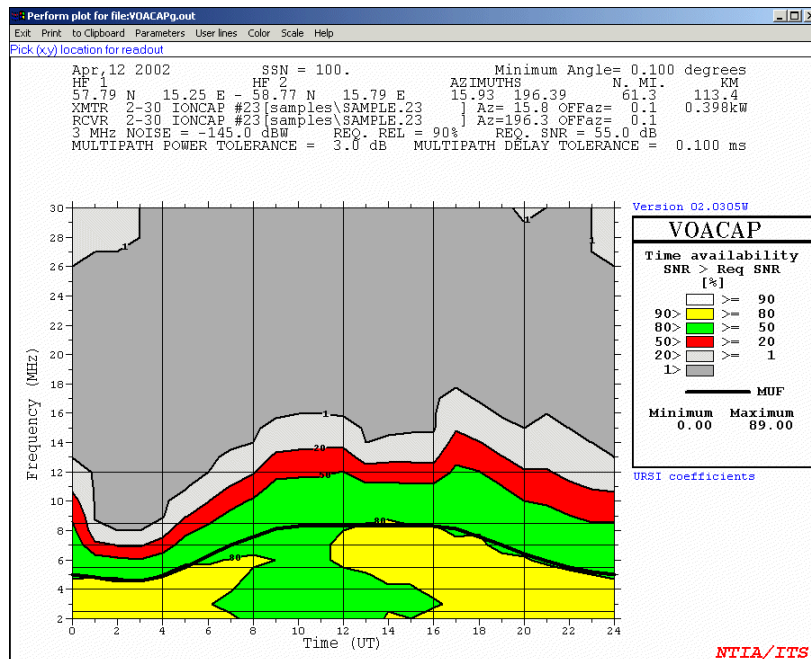


Figure 18.9: Reliability of link between HF 1 and HF 2.

You may at some time notice that the result indicates the use of URSI ionospheric coefficients even though CCIR coefficients were selected. This will appear for VOACAP and ICEPAC when both a month and a day are defined in "Groups" in the input data window and is due to the limitation of the CCIR coefficients not

supporting day-of-month definition. Thereby the calculation reverts to the URSI values, which support day-of-month definition.

Change of parameter to plot is done by selection under the **Parameters** menu when in the *Graph* window. There are many options and selections, including printing and sending to Clipboard for use of the diagrams in other applications. You may experiment with displaying different types of results to get familiar with the capabilities.

Changing data in the input data window and selecting **Run** will perform calculations with the changed data. The following procedure will set preferences for subsequent calculations initiated from WRAP.

- In the **VOACAP Point-to-Point data input** window: Make the desired changes. Note that some parameters are set from WRAP, and if these are changed here they will be overwritten by WRAP data (see **Table 18.1**).
- Select **File - Save as...** and browse to the directory and file `\itshfbc\saved\WRAPDef\WRAPDefP.voa`. Mark this file and press **Save**.
- Close the **VOACAP Point-to-Point data input** window.
- Mark one of the HF stations in the project list view and start the HF Planning/VOACAP software again. Notice now that the changed parameters will appear.

The procedures for using ICEPAC and REC533 are similar to VOACAP. There are some differences between the calculation methods and options. Details of these are beyond the scope of this WRAP manual. Please refer to the ITS HF documents.

Finally, this is how to perform linking/unlinking of stations to form/break the point-to-point link. Again, this function is only available for station class FX, i. e. *Fixed station*. The Link/Unlink commands are dimmed and inactive for other classes of station.

Breaking a link:

- Right-click on a linked station in the project list view.
- Select **Unlink**. Note that the station name in the *Link To* column disappears.

The antenna azimuths and tilts of the unlinked stations will be retained. The two stations are now independent and can be linked to other unlinked stations of class *Fixed station* in the project.

Making a link

- Left-click on the first station to link to mark it. Press **Ctrl** while left-clicking on the second station to link.
- Then right-click on one of the marked stations and select **Link**. A window *Link frequency* appears prompting the selection of which pair of frequencies (for a duplex link) that shall define the transmit/receive frequencies of the link. Select frequency and press **OK**.

Now the link has been formed, indicated by the appearance of a station name in the *Link To* column. The antenna azimuths and tilts of both stations have automatically been changed to direct the antennas towards the other station.

18.3.2 Example: Point-to-area calculation

The VOAAREA/ICEAREA/REAREA programs use the basic propagation calculations provided by the corresponding VOACAP/ICEPAC/REC533 programs. A calculation grid of a selectable number of points is evenly distributed over the area of interest, and a point-to-point calculation is performed between the marked station and each grid point. The area displays are then formed in the AREA programs by interpretation of the results.

One plotted area result can only represent the coverage for one set of defined conditions of solar activity, time of day and time of year. For other displays than Maximum Usable Frequency (MUF) the display is done for a single frequency.

The same sample file as for the previous point-to-point example can be used for the point-to-area calculations. Perform the following:

- Open the sample project **HFDemo.wpe**, open the **Stations in Project** folder to list the stations in the list view.
- To illustrate which antennas that will be used for transmission and for reception: Change the receiving antenna on **HF 2** as follows:
 - Double-left-click on **HF 2**
 - Select the **Rx Equipment** tab
 - For **HF Antenna: Select...**
 - Browse to the **..\itshfbc\antennas\samples** directory and choose the **Samples.10** antenna (this is a vertical monopole).
 - Close **Edit Station** with **OK** to accept the change.

- Mark the **HF 1** station in the list view. Click on the drop-down arrow at the **HF** icon in the menu bar. Select the **ICEAREA...** function.
- The following data window will appear, with data as shown *if no preferences have been set before*. Previous preferences settings in the ICEAREA settings file for WRAP (*WRAPDefA.ice*) may give a different display.

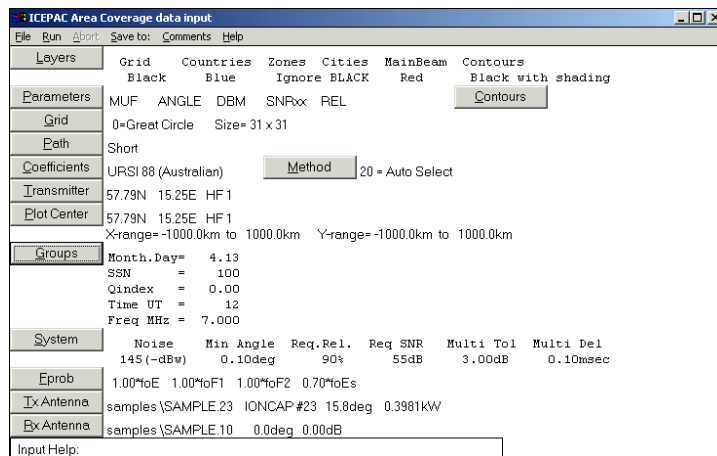


Figure 18.10: Input data for the ICEAREA calculation.

- Select **Run - Calculate - Calculate/Screen**. This choice will perform the calculation and directly present in the screen, after the following steps.
- Note that VOAAREA/ICEAREA/RECAREA now opens a window *Select OLD file to Calculate/Screen*. Now browse to the directory where the WRAP default file resides and select it:
 - ...*itshfbc\areadata\WRAPDef\WRAPDefA.ice*
 - Press **Open** and then **Yes** on the following window to confirm the file selection.
 This starts the calculation.
- An empty screen **World Map Plot...** is displayed when the calculation has finished. Selection of which of the calculated parameters to plot is done in the **Parameter** menu. Select **SNRxx**, which will show the calculated signal-to-noise ratio at the required reliability (which was 90%). See **Figure 18.11**.

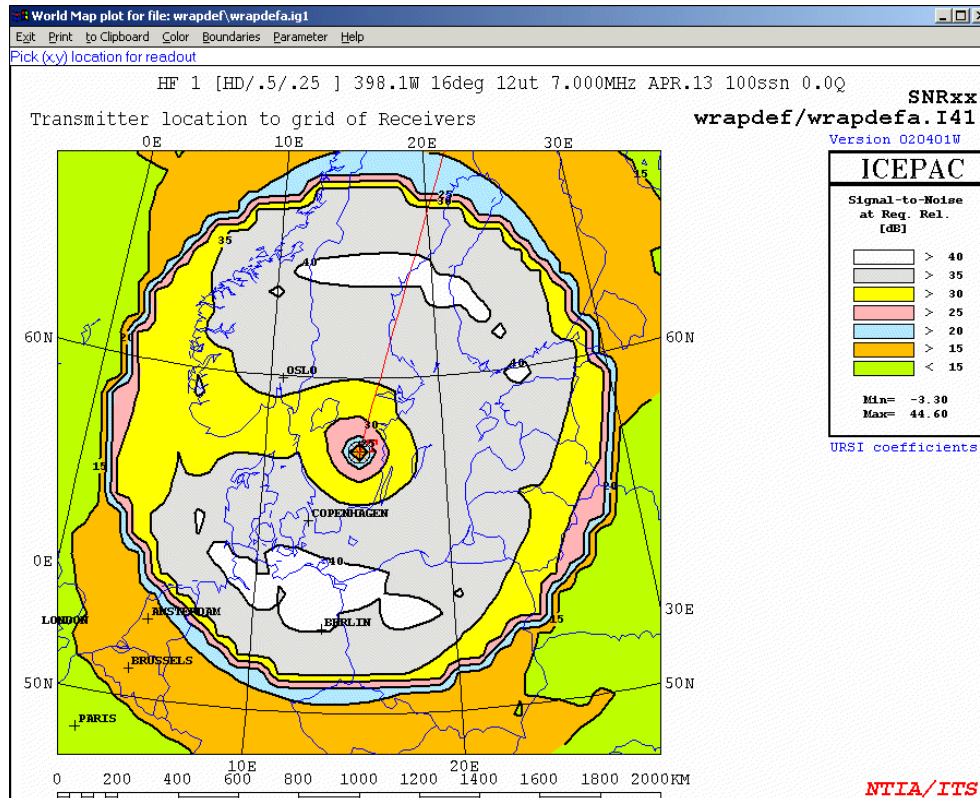


Figure 18.11: Result from area coverage calculation with ICEAREA.
Parameter: SNR at 90% reliability. The receiving antenna is a vertical monopole.

There are many selections and options for the display. You should try out a few to get familiar with the capabilities. Then close the **World Map Plot...** window and go back to the **ICEPAC Area Coverage data input** window, where changes in the default settings can be made and stored for subsequent calculations.

Important note: There is a difference in the procedure for changing the input data to AREA calculation (VOAAREA/ICEAREA/RECAREA) compared to POINT-TO-POINT (VOACAP/ICEPAC/REC533). Changes directly in the input data screen gain effect for calculations immediately for the POINT-TO-POINT calculations, without a need to save in a file. This is not the case for the AREA calculations – changes must be saved in a file, and this file must be selected before the calculation starts.

Proceed as follows to learn about this.

- Select another antenna for the receiver:
 - Press **Rx Antenna** in the ICEPAC Area data input window.
 - Select **Receive Antenna - Samples - SAMPLE.23 - Accept - Accept**. Now the Rx Antenna will be SAMPLE.23, which is a horizontal dipole.

- In order for this change to gain effect for the calculation:
 - Select **File - Save as** and create the file with a suitable name, in a suitable directory. For this example you may replace the **...\itshfbc\areadata\WRAPDef\WRAPDefA.ice** file.
Note that if the calculation is started again from within WRAP this antenna will again be replaced by the receiving antenna defined for link in WRAP. If this is not desirable you should save under a different file name.
- Then proceed as before: Select **Run - Calculate - Calculate/Screen**. This choice will perform the calculation and directly present in the screen, after the following steps.
- Note that VOAAREA/ICEAREA/REAREA now opens a window *Select OLD file to Calculate/Screen*. Now browse to the directory where the WRAP default file resides and select it:
 - **...\itshfbc\areadata\WRAPDef\WRAPDefA.ice**
 - Press **Open** and then **Yes** on the following window to confirm the file selection.
This starts the calculation.
- An empty screen **World Map Plot...** is displayed when the calculation has finished. Selection of which of the calculated parameters to plot is done in the **Parameter** menu. Select **SNRxx**, which will show the calculated signal-to-noise ratio at the required reliability (which was 90%). See **Figure 18.12**.

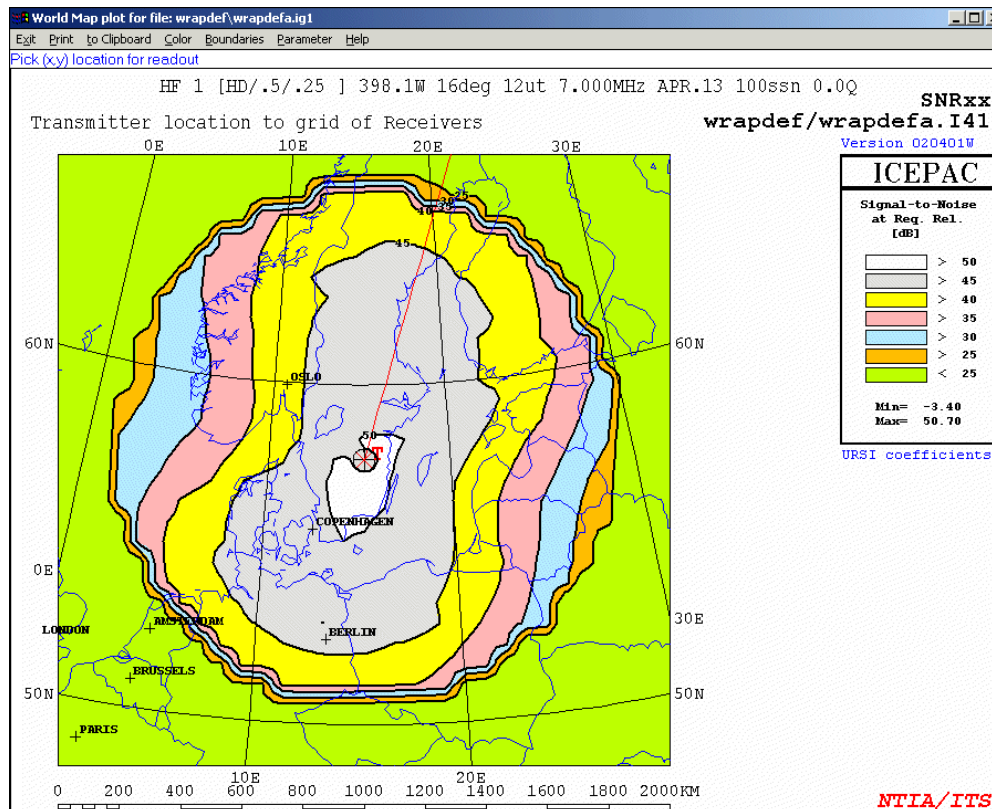


Figure 18.12: Result from area coverage calculation with ICEAREA.
Parameter: SNR at 90% reliability. The receiving antenna is a horizontal dipole.

This is a way to quickly calculate the coverage for different antennas and other changed parameters. Remember that the input data file must be saved and selected as the input data file for the calculation, otherwise the changes will not be recognised by the ITS HF AREA software. Also remember that WRAP-resident data changed in the AREA Data input forms, that are taken from WRAP station data when starting the calculation from WRAP, will be overwritten.

Notice in the results displayed in **Figure 18.11** and **Figure 18.12** show what is expected: The horizontal dipole receiving antenna gives higher reliability, in particular for short distances, than the vertical monopole. This is due to the low gain of the monopole at high elevation angles (i. e. at short distances), whereas the dipole has its maximum gain at high elevation angles.

18.3.3 Example: Get frequency limits

The ITS ICEPAC software can be used to automatically find the low and high frequency limits of ionospheric propagation to support the operator in selecting frequencies. The function requires that at least one HF link is defined in the project. The transmitting and receiving station data for the marked link is used as input to the ICEPAC calculation when using the function from the Edit Station window. When using the function from the other windows where it is available it is possible to select which station that will be used to define the transmitter properties. The linked station will define the receiver

properties of the link. See **Figure 18.13** for the window that opens when starting this function.

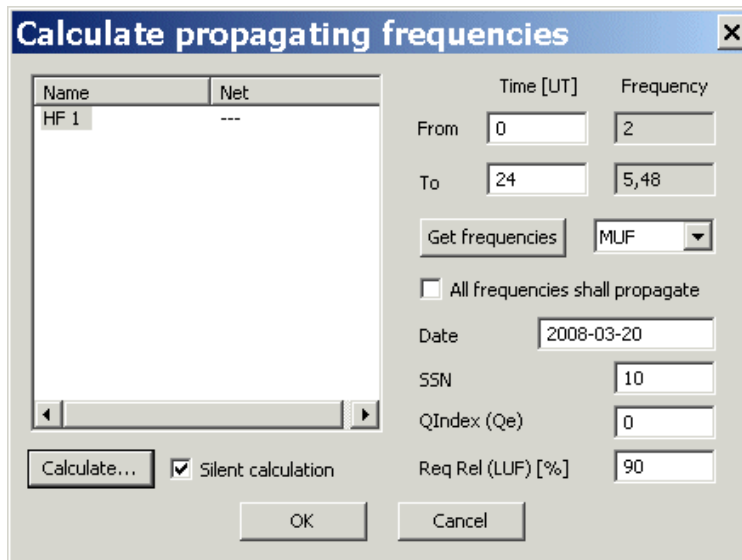


Figure 18.13: Window for the Calculate propagating frequencies function for HF links

The following should be noted when using this function:

- Checking the *Silent calculation* box results in not opening the ITS HF window. The result is retrieved automatically to the WRAP window.
- The upper frequency limit can be selected as one of the following calculated predicted frequencies:
 - FOT: Optimum working frequency: 90% propagation mode probability
 - MUF: Maximum usable frequency: 50% propagation mode probability
 - HPF: Highest probable frequency: 10% propagation mode probability
 - HPF+20%: HPF + 20%

Which one to select depends on the application. For systems with their own capability to select optimum frequencies of operation it is normally best to select a high frequency limit, since this will allow them to utilise high frequencies of operation. These normally give best link quality when the propagation supports them. For fixed-frequency systems a more long-term reliable frequency range should be selected, which means that the FOT is a good choice.

- The lower frequency limit is always the LUF – Lowest usable frequency. The LUF depends to a large extent on the value for the required reliability.
- The *Get frequencies* button works when a calculation has been performed which results in the output data file from the ICEPAC software. There will be a warning message if this file does not exist.

- The check box *All frequencies shall propagate* is normally checked when all frequencies in the allotment or assignment shall have propagation within the selected hours of the day. This is typically the case when preparing frequency tables for frequency hopping systems or for fixed frequency systems just using a single or very few frequencies.
- When the check box *All frequencies shall propagate* is NOT checked the result is the lowest and highest frequency limit found within the selected time interval of the day. This is typically the application when preparing frequency tables for ALE systems.
- In some cases the returned “High” frequency limit will actually be lower than the “Low” frequency limit. This is the case when the required reliability cannot be fulfilled at the lowest usable frequency LUF. There will be a warning message about this. To anyway be able to retrieve a low frequency of some relevance the value for the *Req. Rel.* may be reduced and the calculation run again. However, the proper engineering solution is to improve the link budget by increasing power, selecting other antennas or simply accept that communication will probably not be possible for some hours of the day.
- The only applicable calculation in the ICEPAC operator window to support this WRAP function is *Run – Graph*. Only this mode creates the required output data file to be read by WRAP.
- The results of the prediction may be studied graphically in ICEPAC. However, this is not necessary in order for WRAP to retrieve the results.
- The ICEPAC windows should be closed when a calculation has been performed. Otherwise you cannot start a new calculation or save the calculated frequency limits to the WRAP fields of entry.
- This function can be used to calculate a range of frequencies that should support operation in an area, such as between mobile stations and/or in a network with many links of varying distances. However it is important to note that the frequency limits should then be calculated based on a selected link that can be considered to be representative for all the links of the network. It is also possible to repeat the calculation for the shortest and the longest link within the network and select the smallest common frequency range between the two results.

This function is available in the following windows of WRAP.

Table 18.4: Availability of Calculate Propagating Frequencies function.

Window of access	Function	Comment
Edit Station - Frequencies tab – Get fq limits	Returns the propagating frequency range limits and writes these in the top line of the Frequencies table with a comment "Interval – Remove this frequency"	<p>This is to support the operator when manually selecting frequencies or editing the frequency table for the station. The new top line is not saved as frequency data. It is removed when moving away from the Frequencies tab.</p> <p>The function is only available when there already is at least one frequency entry within the 2 – 30 MHz range.</p>
Edit Network – Main tab – Get fq limits	<p>Returns the propagating frequency range limits and writes these in the top line of the Frequencies table with a comment "Interval – Remove this frequency"</p> <p>For networks the propagating frequency range can be determined for:</p> <ul style="list-style-type: none"> • All point-to-point links in the network • All point-to-point links from a selected station (normally the master station) to the other stations • A single point-to-point link (if it has been formed in advance). 	<p>This is to support the operator when manually selecting frequencies or editing the frequency table for the network. The new top line is not saved as frequency data. It is removed when moving away from the Frequencies tab.</p> <p>The function is only available when there already is at least one frequency entry within the 2 – 30 MHz range.</p>
Edit Station/Network – Frequencies/Main tab – From allotment – Select Equipment – Calc fq limits	Returns all frequencies of the selected allotment that are within the calculated propagating frequency limits and sets these in the frequency table of the station/network.	This is to support the operator when assigning frequencies in particular to ALE or frequency hopping stations/networks

Window of access	Function	Comment
Create Allotment – Calc band limits	Returns the propagating frequency limits and sets these as the lower band minimum and maximum frequencies.	This is to give support when creating suitable top-level allotments normally to be used for further division into sub-allotments.
Divide Allotment: Setup – Edit Destination Allotment – Propagating frequencies	Returns the propagating frequency limits and sets these as the Low frequency and High frequency values of the destination allotment	This is to support the spectrum manager when preparing allotments in particular to ALE or frequency hopping stations/networks, or when preparing sub-allotments to distribute to other spectrum managers for further preparation into allotments for fixed frequency/ALE pool/frequency hopping table use.

Perform the following to learn more about this function:

- Open the HFDemo.wpe project, open the Stations in Project folder and double-click on the HF1 station. Go to the Frequencies tab.
- Press the Get fq limits button

Assume now that this is a fixed-frequency link that can operate on two frequencies: One to be suitable for day-time operation and one for night-time, and that the prediction shall be valid for the month of January at a sunspot number of 100.

- Enter time of day 8 to 16 hours and time of year as 2009-01-15. Select FOT as the upper frequency limit. The sunspot number shall be 100 and the required reliability for the LUF calculation shall be 90%. Check the checkbox All frequencies shall propagate.
- Mark the HF1 station and press Calculate (or double-click on the HF1 station). This opens the ICEPAC window:

ICEPAC Point-to-Point data input

File Run View Save to: Help

Method 20 = Complete system performance (C.S.P.)

Year 2009 **Coefficients** URSI 88 (Australian)

Time 01 to 24 by 1 hours UT

Groups Month.Day= 1.15
SSN = 100
Qindex = 0.000

Transmitter 57.79N 15.25E HF 1

Receiver 58.77N 15.79E HF 2

Path Short Distances: 113km 61nmi 70mi Azimuth: 15.9deg

Freq(MHz) 7.000 2.500 4.000 5.500 8.500 12.000

System Noise Min Angle Req.Rel. Req SNR Multi Tol Multi Del
145 (-dBw) 0.10deg 90% 55dB 3.00dB 0.10msec

Eprob 1.00*foE 1.00*foF1 1.00*foF2 0.70*foEs

Ix Antenna

#	Min	Max	Design	Directory\Filename.sfx	Model	MainBeam	Power kW
1	2	30	15.000	samples \SAMPLE.23	IONCAP #23	15.8	0.3981

Rx Antenna samples \SAMPLE.23 196.3deg 0.00dB

Input Help:

Figure 18.14: ICEPAC input data window

- Check that the data corresponds with your expectations. You may change parameters in this window, for instance if you wish to use the CCIR ionospheric coefficients instead. The select Run - Graph to perform the calculation.
- Select the REL parameter for display in the ICEPAC graph window and study the frequency variation over the day. You may also select to show the FOT curve. This is done by selecting User lines - FOT, then Parameters and select REL again for plotting.
- Return to the WRAP window (let the ICEPAC windows be open or minimised). Press the Get frequencies button. This fills the minimum and maximum frequency of propagation into the frequency fields. Take note of the highest frequency, which is the best day-time frequency to use as determined by a long-term prediction for this link.
- Change the time interval to 16 to 8 and press Get frequencies. The highest frequency that is filled is now the best frequency for night-time operation.

- You may also try to check and un-check the All frequencies shall propagate checkbox and then press the Get frequencies button to see the difference. Do this also for a time interval of 0 to 24 to see the total predicted frequency range if frequencies could be selected at will for this link.
- Finally press the OK button. If this is not active it is due to ICEPAC windows still being opened. They need to be closed to activate the OK button.
- The frequency table in the Edit Station/Frequencies tab now has a new entry at the top. This is just information to the user of the frequency range that should provide propagation for this link under the conditions of the previous predictions. Moving away from the Frequencies tab removes this line automatically.

Note again that this function is available when selecting frequencies from an allotment in Edit Station/Frequencies and in Edit Network/Frequencies, when creating an allotment and when dividing an allotment.

