Australian Government
Bureau of Meteorology

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Space Weather Services

ASAPS for Windows V5

Tutorial

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1. Introduction

1.1 About this tutorial

This introduction contains background information on some of the terms used in ASAPS and HF sky wave propagation in general. If you are using ASAPS for the first time, it is recommended you familiarise yourself with this information.

The tutorial includes 39 exercises. Notes precede some exercises and may be useful when performing the task. Procedures on performing the exercises are provided.

1.2 Time

All ASAPS predictions use universal time (UT). Universal time is the same as Greenwich Mean Time (GMT) or Zulu (Z) time and 0000 UT occurs when it is midnight at Greenwich, UK.

ASAPS computes frequency predictions for each UT hour. An hour is considered to begin 30 minutes before the hour and end 30 minutes after. For example, prediction data for 07 UT is generally applicable to the period between 0630 UT and 0730 UT.

1.3 Terminals and circuits

In ASAPS, a transmitter or receiver location is called a terminal or base (in an Area prediction) and a communications path between two terminals is called a circuit.

1.4 Bearings

Bearings indicate the angle in the horizontal plane from true (geopgraphic) north to the direction of the other terminal in a circuit. Angles are measured clockwise from true north: north = 0°, east = 90°, south = 180° and west = 270°. Bearings in ASAPS may be specified in either degrees or mils. Note that 1 degree = 60 minutes and 1 minute = 60 seconds. There are 6,400 mils in 360°, 17.78 mils = 1 degree and 0.296 mils = 1 minute.

1.5 Circuit types

ASAPS defines three types of sky wave circuits: district/NVIS (Near Vertical Incidence Sky wave), short path and long path.

District/NVIS circuits may be used for communications between a terminal and locations situated within 300 km of the terminal. The prediction is based on the ionosphere directly above the terminal.

The great circle is the line of intersection between a plane that passes through the centre of a sphere. Two locations that lie on a great circle divide it into a short segment and a long segment.

The ASAPS short path is the shorter of the two segments on the great circle while the longer segment is termed the long path. For example, the short path distance between Sydney, Australia and Los Angeles, USA, is approximately 12,100 km, across the Pacific Ocean while the long path is approximately 28,000 km.

1.6 Path length

Path length refers to the distance (across the ground) a wave may travel either via the surface wave or the sky wave. The path length of the short path sky wave Sydney to Los Angeles circuit is approximately 12,100 km.

1.7 Hops and modes

One hop is defined as an HF sky wave travelling from a location, being refracted once from the ionosphere and returning to Earth. Two hops occur when there are two refractions from the ionosphere and an intermediate ground reflection.

ASAPS does not consider multihop paths involving successive reflections from both the E and F layers, sporadic E modes, trans-equatorial propagation, nor does it factor in ionospheric tilts.

The modes which are examined for various path lengths are listed in Table 1. The first mode has the minimum number of F layer hops geometrically possible for a maximum hop length of 4,000 km along the great circle path. The second mode has the next greater number of hops.

If communications are required between Brisbane, Australia and Manila, Philippines, a distance of 5,813 km, the first F mode will be the 2F (two hops via the F layer) and the second F mode will have one extra hop, the 3F. There will be no first E mode (2E - two hops via the E layer) since the maximum distance a wave is likely to travel by this layer over two hops is about 3,600 km (2*1,800). The second E mode (3E) will possibly cover the distance 5,400 km (3*1,800) but communications by this mode would require a very low elevation angle. With E region communications, consideration should be given to the number of traverses through the daytime absorbing D region and Earth reflections, as these may reduce the signal strength below acceptable levels.

Table 1. Propagation modes examined for various path lengths.

Circuit length (km)	First mode		Second mode	
0 - 499	1E	1F	-	-
500 - 2,049	1E	1F	2E	2F
2,050 - 3,999	-	1F	2E	2F
4,000 - 4,099	2E	2F	3E	3F
4,100 – 6,149	-	2F	3E	3F
6,150 - 7,999	-	2F	-	3F
8,000 - 8,199	-	3F	4E	4F
8,200 – 11,999	-	3F	-	4F
>= 12,000	Composite F mode (3,000 km hop length)			

Complex modes can occur and involve propagation via two or more layers. Mixed modes involve propagation of two or more signals simultaneously. Complex and mixed modes may result in fading if a number of signals are received which are of similar amplitude and out of phase. GRAFEX predictions indicate when complex and mixed modes may occur and cause fading.

1.8 Propagation of an HF radio wave

The high frequency (HF) band is usually defined as ranging between 3 and 30 MHz. An HF wave may propagate across the surface of the Earth (surface wave), propagate via the ionosphere (sky wave) or it may travel directly to a location by line-of-sight.

The extent of coverage of the ground wave is dependent upon frequency, terrain and sea state, transmitter power, noise, antennas and their position and the conductivity of the surface over which the radio wave travels. The range improves with lower frequencies and is greatest over sea water and least over thick ice.

The choice of frequency used when an HF radio wave travels via the ionosphere is dependent upon the time of day (higher frequencies during the day), the solar cycle (higher frequencies around solar maximum), latitude (generally higher frequencies at lower latitudes), the seasons and path length.

During the day the band of frequencies available for HF sky wave propagation extends from the lowest frequency through to the upper frequency which is dependent upon the radio wave being refracted (bent; often the radio wave is said to be reflected) back to the Earth's surface. The lowest frequency is dependent upon ionospheric absorption of the radio wave. At night, ionospheric absorption becomes negligible. Around sunset and particularly sunrise, the ionosphere changes rapidly. Successful communications during these times normally requires changing frequencies more frequently than during the day or night.

Note that while a wave may propagate to a location the sensitivity of the receiving equipment will determine if the wave is detected.

1.9 The ionosphere

The ionosphere is usually considered to extend from about 50 to over 500 km in altitude. The three regions of the ionosphere, in increasing altitude are the D, E and F regions.

The D region is the lowest region of the ionosphere. This region absorbs HF radio waves and reduces their signal strength. Absorption is normally greatest during the middle of the day, at solar maximum, in summer and at lower latitudes (although in the polar regions, absorption can sometimes be very high). Absorption is also greater at lower frequencies. At night the D region becomes insignificant and D region absorption effects become unimportant.

The E region extends in altitude from about 90 to 140 km. This region is capable of refracting HF radio waves. Because it is at a lower altitude than the F region, sky wave communications using the E region may require more hops, depending on the length of the circuit. In such cases the radio wave traverses the absorbing D region more frequently and more Earth reflections occur, leading to reduced signal strength. However, if communications are required for short distances (say less than 3,000 km) the E region can provide good daytime communications. Communication using the E region is not possible at night, as the electron density region becomes insignificant.

The F region is the highest region (140 to over 500 km in altitude) and is constantly present though generally at reduced electron density during the night (higher frequencies are therefore less likely to be reflected from the ionosphere at night). The longest hop lengths can be attained using the F region because it has the greatest height. This in turn may reduce Earth reflections and traverses through the D region on longer circuits, reducing signal losses. The F region also supports higher frequencies. Using higher frequencies during the day reduces wave absorption.

Sporadic E is a dense, thin layer that sometimes occurs at altitudes similar to the E region. It can prevent HF radio waves meant for reflection from the F region reaching that region. Instead, the radio waves are refracted from the sporadic E layer and traverse the ionosphere via a different path. The wave may not propagate to the receiving terminal. Sometimes sporadic E is partially transparent. That is, it allows transmission of some of the signal through to the F region while itself simultaneously reflecting some of the signal. This can result in a loss of signal strength at the receiver and sometimes even fading of the signal as the reflectivity of the sporadic E layer varies. Sporadic E is most likely to affect F region communications during daylight hours in summer and at lower latitudes. Sporadic E can occur day or night.

Spread F is a phenomenon where the reflecting layer in the F region becomes diffuse. The receiving antenna may detect the signal over a longer duration of time than is normal, degrading the signal quality. Spread F is more likely to occur at equatorial, low and high latitudes at night.

1.10 The lower limit of the frequency range – the ALF

The usable HF frequency band, Figure 1 (p. 14), has a lower limit that is dependent upon location, time of day, the solar cycle, and the seasons. During the day, the D region can absorb HF radio waves thereby reducing signal strength. The lower the frequency, the more energy will be lost from the radio wave through absorption. Space Weather Services provides an indicator called the Absorption Limiting Frequency (ALF) which is a guide to the lowest frequency usable.

There is no ALF at night because the D region becomes insignificant. During the day the ALF varies with changes in the predicted absorptive behaviour of the D region. Communications using frequencies that are close to the ALF may suffer low signal strength due to increased attenuation. However, note that the lower limit of the usable frequency band for any particular circuit also depends upon factors such as receiver site noise and transmitter power.

Sometimes when a solar flare occurs, D region absorption of an HF sky wave increases above normal levels. This is called a short wave fadeout (SWF, but also called a daylight fadeout or sudden ionospheric disturbance, SID). Fadeouts usually cause less disruption to higher frequencies, although, occasionally a flare is so large that all HF sky wave frequencies are absorbed in the affected region of the world. During these times, HF propagation by line-of-sight and the ground wave may be still possible.

1.11 The upper limits of the frequency range – EMUF, OWF, MUF, UD

If a frequency is too high, an HF radio wave may penetrate the ionosphere rather than be refracted back to Earth. For the F region, a range of upper limit frequencies may be given in ASAPS predictions, Figure 1 (p. 14). The Optimum Working Frequency (OWF) is that frequency which should be successful 90% of the duration of the prediction. The median Maximum Usable Frequency (median MUF or just MUF) should be successful 50% of the time. The Upper Decile MUF (UD) should be successful 10% of the time. These percentages are dependent upon the prediction being correct.

As an example, consider the following values for a particular hour in some prediction: ALF = 5 MHz, OWF = 13 MHz, MUF = 17 MHz and UD = 21 MHz.

If the operator chooses a frequency close to, or lower, than 5 MHz for this hour, then the signal is likely to be highly attenuated as it passes through the D region of the ionosphere, possibly leading to low signal strength.

A frequency between 5 MHz and 13 MHz has a greater than 90% chance of being reflected by the ionosphere because it is below the OWF. So, if it is a monthly prediction, then the signal is likely to be reflected over 90% of the time (or about 27 days of the month) at that hour. Choosing a frequency between the ALF and OWF should usually provide reliable communications.

If the frequency chosen lies between 13 MHz and 17 MHz, the chance of the signal being reflected is reduced to between 50% and 90% (50% for the MUF and 90% for the OWF). The reliability of communications is decreased because there is a greater chance the wave will penetrate the ionosphere. The closer the frequency is to the OWF, the greater the reliability will be, but because the frequency is above the OWF, the reliability is less than 90%. For a monthly prediction, a frequency that lies between the OWF and MUF should be reflected between 15 (50%) and 27 (90%) days of the month.

Should the operator choose to use a frequency between 17 MHz and 21 MHz, the chance of the signal being reflected is further reduced. The signal only has a 10% to 50% chance of being reflected (between 3 and 15 days of the month).

Increasing the frequency above the UD of 21 MHz reduces the reliability to less than 10% of the time (less than 3 days of the month). That is, a frequency greater than 21 MHz will only propagate successfully less than 3 days of the month, while for the other 27 days it is likely to penetrate the ionosphere.

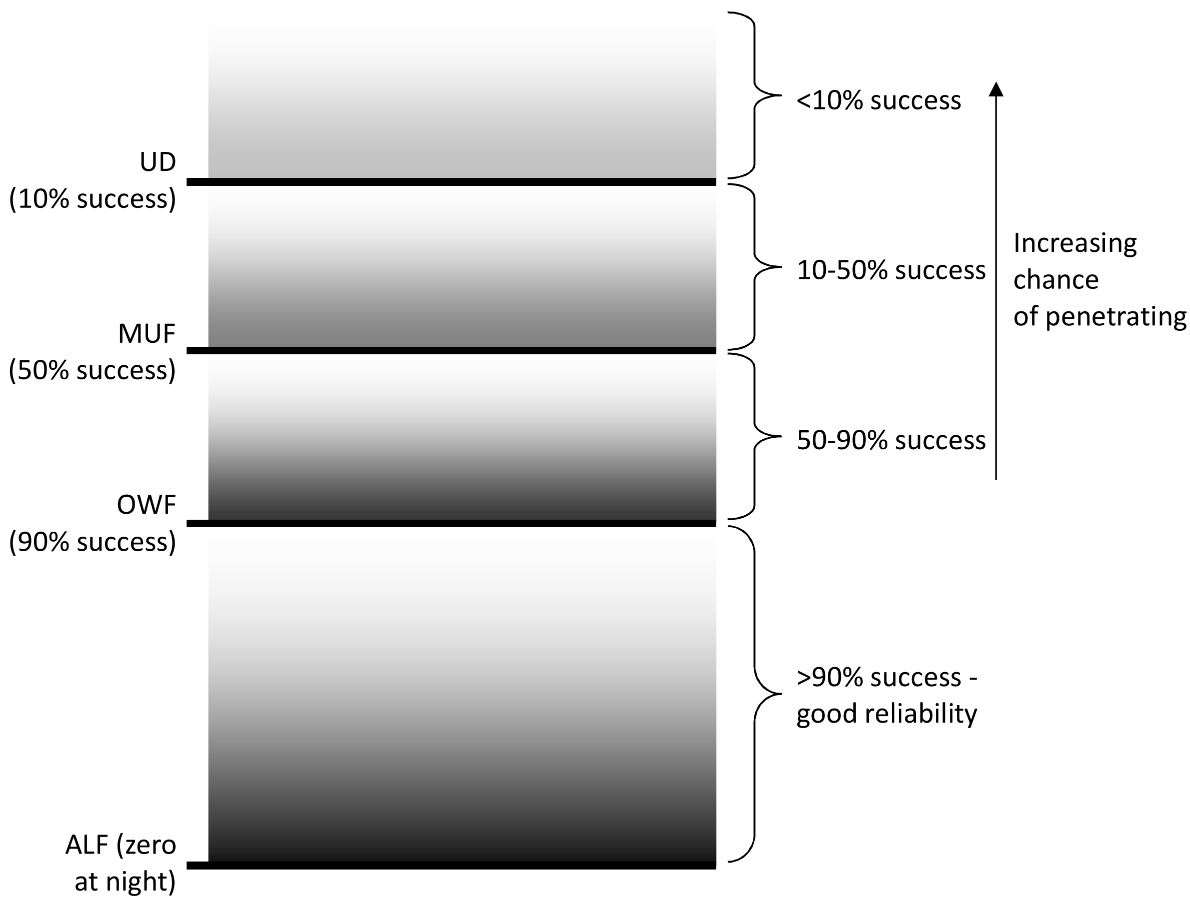

Figure 1. Upper and lower frequency limits for HF sky wave communications.

ASAPS GRAFEX predictions may also provide the EMUF for the E region. The EMUF is that frequency which should provide successful propagation 50% of the time by the E region, if the prediction is correct. Field Strength predictions will provide the MUF (EMUF) and OWF for any E layer modes available. That is, those frequencies that should provide successful communications 50% and 90% of the time by the E region, respectively.

1.12 Disturbances in the ionosphere

Activity on the Sun can cause disturbances in the Earth's magnetic field that in turn can cause disturbances in the ionosphere. Ionospheric disturbances that affect HF sky wave communications usually manifest themselves as a drop or depression in the highest usable frequencies. For example, a prediction that is correct may have as its OWF, 12 MHz, at some particular time. An ionospheric disturbance may result in a depression of 20% on this circuit. That is, the OWF during the ionospheric disturbance decreases approximately 2.4 MHz (20/100 * 12) to 9.6 MHz at this time. The usable HF frequency band during the disturbance is now between the ALF and 9.6 MHz (if the OWF is selected as the highest frequency that can be used). Communications at frequencies higher than 9.6 MHz at this time now have a greater chance of penetrating the ionosphere.

1.13 The T index

For any circuit, the range of frequencies that may be reflected from the ionosphere varies with solar activity. The level of solar activity is often measured using the sunspot number and generally the higher the sunspot number the higher the maximum frequencies that can be reflected on the circuit. The sunspot number can therefore be used to predict the range of frequencies usable on a circuit.

However, the range of frequencies is not solely reliant on solar activity. The ionosphere also changes with the time of day, the seasons and location. For these reasons Space Weather Services developed the T index.

The T index is an effective sunspot number because it is derived from the relationship between the sunspot number and monthly median foF2 (highest frequency reflected vertically from the F region of the ionosphere) values. World maps of ionospheric behaviour when T = 0 (low solar activity) and T = 100 (high solar activity) have been produced using the relationships between T and foF2 for locations where data have been obtained. There are world maps for each hour, each month and low and high levels of solar activity (576 maps). Since past ionospheric behaviour (and hence T index) is known, future ionospheric behaviour can be predicted, based on expected solar activity. The predicted T index and the world maps are used to determine the predicted foF2 value at ionospheric reflection points for a certain circuit for a certain hour. This foF2 value is then converted into a frequency suitable for oblique propagation at that hour. The process is repeated for other hours.

The T index may take on any value depending on the reflectivity of the ionosphere but normally ranges between -50 and 200. Usually, the greater the solar activity, the greater the T index and the higher the frequencies supported by the ionosphere. However, the T index can decrease markedly or become negative during solar minimum and disturbed periods, indicating lower frequencies should be used.

Space Weather Services produces monthly T indices, daily T indices for the Australian region and real time T indices for the northern and southern hemispheres, Australian, New Zealand and Antarctic regions. The real time T indices are updated each hour and are computed from data received from various stations within each region. The real time T indices are also determined from automatically computer scaled, “auto scaled”, data which may produce errors on occasions.

The monthly and real time T indices can be found on the Space Weather Services web site (www.sws.bom.gov.au) on the *HF Systems* page under *Global HF* then *T index*. The monthly T indices can also be obtained by subscribing to the Space Weather Services *Observed and Predicted T indices* mailing list. The daily T indices for the Australian region can be obtained by subscribing to the *Daily HF Propagation Report* list. To subscribe to either of these lists, go to the *Products & Services* page and click on *Mailing List*.

The monthly T indices can be used to produce predictions for anywhere in the world. The daily T indices for the Australian/New Zealand region should only be used for communications within that region while the various real time T indices should only be used for the particular hour for which the T indices were derived and for the correct region.

The monthly T indices are based on the expected long term behaviour of the Sun. Sometimes, unexpected events occur on the Sun which disturb the ionosphere or make the ionosphere behave unexpectedly; at other times Space Weather Services incorrectly predicts the slowly varying solar activity. A prediction based on the monthly T index becomes temporarily incorrect.

For communications in the Australian/New Zealand region in such cases, communicators can be guided as to the usable frequency range by the daily T indices for this region. If a prediction using the monthly T has been computed for communications in this region and the daily T index departs from the monthly T by more than about 20 points, it is advisable that either a new prediction be produced, based on the daily T index, or operating frequencies be altered to allow for the change. Alternatively, an *HF warning* issued by Space Weather Services will indicate when frequencies should be decreased.

Where a prediction for communications other than in the Australian/New Zealand region has been produced using the monthly T index and the prediction is inaccurate, operators can be guided by the HF warning, the real time T indices or in Europe, the *Automated Daily European HF Propagation Report*. The *HF warning* and the *European HF Propagation Report* can be subscribed to from the *Products & Services* page under *Mailing List*. Both these reports should indicate when frequencies are expected to decrease. The real time T indices can also be used as a guide to conditions in the ionosphere.

Sometimes the predicted monthly T index is lower than the observed T index over a period of time. This indicates that solar activity was greater than expected. The daily reports will then indicate that frequencies are enhanced or above predicted values.

Enhancements of the ionosphere resulting in the observed T index being greater than the predicted T index do not normally pose a problem to communications. This situation indicates that the frequencies calculated using the predicted T are still usable but there may be higher frequencies in the frequency set that successfully propagate. Depressions on the other hand may result in some of the operating frequencies predicted based on the monthly T index, being too high so that their use results in penetration of the ionosphere. When depressions occur, the *HF warning* should indicate the use of lower frequencies.

1.14 Sunspot number and the 10.7 cm solar flux

The sunspot number is a count of the number of sunspots and sunspot groups that are observed on the surface of the Sun. The accuracy of the sunspot number is therefore weather, equipment and observer dependent. The 10.7 cm solar flux is an alternative estimate of solar activity and is a measure of the radio emission from the Sun at a wavelength of 10.7 cm (frequency 2,800 MHz). If either the sunspot number or 10.7 cm flux is chosen as the preferred index, ASAPS converts the value to a T index when computing the prediction.

1.15 The decibel and logarithms

The decibel (dB) is a unit of relative measurement used in various ASAPS prediction formats. The information here may be of help.

The use of the decibel involves the use of logarithms. Just as division is the reverse of multiplication, the logarithm (usually abbreviated to "log") is the reverse of exponentiation.

If: $A^B = C$
then (log of C to base A) $\log_A C = B$

Some rules of logarithms are:

$$\log_A B^C = C * \log_A B$$
$$\log_A (B * C) = \log_A B + \log_A C$$
$$\log_A (B / C) = \log_A B - \log_A C$$
$$\log_A A = 1$$

$\log_A 1 = 0$
$\log_A A^B = B$
$A^{\log_A B} = B$

If A = 10 then $10^B = C$
so that $\log_{10} C = B$

For example: $10^2 = 100$
therefore $\log_{10} 100 = \log_{10} 10^2 = 2 * \log_{10} 10 = 2 * 1 = 2$

The decibel is applied to any quantity that has been subjected to the transformation of 10 times the common logarithm (log to base 10) of the ratio of that quantity to some reference quantity:

$$X \text{ (dB)} = 10 * \log_{10} (x / x_{ref})$$

When x_{ref} is just one unit of the units used to measure the quantity x, the symbol dB is appended with the symbol for that unit. For example, power may be measured in megawatts (MW), kilowatts (kW), watts (W), milliwatts (mW) or microwatts (µW). If x is power in watts (W) and x_{ref} is 1 W, then the unit for X is dBW (decibels above 1 watt). If x_{ref} is milliwatts (mW), then the unit for X is dBmW, or more usually dBm (decibels above 1 milliwatt).

If x_{ref} is some other quantity, y, then the unit of X is just dB.

As an example of the decibel's use, consider the signal-to-noise ratio (SNR):

$$\begin{aligned} \text{SNR (dB)} &= 10 * \log_{10} (\text{signal power (W)} / \text{noise power (W)}) \\ &= 10 * \log_{10} (\text{signal power (W)} / 1 \text{ W}) - 10 * \log_{10} (\text{noise power (W)} / 1 \text{ W}) \\ &= \text{signal power (dBW)} - \text{noise power (dBW)} \end{aligned}$$

The following ratios may be helpful for the equation: $X \text{ (in dB)} = 10 * \log_{10} (x_1 / x_2)$

-40 dB	x_2 10000 times greater than x_1	$10 * \log_{10} (1 / 10000)$
-30 dB	x_2 1000 times greater than x_1	$10 * \log_{10} (1 / 1000)$
-20 dB	x_2 100 times greater than x_1	$10 * \log_{10} (1 / 100)$
-10 dB	x_2 ten times greater than x_1	$10 * \log_{10} (1 / 10)$
-6 dB	x_2 four times greater than x_1	$10 * \log_{10} (1 / 4)$
-3 dB	x_2 twice as large as x_1	$10 * \log_{10} (1 / 2)$
0 dB	x_2 equal to x_1	$10 * \log_{10} (1 / 1)$
3 dB	x_1 twice as large as x_2	$10 * \log_{10} (2 / 1)$
6 dB	x_1 four times greater than x_2	$10 * \log_{10} (4 / 1)$
10 dB	x_1 ten times greater than x_2	$10 * \log_{10} (10 / 1)$
20 dB	x_1 100 times greater than x_2	$10 * \log_{10} (100 / 1)$
30 dB	x_1 1000 times greater than x_2	$10 * \log_{10} (1000 / 1)$
40 dB	x_1 10000 times greater than x_2	$10 * \log_{10} (10000 / 1)$

For example, signal-to-noise is the ratio of the received power to the noise power. If the required signal-to-noise is 6 dB, then the signal power is required to be four times greater than the noise power.

At times, there may be the requirement to convert a value measured in some quantity into decibels. For example, in the equation, $P_t + G_a = SNR - NP + B$, the transmitter power, P_t, is required to be converted to decibels. As an example, consider a transmitter power of 350 W. This can be converted to decibels from:

$$\begin{aligned} X\ (\text{dB}) &= 10 * \log_{10} (x / x_{ref}) \\ &= 10 * \log_{10} (350 / 1) \\ &= 25.4\ \text{dBW} \end{aligned}$$

The “W” is appended to the unit of decibel since the quantity is referenced to 1 W. From the list of conversions of ratios to decibels above, it can be seen that 25.4 dBW results in a power ratio where the transmitter power is somewhere between 100 times (20 dB) and 1000 times (30 dB) greater than 1 watt; and 350 W lies between 100 and 1,000 W.

At other times, it may be necessary to convert from decibels back to the usual unit for a particular quantity. As an example, consider a transmitter power of 7.5 dBW. From the list above, it can be seen the actual transmitter power lies somewhere between 4 and 10 W.

Now	$\log_A C = B$
and if A = 10 then	$\log_{10} C = B$
if	$10 * \log_{10} C = 7.5$
then	$\log_{10} C = 7.5 / 10$
therefore	$B = 7.5 / 10$
from earlier	$A^B = C$
and as A = 10 then	$10^B = C$
therefore	$10^{7.5/10} = 5.6$

Hence a transmitter power of 7.5 dBW (7.5 dB above 1 W) is actually 5.6 W.

2. Databases menu

Clicking on *Databases* accesses the databases where much of the information required for a prediction is stored. There are eight databases: Configuration, Terminals, Circuits, Frequency Sets, Antennas, Areas of interest, Station configurations and T index. Refer to the sub-sections below for details.

2.1 The tab and enter keys

The *Tab* key on the keyboard moves the cursor between text boxes, buttons and lists in the dialogues without using the mouse. Pressing the *Enter* key on the keyboard when a button is selected has the same effect as clicking the left mouse button.

2.2 Configuration database

Clicking on *Databases|Configuration* displays the *ASAPS Configuration* dialogue. In the *ASAPS Configuration* dialogue, the distance units (kilometres, nautical miles, statute miles), preferred index (T, 10.7 cm flux, sunspot number), co-ordinate units (decimal degrees or degrees and decimal minutes) and bearing units (degrees or mils), can be specified. The colours of the Area Colour Scale used in the Area prediction graphs and the GRAFEX Graph can also be selected.

The desired font, font style and font size can be specified by clicking on the *View/Print Font* button. If the prediction is to be printed, the width of the top and left margins can be specified in the *Left margin* and *Top margin* fields.

Computed prediction files are stored in the "user" directory under the directory specified in the *User Directory* field.

Exercise 1. Altering the configuration of ASAPS

Set up the configuration of ASAPS as follows: Distance units = Kilometres, Co-ordinate units = Decimal degrees, Preferred index = T index, Bearing units = Degrees, GRAFEX Graph = Solid Fill, Area Colour Scale = Splatter.

- Select ***Databases*** from the menu bar then ***Configuration*** in the drop-down menu. The **ASAPS Configuration** dialogue appears.
- Select the option buttons (these will darken) or buttons as specified above and when completed click on the ***OK*** command button.
- The predictions will now use these selections.

2.3 Terminals and circuits databases

These two databases are accessed by pressing *Databases* then either *Terminals* or *Circuits*. The *Terminals* or *Circuit* dialogue will be displayed. Terminals and circuits may be added to their respective databases via these dialogues. Alternatively, terminals and circuits may be saved when entering the details of a prediction in the *Prediction Details* dialogue; terminals may also be entered in the *Area Prediction details* dialogue. These dialogues are accessed from the *Predictions* drop-down menu.

In the Circuits database or the *Prediction Details* dialogue, a terminal, its location, bearing and distance to the other terminal can be entered as an alternative to entering two terminals and their co-ordinates.

Terminal and circuit names are case independent. For example, provided the location is the same then perth, Perth and PERTH are equivalent.

When entering geographic co-ordinates in ASAPS, latitudes north of the equator are considered positive and latitudes south of the equator, negative. To enter the latitude of Hobart, Australia, 42.88° S, for example, type -42.88 in the *Lat.* field. West longitudes are also entered as negative values. For example, New York, U.S.A. has a longitude of 74.01° W; this can be entered in the *Long.* field as -74.01. Alternatively, if only the east longitude of the site is known then this can be entered as a positive number. For instance, the east longitude of New York, U.S.A. is 285.99° E, which is entered as 285.99. ASAPS converts all longitudes greater than 180° to west longitudes.

2.3.1 Adding terminals to the terminals database

Exercise 2. Adding terminals to the Terminals database

Add the following six terminals to the Terminals database if they do not already exist.

1. **Auckland (36.88° S, 174.75° E)**
2. **Canberra (35.25° S, 149.16° E)**
3. **Perugia (43.07° N, 12.23° E)**
4. **London (51.50° N, 0.18° W)**
5. **Ship (46.23° S, 138.54° E)**
6. **Arequipa (16.24° S, 71.33° W)**

- Select ***Databases*** in the menu bar then ***Terminals*** from the drop-down menu. The **Terminals** dialogue appears. The **Tab** key moves the cursor from one field or button to the next.
- See if the first terminal exists in the database by either typing the name of the terminal then pressing **Enter** or the **spacebar** on the keyboard to view the latitude/longitude, or scrolling through the list of terminals and if it exists, clicking on it. The terminal does not exist in the database if nothing appears in the **Lat.** and **Long.** fields when the terminal name is entered and the **Enter** or the **spacebar** key is pressed or it is not displayed in the list of terminals.
- If the terminal exists in the list, check the latitude and longitude are comparable to those above. If they are not comparable, change them then click on ***Add/Modify***.
- If a terminal does not exist, type the terminal name, latitude and longitude in the appropriate text boxes then click on ***Add/Modify***. Remember that southern latitudes and western longitudes are entered as negative numbers.
- Click the ***Done*** command button if any terminals have been altered or added, otherwise click on ***Cancel***.

2.3.2 Adding circuits to the circuits database

ASAPS defines three circuit types, district/NVIS, short and long. Refer to Section 1.5 for further information.

If both short and long path circuits between two terminals are required then the circuit names must be distinguished from each other. For example, if the "Adelaide-Hobart" short path circuit already exists in the Circuits database and this is to be retained, call the Adelaide-Hobart long path circuit a different name, for example "Adelaide-Hobart-l". Note that the maximum number of characters in a circuit name is 20.

Extra white spaces within circuit names can result in two circuits with the same locations in the database. For example, ASAPS considers the circuits "London - Paris" and "London-Paris" to be two distinct circuits.

Exercise 3. Adding circuits to the Circuits database

Add the following five circuits to the Circuits database if they do not already exist.

1. **Canberra-Ship (short path)**
2. **Auckland-Limbunya (17.12° S, 129.48° E) (short path)**
3. **Perugia-London (long path)**
4. **Arequipa district (District/NVIS)**
5. **Bujumbura (3.38° S, 29.37° E)-X (distance: 1300 km, Tx→Rx bearing: 285°) (short path)**

- Select ***Databases*** from the menu bar then ***Circuits*** from the drop-down menu. The **Circuit** dialogue appears.
- See if the first circuit exists in the database by scrolling through the list or typing the name, **canberra-ship**, in the **Circuit Name** field then pressing **Enter** or the **spacebar**. If the circuit exists in the database, the fields in the **Tx** and **Rx** group boxes will now be filled or the circuit name will be displayed in the list of circuit names. If the circuit exists, verify the terminal names, latitudes, longitudes and path type are correct. If the circuit is not in the database, enter **canberra** in the **Tx** name list box and press **Enter** or the **spacebar** to display its latitude and longitude, if it exists. If **canberra** is not in the database, type in its latitude and longitude. Repeat for the **Rx** fields. Select the correct path type then click on ***Add/Modify***. It is not necessary to enter the bearings and distance, as ASAPS will calculate these.
- Repeat for circuits 2 and 3.
- For circuit 4, it is only necessary to enter details in the **Circuit Name**, **Tx** fields and select the ***District/NVIS*** path type, as ASAPS will fill in the **Rx** fields. The distance displayed is 0 km.
- For circuit 5, enter the details in the **Circuit Name** and **Tx** fields. Leave all the **Rx** fields as they are, enter the path type (**short**), distance (**1300**) and bearing in the **Tx→Rx** field (**285**). Now enter the **Rx** name (**X**). Click on the ***Add/Modify*** button.
- If no circuits needed to be entered, click on ***Cancel***, otherwise click on the ***Done*** command button when all data have been entered.

2.3.3 Modifying terminals and circuits

Select *Databases|Terminals* and then select the terminal to be modified in the *Terminals* dialogue. Make the required changes, click on *Add/Modify*, then *Done*. Clicking on *Cancel* rather than *Done* does not save the changes made. A similar procedure is used to modify a circuit from the *Circuit* dialogue.

2.3.4 Deleting terminals and circuits

Select *Databases|Terminals*, select the terminal to be deleted in the *Terminals* dialogue and press the *Delete* button. Repeat this procedure to delete other terminals and finally press *Done*. If *Cancel* is selected after deleting the terminal(s) instead of *Done*, the deletions will not be made. Note that deleting a terminal from the Terminals database will result in the deletion of all circuits that use the terminal. To remove circuits from the Circuits database, use the same procedure in the *Circuit* dialogue.

2.4 Frequency set database

Pressing *Databases|Frequency Set* accesses the *Frequency Set* dialogue. This dialogue requires a frequency set name (at most 15 characters) and the frequencies to be entered (maximum of 100 frequencies). Frequencies between 1 and 60 MHz may be entered. However, the Surface Wave format of the Area prediction will only be computed if the frequencies in the frequency set range between 1 and 50 MHz.

2.4.1 Adding frequency sets

Exercise 4. Adding frequency sets to the Frequency Set database

Add the following frequency sets to the Frequency Set database. “tuteset”: 3226, 6544, 10876, 15235 and 19666 kHz; “local”: 3118, 4559, 5724 and 7611 kHz.

- Select ***Databases*** from the menu bar, then ***Frequency Set*** from the drop-down menu.
- See if the sets already exist by pressing the ▼ button in the **Name** list box to display the sets, or type in the name of the set and press the **Enter** or **spacebar** key. If a set exists and is selected, its frequencies will be displayed in the **Frequencies** group box. If this is the case, ensure the frequencies are correct.
- If the **tuteset** frequency set does not exist, type the name of the set in the **Name** list box.
- The frequencies are to be added in kilohertz (kHz), so ensure the ***kHz*** button is selected.
- Enter the first frequency (no comma required) in the upper box of the **Frequencies** group box and press the ***Add*** button within the **Frequencies** group box or just press the **Enter** key on the keyboard. Repeat for the other frequencies in the set.
- Click the ***Add*** command button on the right, outside the **Frequencies** group box, after all the frequencies for a set have been added.
- Repeat the above procedure for the **local** frequency set, if it does not already exist in the database. Note that when **local** is entered in the **Name** list box, the frequencies in the **tuteset** frequency set remain visible. This is to allow for the possibility of having the same set of frequencies referred to by two or more names, or to rename a set, or to save entering some of the frequencies for the new frequency set if its frequencies are very similar to the last set entered. To remove an unwanted list of frequencies, press the **Enter** or **spacebar** key after typing in the new frequency set name, then add the frequencies for the new set. Enter the new frequencies, ensuring the **Enter** or **spacebar** key or the ***Add*** button in the **Frequencies** group box is pressed after each addition. Press the right ***Add*** button to enter the frequency set in the database.
- When all the frequency sets have been entered, click on the ***Done*** command button to add the sets to the Frequency Set database.

Exercise 5. Importing frequency sets into the Frequency Set database

Add the following frequency sets to the Frequency Set database by producing a file called “suite.txt” and importing the file into the database. The frequency sets are “long”: 15222, 20851, 24943 and 29749 kHz and “test”: 5.143, 9.858, 13.544 MHz. See *Help|Contents|Databases|Frequency Sets|Updating from a file* for the file format.

- Outside the ASAPS application, invoke a Windows text application like Microsoft Word, Notepad or Wordpad. Use the Search feature in Windows Explorer to find these applications.
- Enter the following data in the same format as shown.

  long
  4

15.222
20.851
24.943
29.749
test
3
5.143
9.858
13.544

- Select ***File|Save As…*** and in the **Save in** list box, select the required directory (usually the ASAPS **user** directory). In the **Save as type** list box, select either Text Document or Plain Text (*.txt) and enter the name **suite** in the **File name** list box. Click ***Save,*** then select ***File|Exit*** or click the **X** button at the top right corner of the MS application.
- In ASAPS, select ***Databases|Frequency Set*** and click the ***Import from a file ….*** button, the **Select Frequency Set data file** dialogue appears. Select ***.txt** in the **Files of type** list box, the appropriate drive and location of the file **suite.txt** and select the file. Click on ***Open***.
- Confirm that the **long** and **test** frequency sets are now in the database. To save these two sets to the database press ***Done***.
- Note that this procedure will overwrite a frequency set of the same name that already exists in the database.

2.4.2 Modifying a frequency set

Frequencies can be added or removed from an existing set. From the *Databases* menu select *Frequency Set*. Select the set that requires modification from the *Name* list box. To add a frequency to the set, type the frequency in the *Frequencies* group box and click *Add*. To remove a frequency from a set, select the frequency to be deleted (the frequency will then be highlighted) and click on *Delete* (the *Delete* button below the *Add* button in the *Frequencies* group box). When all the required frequencies have been added or deleted, click on *Done*.

2.4.3 Deleting a frequency set

From the *Databases* menu choose *Frequency Set*. Select the set to be deleted in the *Name* list box. Click on the *Delete* button (above *Cancel*), then *Done* to delete the set.

2.5 Antennas database

The *Antenna* dialogue is accessed by pressing *Databases|Antennas*. The gain patterns for two-dimensional (“2D” - elevation/frequency) and three-dimensional (“3D”- elevation/frequency/bearing) antennas can be added, modified or deleted.

Two-dimensional antennas require gains to be added for take-off angle and frequency combinations. The gain for a particular take-off angle and frequency is the same regardless of the bearing of the antenna. That is, two-dimensional antennas are considered omnidirectional.

Three-dimensional antennas require gains to be entered for combinations of take-off angles, frequencies and bearings.

Antenna gain patterns for specific Andrew and Codan antennas may also be accessed.

2.5.1 Antenna gain

The antenna gains in ASAPS are expressed in dBi (decibels above isotropic).

That is, all gains are referenced or compared to a theoretical isotropic antenna. An isotropic antenna, if it existed, would radiate energy equally well in all directions.

If an antenna produces 1.5 times more power at a distant point than an isotropic radiator under similar conditions, the gain of the antenna is:

$$10 * \log_{10} (\text{power of antenna} / \text{power of isotropic}) = 10 * \log_{10} (1.5 / 1) = 1.76 \text{ dBi}$$

If the antenna produces one tenth of the power of an isotropic antenna at a distant point, the gain would be:

$$10 * \log_{10} (0.1 / 1) = -10 \text{ dBi}$$

Therefore, the larger and more positive the gain value, the greater the gain. For example, a gain of 15 dBi is better than a gain of -3 dBi.

The gain of an antenna is dependent upon the frequency used and varies with take-off angle and bearing. The gain is also reliant on ground conductivity, obstructions and terrain.

The gains of antennas provided in the Antennas database do not include any losses associated with tuning units or coupling devices.

Real measurements on antennas are usually referenced to a half-wave dipole being at the same height and having the same polarisation as the test antenna. The gain of a half-wave dipole in free space is 2.15 dB lower than the gain of an isotropic radiator.

The relationship between the gain of an isotropic radiator (G_i) and a half-wave dipole (G_d) is:

$$G_d = G_i - 2.15 \text{ dB}$$

2.5.2 Antenna gain and installation offsets

The *Antenna* dialogue allows a *Gain offset* to be entered for 2D and 3D sky wave antennas and an *Installation offset* to be entered for 3D sky wave antennas.

The *Installation offset* specifies the reference bearing for the 3D antenna pattern as a whole, that is, it defines the antenna's current orientation relative to its orientation as entered in the antenna database. For example, if the bearing of the main lobe of the antenna gain pattern as entered in the antenna database is 0° (true north) and the bearing of the main lobe of the actual antenna is 60°, then the required installation offset is 300° (the angle measured counter clockwise from the orientation of the antenna in the database to the orientation of the real antenna).

The *Gain offset*, expressed in decibels, is defined as:

$$\text{Gain offset (dB)} = 10 * \log_{10} (\text{antenna efficiency})$$

where the efficiency of the antenna, expressed as a fraction, is determined from:

$$\text{antenna efficiency} = (\text{power radiated from the antenna}) / (\text{power input to the antenna})$$

and power is measured in watts. Therefore, the maximum *Gain offset* value any antenna can have is 0 dB (100%). Antennas with lower efficiency have gain offset values that are negative (see Section 1.15). The lower limit of efficiency in ASAPS is -20 dB (1%).

Ground wave antenna efficiencies are specified under the *Surface Wave Parameters* button in the *Area Prediction details* dialogue (entered as percentages 1 to 100%).

If antennas and cables are well maintained, antenna efficiency can be high. Corrosion, salt residue and cable losses reduce antenna efficiency at all take-off angles and frequencies.

When antenna efficiency is unknown, use a gain offset value of 0 dB (i.e., 100% efficient).

2.5.3 Adding a 2D antenna

Exercise 6. Adding a 2D antenna to the Antennas database

Add the following 2D antenna to the Antennas database. The name of the antenna is "antute1" and it can be described as a sloping long wire (note the gain pattern below is not a real antenna). The gain pattern for the antenna follows:

deg\MHz	5	15	25
20	-10	-8	-10
40	-1	5	6
60	3	10	15
80	-5	-10	-3

- Select ***Databases*** in the menu bar then ***Antennas*** in the drop-down menu. The **Antenna** dialogue appears.
- Ensure the antenna type displayed is **2D**.
- In the **Name** list box type **antute1** and press the **Enter** key on the keyboard. The text **deg\MHz** appears in row 1 column A of the Gain Data spreadsheet. This indicates that take-off angles are to be entered down column A and frequencies are to be entered across row 1.
- Enter the description (**sloping long wire**) of **antute1** in the **Description** box. Do not press the **Enter** key.
- Select an empty rectangle in row 1 of the **Gain Data** spreadsheet, the perimeter of the rectangle will darken. Enter the first frequency (**5**) and press the keyboard **Enter** key. The perimeter of the next empty rectangle in row 1 should darken. Enter the next value (**15**) and press **Enter**. Repeat for the last frequency (**25**). If an error is made in entering a value, continue entering the value, then select it and press the function key **F1** to remove it. Note that the frequencies are automatically sorted in increasing order of magnitude.
- Use the arrow keys on the keyboard, or the left mouse button, to move the cursor to an empty rectangle in **column A**. Enter the first take-off angle (**20**) and press the **Enter** key. Note that default gain values of **-25** dBi appear for each frequency at that angle. Repeat for the other take-off angles. Note also that the angles are automatically sorted in increasing order of magnitude.
- To enter the gain values, use the arrow keys or the left mouse button to move to the appropriate rectangle, type the gain value and press the **Enter** key. Use the arrow keys or left mouse button to move to the next location. Repeat for the other gain values. If an incorrect gain value is entered, backspace over the value and enter the correct value.
- When all data have been entered click the ***Add/Modify*** command button then ***Done***.

2.5.4 Modifying a 2D antenna

The gain, frequency and take-off angle values of a two-dimensional antenna can be altered. Open the *Antenna* dialogue by selecting *Databases|Antennas* and select the antenna to be modified from the *Name* list box. Modify the gain, frequency and take-off angle values as required. Click on *Add/Modify* then *Done*.

Additional frequencies, take-off angles and corresponding gains can also be added to a two-dimensional antenna. Select an empty cell in the frequency row or elevation angle column, add the value then add the corresponding gain values. To delete a frequency or elevation angle from the antenna gain pattern, select the appropriate cell and press the *F1* function key on the keyboard. The corresponding gains for that frequency or elevation angle will also be removed. Click on *Add/Modify* then *Done* to save the changes.

Existing two-dimensional antennas can be exported to a text file, modified then imported back into the database. See *Help|Contents|Databases|Antenna Types|Importing and Exporting Antennas* for the format of the antenna file. Only one antenna per file is permitted. With the two-dimensional antenna to be modified displayed in the *Antenna* dialogue, select *Export Antenna …* and save the file. Close the *Antenna* dialogue. Select *File|Open Predictions/Files…*, open the text file and edit the antenna data. Ensure the values for number of take-off angles and frequencies match the number of gain values in the file. Save and close the file. From the *Antenna* dialogue, select
Import Antenna …, open the file and import the file back into the Antennas database. Save the changes by pressing *Done*.

Two-dimensional antennas in the database can be renamed by selecting the antenna in the *Name* list box, clicking on *Rename*, entering the new name, pressing *OK* then *Done*.

2.5.5 Adding a 3D antenna

Exercise 7. Adding a 3D antenna to the Antennas database

Enter the following 3D antenna, "antute2". Consider "antute2" to be a vertical log periodic antenna (the gain pattern below is not that of a real antenna).

At 2 MHz the gain pattern is:

Take-off	Bearing	Gain
20	350	1
40	350	9
60	350	6
20	0	3
40	0	11
60	0	7
20	10	2
40	10	8
60	10	2

At 4 MHz the gain pattern is:

Take-off	Bearing	Gain
20	350	3
40	350	13
60	350	9
20	0	6
40	0	15
60	0	10
20	10	0
40	10	12
60	10	5

- Select ***Databases|Antennas***. Select **3D** in the **Type** list box. Enter the name of the antenna, **antute2**, and the description of the antenna, **vertical log periodic**, in the appropriate fields.
- Enter the first frequency (**2**) in the upper box of the **Frequency (MHz)** group box and press ***Add***.
- In the **Data for selected frequency** group box press ***New*** and when the **Add Record** dialogue appears, select ***Yes***. The second cell in column A is highlighted. Enter the first take-off angle (**20**), press the keyboard **Enter** and use the ← → keys to move the cursor to the bearing column. Type in the correct bearing (**350**), press **Enter** and move the cursor to the gain column. Type in the gain value (**1**), press **Enter**. Press the ***New*** button again and repeat the procedure to add the remainder of the gain pattern for 2 MHz. Do not press ***New*** after the last record has been entered. However, if ***New*** is pressed after the last record was entered, select any cell in the unwanted record and press ***Delete***.
- Return to the **Frequency (MHz)** group box, type in the other frequency (**4**) in the upper box, click on ***Add*** and ensure this frequency is highlighted.

- Press ***New*** in the **Data for selected frequency** group box and enter the gain data as for the other frequency.
- If you discover you have made a mistake entering the gain pattern, highlight the value to be changed, enter the new value then press **Enter**. Surplus gain records that have been added can be removed by highlighting all or part of the record and clicking on ***Delete*** (under ***New***).
- After entering the last record, press ***Add/Modify***, then ***Done***.

2.5.6 Modifying a 3D antenna

Frequencies and their corresponding gain patterns can be added to an existing 3D antenna by using the method in Exercise 7. Frequencies and their corresponding gain patterns can also be deleted by highlighting the frequency, pressing *Delete* in the *Frequency (MHz)* group box, *Add/Modify* then *Done*.

A record for a specific frequency can be deleted by highlighting the frequency to view its gain pattern, then double clicking on the row number of the record to be deleted. This action should highlight the whole record. Press *Delete* in the *Data for selected frequency* group box, *Add/Modify* then *Done*.

A record for a specific frequency can be altered by firstly selecting the appropriate frequency to display its gain pattern. Highlight the take-off angle, bearing or gain to be altered, press the *Backspace* key on the keyboard to remove the value, enter the new value and press *Enter*. Press *Add/Modify* then *Done*. New records can be added for particular frequencies by pressing *New*, adding the data then *Add/Modify* then *Done*.

Antennas can be renamed by selecting the antenna in the *Name* list box, clicking on the *Rename* button, entering the new name at the *Rename Antenna* dialogue then pressing *Done*.

2.5.7 Importing and exporting antennas

Information on importing and exporting 2D and 3D antenna files can be found in *Help|Contents|Databases|Antenna Types|Importing and Exporting Antennas*; the data format for 2D and 3D antennas is located there. Only one antenna per file is allowed. Adding antennas to the Antennas database is probably achieved more easily by importing an antenna file into the database rather than adding gain patterns using the *Antenna* dialogue as per Sections 2.5.3 and 2.5.5.

Exercise 8. Importing an antenna data file into the Antennas database

Produce the following 3D antenna file and import it into the Antennas database. Call the file "ant". Make sure you type spaces where shown. See Importing and Exporting Antennas in the Help file for more information on the format of this file.

```
id= 2
name= antute3
***
desc= any old antenna
bearing_offset= 4
gain_offset= -2

2
10.1
6
10 1 0
```

20 2 0
30 3 0
10 4 25
20 5 25
30 6 25
15.8
6
10 7 0
20 8 0
30 9 0
10 10 25
20 11 25
30 12 25

- Outside of the ASAPS program, invoke a Windows text application such as Word, Notepad or Wordpad. Use the Search tool in Windows Explorer to find the application in the appropriate drive.
- Enter the data for the antenna as above then press ***File|Save As…***. Select the required directory in which to save the file in the ***Save in*** list box. Type the name of the file **ant** in the **File name** list box and in the **Save as type** list box, choose a text type such as **Plain Text (*.txt)**. Press ***Save***.
- Close the file and application by clicking ***File|Exit***.
- Select ***Databases|Antennas***. Press ***Import Antenna …***. Find the file in the correct drive and directory, select it and press ***Open***. ASAPS will verify the format of the file is correct. If the format of the file is correct, the antenna will be imported. Note it is not necessary to select the correct antenna type (i.e. 2D or 3D) before importing the antenna.
- View the antenna **antute3** by selecting it from the **Name** list box. Confirm the data is correct. Press ***Done*** to save the antenna in the database.

2.5.7.1 Importing 2D and 3D Andrew Antennas gain data

Andrew Antennas has provided 2D gain patterns of some of its antennas. These are located in the Antennas→Andrew→2D directory under the ASAPS installation directory. A 2D Andrew antenna is imported into the Antenna database by specifying *2D* in the *Type* list box of the *Antenna* dialogue, pressing *Import Antenna ...*, specifying the desired antenna from the 2D Andrew directory, and pressing *Done*. The Andrew antenna will then be saved in the Antenna database.

Andrew Antennas has also provided 3D gain patterns of some of its antennas. These are located in the Antennas→Andrew→3D directory under the ASAPS installation directory. A 3D Andrew antenna is imported into the Antenna database by specifying *3D* in the *Type* list box of the *Antenna* dialogue, pressing *Import Antenna ...*, specifying the desired antenna from the 3D Andrew directory, and pressing *Done*. The Andrew antenna will then be saved in the Antenna database.

2.5.7.2 Importing 3D Codan gain data

There are 3D gain patterns for various Codan antennas modelled using the antenna modelling software EZNEC. The files are located in the Antennas→Codan directory under the ASAPS installation directory. The Codan gain patterns may be imported into the Antenna database by specifying *3D* in the *Type* list box of the *Antenna* dialogue, clicking on *Import NEC gain data* then specifying the desired antenna file in the Codan directory. To save the file in the Antenna database, ensure *Done* is pressed.

2.5.8 Deleting a 2D or 3D antenna

Select *Databases|Antennas* from the menu bar. Select the antenna to be deleted from the *Name* list box or type in the name of the antenna. The gain pattern of the antenna is displayed. Click on the *Delete* button then *Done*. No deletions will be made if the *Cancel* button is pressed instead of *Done*.

2.6 Areas of interest database

This database is accessed by clicking on *Databases|Areas of Interest*; the *Area of interest* dialogue is displayed. The name, latitude and longitude bounds, and the resolution of the area are required. Southern latitudes and western longitudes should be entered as negative values.

The number of rows and columns specify the sampling intervals and hence determine the resolution of the plotting grid in the Area prediction. In ASAPS 5.3 the latitude and longitude resolution may be entered as either the number of rows/columns or as degrees. The minimum and maximum number of rows/columns is 2 and 100, respectively. The more rows and columns entered, the greater the resolution of the prediction but the longer the computation time.

In most cases, users will find that entering the resolution in degrees is easier then calculating the number of rows and columns. Note that if the degree resolution entered results in the number of rows or columns being greater than 100, ASAPS will default to the greatest resolution possible. For example, if the latitudinal extent of the area is 80 degrees and the latitudinal resolution entered is 0.5 degrees (161 rows), ASAPS will default to a latitudinal resolution of one degree. The number of rows will then be 81.

The following discussion concerns the calculation of rows and columns for an area of interest.

The number of rows is determined by taking the absolute value of the difference between the northern and southern boundaries of the area, dividing this by the latitude resolution of the grid and then adding one extra row.

The absolute value of a number is written |A|. The absolute value of a number, A, is A if A is positive and -A if A is negative. Example 1: let A = 15.6. Then |15.6| = 15.6. Example 2: Let A = -9.2. Then |-9.2| = - (-9.2) = 9.2.

Consider an area's northern boundary is 20° N, its southern boundary is 5° S and the latitude resolution required is 5°. The number of rows required is 6, ((|20 - (-5)| / 5) + 1) or ((|(-5) - 20| / 5) + 1). Note that when determining the absolute value, the order of the numbers is irrelevant. Consider where the northern boundary is 5° S, the southern boundary is 40° S and the resolution required is 5°. The number of rows required is 8, ((|(-5) - (-40)| / 5) + 1) or ((|(-40) - (-5)| / 5) + 1).

The number of columns is determined by taking the absolute value of the difference between the eastern and western boundaries of the area, dividing this by the longitude resolution of the grid and then adding one extra column. Consider where the western boundary is 60° E, the eastern boundary is 170° E and the longitude resolution required is 10°. The number of columns required is 12, ((|170 - 60| / 10) + 1) or ((|60 - 170| / 10) + 1). Consider where the western boundary is 70° W, the eastern boundary is 5° W and the longitude resolution required is 5°. The number of columns required is 14, ((|-70 - (-5)| / 5) + 1) or ((|-5 - (-70)| / 5) + 1).

When the area of interest is intersected by the 0° (360°) longitude line, determine the difference between each boundary and 0° longitude, sum these then continue as usual (i.e. divide by the resolution and add one). For example, consider the western boundary is 320° E (40° W) and the eastern boundary is 30° E and the required resolution is 10°. The number of columns required is 8, ((|320 - 360| + |0 - 30|) / 10 + 1) or ((|(-40) - 0| + |30 - 0|) / 10 + 1). This procedure should also be

followed when one boundary is in degrees east and the other in degrees west (alternatively, change one of the boundary values to the longitude type of the other). For example, consider the western boundary is 150° E and the eastern boundary is 110° W (250° E) and the required resolution is 10°. The number of columns required is 11. That is:
((|150 - 180| + |-180 - (-110)|) / 10 + 1) or (|150 - 250| / 10 + 1).

Exercise 9. Adding areas of interest to the Areas of Interest database

Add the following areas of interest: "austasia" from 35.0° N to 25.0° S and 90.0° E to 160.0° E, gridlines every 5° latitude and every 10° longitude and "sth america" from 10.0° S to 40.0° S and 90.0° W to 30.0° W, gridlines every 5° in latitude and longitude.

- Select ***Databases|Areas of Interest*** to view the **Area of interest** dialogue.
- In the **Name** list box enter **austasia**.
- In the side limits boxes enter the boundaries - North: **35**, South: **-25**, West: **90** and East: **160**.
- Enter the number of rows **13** ((|35 - (-25)| / 5) + 1) and the number of columns **8** ((|90 - 160| / 10) + 1), or enter **5.0** in the **Latitude resolution** box and **10.0** in the **Longitude resolution** box.
- Press ***Add/Modify*** and answer **Yes** in the **Add Record** dialogue. If you answer **No** to this question, the details of the Area of Interest will not be saved in the database.
- In the **Name** list box enter **sth america**.
- In the side limits boxes enter the boundaries - North: **-10**, South: **-40**, West: **-90** and East: **-30**.
- Enter the number of rows **7** ((|-10 - (-40)| / 5) +1) and the number of columns **13** ((|-90 - (-30)| / 5) +1) or **5.0** in both the **Latitude resolution** and **Longitude resolution** boxes.
- Press ***Add/Modify,*** answer **Yes** in the **Add Record** dialogue, then ***Done*** to save both of these areas to the database.

2.7 Station configurations database

The *Station Configuration* dialogue is accessed by clicking on *Databases|Station configurations*. The Station Configurations database is where many station parameter values are specified. The parameters are: transmitter power, antenna types (sky wave), frequency set (sky wave and multi-surface), receiver bandwidth, man-made noise, required signal-to-noise, minimum take-off angle (sky wave), required percentage days of ionospheric support (sky wave), polarisation coupling loss algorithm (sky wave), prediction confidence level and atmospheric noise model. Table 2 indicates which site, transmitter or receiver, the station parameters in the Station Configurations database refer to. Only integer values may be entered in the Station Configurations database. More information on the parameters is provided in sub-sections 2.7.3 to 2.7.13.

Table 2. Station parameters applicable to the bases.

Station parameters	Transmitter site	Receiver site	Comment
Tx Power	•		
Tx Antenna	•		
Rx Antenna		•	
Frequency Set	•	•	

Station parameters	Transmitter site	Receiver site	Comment
ManMade Noise		•	
Bandwidth		•	
Required S/N		•	
Min. Angle	•	•	The larger of the minimum angles of the transmitting and receiving antennas.
Required % Days		•	Usually the same for two-way communications.
Polarisation Coupling Loss		•	
Prediction Confidence Level		•	
Atmospheric Noise		•	

The station parameters and values used in computing a prediction format are displayed in the header section of the format. It is good practice to check the values used when viewing any format.

2.7.1 Set as default tick box

When the *Set as default* tick box is activated (tick in box) the station configuration displayed becomes the default station configuration. The parameters specified in the default station configuration will be used when a new prediction is computed. Note there is a station configuration called “DEFAULT”. Just like other station configurations, the “DEFAULT” station configuration is specified as the default station configuration by ensuring a tick is displayed in the *Set as default* tick box before pressing *Done* in the *Station Configuration* dialogue.

Station configurations can be added, modified or deleted. A station configuration that is marked as the default (tick in *Set as default* tick box) cannot be deleted until another station configuration is selected as the default and the station configuration to be deleted is again displayed in the *Station Configuration* dialogue. The “DEFAULT” station configuration cannot be deleted, but can be altered.

When opening, viewing or re-computing a prediction it is important that the correct station configuration is set as the default. This is because ASAPS computes predictions on the fly, using many of the station parameters in the current default station configuration. When a prediction file is opened, being viewed or re-computed, the results are based on the following parameter values of the current default station configuration: transmitter power, antenna types, bandwidth, required signal-to-noise, minimum angle and required % days of ionospheric support, and the parameter values in the original default station configuration: man-made noise, polarisation coupling loss (and polarisation if the Full calculation is used), prediction confidence level and atmospheric noise.

2.7.2 Specifying parameters in station configurations

So that predictions are as accurate as possible, consideration should be given to ensuring the correct station parameter values are used in a computation.

If a prediction for one-way communications is required then it is simply a matter of ensuring the correct transmitter and receiver parameters are entered in the default station configuration then computing the prediction.

If the station parameters at both locations for two-ways communications are the same, a prediction for communications from A to B (or B to A) may be adequate since in ASAPS ionospheric paths are symmetrical; that is, the propagation modes and pathlosses in both directions are the same. However, if atmospheric noise is considered to be substantially different at the two locations it may warrant, in the case of GRAFEX and Field Strength predictions, a prediction containing the two circuits A to B and B to A, being computed. For Area predictions two predictions would be required, one where the base is the transmitter and the other with the base as the receiver.

Atmospheric noise is used in the SNR Frequency Selection and SNR Frequency Set Test formats of GRAFEX predictions, Field Strength predictions and the sky wave formats of Area predictions. Atmospheric noise is optional in the Surface Wave and Multi-surface formats of Area predictions.

For two-way communications where the station parameters at the two locations are different, two station configurations should be set up and two predictions computed. For example, consider two-way communications are required between locations A and B. The first station configuration should contain information for communications from A to B while the second station configuration should contain information for communications from B to A.

Two GRAFEX and Field Strength predictions should be computed – one prediction with the circuit for communications from A to B and another prediction containing the circuit for communications from B to A. Two Area predictions would be required, one where the base was specified as the transmitter and the other where the base was specified as the receiver. When computing a prediction it is essential that the correct station configuration be set as the default. For example, before computing the prediction for communications from B to A, the station configuration set up for communications from B to A should be set as the default by ensuring a tick is displayed in the *Set as default* tick box then pressing *Done* in the *Station Configuration* dialogue.

Exercise 10. Entering parameters in the Station Configurations database

Produce a station configuration with the configuration name "statute" and the following parameters: Tx Power = 1000 W, Tx Antenna = SLW, Rx Antenna = WH35, Frequency Set = tuteset, Man-made Noise = -150 (rural) dBW/Hz, Bandwidth = 3000 Hz, Required S/N = 3 dB, Min. Angle = 30°, Required % Days = 90, Polarisation Coupling Loss = Full Calculation, Tx Antenna Polarisation = Vertical, Rx Antenna Polarisation = Vertical, Prediction Confidence Level = 90%, Atmospheric Noise = CCIR 322. Set this configuration as the default.

- Select ***Databases*** in the menu bar then ***Station configurations*** in the drop-down menu. The **Station Configuration** dialogue appears.
- Enter the above values. The frequency set "tuteset" was entered in the frequency set database in Exercise 4 (p. 22). In some cases the desired value for the parameter will be in the drop-down list which can be accessed by clicking on the arrow button. Select from the list by clicking on the value required.
- Ensure this new station configuration is set as the default by ensuring the **Set as default** box is ticked.
- When all values have been entered click on the ***Add/Modify*** command button then ***Done***.

2.7.3 Transmitter power

Transmitter power may be entered as watts (W), kilowatts (kW) or megawatts (MW) and ranges between 1W and 10 MW.

The transmitter power increases the signal power, in turn improving the signal-to-noise ratio. If the signal-to-noise at a particular frequency then increases above the required signal-to-noise of the receiver, the signal at that frequency may be detected.

2.7.4 Tx/Rx antenna

Choose any of the 2D or 3D antennas from the Antennas database. If the "Full Calculation" polarisation coupling loss algorithm is chosen, the polarisation (either Vertical or Horizontal) of the antennas will also be required. For antennas with both horizontal and vertical components of polarisation, the "Approximation" polarisation coupling loss algorithm can be used. See Table 3 (p. 38) for polarisations of antennas included in the Antenna database.

If the gain patterns of the antennas are unknown, the isotopic antenna may be substituted. In this case, the "Approximation" polarisation coupling loss algorithm should also be selected. The gain of the isotropic antenna is 0 dB in all directions.

Use of the isotropic antenna in the station configuration when the "Full Calculation" is specified, can be useful for determining the best antenna polarisation combination for the real antennas. The polarisation of antennas for certain circuits (Table 3, p. 38) results in variations in the polarisation coupling loss which in turn affects signal-to-noise, field strength and the power required to achieve the required signal-to-noise. By selecting both transmitting and receiving antennas as isotropic and then varying the polarisations of the antennas, the Pathloss format of a Field Strength prediction will show which combination of antenna polarisations results in the least losses for the circuit being studied. The variations in pathloss will also be reflected in the Noise_Pathloss, Signal-to-Noise, Field Strength and Estimated Power Required formats of a Field Strength prediction.

The Surface Wave and Multi-surface prediction formats of an Area prediction use the antennas listed under the *Surface Wave Parameters* button in the *Area Prediction details* dialogue.

The gain patterns of antennas affect the signal strength at the input to the receiver. Antennas that provide good gain in the required direction, both azimuth and elevation, will result in greater signal strength than those that emit or receive a signal at less than optimum take-off angles and bearings.

2.7.5 Frequency set or frequency

The frequency set specified in the default station configuration is used in some of the GRAFEX prediction formats (a frequency set is not used in the other GRAFEX formats). The frequency set(s) specified in the *Prediction Details* dialogue is used in Field Strength files. The frequency set specified in the *Area Prediction details* dialogue is used in the sky wave and Surface Wave formats of an Area prediction. The frequency used in the Multi-surface prediction format of an Area prediction is specified under the *Surface Wave Parameters* button in the *Area Prediction details* dialogue.

The frequency limits for all sky wave formats are 1 to 60 MHz. The frequency range for the Area prediction Surface Wave and Multi-surface formats is 1 to 50 MHz.

2.7.6 Man-made noise

Man-made noise originates from power lines, welding machines, ignition systems, neon lights, etc., and is therefore greater in urbanised areas. Interference is a type of environmental noise caused by unusual propagation conditions or radio regulations or restrictions not being met or implemented.

The man-made noise power at the receiver site, as specified in the default station configuration, is for a frequency of 3 MHz; selected from one of the standard categories or entered manually. The standard categories are: ship -130, city -140, residential -145, rural -150, remote -164 or no man-made noise -204; or the user may choose to enter a value between -100 and -204. Man-made noise may be excluded from the SNR Frequency Selection, SNR Frequency Set Test formats of GRAFEX predictions, Field Strength prediction formats and Area prediction formats by specifying the “-204 (Ignore)” option.

Man-made noise is calculated for frequencies other than 3 MHz using the formula:

$$N_m = N_3 - (d * \log_{10}(f / 3))$$

where: N_m = man-made noise in dBW/Hz at frequency f MHz
N_3 = man-made noise in dBW/Hz at 3 MHz
d = a constant; 13.5 (ship), 27.7 (city, residential or rural), 28.6 (remote), or 28.0 (if user specified)
f = frequency in MHz

Specifying a noisier man-made environment in a prediction may result in the signal power lying below the noise power causing the signal to be undetected at the receiver.

Recommendation ITU-R 372-9 (Radio Noise) has changed the “business” category to “city”. While the category name has been altered, the category value, -140, has not. ASAPS 5 has been altered to reflect the change.

2.7.7 Atmospheric noise

Atmospheric noise is caused by lightning discharges in thunderstorms. Thunderstorms have seasonal, diurnal and geographic variations and are more prevalent in equatorial regions, particularly around northern South America, central Africa and south-east Asia. The effect of atmospheric noise is greater at lower frequencies. However, the D region of the ionosphere reduces atmospheric noise levels during the day by absorption, particularly at the lower frequencies.

In ASAPS 5 there is a choice of two atmospheric noise models, CCIR Report 322 (“World Distribution and Characteristics of Atmospheric Radio Noise”) (1963) and that published in Recommendation ITU-R P.372-8 (“Radio Noise”) (2003).

The CCIR Report 322 model was derived from global observations and consists of the 1 MHz noise reference maps and charts of the extrapolation with frequency and the statistical variability (mean values and upper/lower deciles, exceeded 50%, 10% and 90% of the time, respectively). A more recent version of the reference maps showing the median noise at 1 MHz was published in Recommendation ITU-R P.372-8 (“Radio Noise”) (2003). The CCIR 322 and ITU 372-8 models differ only in the 1 MHz reference maps. The extrapolation method to convert the noise levels at other frequencies and the statistical variability data are the same.

The original CCIR data are considered to be more appropriate for Australian conditions but the new ITU option is probably more suitable globally. Measurements have shown that the daytime atmospheric noise levels over inland Australia are typically 6 to 10 dB lower than the values predicted by the CCIR 322 report. However, the ITU model predicts even higher levels, about 10 dB higher than the values predicted by the CCIR maps at 1 MHz. It is assumed that this holds true for the ocean areas around Australia. Hence, use of the CCIR model is recommended in the

Australasian region. The CCIR maps underestimate the noise in equatorial and certain northern hemisphere regions and there the ITU model is probably more suitable.

If communications between a location within Australia and one outside Australia are required, two predictions may provide better accuracy. For communications from Australia it is suggested the ITU model be specified. For communications into Australia the CCIR model may provide more accurate predictions.

2.7.8 Bandwidth

This is the actual pre-detection bandwidth of the receiver in hertz. The allowable range is 1 to 65,535 Hz.

The signal received at an antenna is a mixture of the signal from the transmitter and unwanted signal such as interference and noise. A greater bandwidth results in greater transmission rate of a signal but more input from noise. Reducing the bandwidth has traditionally been used to limit noise input in a receiving system. The rate at which information is passed is slower but the signal-to-noise ratio should be improved.

2.7.9 Required signal-to-noise

The threshold or minimum signal-to-noise ratio required for the specified bandwidth in units of decibels. The allowable range is -99 to 300 dB for the sky wave and Multi-surface formats and -99 to 99 dB for the Surface Wave format. Frequencies from the specified frequency set with predicted signal-to-noise values lower than the Required S/N specified in the default station configuration are not considered in the prediction formats that use this parameter, see Table 5 (GRAFEX, p.51), Table 19 (Field Strength, p. 98), Table 35 (Area, p. 130).

2.7.10 Minimum angle

This is the minimum sky wave antenna take-off angle of interest, in degrees. The take-off angle range is 0 to 90 degrees. If an antenna transmits or receives practically no energy below a certain angle, there is no point in considering the lower angles. Frequencies with take-off angles lower than the Min. Angle specified in the default station configuration are not considered in the prediction formats that use this parameter, see Table 5 (GRAFEX, p. 51), Table 19 (Field Strength, p. 98), Table 35 (Area, p. 130). Most simple antennas have a practical minimum elevation angle of around five to ten degrees. When the transmitting and receiving antennas have different gain patterns it is suggested the larger minimum elevation angle be specified as the minimum angle.

2.7.11 Required % days

The required probability of ionospheric support, expressed as a percentage is relevant to the receiver location, although for two-way communications, this will usually be the same at both locations. The allowable range is 0 to 99%.

A 90% support rating implies interest only in frequencies in the frequency set that are less than or equal to the OWF (the lower decile). A 50% support rating implies interest in frequencies less than or equal to the MUF (the median). Lowering this parameter will broaden the available spectrum but make the communication circuit less reliable. For good reliability a 90% support rating is usually chosen. Frequencies greater than the frequency at the Required % Days value specified in the default station configuration are not considered in the prediction formats that use this parameter, see Table 5 (GRAFEX, p. 51), Table 19 (Field Strength, p. 98), Table 35 (Area, p. 130).

2.7.12 Prediction confidence level

This parameter indicates the percentage probability that an actual signal-to-noise or noise_pathloss measurement, at the time for which the prediction was made, will exceed the predicted signal-to-noise or noise_pathloss level. Both signal-to-noise and noise_pathloss predictions are statistical in nature because the noise and pathlosses are constantly fluctuating. In ASAPS 4 and earlier versions, the signal-to-noise was defined as the difference (in dB) between the median signal power and the upper decile noise power at the output terminals of the receiving antenna. This led to signal-to-noise and noise_pathloss values which had, approximately, an 82% probability of being exceeded by the actual signal-to-noise or noise_pathloss at the time for which the prediction was made. For example, if 100 signal-to-noise measurements for a radio circuit were made within half an hour either side of a given UT hour, and the prediction was 100% accurate, 82 of these measured signal-to-noise values would exceed the predicted signal-to-noise value for that particular hour given the specified station parameters.

ASAPS 5 allows the user to alter the prediction confidence level. A prediction confidence level, say 90%, implies that for 90% of the time, the measured signal-to-noise or noise_pathloss will exceed the predicted noise_pathloss or signal-to-noise. A 50% prediction confidence level indicates a 50% probability an actual noise_pathloss or signal-to-noise measurement will exceed the predicted noise_pathloss or signal-to-noise. A higher prediction confidence level results in lower predicted signal-to-noise ratios. There is then a greater likelihood these predicted signal-to-noise ratios will lie below the required signal-to-noise value specified in the default station and availability of frequencies is likely to be reduced. Decreasing the prediction confidence level is likely to increase availability of frequencies.

To increase the probability from 82% to 90% requires the predicted signal-to-noise figure to be decreased by about 4.1 dB. This is the lower decile signal-to-noise. For a prediction confidence level of 99%, the predicted signal-to-noise would have to be reduced by about 25.7 dB.

A prediction confidence level of 50% should be considered in a typical case. For engineering purposes or worst case, a 90% prediction confidence level should be specified since this leads to lower predicted signal-to-noise and noise_pathloss values. With a 90% prediction confidence level the likelihood a predicted signal-to-noise value will exceed the system threshold (required signal-to-noise) is low and therefore the predicted coverage will be smaller. So, there is a 90% probability that the actual coverage will be better than the predicted worst case. Better quality circuits have high signal-to-noise and noise_pathloss values. However, if lower signal-to-noise and noise_pathloss are acceptable, it implies acceptance of poorer quality conditions to attain a higher success rate (say 90% instead of 50%).

The prediction confidence level also affects the Estimated Power Required calculations which show the power required to achieve the specified required signal-to-noise. Since a higher prediction confidence level lowers the noise_pathloss (poorer quality communications), a higher transmitter power is then needed to meet the specified signal-to-noise.

The prediction confidence level is related to the grade of service and availability of the circuit. Grade of service is often expressed as the minimum signal-to-noise required for the particular type of service. It is a measure of the required quality of the circuit. Availability, in this context, is the percentage of time a circuit achieves a specified grade of service or better. It is a measure of the number of times when the predicted signal-to-noise exceeds a constant threshold signal-to-noise at a particular time.

2.7.13 Polarisation coupling loss

When a radio wave enters the ionosphere, it is split into two oppositely polarised waves (the o-wave and x-wave) due to its interaction with the Earth's magnetic field. Depending upon the location, orientation and take-off angle, more of the energy from the wave may be transferred into one or other of these characteristic waves. As they traverse the ionosphere they are absorbed differently, especially at low frequencies (5 MHz and below). At low frequencies during the daytime, the x-wave will suffer considerably more absorption than the o-wave. At the receiving antenna, further significant losses can occur if there is a mismatch between the polarisations of the antenna and the incoming radio wave.

How much energy is transferred to each of the characteristic waves is dependent upon the wave frequency, the electron gyrofrequency (this is dependent upon the magnetic field which varies at different latitudes and longitudes), bearing and elevation angle of the wave. If most of the energy from the transmitted wave is directed into the x-wave, signal loss can be severe at lower frequencies. It is therefore important with certain circuits to attempt to use a combination of antenna polarisations that transfer most of the energy into the o-wave to limit signal loss.

In ASAPS 4 and earlier versions, a simple algorithm was used for determining the polarisation coupling loss. In ASAPS 5, this algorithm is called the “Approximation” algorithm. A new algorithm, called the “Full Calculation” has also been provided which requires input of the polarisation of the antennas.

SWS recommends users select the default “Approximation” algorithm for most propagation prediction scenarios. The “Approximation” algorithm should be used for circularly or elliptically polarised antennas. This algorithm should also be used if only interested in night time propagation or only using the higher frequencies (i.e., greater than 10 MHz). In these cases the o-wave and x-wave have comparable strengths.

The “Approximation” algorithm for polarisation coupling loss takes into account only the mode type, hop length and the number of hops along the circuit. This algorithm does not consider the propagation path or bearing of the circuit.

The “Full Calculation” algorithm is only applicable to linearly polarised antennas and uses the antenna polarisations of the transmit and receive antennas selected in the station configuration. If the receiving antenna can detect both horizontal and normal components simultaneously, the “Approximation” algorithm should be used since most of the energy arriving at the antenna is captured.

The “Full Calculation” algorithm takes into account the polarisations of the linear transmitting and receiving antennas, the amount of energy transferred from the incident radio wave into each characteristic wave at each entry point into the ionosphere on successive hops, the geomagnetic field at each entry and exit point, the ionospheric absorption suffered by the characteristic waves, ground reflection losses and the polarisation matching between the down-coming characteristic waves and the receiving aerial.

The “Full Calculation” should be used for linear antennas where the angle between the direction of propagation and the geomagnetic field approaches 90° (e.g. high latitude north-south circuits or low latitude east-west circuits where the radio wave propagation is transverse, i.e., perpendicular, to the Earth’s magnetic field). In these cases, the much of the radio energy is transferred to the x-wave which is more heavily absorbed than the o-wave.

Table 3 (p. 38) is a guide to the polarisations of the antennas in the database. The polarisation of the main lobe of an antenna at far field is normally considered representative of the antenna polarisation. The polarisation of an antenna at far field is generally the same as the orientation of the antenna element(s) and perpendicular to the direction of wave propagation.

Table 3. Polarisations of antennas in the antenna database.

Antenna	Name	Polarisation	Comment
Conical monopole	CM, CM1	vertical	
Delta	DELTA, DELTA1	horizontal	Usually horizontal if unaffected by ground. Two crossed deltas, fed out of phase provide circular polarisation.
Horizontal log periodic	HLP, HORLOG*	horizontal	
Horizontal dipole	HORDIP*	horizontal	
Half wave dipole, end pattern	HWDE	horizontal	Can be vertical if mounted vertically.
Half wave dipole, side pattern	HWDS	horizontal	Can be vertical if mounted vertically.
Log spiral	LS	combination	
Rhombic	R	horizontal	Can be vertical if mounted vertically.
Sloping long wire	SLW	vertical	Can have both components but usually stronger in the vertical sense.
Spiracone		combination	
Vertical monopole	SVM	vertical	
Vertical log periodic	VLP	vertical	
Whip	WH25, WH35	vertical	

Table 4 (p. 39) shows recommended combinations of antennas for various one-hop or two-hop circuits using the lower HF frequencies. However, there are no preferred antenna polarisations for night time two-hop paths. For two-hop paths, take the average of the dip latitudes at the two sky reflection points. In Table 4, the symbol "I" refers to the magnetic dip angle (that is, inclination) and Δ refers to the propagation mode's take-off angle.

Figure 2 (p. 40) displays contours of magnetic dip. Horizontal and vertical lines are geographical latitude and longitude, respectively. Use this map to determine the approximate dip latitude of the sky reflection point(s) and then refer to Table 4 to select the most suitable combination of antenna polarisations. For example, consider a two hop path from Rockhampton, Australia (23.37° S, 150.52° E) to Manila, Philippines (14.58° N, 120.98° E). From Figure 2, the two sky reflection points of this circuit will be located at approximately 9° S and 31° S, magnetically. The average magnetic dip latitude of these two points is 20°. In using Table 4 for the determination of the appropriate antenna combination, the column indicating I < 30° should therefore be used for this circuit.

The isotropic antenna may be used to determine the best combination of antenna polarisations for use with a particular circuit (and a particular frequency) when the "Full Calculation" polarisation coupling loss algorithm is specified in the default station configuration, since no antenna gain information is used in the calculation of the pathloss. The antenna polarisations can then be varied to determine which combination of polarisations will result in the least losses along the radio wave path and hence the strongest signal. Note that variations in pathlosses will be reflected in the

Pathloss, Noise_Pathloss, Signal-to-Noise, Field Strength, Estimated Power Required and BUF formats.

As an example, consider the circuit A (1° S, 120° E) to B (1° S, 125° E). This circuit is 556 km in length and oriented east-west. The magnetic dip angle, I, is less than 30° (Figure 2). When the transmitting and receiving antennas are both specified isotropic and the polarisations of both antennas specified as horizontal and horizontal, vertical and vertical, horizontal and vertical or vertical and horizontal, the significance of the polarisations can be seen. For this circuit, horizontal polarisation of both antennas, as suggested in Table 4, is likely to result in fewer losses along the path and a stronger signal, particularly at the lower frequencies.

The energy at the receiving antenna is dependent upon the initial polarisation, how much energy is transferred into each of the characteristic waves, the amount of absorption suffered, ground reflection losses on multihop paths and the polarisation of the radio waves with respect to the polarisation of the receiving antenna.

Polarisation coupling loss and therefore antenna choice is less important at:

- higher frequencies (greater than about 10 MHz), where the geomagnetic field exerts less influence on the radio wave, or
- when the antennas are capable of transmitting and receiving circular or elliptical polarisation.

Table 4. Recommended antenna polarisations for geographical regions, propagation directions and path types.

Latitude of sky reflection point(s)	Time	North-south paths		East-west paths		Other	
		$\Delta > 45°$	$\Delta < 45°$	$\Delta > 45°$	$\Delta < 45°$	$\Delta > 45°$	$\Delta < 45°$
Low I < 30°	Day	Both vertical	Any	Both horizontal	Both horizontal	Any	Any
	Night	Both same	Any	Both same	Both same	Any	Any
Middle 30°<I<60°	Day	Both vertical	Both vertical	Any	Any	Any	Both vertical (any for two- hop)
	Night	Any	Any	Any	Any	Any	Any
High I > 60°	Day	Any	Both vertical	Any	Both vertical	Any	Both vertical
	Night	Any	Both same	Any	Both same	Any	Both same

(Δ = take-off angle, I = magnetic dip angle)

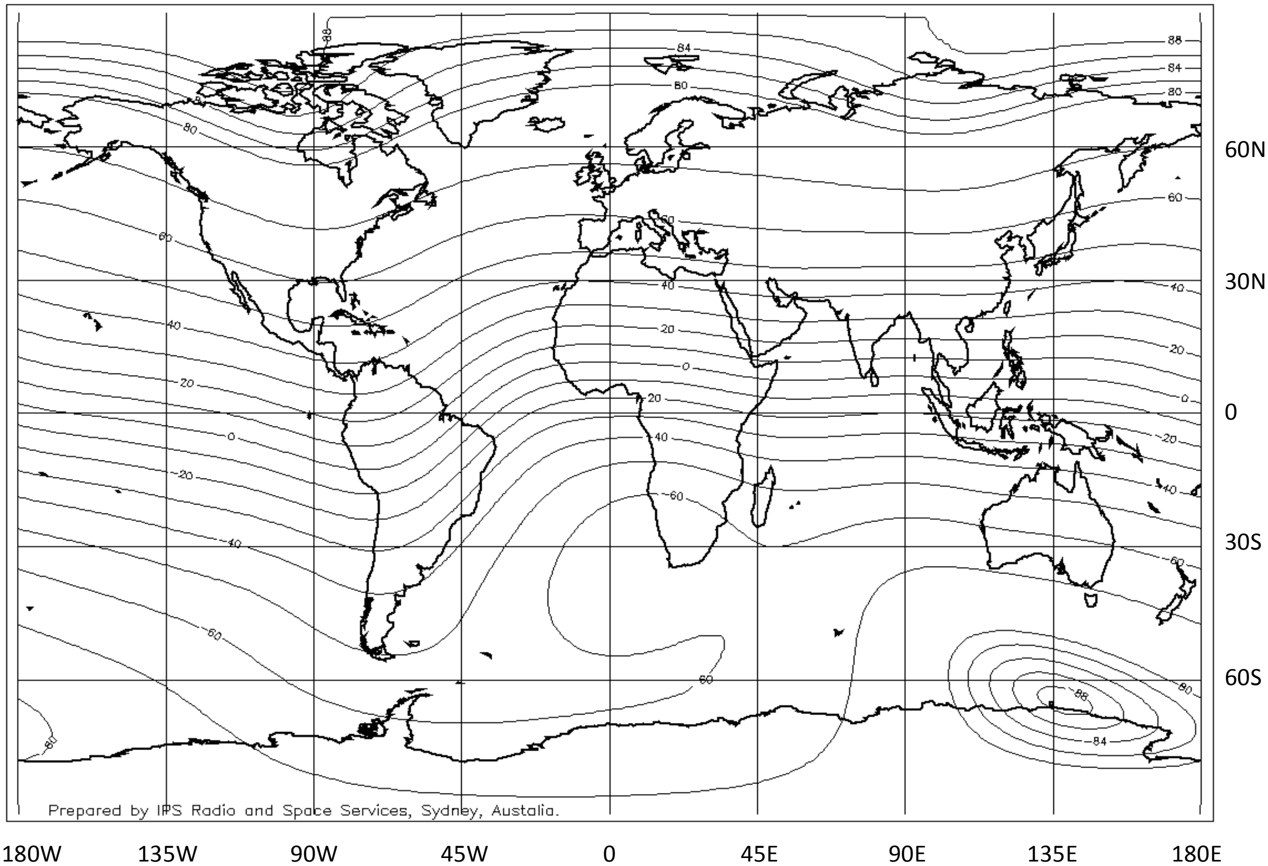

Figure 2. World map of magnetic dip angle (I) for use with Table 4.

2.8 T index database

The T index database should be regularly updated so predictions are as accurate as possible. ASAPS will remind the user if the T index database has not been updated in the last month.

Sometimes the T indices for past months have changed because new ionospheric data from stations around the world have been included in the computation of the T index.

2.8.1 Updating from the web

If the computer is connected to the Internet, in ASAPS click on *Databases|T indices|Update from the Web* to obtain new data, then click *Done*. If the computer is not connected to the Internet when this is attempted, ASAPS will advise there is no connection. The monthly T indices are located on the Space Weather Services web site at: www.sws.bom.gov.au/HF_Systems/6/4/1.

2.8.2 Updating from a file

The monthly T indices may also be saved as a text file from the web page in Section 2.8.1. To update the T index database in ASAPS from a saved file, click on *Databases|T indices|Update from a file…*. Select the appropriate drive, directory and file, click on *Open* then *Done* to save the update.

The T indices may also be obtained by e-mail subscription (Section 1.13). When the monthly T index file is updated, susbscribed addresses are emailed the file.

Exercise 11. Updating the T index database

Change the T index for December 1999 to 10 and May 2000 to -5.

- Select ***Databases*** in the menu bar then ***T indices*** from the drop-down list. The **T indices** dialogue is displayed.
- Note that all years and months are not displayed in the database. Click anywhere in the database/spreadsheet to display the horizontal and vertical scroll bars.
- Scroll to then click or use the arrow keys to move to the cell for the required year and month. The value is highlighted by a darkened line around the perimeter of the cell. Type in the new value and press **Enter** on the keyboard.
- Repeat for the other value. Click on the ***Done*** command button.
- Verify the values have been changed by opening the T index database again.

3. Predictions menu and prediction dialogues

The Predictions menu accesses the two prediction dialogues, allows previously computed predictions to be viewed, and prediction files to be deleted.

3.1 Prediction dialogues

Besides the data entered in the databases, certain other information is required to compute a prediction. This information is entered via the prediction dialogues. There are two prediction dialogues – the *Prediction Details* dialogue and the *Area Prediction details* dialogue.

ASAPS 5 produces three types of predictions: GRAFEX, Field Strength and Area predictions.

When a prediction for various time periods (including a whole solar cycle) or point-to-point circuits is required, a GRAFEX and/or Field Strength prediction should be computed. GRAFEX and Field Strength predictions are produced by pressing *Predictions|Do Prediction*. The *Prediction Details* dialogue is displayed.

If requiring a prediction for communications between a base and locations within an area, an Area prediction should be computed. Area predictions are computed by pressing *Predictions|Do Area Prediction*. The *Area Prediction details* dialogue is displayed.

3.1.1 Data entry common to both dialogues

The *Prediction Details* and *Area Prediction details* dialogues have common buttons and fields. These are the date (day, month, year), index, T index estimator, frequency set and path type. The *Tab* key will move the cursor through the fields in the prediction dialogues. For information on data entry specific to the prediction dialogues, refer to Sections 3.2 and 3.3.

3.1.1.1 Date fields

The default for the date is the current month and the current year. Pressing the *Tab* key at the *Day*, *Month*, *Year* and *Index* fields in the *Prediction Details* or *Area Prediction details* dialogues will input the default values (the *Day* field will remain blank). The resulting prediction will be based on the ionospheric maps for the current month and the T index in the database for the current month and year.

If a monthly prediction is required, March for example, March can be entered in the *Month* field and the *Day* field left blank. In this case, the resulting prediction will be based on the ionospheric maps for the specified month, March. If a prediction for a certain day or small range of days is required, the prediction may be slightly more accurate if a day is entered, as ASAPS will use the ionospheric maps for the month and the adjacent month’s maps. For instance, communications may be required on the 3 April. If the *Day* field is left blank, the prediction computed will be based on the April ionospheric maps. However, if the day (3) is entered in the *Day* field, ASAPS will interpolate between the March and April maps. Note however, that there are likely to be only small variations in two such predictions given the same T index.

When producing a prediction the *Year* field should display the value of the year required to avoid confusion when using the prediction.

3.1.1.2 Index

There is a choice of three indices; T index (T), sunspot number (SSN) and the 10.7 cm radio flux (F10). Which index is displayed in the prediction dialogues and predictions is dependent on the index specified in the Configuration database. The allowable range for the T index is -50 to 200.

The default value for the index (T index/10 cm flux/sunspot number) is the value for the current month and year.

Indices are updated by updating the T index database. The SSN and F10 indices for a prediction are calculated from the T index value(s).

3.1.1.3 T index estimator

If real time foF2 (F region vertical MUF) data from a location are accessible, ASAPS can estimate the T index for the location at that hour by using the *T index estimator*.

Real time foF2 data should only be used when the ionospheric reflection point of the circuit is close to the location from which the foF2 data was obtained, that is, within 300 km of the site. The data may be used for NVIS or longer circuits with one ionospheric reflection which is within 300 km of the data collection location. For circuits with more than one ionospheric reflection, the T index estimator should not be used since the ionosphere at the other ionospheric reflection point may be quite different from where the foF2 was obtained.

A prediction obtained from a T index estimation based on real time foF2 should not be used for an extended period of time since the reflectivity of the ionosphere can be quite variable, for example, near sunrise.

At times, the estimated T index based on the given foF2 for a particular hour and location may lie outside the allowable range of -50 to 200. This will be because the foF2 value is either particularly low or high in comparison to the median values used to determine the relationship between the T index and hourly foF2 values at that location. Where the estimated T index lies outside the allowable range, the lower (-50) or upper (200) limit could be used in the computation to approximate real time conditions by just entering the value (-50 or 200) in the *Index* field. For example, if the estimated T index is given as -60, a T index of -50 can be entered in the *Index* field.

3.1.1.4 Do Prediction button

Pressing this button results in the computation of the prediction which will be based on the information in the default station configuration and the data entered in the dialogue.

3.1.1.5 Cancel

Pressing this button cancels the prediction. The prediction is not computed.

3.1.1.6 Map and map tick boxes

In the two dialogues there is a choice of six smaller geographic regions other than the world map for use when preparing a prediction. Ticking a box other than “World” displays a higher resolution map of an area. The maps may be used to specify terminals (Sections 3.2.4 and 3.3.4) or areas of interest (Section 3.3.5).

3.2 Do Prediction - prediction details dialogue

Clicking on *Predictions|Do Predictions* displays the *Prediction Details* dialogue. From this dialogue GRAFEX and Field Strength predictions may be computed.

3.2.1 Circuit #

When each circuit is entered, it is given a number in the prediction. The first circuit entered will be circuit number 1. Circuit details may be modified before a prediction is computed by selecting the appropriate circuit number from the drop down list to display the circuit’s details, altering details as required and pressing *Modify*. Alternatively, the circuit may be deleted from the prediction by pressing the *Delete* button. The same procedure can be followed when re-computing a prediction.

3.2.2 Global change

When global changes are activated (tick in box) changes in the date (day, month, year), index value or frequency set may be made to all circuits in the prediction. The *Global change* button may be activated at any time during the initial computation or re-compute to change data for all circuits in the prediction.

Note that a global change to the frequency set will only affect the results in the Field Strength prediction. The GRAFEX prediction results will be based on the frequency set specified in the default station configuration.

To ensure global changes are saved, actively select the day, month, year, index or frequency set, even though the value required may already be displayed in the field to be altered. Care should be taken when performing global changes on circuits. For example, an initial change of the T index for one circuit may be overridden by a global change of the month, causing the T index for that circuit to revert to the value for the month and year specified globally.

3.2.3 Circuit Name

The circuit name should give an indication of the communication path. Circuit names generally are composed of the two terminal names separated by a hyphen, for example, Singapore-London. The circuit name may be at most 20 characters long. Circuits may be selected from the Circuits database by either typing the name and pressing the space bar or clicking on the down arrow button and scrolling through the list. New circuits are typed in the *Circuit Name* field (together with the terminal information). In the latter case, ASAPS will prompt the user to save the circuit and perhaps the terminals to the respective databases, before computing the prediction.

3.2.4 Tx/Rx group boxes

Terminal names indicate a location, for example, Hamburg and may be at most 16 characters long. The transmitter (Tx) and receiver (Rx) may be selected from the Terminals database by either typing the name and pressing the space bar (or Enter key) or clicking on the down arrow button and scrolling through the list of terminals. For terminals not in the database, the name, latitude and longitude can be typed or the mouse buttons can be used to click on the map (left button for the Tx - wave symbol; right button for the Rx - target symbol). This will result in the latitude and longitude fields being automatically filled. The resulting terminal name is derived from the location's co-ordinates; this name may be changed. A circuit name must be entered in the *Circuit Name* list box. The new terminals and circuits will be saved when the prediction computation is performed.

The latitudes and longitudes of terminals may be specified in either decimal degrees or degrees and minutes. The preferred units are specified in the Configuration database. When entering the latitude and longitude of a location ensure the correct units are used.

3.2.5 Path

Three path types are defined, district/NVIS, short and long. Refer to Section 1.5 for further details.

The default path type is the short path. Change the path type from the drop down list if a district/NVIS or long path circuit is required.

3.2.6 Distance

This field displays the distance, in the preferred units (kilometres, nautical miles or miles - specified in the Configuration database), between the two terminals. If the locations of the two terminals are entered, the distance between them will be displayed. If one terminal's latitude and longitude are unknown but its distance and bearing in relation to the other terminal are available, these values may be entered. Ensure when entering such data the correct units are used and the bearing is entered in the correct field (Tx→Rx or Rx→Tx).

3.2.7 Bearings

These two fields, *Tx→Rx* and *Rx→Tx*, display the bearings in the preferred units (degrees or mils - specified in the Configuration database), between the transmitter (*Tx*) and receiver (*Rx*). These fields may be useful when the latitude and longitude of one of the terminals is unknown. For example, if the transmitter site location is known and the receiver site is known to be due south of the transmitter a certain distance, then the appropriate bearing value should be entered in the *Tx→Rx* field. See Section 1.4 for further information. Ensure when entering bearing data the correct units are used.

3.2.8 Frequency set

The *Frequency Set* list box initially displays the frequency set specified in the default station configuration.

The frequency sets saved in the Frequency Set database are accessed from the *Frequency Set* drop down list.

Any number of individual circuits may be entered in the *Prediction Details* dialogue; for each circuit a different frequency set may be specified from the Frequency Set database. The circuit predictions in the Field Strength prediction will be based on the frequency set(s) specified in the *Frequency Set* list box in the *Prediction Details* dialogue. However, all circuits in the resulting GRAFEX prediction will be based on the frequency set specified in the default station configuration.

Circuits in GRAFEX and Field Strength predictions will only be based on the same frequency set if the frequency set specified in the default station configuration is the same as that specified in the *Frequency Set* list box of the *Prediction details* dialogue for all circuits in the prediction.

A Field Strength prediction file will only contain predictions for those circuits where a frequency set other than “(NONE) GRAFEX” was specified in the *Frequency Set* list box. If “(NONE) GRAFEX” is specified for all circuits, a Field Strength prediction will not be computed. The GRAFEX prediction will contain data for all circuits and be based on the frequency set specified in the default station configuration.

3.2.9 Frequency set selection/testing button

When ASAPS is opened, the initial or default values under the *Frequency Set Selection/Testing* button for the hours and minimum and maximum number of frequencies in sets are the whole 24 hours, 3 and 5, respectively. If these values are altered, the new values will be used in computing all subsequent GRAFEX predictions until the values are altered again or ASAPS is closed.

The results of GRAFEX predictions computed in a previous use of ASAPS that are opened will be based on the values selected under the *Frequency Set Selection/Testing* button at the time the prediction file is opened, which may not be the values used in the original computation of the prediction. If it is desired that an existing prediction which is closed, use different values to those presently specified under the *Frequency Set Selection/Testing* button, change the values first, then open the prediction file. This is achieved by selecting *Predictions|Do Prediction*, changing the values under the *Frequency Set Selection/Testing* button, pressing *OK,* then *Cancel* in the *Prediction Details* dialogue. The prediction can then be opened from *Predictions|View Predictions*. This procedure does not apply to the *Create a standard sunspot cycle* tick box which can only be used in an initial computation or when re-computing a prediction. That is, a solar cycle prediction cannot be produced from an initial monthly prediction and vice versa.

3.2.9.1 Frequency set selection/testing button - hours

Each hour is associated with a tick box. If no hours are selected (no ticks) then the GRAFEX and SNR Frequency Set Test and Frequency Selection formats of the GRAFEX prediction are not computed. When at least one hour is selected, the GRAFEX and SNR Frequency Selection formats will be computed. The GRAFEX and SNR Frequency Set Test formats will be computed if at least one hour is selected and a frequency set is specified in the default station configuration.

The hours specified apply to all circuits in the GRAFEX prediction. Different ranges of hours cannot be specified for different circuits in the prediction.

Field Strength prediction results are unaffected by this option; results for the 24 hours are computed.

3.2.9.2 Frequency set selection/testing button - min/max number of frequencies

This refers to the two *Number of frequencies to be selected* boxes. Both the *Minimum* and *Maximum* values may range between 2 and 12. The minimum value must not be greater than the maximum value and the maximum value must not be less than the minimum value. These values dictate how many frequency sets will be computed in the GRAFEX and SNR Frequency Selection formats of a GRAFEX prediction (note also that at least one hour must be ticked for these two formats to be computed).

The values apply to all circuits in the GRAFEX prediction. Different values cannot be specified for different circuits.

Field Strength prediction results are unaffected by this option results are based on the specified frequency set(s).

3.2.9.3 Frequency set selection/testing button - create a standard sunspot cycle set

A tick in the *Create a standard Sunspot cycle set of 16 Month/T indices* box results in ASAPS computing “planning” predictions representing communications over a whole solar cycle. Sixteen predictions for each circuit are computed for the T indices 0, 50, 100 and 150 and months March, June, September and December; representative of a whole solar cycle. This option is useful when a communications circuit or circuits will be in operation for a number of years. Both the GRAFEX and Field Strength prediction files will contain 16 predictions for each circuit that this option is specified for.

Planning predictions and the usual predictions (say, a monthly prediction) may be combined in the one prediction file. The details of circuits for planning predictions should be entered first. When the last circuit requiring a planning prediction has been entered, tick the *Create a standard Sunspot cycle set of 16 Month/T indices* box then continue entering the details of the shorter time period predictions.

3.2.10 Add/Modify button

If “(NEW)” is shown in the *Circuit #* list box this button displays as *Add* and new circuits may be added to the prediction. If a number is shown in the *Circuit #* list box this button changes to *Modify* and the circuit’s details that are displayed may be altered.

3.2.11 Delete button

This button is only active when a number is displayed in the *Circuit #* list box. The circuit displayed can be deleted from the prediction. Deleting a circuit from a prediction does not result in the circuit being deleted from the Circuits database.

3.3 Do Area Prediction - area prediction details dialogue

Clicking on *Predictions|Do Area Prediction* displays the *Area Prediction details* dialogue.

3.3.1 Name

Entering a name for the Area prediction is optional. If no name is entered, ASAPS will compose a title of at most 40 characters long, from the base name and the area name

3.3.2 Path

The short path is initially displayed and is the default. The path may be specified as either short or long. Refer to Section 1.5 for more information.

3.3.3 Frequency set

The *Frequency Set* list box initially displays the frequency set specified in the default station configuration. If "(NONE) GRAFEX" is specified in the default station configuration then the list box is blank.

The *Frequency Set* list box allows selection of a frequency set from the Frequency Set database. The frequency set specified will be used in the computation of the sky wave and Surface Wave formats of the Area prediction and the associated Field Strength prediction. The associated GRAFEX prediction will be based on the frequency set specified in the default station configuration. If it is required that the GRAFEX prediction be based on the same frequency set as the Area and Field Strength predictions, the same frequency set should be specified in the default station configuration as in the *Frequency Set* list box of the *Area Prediction details* dialogue.

To ensure the Surface Wave computation of an Area prediction is successful, frequencies in the specified frequency set should range between 1 and 50 MHz. Refer to Section 2.4.

3.3.4 Base group box

A base may be entered by typing its name and co-ordinates, selecting from the drop-down list or by clicking on the map with the left mouse button to enter the location. A wave symbol appears on the map at the location of the base. If the left mouse button is used to select a base on a map, the geographic co-ordinates of the location will be displayed in the *Base* list box. If desired, this default name can be changed in the *Base* list box. If the base is specified as the receiver in the *Base is* list box, the wave symbol on the map changes to a target symbol.

Clicking on the "…" button accesses the Terminals database, enabling changes to be made to terminal (adding, modifying or deleting).

If the terminal entered does not exist in the Terminals database or is not added to the database via the "…" button, the prediction will be computed but the terminal will not be saved to the Terminals database for use in other predictions.

The base may be specified as either the transmitter (*Tx*) or receiver (*Rx*) in the *Base is* list box.

3.3.5 Area of interest group box

Areas of interest may be specified in the *Area Prediction details* dialogue in one of three ways:

1. Select a pre-defined area from the *Area of Interest* list box, or
2. Click on the "…" button in the *Area of interest* group box and add an area to the database, or
3. Depress the right mouse button on the north-west or upper left corner of the desired area, drag then release the button at the south-east or lower right corner to define an area on

one of the maps. Then enter the name of the new area in the *Area of interest* dialogue and specify its resolution. To define an area that straddles the side boundaries of the World map, click with the right mouse button on the north-west or upper left corner of the area, depress the right mouse button and drag to the other side of the map, releasing when the desired south-east or lower right corner of the area has been reached.

3.3.6 Surface wave parameters button

The data entered in the *Surface Wave Parameters* dialogue is only relevant to the Surface Wave and Multi-surface formats of Area predictions.

The default values are sea water, sea state 2, vertical monopole antennas one metre in length on the ground with 100% efficiency, atmospheric noise included and 2200 kHz as the multi-surface frequency. These values will be used in the Surface Wave and Multi-surface formats unless the values are altered. Changes to these values will be reflected in new predictions.

Previously computed predictions, when opened, will use the values specified under the *Surface Wave Parameters* button at the time of opening. These values may not necessarily be those used to produce the initial computation. If it is required the initial values be used, select *Predictions|Do Area Prediction* to view the *Area Prediction details* dialogue and under the *Surface Wave Parameters* button enter the required values. Press *OK* then in the *Area Prediction details* dialogue, press *Cancel*. Finally, open the Area prediction required. This procedure may also be used to change these parameters from the initial values used in the prediction.

3.3.6.1 Surface wave parameters button - surface type

Choose one of the eight ground types listed, together with their permittivities and conductivities. This parameter applies only to the Surface Wave format of Area predictions. Conductivity and permittivity of a ground type should not be altered unless data are available.

3.3.6.2 Surface wave parameters button - sea state loss

The surface wave can be attenuated by rough seas. This loss factor is applied in the Surface Wave format when sea water is specified as the surface type. It is also applied in the computation of the Multi-surface format when the wave travels over sea.

In general, rougher sea results in greater attenuation of the ground wave. Further, since lower frequencies are less affected by sea state, the sea state loss factor is only applied to frequencies greater than 2 MHz.

3.3.6.3 Surface wave parameters button - Tx/Rx antennas

There are three antenna choices for the Surface Wave and Multi-surface formats of Area predictions: reference dipole, vertical monopole and vertical dipole. The gain patterns of these three antennas in ASAPS are very similar so that altering the antenna type for Surface Wave and Multi-surface formats has little effect on their results.

3.3.6.4 Surface wave parameters button - antenna length

The allowable range is 0.01 to 330 metres. The optimum monopole antenna length is normally considered to be one quarter the wavelength of the operating frequency.

Optimum monopole antenna length (metres) = 75 / frequency (MHz)

The optimum length of a dipole antenna is normally considered to be one half the wavelength of the operating frequency.

Optimum dipole antenna length (metres) = 150 / frequency (MHz)

The antenna should be vertical and improved performance will be obtained with a ground screen.

3.3.6.5 Surface wave parameters button - antenna height

This parameter refers to the height of the antenna above the average ground level along the path. The allowable range is 0 to 100 metres. Increasing the antenna height will probably reduce the ground wave's range.

3.3.6.6 Surface wave parameters button - antenna efficiency

Antenna efficiency depends on the state of the antenna and may range from 1 to 100%. Greater antenna efficiency is likely to improve the ground wave range. More detail concerning antenna efficiency can be found in Section 2.5.2.

3.3.6.7 Surface wave parameters button - atmospheric noise tick box

Atmospheric noise will be included in the computations of the Surface Wave and Multi-surface formats of the Area prediction when a tick is displayed in this box. The atmospheric noise model then used in the computations will be that specified in the default station configuration.

If no tick is displayed in the *Atmospheric noise* tick box, atmospheric noise will be excluded from the surface wave and multi-surface computations.

It is suggested that atmospheric noise should normally be included in these computations.

3.3.6.8 Surface wave parameters button - multi-surface frequency box

Specify the frequency, in kilohertz, for the Multi-surface format of an Area prediction. The Multi-surface format displays the computed range of a specified frequency travelling via the ground wave. The allowable frequency range is 1,000 to 50,000 kHz (1 to 50 MHz).

3.4 Viewing predictions

A previously computed prediction that is closed (not displayed in any of its formats) may be opened by selecting *Predictions|View Predictions*. The *Open Prediction File* dialogue is displayed. Clicking on the down arrow button in the *Files of type* list box displays the three prediction file types (Area Predictions (*.AHD), Field Strength files (*.FSH) and GRAFEX Predictions (*.PRD)). Select the prediction file type from the list, left click on the file required then press *Open* to view the prediction. Pressing *Cancel* will exit the *Open Prediction File* dialogue without opening a file.

3.5 Deleting predictions

In the computation of a Field Strength or Area prediction, a GRAFEX prediction is always computed. A Field Strength prediction is also computed in the computation of an Area prediction. A Field Strength prediction will only be computed when a GRAFEX prediction is computed, if a frequency set has been specified in the *Frequency Set* list box of the *Prediction Details* dialogue.

To delete a prediction file, firstly ensure all views of the file and any associated files are closed (that is, any GRAFEX (*.PRD), Field Strength (*.FSH) or Area (*.AHD) prediction displays).

Select *Predictions* then *Delete a Prediction*. The GRAFEX predictions, with their ".PRD" extensions are listed in the *Open a prediction and associated files for deletion* dialogue. Left click on the file to be deleted. Press *Yes* to delete the file. If a ".PRD" file is deleted, all other associated files with the same file name (but different extension) are deleted also. For example, if the files tute.AHD (an Area prediction file), tute.FSH (a Field Strength prediction file) and tute.PRD (a GRAFEX prediction file) all exist, then deleting tute.PRD removes all three files. Only one prediction file may be deleted at a time.

4. GRAFEX predictions

GRAFEX predictions provide information about ionospheric support for sky wave communications between two locations.

The formats available are:

- GRAFEX Table
- GRAFEX Graph‡
- GRAFEX Frequency Table
- GRAFEX Frequency Plan Table†
- GRAFEX Frequency Plan Graph†
- GRAFEX Frequency Selection#
- GRAFEX Frequency Set Test*
- SNR Frequency Selection#
- SNR Frequency Set Test*

‡ The frequency set selected in the default station configuration is displayed on the graphs.

† Only produced if a frequency set is selected in the default station configuration.

Only produced if at least one hour is selected under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue.

* Only produced if at least one hour is selected under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue and a frequency set is selected in the default station configuration.

The last four formats are new to ASAPS 5.

GRAFEX prediction file names have a ".PRD" extension.

Some knowledge of the antenna take-off angles is useful when interpreting the results in order to determine the most probable propagation mode and hence the most appropriate frequencies. A frequency set may be specified and ASAPS will compute a frequency schedule (GRAFEX Frequency Plan formats). ASAPS can compute appropriate frequency sets, either based on ionospheric support only (GRAFEX Frequency Selection format) or including specified station parameter values (SNR Frequency Selection format). ASAPS is also capable of testing the suitability of a frequency set based on ionospheric support only (GRAFEX Frequency Set Test format) or including the specified station parameter values (SNR Frequency Set Test format).

Table 5 (p. 51) displays which parameters in the Station Configurations database influence the results of the GRAFEX formats. See Section 2.7 for detailed information on the station parameters. Those parameters used in a particular format are displayed in the header section of the prediction.

Table 5. Station parameters applicable to GRAFEX prediction formats.

Station parameters	Prediction formats							
	GRAFEX table	GRAFEX graph	GRAFEX frequency table	GRAFEX frequency plan formats	GRAFEX frequency selection	GRAFEX frequency set test	SNR frequency selection	SNR frequency set test
Tx power							●	●
Antenna types							●	●
Frequency set		●		●		●		●
Man-made noise							●	●
Bandwidth							●	●
Required S/N							●	●
Min. take-off angle							●	●
Required % days							●	●
Pol. coupling loss							●	●
Predict. confid. level							●	●
Atmos. noise model							●	●

4.1 GRAFEX prediction formats

Each prediction displays a header containing the data used in the computation of the prediction. Always verify the details are correct before using a prediction.

4.1.1 GRAFEX table

This format displays sky wave frequency predictions for 24 hour communications between two terminals based on ionospheric support only. The header section shows the circuit, latitudes and longitudes of the terminals, prediction date, and T index used in computing the frequency predictions, bearings and path type.

The format will normally display the expected propagation conditions, via symbols, for frequencies between the second mode ALF and the first mode UD, and the first and second mode ALFs, EMUFs and OWFs. For information on interpreting this format, refer to *Help|Contents|The GRAFEX Prediction|GRAFEX Windows Help|How To Use a GRAFEX Prediction*.

4.1.2 GRAFEX graph

Two graphs may be displayed (one for district/NVIS or circuits greater than 12,000 km) for the first and second E and F propagation modes. Colour blocks display frequencies within certain frequency ranges. If a frequency set was specified in the default station configuration, lines will be drawn across the graphs indicating the frequencies in the set and will be thicker where ASAPS computes that frequency as the optimum frequency based on ionospheric support only.

4.1.3 GRAFEX frequency plan table/graph

These two formats will not be produced if "(NONE) GRAFEX" is specified as the frequency set in the default station configuration.

When a frequency set is specified in the default station configuration these formats display frequency schedules for the first and second E and F modes based on ionospheric support only. For the F modes a frequency schedule is computed for probability of propagation below the OWF and for probability of propagation between the OWF and MUF. For the E modes the schedules are computed for probability of propagation below the EMUF.

4.1.4 GRAFEX frequency table

This is a table displaying the ALF, EMUF, OWF, MUF and UD for the first two propagation modes. Some users may find this format easier to interpret than the GRAFEX Table format.

4.1.5 GRAFEX frequency selection

The GRAFEX Frequency Selection format computes one or more frequency sets for the circuits in a prediction based on ionospheric support only. At least one hour and the minimum and maximum number of frequencies in the sets must be specified under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue for this format to be computed.

As an example, if the hours from 04 to 19 UT and the minimum and maximum number of frequencies of three and five, respectively, are selected, ASAPS will compute three frequency sets for communications between 04 to 19 UT for all circuits in the prediction. One set will contain three frequencies, the next set, four frequencies and the last set, five frequencies.

All circuits in the prediction are considered part of the same network. That is, the selected frequency sets are optimised for use over all the circuits.

This format may be viewed as either a short (*Concise*) or full (*Verbose*) report under the *View* menu when viewing the prediction. The *Concise* report gives a summary of the overall availability by the main mode and all modes, and the score. The *Verbose* report details when there may be outages and the frequencies available for use at each hour. The *Verbose* report also lists the frequency sets considered in determining the final frequency set(s).

See Section 4.2 for details on main mode, all modes, usability, availability and score.

4.1.6 GRAFEX frequency set test

The GRAFEX Frequency Set Test format computes the usability or success of a frequency set based on ionospheric support only. To produce the GRAFEX Frequency Set Test format, a frequency set must be specified in the default station configuration and at least one hour specified under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue.

Consider the "broadcast" frequency set is chosen in the default station configuration and the 24 hours are selected under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue. The resulting GRAFEX prediction will contain a GRAFEX Frequency Set Test format which analyses the suitability of the "broadcast" frequency set for communications over the 24 hours.

All circuits in the prediction are considered part of the same network. That is, the frequency set being tested is tested for use over all the circuits.

The results may be viewed as either a short (*Concise*) or full (*Verbose*) report from the *View* menu. The *Concise* report gives a summary of the overall availability of the main mode and all modes and the score for the frequency set being tested. The *Verbose* report displays details such as when outages may occur and a usability summary for each frequency and hour.

See Section 4.2 for details on main mode, all modes, usability, availability and score.

4.1.7 SNR frequency selection

Unlike the GRAFEX Frequency Selection format, the SNR Frequency Selection format uses many of the station parameters specified in the default station configuration to determine the suitability of frequency sets, see Table 5 (p. 51). For this reason, the SNR Frequency Selection format should only be used if these parameters are known or can be reasonably estimated. For details on the station parameters, refer to Section 2.7.

The SNR Frequency Selection format computes one or more frequency sets for use on the circuits in a prediction. The frequency sets with the highest score are selected as the optimum frequency sets. To compute this format, at least one hour and the minimum and maximum number of frequencies in the sets must be specified under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue.

As an example, if the hours from 00 to 06 UT and the minimum and maximum number of frequencies of three and three, respectively, are selected, ASAPS will compute one frequency set containing three frequencies for communications between 00 to 06 UT for all the circuits in the prediction file.

The results may be viewed as either a short (*Concise*) or full (*Verbose*) report under the *View* menu when the prediction is opened. The *Concise* report displays the main and all modes availabilities and the all modes score for the selected frequency set(s). The *Verbose* report displays the same information as the *Concise* report, and tables displaying the usability of frequencies on the main and all modes. In the *Verbose* report, the frequency sets considered in determining the best frequency set are also listed with their availabilities and score. The frequency set(s) selected have been optimised for performance over all circuits in the prediction.

While the frequency sets with the highest scores are selected as the best frequency sets, the user may find one of the other frequency sets in the selection process has a similar score but greater availability. If further investigation of one of these other sets is desired, enter the frequency set in the Frequency Set database, select that frequency set in the default station configuration and re-compute the prediction for the required circuits and time. Ensure the results of the SNR Frequency Set Test format are viewed.

The computation of the SNR Frequency Selection can be time consuming when there are large numbers of circuits in the prediction. As an example, a SNR Frequency Selection computation containing 128 circuits for three frequency sets took 16 minutes to display the *Concise* report when tested using 2.3 GHz CPU, 512 MB RAM and Windows XP operating system. It then took another 16 minutes to compute and display the results for the *Verbose* report. Computation times will be even longer when 3D antennas are used.

See Section 4.2 for details on main mode, all modes, usability, availability and score.

4.1.8 SNR frequency set test format

Unlike the GRAFEX Frequency Set Test format, the SNR Frequency Set Test format uses many of the station parameters specified in the default station configuration to determine the suitability of the frequency set being tested, see Table 5 (p. 51). For this reason, the SNR Frequency Set Test format should only be used if these parameters are known or can be reasonably estimated. For details on the station parameters see Section 2.7.

The SNR Frequency Set Test format calculates the usability or success of the specified frequency set. To compute the SNR Frequency Set Test format, a frequency set must be specified in the default station configuration and at least one hour specified under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue.

Consider the "amateur" frequency set is specified in the default station configuration and the hours 11 to 17 are selected under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue. The resulting GRAFEX prediction will contain a SNR Frequency Set Test format which analyses the suitability of the "amateur" frequency set for communications between 11 and 17 UT on all circuits in the prediction.

The information displayed in the SNR Frequency Set Test format is similar to that in the BUF (Best Usable Frequency) format of the associated Field Strength prediction (see Section 5.1.12). However, where the BUF format displays only the frequency from the specified set with the highest signal-to-noise value above the required signal-to-noise (Required S/N), the SNR Frequency Set Test format displays all frequencies from the specified set that satisfy the required signal-to-noise.

The results may be viewed as either a short (*Concise*) or full (*Verbose*) report under the *View* menu when the prediction is opened. The *Concise* report displays the main and all modes availabilities and the all modes score. The *Verbose* report displays the same information as the *Concise* report including tables displaying the usability of frequencies on the main and all modes.

See Section 4.2 for details on main mode, all modes, usability, availability and score.

4.2 Definitions of terms in the frequency selection and test formats

The GRAFEX/SNR Frequency Selection and Set Test formats provide information on the usability of a frequency, the availabilities of the main mode and all modes, and a score.

4.2.1 Main mode and all modes

Table 1 (p. 11) displays the modes examined in ASAPS predictions. For hop lengths less than or equal to 3,000 km, the main mode is the first F mode. The second F mode becomes the main mode for hop lengths greater than 3,000 km in length.

All modes information displays usability of all the modes listed in Table 1 for the specified path length, including the main mode.

4.2.2 Usability - GRAFEX frequency selection and GRAFEX frequency set test formats

There are a number of rules in determining the usability of a frequency on the main mode and all modes in the GRAFEX Frequency Set Test and GRAFEX Frequency Selection formats.

No frequency will be selected as usable at a particular hour if the available spectrum for the circuit at that hour is less than 1 MHz. Further, a frequency will not be selected if the percentage ratio

100 * (frequency - bottom frequency) / (top frequency - bottom frequency)

is less than 10%. In such a case, an A, * or % symbol may be displayed for the main mode at that hour in the usability summary of the *Verbose* report of either of these two formats.

The symbols A, * and %, have the following meanings:

A = highest frequency within the available spectrum is too close to the ALF to be usable;
* = propagation not possible via the main mode, but by some other mode;
% = propagation on some mode only possible on a frequency with 50 - 90% probability of ionospheric support (i.e., between the OWF and MUF).

In the above relation, "frequency" is the frequency under consideration and the "bottom" and "top" frequencies refer to the available spectrum and are defined below.

For circuits up to 500 km in length:

- Only one-hop modes are considered on these short circuits. A frequency is selected as usable on the main mode if it satisfies the 10% rule (above) and lies between the ALF (bottom frequency) and the OWF (top frequency). A frequency is usable on all modes if it satisfies the 10% rule and lies between the ALF (bottom frequency) and the larger of the OWF and EMUF (top frequency).

For circuits between 500 and 12,000 km:

- If the main mode is the first F mode (i.e., circuit lengths of 500 to 3,000, 4,000 to 6,000 and 8,000 to 9,000 km), then a frequency is usable on the main mode if it satisfies the 10% rule and lies between the main mode OWF (top frequency) and the larger of the main mode ALF or second mode EMUF (bottom frequency).
- If the main mode is the second F mode (i.e., circuit lengths of 3,000 to 4,000, 6,000 to 8,000 and 9,000 to 12,000 km), a frequency is usable on the main mode if it satisfies the 10% rule and lies between the main mode ALF (bottom frequency) and the main mode OWF (top frequency).
- A frequency is usable on all modes if it satisfies the 10% rule and lies between the second mode ALF (bottom frequency) and the largest value of the first and second mode OWFs and EMUFs (top frequency).

For circuits over 12,000 km in length:

- For these circuits, only a composite F mode is considered, that is, there is no specific number of hops. A frequency is usable on the main mode if it satisfies the 10% rule and lies between the OWF (top frequency) and the ALF (bottom frequency). Because no second mode is given, the usability and availability for the main mode and all modes are the same.

The *Verbose* reports of these two formats display usability summaries for the main mode and all modes. The usability summaries indicate which frequencies are usable at each hour required for communications. The all modes usability summary does not indicate which mode a frequency that is usable is expected to propagate on. This information may be ascertained from the GRAFEX Table or GRAFEX Frequency Table formats.

4.2.3 Availability – GRAFEX frequency selection and GRAFEX frequency set test formats

Availability is defined as the number of hours when at least one frequency is usable, out of the total number of hours communications are required (selected under the *Frequency Set Selection/Testing* button). Availability is expressed as a percentage. For example, if the prediction has been computed for all 24 hours for two circuits and the main mode propagates 19 of the 24 hours on circuit one and 17 of the 24 hours on circuit two, then the availability of the main mode for circuit one is 79.2% [(19 * 100) / 24] and the main mode availability of circuit two is 70.8% [(17 * 100) / 24]. Network main mode availabilities are also calculated. The network main mode availability is the average of the main mode availabilities of all circuits in the prediction. In this example, the main mode network availability is 75% {[(19 + 17) * 100] / (2 * 24)}.

The all modes availability for the GRAFEX Frequency Selection and GRAFEX Frequency Set Test formats is determined by considering all possible modes for a circuit of that length. A network availability for all modes is computed and is the average of the sum of the all modes availability for all circuits in the prediction.

4.2.4 Score - GRAFEX frequency selection and GRAFEX frequency set test formats

The score is a quality rating. The score is based on how close the frequencies are to the upper limit (OWF) of the range of usable frequencies for each hour and how often propagation is possible on each of the frequencies. The score can take on negative values at times. The more positive the score, the better the quality of communications; that is, a score of 20 is better than 10 which is better than a score of -5. A network score is also calculated and is the sum of the scores of all the circuits for a particular frequency set.

When comparing frequency sets in the GRAFEX Frequency Selection and Frequency Set Test formats, better quality communications are likely if the frequency set with the highest score is selected. If the number of hours on which communications are possible is of interest (i.e., the system may have a low signal-to-noise threshold), then selection of a frequency set can be based availability.

The *Verbose* report of the GRAFEX Frequency Selection also displays a list of frequency sets considered in the selection of the best set. The list shows the frequencies in the sets, availabilities and score. The frequency set from the list with the highest score is selected as the best set containing the required number of frequencies.

4.2.5 Usability - SNR frequency selection and SNR frequency set test formats

In the SNR Frequency Selection and Frequency Set Test formats, a frequency must satisfy the required signal-to-noise (Required S/N), minimum take-off angle (Min. Angle) and % days probability of ionospheric support (Required % Days) at a particular hour. These three parameters are specified in the default station configuration. If a frequency satisfies the above three parameters and lies above the ALF (for E modes) or above the greater of the ALF or E-cutoff frequency of the next higher mode (for F modes), the frequency may be usable. Often the E-cutoff frequency of the next higher mode will be greater than the ALF of the mode being considered.

The E-cutoff frequency is a prediction of the highest frequency which is reflected by the E layer for a take-off angle appropriate for the F layer propagation mode on the transmission frequency. For the propagation mode being considered the E-cutoff frequency is normally higher than the EMUF of the next higher mode. Frequencies below the E-cutoff frequency are not considered for propagation on an F mode in the SNR formats because they are unlikely to penetrate the E region.

The ALF for a mode is displayed in the GRAFEX Table or GRAFEX Frequency Table formats.

If the frequency set specified in the *Frequency Set* list box of the *Prediction Details* dialogue was the same as that specified in the default station configuration, the associated Field Strength prediction can be viewed to estimate the E-cutoff values. All formats apart from the Estimated Power Required (EPR) or Best Usable Frequency (BUF) of the associated Field Strength prediction file may be viewed to estimate the lower limit.

The E-cutoff values for a frequency set selected in the SNR Frequency Selection format can be estimated by first entering the selected frequency set in the Frequency Set database, re-computing the prediction, ensuring the frequency set is specified in the *Frequency Set* list box in the *Prediction Details* dialogue and viewing one of the Field Strength Table formats (not EPR or BUF) of the corresponding Field Strength prediction file.

Viewing the Field Strength prediction results for the F modes will show the lowest frequency in the specified set which is above the greater of the ALF or E-cutoff frequency (during the day) for that mode at a certain hour. Frequencies below the greater of the ALF or E-cutoff frequency will have the symbol ".." associated with them.

The probability of ionospheric support (Required % Days) specified in the default station configuration restricts the frequencies that may be usable to those with probabilities equal to or greater than the value specified. If the Required % Days value is specified as 50% in the default station configuration, frequencies equal to and lower than the MUF will be considered for usability in the SNR Frequency Selection and SNR Frequency Set Test formats. If the Required % Days value is specified as 90%, frequencies equal to and below the OWF will be considered for usability. A Required % Days value of 70% would mean the upper limit for usability lies between the MUF and the OWF. See Section 1.11 for definitions.

The minimum take-off angle (Min. Angle) in the default station configuration limits the frequencies considered in the SNR formats to those that have take-off angles equal to or greater than the angle specified. Some antennas may have poor gain at lower elevation angles which will reduce signal strength at those angles, or it may be that only transmissions from locations closer to the transmitter or receiver are of interest. Frequency/mode combinations with predicted take-off angles lower than the specified minimum take-off angle are not considered usable.

The required signal-to-noise (Required S/N) specified in the default station configuration is the lower limit of signal-to-noise values considered in the selection or test of frequency sets. Frequency/mode combinations with predicted signal-to-noise values lower than the required signal-to-noise are not considered in determining usability.

Consider the case where a frequency set is being tested for use on a particular circuit. For this circuit, there are only two modes available, the main mode and another mode. The values specified in the default station configuration are: required signal-to-noise=3 dB, minimum take-off angle=10° and the probability of ionospheric support=70%.

At a certain hour, the corresponding Field Strength prediction to the GRAFEX prediction shows frequency X to have the following values for the main mode: signal-to-noise=1 dB, take-off angle=15° and the probability of ionospheric support=79%, and the following values for the other mode: signal-to-noise=7 dB, take-off angle=22° and the probability of ionospheric support=82%.

In the *Verbose* report of the SNR Frequency Set Test format, the usability summary for the main mode would show frequency X as unusable at the particular hour. Even though the main mode values for the take-off angle and ionospheric support exceed the limits in the default station configuration, the signal-to-noise value (1 dB) is below the value required (3 dB). The usability summary for all modes would however, indicate that frequency X is usable at this particular hour since the signal-to-noise, take-off angle and probability values for the other mode equal or exceed the values in the default station configuration.

4.2.6 Availability - SNR frequency selection and SNR frequency set test formats

The *Concise* and *Verbose* reports of the SNR formats display availabilities for the main mode and all modes. The availabilities are expressed as a percentage and indicate the number of hours that communications on at least one frequency, are possible. For example, if communications are required between 00 and 15 UT, a total of 16 hours, and only seven of those hours have any frequencies that are usable on the main mode, the main mode availability is 43.8% (100*7/16). The availability does not indicate when and which frequencies are usable, the usability summaries in the *Verbose* reports provide this information. If there is more than one circuit in a prediction, main mode and all modes availabilities for the network of circuits are computed. The main mode and all modes network availabilities are the averages of the main modes and all modes availabilities for the circuits in the prediction.

4.2.7 Score - SNR frequency selection and SNR frequency set test formats

The score in ASAPS 5.3 has been redefined. The score is defined as the logarithmic average of the maximum signal-to-noise values of all modes that satisfy the required criteria, for each frequency.

For N signal-to-noise values:

$$\text{Score} = 10\times\log_{10}\left\{\left(\sum_{1}^{N} 10^{\frac{SNR_N}{10}}\right)\Big/ N\right\}$$

where N = number of frequencies in the frequency set tested or selected

SNR_N = maximum signal-to-noise value of all modes for a particular frequency

The information provided in the corresponding field strength prediction (specifically in the Probability, Take-off Angle and Signal-to-Noise prediction formats) is used to determine whether a frequency/mode combination is usable. The signal-to-noise data are used to compute the score.

Example:

Consider communications are required on a particular circuit at one particular hour of some month. The frequency set containing the three frequencies, 5, 9 and 15 MHz, will be used. The required percentage days of ionospheric support, required signal-to-noise and minimum take-off angle are specified as, 75%, 3 dB and 5°, respectively, in the default station configuration.

The length of the circuit indicates the 1E, 1F, 2E and 2F modes will propagate. Table 6 displays the predicted signal-to-noise (SNR), take-off angle (TOA) and level of ionospheric support (Prob.) results for the frequency/mode combinations.

Those frequency/mode combinations that satisfy all three criteria (required percentage days of ionospheric support: 75%, required signal-to-noise: 3 dB and minimum take-off angle: 5°) are displayed in bold type in Table 6.

As an example, the 15 MHz/2F mode combination is not selected because its probability of ionospheric support (53%) does not satisfy the required percentage days of ionospheric support (75%).

Table 6. Results of field strength prediction used in SNR score calculation.

Criteria	Frequency/mode combinations											
	5/1E	**9/1E**	15/1E	**5/1F**	**9/1F**	**15/1F**	5/2E	9/2E	15/2E	5/2F	**9/2F**	15/2F
SNR	**24**	**54**	-	**49**	**51**	**61**	-2	-	-	0	**31**	43
TOA	**13**	**15**	-	**35**	**35**	**38**	29	-	-	49	**54**	63
Prob.	**99**	**99**	-	**99**	**81**	**76**	99	-	-	99	**79**	53

The maximum signal-to-noise value of the 5 MHz propagation modes that satisfy the criteria (5 MHz/1E = 24 dB and 5 MHz/1F = 49 dB), is 49 dB. The maximum signal-to-noise value for the 9 MHz propagation modes (54, 51 or 31 dB) is 54 dB and the maximum signal-to-noise value for the 15 MHz propagation modes (only the 15 MHz/1F mode satisfies) is 61 dB.

The number of frequencies in the set, N, is three.

The score is then

$$\text{Score} = 10 \times \log_{10}[(10^{4.9} + 10^{5.4} + 10^{6.1})/3]$$

= 57.24 dB

For communications over a number of hours and months, the process is repeated and the score result is the average of the scores for each hour.

A network score is computed if a prediction contains more than one circuit. The network score is the average of the scores for the individual circuits and gives an indication of the circuit signal-to-noise values over the network. The scores are displayed in both the *Concise* and *Verbose* reports.

4.3 Frequency set specification

Frequency sets for GRAFEX predictions are specified in the Station Configurations database and cannot be selected or altered in the *Prediction Details* or *Area Prediction details* dialogues.

Table 7 shows which GRAFEX formats are produced and which frequency set is used for various frequency set specifications and when at least one hour is specified under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue. In this example, the frequency set choices in the default station configuration are Set A, Set B or "(NONE) GRAFEX". The "maritime" frequency set is specified in the *Frequency Set* list box of the *Prediction Details* or *Area Prediction details* dialogue.

Table 7. Frequency set specification in GRAFEX prediction formats.

Frequency set specified in default station configuration	Set A	Set A	(NONE) GRAFEX	(NONE) GRAFEX	Set B	Set B
Frequency set specified in prediction dialogues	maritime	maritime	maritime	maritime	maritime	maritime
At least one hour selected in *Prediction Details* dialogue	Yes	No	Yes	No	Yes	No
GRAFEX Table/Graph and Frequency Table formats computed?	Yes	Yes	Yes	Yes	Yes	Yes
GRAFEX Frequency Plan formats computed?	Yes - Set A	Yes - Set A	No	No	Yes - Set B	Yes - Set B
GRAFEX/SNR Frequency Selection formats computed?	Yes	No	Yes	No	Yes	No
GRAFEX/SNR Frequency Set Test formats computed?	Yes - Set A	No	No	No	Yes - Set B	No

The frequency set specified in the default station configuration will be used in the prediction. The default station configuration is selected by displaying the required station configuration in the *Station Configuration* dialogue and ensuring the *Set as default* option button is ticked. All circuits in a GRAFEX prediction file use the same frequency set, that is, the frequency set specified in the default station configuration (except the GRAFEX and SNR Frequency Selection formats which actually compute suitable frequency sets).

If no frequency set is required in a GRAFEX prediction, select "(NONE) GRAFEX" in the *Frequency Set* list box of the default station configuration. In this case, the GRAFEX Frequency Plan Table/Graph and GRAFEX/SNR Frequency Set Test formats will not be produced.

4.4 Producing a GRAFEX prediction

Exercise 12. Producing a GRAFEX prediction

Produce a GRAFEX prediction for the current month and year for the seven circuits below using the frequency set “tuteset”. Ensure the Frequency Set Selection formats are produced for two to five frequencies and the Frequency Set Selection and Frequency Set Test formats are produced for the hours 03-20 UT. Call the prediction file “tute1”. View the formats of this GRAFEX prediction.

1. **Canberra to Ship (46.23° S, 138.54° E) - short path**
2. **Arequipa District - district/NVIS**
3. **Dakar (14.67° N, 17.43° W) to Lagos (6.45° N, 3.40° E) - short path**
4. **Auckland to Limbunya - short path**
5. **Seattle (47.60° N, 122.34° W) to Z (750 km south of Seattle) - short path**
6. **Yangon (16.47° N, 96.10° E) to Son Hai (11.25° N, 109.01° E) - short path**
7. **Perugia to London - long path**

- The frequency set, if any, specified in the default station configuration is used in producing the GRAFEX formats. In Exercise 4 (p. 22) the **tuteset** frequency set was added to the frequency set database. In Exercise 10 (p. 32), the **statute** station configuration was chosen as the default station configuration and **tuteset** was the frequency set specified. You can check this by clicking on ***Databases|Station configurations*** and viewing the **statute** station configuration. Note the **tuteset** frequency set is specified and **statute** is the default station configuration (tick in box).
- Select ***Predictions*** from the menu bar. In the drop-down menu, click on ***Do Prediction*** to view the **Prediction Details** dialogue. Note that **tuteset** is displayed in the **Frequency Set** list box because it was specified in the default station configuration, **statute**. The frequency set could be changed but it would have no effect on the resulting GRAFEX prediction which would use the **tuteset** frequency set.
- Remember the **Tab** key moves the cursor from one field to the next, not **Enter**. Move the cursor to the **Circuit Name** list box by pressing **Tab**. This will enter the current month, year and index as required. Type in the first circuit name, **canberra-ship**, then press **Enter** or the **spacebar**. If this circuit exists in the Circuits database, the Tx and Rx information should be displayed. Check the path type. Click on the ***Add*** command button. Note that if ***Add*** is clicked more than once, the resulting prediction will have the same circuit saved in it the number of times ***Add*** was clicked.
- Click in the **Circuit Name** list box and repeat the above procedure for the next circuit. If a circuit does not exist, the **Tx** and **Rx** fields will be blank. Enter the name of the Tx and press **Enter** or the **spacebar**. If the terminal exists in the database, the **Lat.** and **Long.** fields will be filled. If this is the case, check the location is similar to that required. If the terminal does not exist in the database, type in the location of the new terminal. For circuit 5, after entering the Tx details, leave the Rx fields as they are, check the path type, enter the distance (**750**) and the Tx→Rx bearing (**180**) then go back and enter the Rx name (**Z**). Ensure ***Add*** is pressed after the details of each circuit are entered.
- When all the circuits have been entered, click on the ***Frequency Set Selection/Testing*** button. Alter the minimum and maximum frequencies to **2** and **5** frequencies, respectively and select the hours required (**03** to **20** UT). Click on ***OK*** then the ***Do Prediction*** command button. The **Save Prediction** dialogue will appear.
- Type **tute1** in the **File name** text box and click on ***Save*** or press **Enter**. A prediction file called **tute1** containing seven circuits should now have been computed.

- The **Open** dialogue is now displayed. In the **Files of type** list box select **GRAFEX Table (*.PRD)**. Open the file by double-clicking on the file name **tute1.PRD**.
- To view the different circuits, press the ← → keys on the keyboard (not those in the numeric keypad) or select ***View|Next Circuit*** or ***Previous Circuit***. Holding down the ← or → key will cycle quickly through the circuits.
- To view the other GRAFEX formats select ***View*** from the menu bar then ***New View*** from the drop-down menu. Select the other formats from the list (i.e., GRAFEX Graph, GRAFEX Freq Plan Table, GRAFEX Freq Plan Graph, GRAFEX Frequency Table, GRAFEX Frequency Selection, etc.).
- The GRAFEX Freq Plan Table and Freq Plan Graph both show the recommended frequencies from the specified frequency set, **tuteset**, which should provide 50-90% and greater than 90% probability of propagation for the first and second modes where possible.
- The GRAFEX Frequency Table displays the UD, MUF, OWF and ALF for the F region and the MUF for the E region (i.e., EMUF), for the first and second modes or allowable modes on long circuits (see Sections 1.10 and 1.11).
- The GRAFEX Graph format displays lines across the graph(s) which indicate frequencies in the specified set, here **tuteset**. These lines may be thickened where the frequency is closest to and below the OWF.
- The GRAFEX and SNR Frequency Selection formats show the availability of four frequency sets ASAPS has computed to be the best for the hours 03-20 UT. View the *Verbose* reports by selecting ***View|Verbose***. The SNR Frequency Selection format may take a couple of minutes to display the *Concise* report. This format has used the information contained in the default station configuration, **statute**, to determine the best frequency sets. The GRAFEX Frequency Selection format shows the best frequency sets for the circuits based on ionospheric propagation conditions only. In both formats, five frequency sets have been selected, one containing two frequencies, one containing three, one containing four and one containing five frequencies.
- The GRAFEX and SNR Frequency Set Test formats test the frequency set, **tuteset**, specified in the default station configuration, **statute,** for availability during the hours 03-20 UT. View the *Verbose* reports by selecting ***View|Verbose***. The GRAFEX Frequency Set Test results are based on propagation of the frequencies in **tuteset** while the SNR Frequency Set Test results are based on whether the frequencies in **tuteset** meet the three criteria specified in **statute** (Required S/N, Min. Angle and Required % days). Whether each frequency meets the Required S/N at each hour is dependent upon the other values and parameters specified in **statute**.

When the GRAFEX Table, GRAFEX Freq Plan Table or GRAFEX Frequency Table formats are displayed, choosing *View|All Circuits* allows the user to scroll through all the circuits in the prediction file in the format being viewed.

4.5 The View menu

Clicking on *View* in the menu bar when a GRAFEX prediction format is currently the active window gives access to the other GRAFEX formats by selecting *New View*. By selecting *Re-compute* the *Prediction Details* dialogue is displayed allowing the current prediction to be modified and saved with either the same or a different file name. The hot keys displayed to the right of the items in the View menu may be used instead of returning to the *View* menu to select an option.

If the GRAFEX Table/Graph, GRAFEX Frequency Plan Table/Graph or GRAFEX Frequency Table format is the current view and the prediction contains multiple circuits, clicking on *Next Circuit* or

Previous Circuit will display the next or previous circuit in the prediction. It is easier to use the ← → keys on the keyboard.

If the GRAFEX Table, GRAFEX Frequency Plan Table or GRAFEX Frequency Table format is the current view and there are multiple circuits in the prediction, then selecting *All Circuits* will display all the circuit information in the prediction for these views when selected. Clicking on *All Circuits* again will restore these formats to viewing a single circuit.

Selecting *Select Frequency Set* (or *f* on the keyboard) will display the *Frequency Set Select* dialogue which enables a frequency set to be selected from the Frequency Set database. This process allows the prediction results to reflect the frequency set change temporarily.

If viewing one of the GRAFEX or SNR Frequency Selection or Frequency Set Test formats, clicking on *Concise* or *Verbose* displays either the short or full report.

4.6 Re-computing a GRAFEX prediction and global changes

Re-computing a prediction allows modifications to be made to existing circuits in a prediction (date, index, circuit details, path type and information under the *Frequency Set Selection/Testing* button). Circuits may also be added to and deleted from the prediction.

If the GRAFEX prediction to be re-computed is not open, click on *Predictions|View Predictions*, select *GRAFEX Predictions (*.PRD)* in the *Files of type* list box and the required file in the *Open Prediction File* dialogue. With the GRAFEX prediction open, select *View|Re-compute* to display the *Prediction Details* dialogue.

When re-computing a GRAFEX prediction file, “(NONE) GRAFEX” is displayed in the *Frequency Set* list box of the *Prediction Details* dialogue (even though a frequency set may actually be specified in the default station configuration). If this is not altered to display one of the frequency sets in the Frequency Set database, no Field Strength prediction file will be produced. For example, if a GRAFEX prediction file contains two circuit predictions and in the re-computation, one circuit has a frequency set selected in the *Frequency Set* list box, while “(NONE) GRAFEX” is specified for the other circuit, the resulting Field Strength prediction file will only contain one circuit prediction while the GRAFEX prediction file will contain two circuit predictions. The re-computed GRAFEX prediction file will use the frequency set selected in the default station configuration and the Field Strength prediction file containing the one circuit, will use the frequency set that was specified in the *Prediction Details* dialogue *Frequency Set* list box.

Exercise 13. Re-computing a GRAFEX prediction with global changes

Produce a new prediction for next month called “tute2” that contains all the circuits in “tute1.PRD”.

- If not already viewing the GRAFEX prediction file **tute1.PRD**, select ***Predictions*** in the menu bar then ***View Predictions*** in the drop-down menu. The **Open Prediction File** dialogue appears. Choose **GRAFEX Predictions (*.PRD)** in the **Files of type** list box and open **tute1.PRD**.
- With **tute1.PRD** open in any format and viewing any circuit, select ***View*** from the menu bar then ***Re-compute***. The **Prediction Details** dialogue appears.
- Click on the **Global change** box so a tick appears in the box.
- Change the month to next month (and to next year if the current month is December). Note the T index automatically changes.
- Note that in the **Frequency Set** list box **(NONE) GRAFEX** is displayed, indicating that no Field Strength prediction file will be produced.

- Click on ***Modify*** then ***Do Prediction***. When the **Save Prediction** dialogue appears, save the new prediction as **tute2**.
- In the **Open** dialogue select any of the GRAFEX/SNR formats of **tute2.PRD** to ascertain the change of month to all circuits in the file has been made.
- Use the ← → keys on the keyboard to view the circuits in the prediction file (not for GRAFEX and SNR Frequency Selection and Frequency Set Test formats).
- Note, the formats that use the frequency set specified in the **statute** station configuration are still produced, i.e., GRAFEX Graph, GRAFEX Frequency Plan Table and Graph, GRAFEX and SNR Frequency Set Test and use the **tuteset** frequency set.

Exercise 14. Re-computing a GRAFEX prediction

For all circuits in "tute2.PRD" change the T index to 200. Change the location of the ship in the Canberra to Ship circuit to 50.0° S, 140.0° E. Change the path type of the Perugia-London circuit to short path and change the month for this circuit back to the current month and year (keeping the T index = 200). Save the file as "tute2", view the GRAFEX circuits in their different formats as before and verify the changes have been made.

- With **tute2.PRD** in the active window, select ***View|Re-compute*** to view the **Prediction Details** dialogue. The number in the **Circuit #** list box displays the number of the circuit currently displayed.
- Click on the **Global change** box so that a tick appears. Change the T index to **200** in the **Index** field. Press ***Modify***. Click again in the **Global change** box to turn global changes off.
- If the **Canberra-Ship** circuit is not displayed in the **Circuit Name** list box, click on the ▼ in the **Circuit #** list box and select this circuit (**1**). Change the location of **ship** and press ***Modify***.
- To make the change to the **Perugia-London** circuit, click on the ▼ in the **Circuit #** list box and select this circuit (**7**). Change the path to short path and the month back to the current month. Changing the month also changes the T from 200 to the value for the current month, so change the T index to **200**. Press ***Modify***. This short path circuit could have been named differently so that both the short path and long path **Perugia-London** circuits were saved. Because this was not done, the **Perugia-London** short path circuit has overwritten the long path circuit in the database.
- Now click on the ***Do Prediction*** command button. The **Save Prediction** dialogue is displayed. Enter the name of the prediction file **tute2** then press ***Save***. Overwrite the file **tute2** produced earlier.
- The **Open** dialogue is now displayed. Select any of the GRAFEX/SNR formats, highlight **tute2.PRD** and press ***Open***.
- Confirm the changes have been made and view the other GRAFEX formats. Use the ← → keys on the keyboard to view the circuits in the prediction file.

4.7 Adding and deleting circuits in a GRAFEX prediction

New circuits may be added to an existing GRAFEX prediction file. If the prediction file to be altered is already being viewed, select *View|Re-compute*.

If the file is not open, select *Predictions|View Predictions*. The *Open Prediction File* dialogue is displayed. In the *Files of type* list box, select *GRAFEX Predictions (*.PRD)* then the name of the file to be changed. Select *View|Re-compute*. The *Prediction Details* dialogue is displayed.

In the *Circuit #* field, select *(NEW)* and enter the details of the new circuit. Press *Add* then *Do Prediction* and save the new prediction file or overwrite an existing file.

To delete a circuit from an existing GRAFEX prediction, display the prediction as above, select *View|Re-compute*, then in the *Circuit #* field select the number of the circuit to be deleted. The circuit's details will be displayed in the other fields, press *Delete* then *Do Prediction*.

If it is required that any associated Field Strength prediction display the change, ensure a frequency set(s) is displayed in the *Frequency Set* list box of the *Prediction Details* dialogue for all circuits not being deleted. No associated Field Strength file will be computed if this procedure is not followed.

Exercise 15. Adding circuits to a GRAFEX prediction

Add the short path circuits Friday Island (10.60° S, 142.17° E) to Seoul (37.55° N, 126.97° E) and Bujumbura to X to the prediction file "tute1.PRD" for the current month, year and T index. Call the new prediction file "tute3". View the different formats of "tute3.PRD".

- If you are not currently viewing **tute1.PRD** and the file is open, close or minimise views of other files until you are viewing one of the formats of **tute1.PRD**. If **tute1.PRD** is not open, click on ***Predictions|View Predictions*** and open the GRAFEX prediction file **tute1.PRD**.
- Select ***View|Re-compute***. The **Prediction Details** dialogue is displayed.
- In the **Circuit #** list box select **(NEW)**. The **Month**, **Year** and **Index** fields should display the current values as required. Note that **(NONE) GRAFEX** is displayed in the **Frequency Set** list box indicating that no corresponding Field Strength prediction file will be produced.
- Enter the details for the first circuit **Friday Is-Seoul** then press ***Add***. Enter the details for the other circuit, **Bujumbura-X**, press ***Add*** then ***Do Prediction***.
- Enter the name of the new file **tute3** at the **Save Prediction** dialogue and press ***Save***. Note that at this stage if you wanted to overwrite **tute1**, then you would enter **tute1** instead of **tute3**.
- The **Open** dialogue is displayed. Select any one of the GRAFEX prediction formats and open **tute3.PRD**. Ensure the new circuits have been added and all circuits use the **tuteset** frequency set (except the GRAFEX/SNR Frequency Selection formats) since this is the set specified in the default station configuration.
- Note that **ship** in circuit 1 does not use the new location entered in Exercise 14 of 40.0° S, 150.0° E. Instead, the original co-ordinates of ship are used, 46.23° S, 138.54° E.

Exercise 16. Deleting circuits from a GRAFEX prediction

Delete the circuits Canberra-Ship and Seattle-Z from the prediction file "tute2.PRD". Call the new file "tute2".

- If **tute2.PRD** is not open, select ***Predictions|View Predictions*** and select the **GRAFEX Predictions (*.PRD)** file type of **tute2.PRD**.
- If **tute2.PRD** is already open, view the file in any format.
- Select ***View|Re-compute***. The **Prediction Details** dialogue is displayed.

- In the **Circuit #** field select the **Canberra-Ship** circuit (**1**) and press ***Delete***.
- In the **Circuit #** field, select the **Seattle-Z** circuit (**5**) and press ***Delete***.
- Press ***Do Prediction***. In the **Save Prediction** dialogue enter the name of the file, **tute2** and press ***Save***.
- View **tute2.PRD** in any of the GRAFEX formats and confirm the two circuits have been deleted from the prediction file. This procedure does not delete circuits from the Circuits database.

4.8 Changing the frequency set in a GRAFEX prediction

The GRAFEX formats that use the frequency set specified in the default station configuration are the GRAFEX Graph, GRAFEX Freq Plan Table/Graph and GRAFEX/SNR Frequency Set Test formats. If a GRAFEX prediction is closed and the frequency set in the default station configuration is different to that used to compute the prediction, the GRAFEX formats will display results based on the new frequency set when the prediction is re-opened.

For example, assume the "maritime" frequency set was used to produce a GRAFEX prediction. If the frequency set in the default station configuration is changed to the "beacon" frequency set, the abovementioned formats will use the "beacon" frequency set in their results when the GRAFEX prediction is re-opened. In fact, any GRAFEX predictions that are closed and then re-opened will now use the "beacon" frequency set. This will also occur if a different station configuration that uses another frequency set is specified as the default station configuration before the GRAFEX prediction is re-opened.

The GRAFEX Frequency Plan Table, GRAFEX Frequency Plan Graph, GRAFEX Frequency Set Test and SNR Frequency Set Test formats will not be produced if "(NONE) GRAFEX" is specified in the *Frequency Set* list box of the default station configuration. The GRAFEX Graph format will be produced but no frequency set will be displayed on the graphs.

Exercise 17. Changing the frequency set in a GRAFEX prediction

In "tute1.PRD", "tute2.PRD" and "tute3.PRD", note the frequency set used in the GRAFEX formats then close all views of these files. Alter the "statute" station configuration so the "maritime" frequency set (2, 4, 6, 8, 12, 16 and 22 MHz) is selected. Ensure that "statute" is the default station configuration. View the GRAFEX Graph format of the prediction files, "tute1.PRD", "tute2.PRD"and "tute3.PRD" and note the frequency set now used.

- The GRAFEX prediction files **tute1.PRD**, **tute2.PRD** and **tute3.PRD** may be open. If not, open the files by selecting ***Predictions|View Predictions***, selecting the **GRAFEX Predictions (*.PRD)** file type and the required file(s). View any format that relies on the selection of a frequency set (GRAFEX Graph, GRAFEX Frequency Plan Table/Graph or GRAFEX/SNR Frequency Set Test).
- Note the frequency set currently being used by these prediction files. The **tuteset** frequency set should be used since this is the frequency set specified in the default station configuration.
- Close all views of **tute1.PRD**, **tute2.PRD** and **tute3.PRD** by clicking on the × in the upper right corner of the windows for these predictions, so closing the windows.
- Select ***Databases*** from the menu bar then ***Station configurations*** in the drop-down menu. The **Station Configuration** dialogue appears.
- Display the **statute** station configuration.
- Change the frequency set to **maritime** from the drop-down list. Make sure the ***Set as default*** option button is activated.

- Press the ***Add/Modify*** command button then ***Done***.
- Select ***Predictions*** from the menu bar then ***View Predictions*** in the drop-down menu. In the **Files of type** list box change the file type to **GRAFEX Predictions (*.PRD).** Open the GRAFEX prediction **tute1.PRD**. View any of the formats that rely on the selection of a frequency set (GRAFEX Graph, GRAFEX Frequency Plan Table/Graph or GRAFEX/SNR Frequency Set Test) from ***View*** then ***New View***. Repeat the procedure for **tute2.PRD** and **tute3.PRD**. Note that all the circuits in these prediction files now use the **maritime** frequency set.
- For interest, repeat the exercise except this time do not select a frequency set (i.e., choose **(NONE) GRAFEX** in the **statute** station configuration). Once the prediction files are open, view and note the differences in the GRAFEX Graph, GRAFEX Frequency Plan Table/Graph and GRAFEX/SNR Frequency Set Test formats. Note, the GRAFEX Frequency Plan/Table and GRAFEX/SNR Frequency Set Test formats are not produced, as these require a frequency set to be specified in the default station configuration.

To temporarily view the suitability of a frequency set on those GRAFEX formats that rely on a frequency set being specified, click *View|Select Frequency Set* while displaying a GRAFEX prediction and select a frequency set from the database. Such changes are not saved when the file or ASAPS is closed. The next time ASAPS is run or a GRAFEX file is opened, the frequency set specified in the default station configuration will be used.

Exercise 18. Temporarily changing the frequency set in a GRAFEX prediction

View the effect on “tute3.PRD” of temporarily changing the frequency set used to the “broadcast” frequency set (4.9, 6.1, 7.2, 9.5, 11.8, 13.7, 15.3, 17.8, 21.6 and 26.1 MHz).

- With **tute3.PRD** displayed, view one of the formats that use the frequency set in the default station configuration (GRAFEX Graph, GRAFEX Frequency Plan Table/Graph or GRAFEX/SNR Frequency Set Test).
- Now select ***View*** from the menu bar then ***Select Frequency Set*** from the drop-down menu.
- Highlight the **broadcast** frequency set then click on the ***OK*** command button.
- This procedure allows the user to quickly ascertain the suitability of a frequency set for the circuits in a GRAFEX prediction file.
- Note that this procedure only temporarily changes the frequency set used by the prediction being viewed. Other GRAFEX prediction files that are open will continue to display results based on the frequency set specified in the default station configuration or that set chosen temporarily for them.

4.9 Producing a planning prediction

There may be occasions when an HF system is required to operate over a long period of time. ASAPS can select frequency sets or test a frequency set for coverage for a whole solar cycle, based on T indices of 0, 50, 100 and 150 for the months of March, June, September and December. This combination represents the four seasons of the year for a range of solar activity, a total of 16 month/T indices (and therefore 16 circuits).

Planning predictions and the usual predictions (that is, monthly or for some other short period of time) can be combined in the same prediction file. If planning predictions and the usual predictions are to be combined in one file, ensure the details of the planning predictions are entered first.

Planning predictions may be prepared during a re-compute of a prediction; however, planning predictions will be computed for all circuits in the prediction. It is therefore suggested that a re-compute only be performed on a prediction file that does not contain a planning prediction.

Exercise 19. Producing a planning prediction

Ensure the "tuteset" frequency set is specified in the "statute" station configuration and the "statute" station configuration is selected as the default.

Produce planning predictions for the short path circuits Tokyo (35.70° N, 139.77° E) to Dubai (25.30° N, 55.29° E) and Leiden (52.09° N, 4.30° E) to Marrakech (31.49° N, 8.00° W) for the 24 hours based on a minimum of two and maximum of five frequencies. In the same prediction file produce a prediction for the short path circuit Cairns (16.92° S, 145.77° E) to Los Angeles (34.05° N, 118.25° W) for the current month and year. Call the prediction file "tute4".

- Press ***Databases|Station configurations*** and ensure the **tuteset** frequency set is specified in the default station configuration, **statute**.
- Select ***Predictions|Do Prediction***, the **Prediction Details** dialogue is displayed.
- Whenever combinations of planning predictions and the usual type of predictions are to be combined in the one file, enter the details of the planning predictions first.
- Tab through the **Day**, **Month**, **Year** and **Index** fields and enter the details of the circuit **Tokyo-Dubai**. Press ***Add***. The values in the **Day**, **Month**, **Year** and **Index** fields are irrelevant when producing a planning prediction.
- Enter the details of the second circuit, **Leiden-Marrakech**. Click on ***Add*** then click on the ***Frequency Set Selection/Testing*** button. Select the 24 hours for the prediction, enter the number of frequencies required for the frequency sets then tick the ***Create a standard Sunspot cycle set of 16 Month/T indices*** box. Press ***OK***.
- In the **Prediction Details** dialogue, enter the details of the **Cairns-Los Angeles** circuit for the current month. Click on ***Add*** then ***Do Prediction***, the **Save Prediction** dialogue is displayed. Save the name of the file as **tute4**.
- The **Open** dialogue appears. Ensure one of the GRAFEX or SNR file types is displayed in the **Files of type** list box. Open **tute4.PRD**. There are sixteen circuits each for the **Tokyo-Dubai** and **Leiden-Marrakech** predictions and only one circuit for the **Cairns-Los Angeles** prediction. In the GRAFEX and SNR Frequency Selection and GRAFEX and SNR Frequency Set Test formats the Selections and Tests have been computed based on all 33 circuits.
- Different ranges of hours cannot be specified for different circuits in the one prediction file under the ***Frequency Set Selection/Testing*** button (see Section 3.2.9).

4.10 Station parameters and the SNR formats

ASAPS 5 produces views of GRAFEX predictions on the fly. The SNR formats (SNR Frequency Selection and SNR Frequency Set Test) are based on the values of parameters in the default station configuration at the time. That is, if a prediction file is open and the default station configuration is altered, then other views of the SNR formats when opened will use the new values (except the frequency set). Thus, it is important to ensure the correct station parameters are used in the production of the prediction and ensure when viewing the other formats of the file the station parameters have not been inadvertently altered. A change to the frequency set in the default station configuration does not produce a corresponding change in the SNR formats in this case.

To ensure the correct station parameter values are used when viewing the SNR formats of a GRAFEX prediction, open both SNR formats in the *Verbose* report before changing the default station configuration.

For an existing GRAFEX prediction the station parameters used in the SNR formats (SNR Frequency Selection and SNR Frequency Set Test) may only be altered by either computing a new prediction or changing the station parameters in the default station configuration either before or while the prediction is open.

If a GRAFEX prediction is closed and the default station configuration is altered from that used to compute the prediction originally, the SNR formats of the prediction when re-opened will be based on the values in the current default station configuration (including the frequency set).

Exercise 20. Station parameters and the SNR GRAFEX formats

The station parameters at Bujumbura are: Tx Power = 1000 W, Tx Antenna = Rx Antenna = VLP (Vertical), Frequency Set = amateur (3, 7, 10, 14, 21, 28 MHz), Man-made Noise = -150 dBW/Hz, Bandwidth = 3000 Hz, Required S/N = 2 dB, Min. Angle = 2°, Required % Days = 90%, Polarisation Coupling Loss = Full Calculation, Prediction Confidence Level = 50%, Atmospheric Noise = ITU 372-8.

The station parameters at X are: Tx Power = 500 W, Tx Antenna = Rx Antenna = WH35 (Vertical), Frequency Set = amateur, Man-made Noise = -164 dBW/Hz, Bandwidth = 3500 Hz, Required S/N = 3 dB, Min. Angle = 2°, Required % Days = 90% Polarisation Coupling Loss = Full Calculation, Prediction Confidence Level = 50 %, Atmospheric Noise = ITU 372-8.

Produce predictions for short path communications between Bujumbura and X for the current month using the "amateur" frequency set. Also use ASAPS to select three frequency sets for two to four frequencies for 24 hour communications. Call the Bujumbura to X prediction "tute5a" and the X to Bujumbura prediction, "tute5b".

Compare the results of the SNR Frequency Set Test formats which use the "amateur" frequency set and the SNR Frequency Selection formats of these two predictions.

- Ensure the Frequency Set database contains the **amateur** frequency set.
- The station parameter values at the two locations are different so two station configurations and two predictions will be required.
- Select ***Databases|Station configurations*** and produce two station configurations for communications from **Bujumbura to X** and from **X to Bujumbura**. Note, the Man-made Noise, Bandwidth, Required S/N, Required % Days and Prediction Confidence Level values should be those at the receiver site. Use the same atmospheric noise maps for both circuits. If the Min. Angle values are different, enter the largest of the values in both station configurations.
- The station configuration for communications from **Bujumbura to X** should contain the following values: Tx Power = **1000** W, Tx Antenna = **VLP (Vertical)**, Rx Antenna = **WH35 (Vertical)**, Frequency Set = **amateur**, Man-made Noise = **-164** dBW/Hz, Bandwidth = **3500** Hz, Required S/N = **3** dB, Min. Angle = **2**°, Required % Days = **90**%, Polarisation Coupling Loss = **Full Calculation**, Prediction Confidence Level = **50**%, Atmospheric Noise = **ITU 372-8**.
- The station configuration for communications from **X to Bujumbura** should contain the values: Tx Power = **500** W, Tx Antenna = **WH35 (Vertical)**, Rx Antenna = **VLP (Vertical)**, Frequency Set = **amateur**, Man-made Noise = **-150** dBW/Hz, Bandwidth = **3000** Hz, Required S/N = **2** dB, Min. Angle = **2**°, Required % Days = **90**%, Polarisation Coupling Loss = **Full Calculation** and Prediction Confidence Level = **50**%, Atmospheric Noise = **ITU 372-8**.

- Select the station configuration for communications from **Bujumbura to X** as the default by displaying this station configuration and ensuring the **Set as default** box is ticked. Click on ***Add/Modify*** then ***Done***.
- Produce a prediction for the current month for the short path circuit **Bujumbura to X** by selecting ***Predictions|Do Prediction*** and entering the details. **Bujumbura** should be the location of the transmitter site and **X** should be the receiver. Ensure under the ***Frequency Set Selection/Testing*** button that the whole 24 hours are chosen and the minimum and maximum number of frequencies specified is **2** and **4**, respectively. Call the prediction **tute5a** in the **Save Prediction** dialogue.
- Open the **SNR Frequency Selection (*.PRD)** format of **tute5a.PRD** and view the *Verbose* report. Also view the *Verbose* report of the **SNR Frequency Set Test** format of this prediction. If these views are not opened before the station configuration is changed for the X-Bujumbura circuit, when they are eventually opened, they will be based on the parameters in the default station configuration at the time, which may not necessarily be the Bujumbura-X station configuration.
- Now select ***Databases|Station configurations*** and change the station configuration to that for communications from **X to Bujumbura**. Select this station configuration as the default by ensuring the **Set as default** box is ticked. Click on ***Add/Modify*** then ***Done***.
- Click on ***Predictions|Do Prediction*** to display the **Prediction Details** dialogue and enter the details for the **X-Bujumbura** circuit where **X** is the transmitter and **Bujumbura** is the receiver. Under the ***Frequency Set Selection/Testing*** button ensure the whole 24 hours are selected and the minimum and maximum number of frequencies is **2** and **4**, respectively.
- Click on ***Do Prediction*** and call this prediction file **tute5b**. Open the *Verbose* report of the **SNR Frequency Selection (*.PRD)** format and the *Verbose* report of the **SNR Frequency Set Test** format of **tute5b.PRD**.
- Note which frequencies are selected in the **SNR Frequency Selection** format of the files **tute5a** and **tute5b** and the availability for each frequency set of the main mode and all modes and the score. The **SNR Frequency Selection** format has produced three frequency sets for each prediction for the number of hours selected under the ***Frequency Set Selection/Testing*** button (here 24 hours and sets containing two, three and four frequencies). Note the frequencies selected may not be the same in each prediction due to the differences in the station parameter values at each location.
- The *Verbose* reports of the **SNR Frequency Set Test** format for **tute5a** and **tute5b** show the availabilities of the main mode and all modes for the **amateur** frequency set for communications over the 24 hours. The scores and availabilities may be different, indicating the **amateur** frequency set is more suitable for communications in one direction than in the other, again due to differences in the station parameter values.

4.11 GRAFEX prediction analysis

Exercise 21. GRAFEX prediction analysis

In the Station Configurations database produce a station configuration called "new" with the following station parameters: Tx Power = 1000 W, Polarisation Coupling Loss = Full Calculation, Tx Antenna = WH35 (Vertical), Rx Antenna = WH35 (Vertical), Frequency Set = maritime, Man-made Noise = -150 dBW/Hz, Bandwidth = 3000 Hz, Required S/N = 3 dB, Min. Angle = 2°, Required % Days = 50%, Prediction Confidence Level = 50%, Atmospheric Noise = CCIR 322. Set this station configuration as the default.

- Select ***Databases|Station configurations*** and enter the details for the **new** station configuration. Ensure the **new** station configuration is set as the default. Press ***Add/Modify*** then ***Done***.

Produce a GRAFEX prediction for October, any year, T index of 94 for the short path circuit for one-way communications from Manila (14.58° N, 120.98° E) to Ho Chi Minh (10.46° N, 106.43° E) and for the short path, one-way circuit from Manila to Darwin (12.47° S, 130.85° E). Under the *Frequency Set Selection/Testing* button select the 24 hours and a minimum and maximum of 2 and 4 frequencies, respectively. Ensure the "maritime" frequency set is displayed in the *Frequency Set* list box in the *Prediction Details* dialogue. Call the file "tute6".

Note that because the same station configuration is being used for both one-way circuits, it is assumed that Ho Chi Minh and Darwin have the same station parameters.

- Select ***Predictions|Do Prediction***. Leave the **Day** field blank, select **October** in the **Month** list box, leave the current year in the **Year** field and enter **94** in the **Index** field.
- Enter the short path circuit **Manila-Ho Chi Minh**, ensure the **maritime** frequency set is displayed in the **Frequency Set** list box and press ***Add***. Enter the details for the **Manila-Darwin** short path circuit and again ensure the **maritime** frequency set is displayed in the **Frequency Set** list box. Press the ***Frequency Set Selection/Testing*** button and ensure the **24** hours are selected and the minimum and maximum number of frequencies to be selected is **2** and **4**, respectively. Press ***OK*** then ***Do Prediction***.
- In the **File name** field of the **Save Prediction** dialogue, type **tute6**. Press ***Save***. In the **Open** dialogue, select the **GRAFEX Frequency Table (*.PRD)** file type and select **tute6.PRD**. Press ***Open***.
- To view the different circuits, use the ← → keys or select ***View|Next/Previous Circuit***.

4.11.1 GRAFEX analysis

View the GRAFEX Frequency Table format for the Manila-Ho Chi Minh circuit in tute6.PRD, which should have values similar to those in Table 8.

Table 8. GRAFEX Frequency Table results for Manila-Ho Chi Minh.

```
==============================================================================
ASAPS V5 GRAFEX FREQUENCY TABLE --------------------------------
==============================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path
==============================================================================
First Mode: 1F 13-27 1E  2                Second Mode: 2F 29-48 2E 10
```

UT	UD	MUF	OWF	EMUF	ALF	UD	MUF	OWF	EMUF	ALF	UT
00	26.3	23.9	20.4	13.8	8.0	16.5	15.0	12.9	8.3	4.7	00
01	25.3	22.9	19.6	15.9	9.1	16.9	15.4	13.3	10.0	5.2	01
02	24.5	21.6	18.7	17.2	9.7	16.5	15.0	12.9	11.0	5.5	02
03	23.4	20.1	17.8	18.0	10.1	16.1	14.3	12.4	11.7	5.7	03
04	21.8	18.7	16.6	18.4	10.2	15.4	13.3	11.9	12.0	5.8	04
05	22.3	19.1	16.9	18.4	10.2	15.8	13.7	12.2	12.0	5.8	05
06	24.4	20.7	18.0	17.9	10.0	16.6	14.3	12.8	11.6	5.7	06
07	26.0	21.9	18.8	17.1	9.6	17.5	15.0	13.1	11.0	5.5	07
08	26.6	22.4	19.2	15.6	8.9	18.1	15.4	13.3	9.9	5.2	08
09	26.9	22.7	19.4	13.4	7.8	18.3	15.6	13.4	8.2	4.6	09
10	26.4	21.9	18.0	8.6	5.4	18.0	15.3	12.8	0.0	3.6	10
11	25.2	20.4	16.3	2.4	0.0	17.3	14.4	11.7	1.6	0.0	11
12	24.6	19.9	16.0	2.4	0.0	17.2	14.0	11.4	1.6	0.0	12
13	26.4	21.3	17.1	2.4	0.0	17.7	14.4	11.7	1.6	0.0	13
14	28.5	23.4	18.5	2.4	0.0	18.1	15.0	12.0	1.6	0.0	14
15	28.9	24.1	18.8	2.4	0.0	18.1	15.2	12.1	1.6	0.0	15

16	28.3	23.6	18.4	2.4	0.0	17.5	14.8	11.7	1.6	0.0	16
17	28.3	23.6	18.4	2.4	0.0	17.1	14.4	11.4	1.6	0.0	17
18	27.6	21.6	15.9	2.4	0.0	16.7	13.3	10.0	1.6	0.0	18
19	23.8	17.6	12.3	2.4	0.0	13.6	10.3	7.5	1.6	0.0	19
20	17.5	12.9	8.9	2.4	0.0	10.5	8.0	5.8	1.6	0.0	20
21	13.8	10.1	7.0	2.4	0.0	9.0	6.8	4.9	1.6	0.0	21
22	13.9	11.3	8.7	2.4	0.0	8.8	6.7	4.9	1.6	0.0	22
23	20.0	18.1	15.4	9.8	6.0	12.7	10.5	8.4	4.8	3.8	23

The maximum hop length an HF sky wave can travel via the F region is about 4,000 km and 2,000 km for the E region. The circuit Manila to Ho Chi Minh is 1,644 km in length. Therefore, one hop via the F region will span this length and the first F mode in the prediction therefore has one hop. Because the circuit length is less than the maximum hop length for the E region, there is also a first E mode.

The bearing of the antenna in Manila should be close to 255° and the bearing of the antenna in Ho Chi Minh should be close to 72°.

The suggested take-off angles for the E and F modes are: 1F 13°-27°, 1E 2°, 2F 29°-48° and 2E 10°.

Below the take-off angle information are data for each UT hour: UD (upper decile FMUF), MUF (median FMUF), OWF (optimum working frequency), EMUF and the ALF. Information on these frequencies can be found in Sections 1.10 and 1.11.

When analysing a GRAFEX prediction, firstly determine on which mode the signal is most likely to propagate, based on the take-off angles of the antennas. There is no point in selecting operating frequencies based on the first F mode, if the antennas cannot direct energy into or detect energy on this mode.

Multipath fading can often occur on circuits due to anomalies in the ionosphere and antennas having broad beamwidths. While an operator is generally unable to determine likely paths resulting from ionospheric anomalies, judgements based on the antenna may be made as to which is the most likely propagation mode.

In the discussion below, consider the antennas direct/receive most of their energy at take-off angles around 45°. The most likely mode of propagation will be the second F mode, 2F, although if the beamwidth of the antenna is broad enough, other modes may propagate and cause fading.

The information below, extracted from Table 8 (p. 70), may be used to determine the best frequency in the set for use between 2330 to 0030 UT for the second F mode.

First modes						Second modes					
UT	UD	MUF	OWF	EMUF	ALF	UD	MUF	OWF	EMUF	ALF	UT
00	26.3	23.9	20.4	13.8	8.0	16.5	15.0	12.9	8.3	4.7	00

On the second F mode, the lower two frequencies of the “maritime” frequency set (2.0, 4.0, 6.0, 8.0, 12.0, 16.0 and 22.0 MHz) are likely to be highly absorbed and of poor quality because they are below the second mode ALF (4.7 MHz).

The 6.0 MHz frequency is between the OWF and ALF of the second F mode and so will propagate over 90% of the time (more than 27 days of the month), if the prediction is correct. Noise levels at lower frequencies are normally greater, so the quality of the signal at this frequency may be poorer than for some of the higher frequencies. 6.0 MHz is below the ALF for the first mode (8.0 MHz) so if the beamwidth of the antenna allows this frequency to propagate via the first F mode, it could be highly absorbed, so reducing fading effects. 6.0 MHz may propagate via the second E mode if the antenna allows, which would likely cause fading.

The 8.0 MHz frequency is between the ALF and OWF of the second mode; probability of propagation is over 90% on the second F mode at 00 UT. 8.0 MHz is the ALF for the first mode, so it is likely that, if the antenna permits any signal to propagate via the first E and F modes (i.e., 1E and 1F), the signal would be weak due to high absorption. If the antenna beamwidth permits, this frequency could propagate via the second E mode, so fading may occur between the second E and F modes.

The 12.0 MHz frequency will propagate on the second F mode over 90% of the time, because it is below the OWF for this mode. It is well above the second mode EMUF so even if the antenna allowed propagation at angles appropriate for the second E mode, this frequency is likely to penetrate the E region. Multipath fading may result if the antenna allows propagation of the signal at the take-off angles for the first modes, since 12.0 MHz is above the first mode ALF and below the OWF and EMUF for the first F and E modes, respectively.

The 16.0 MHz frequency will propagate via the second F mode between 10 and 50% of the time (3 to 15 days of the month), as it lies between the UD and the MUF for this mode. 22.0 MHz will propagate less than 10% of the time on this mode.

For high reliability, operators will generally choose a frequency that is at or below the OWF for the propagation mode being considered. If the prediction is correct, the reliability of the circuit will be at least 90%, so if the prediction is calculated for a period of one month, the operating frequency should be reflected from the ionosphere on at least 27 days of the month. Frequencies higher than the OWF may be used, but will have a reduced chance of being reflected by the ionosphere. However, when they are reflected, signal strength will usually be good, since there is less absorption of the signal and noise is generally less significant at the higher frequencies.

In this exercise, the frequencies 6.0, 8.0 and 12.0 MHz should provide high reliability at 00 UT on the second F mode. When there is a choice of frequencies and high reliability is required, generally choose the frequency closest to and below the OWF. However, sometimes fading or interference may necessitate the use of another frequency.

The information below is extracted from Table 8 (p. 70) for 05 UT. Now consider the take-off angle of the antenna to be about 13°. In this case, the most likely modes to propagate are the first E and F modes and the second E mode based on the take-off angles for the modes.

First modes						Second modes					
UT	UD	MUF	OWF	EMUF	ALF	UD	MUF	OWF	EMUF	ALF	UT
05	22.3	19.1	16.9	18.4	10.2	15.8	13.7	12.2	12.0	5.8	05

The 2.0, 4.0 and 6.0 MHz frequencies are likely to be highly absorbed on all modes at 05 UT, because they are below or close to the first and second mode ALFs.

The 8.0 MHz frequency is below the first mode ALF, but can still propagate via the second E mode, as this frequency is above the second mode ALF and below the EMUF (12.0 MHz). If the antenna beamwidth permits, this frequency could also propagate via the second F mode and cause fading between the second E and F modes.

The 12.0 MHz frequency is below the first mode OWF and first mode EMUF. Fading may occur between these two modes if the antenna permits both modes to propagate. The second F mode can propagate over 90% of the time on this frequency if the antenna beamwidth allows.

Sometimes the E region can screen the radio wave from reaching the F region. This is called E-layer screening. E-layer screening is likely when the take-off angles of the F mode in use and the next higher E mode are similar (e.g., 1F and 2E or 2F and 3E) and the operating frequency for the F mode is near the EMUF of the next higher mode. To ensure the F mode propagates in such cases where the take-off angles of the F mode and the next higher E mode are similar, the operating frequency for F region communications should be well above the EMUF of the higher E mode so the radio wave penetrates the E region.

The take-off angles of the first F and second E modes are close to the 13° take-off angle of the antenna. 12 MHz is equal to the second mode EMUF indicating that for 50% of the time, this frequency will be reflected from the E region. Therefore, E-layer screening is likely at this hour, on this frequency. When the second E mode propagates, the signal will suffer greater losses compared to when the wave propagates via the first F mode, since the signal must pass through the D region more times and be reflected from the ground.

The 16.0 MHz frequency is below the first mode OWF and so will propagate over 90% of the time via this mode. This frequency is well above the second mode EMUF and so the radio wave is unlikely to propagate via this mode. E-layer screening is unlikely in this case.

Even if the antenna permitted propagation via the second F mode, the UD for this mode is 15.8 MHz, so 16.0 MHz is too high for this mode to propagate most of the time.

Fading may occur between the first E and F modes since 16.0 MHz is below the first mode EMUF. However, the take-off angle for the 1E mode is 2° and most antennas have poor gain at such low angles.

22.0 MHz is unlikely to propagate reliably, since it is close to or above the UDs and EMUFs for the first and second E and F modes at 05 UT.

The choice of frequencies for the first F mode at 05 UT is then 12.0 or 16.0 MHz. 12.0 MHz may be screened by the E region about half of the time, so 16 MHz will probably provide better communications. 16.0 MHz may also propagate via the first E mode if the antenna is capable of emitting at such low take-off angles. However, this frequency is unlikely to propagate via either of the second modes, since it is above the second mode UD and EMUF.

At night, the ALF becomes zero and E-layer screening will not occur, but fading between F modes is still possible. The choice of frequencies for the F modes then lies between the lowest frequency in the frequency set up to the highest frequency below the OWF, MUF or UD (depending on the reliability required) for the chosen propagation mode. Consideration when choosing frequencies should also be given to the effect of noise and any interference on the frequencies in the set.

View the GRAFEX Frequency Table format for the Manila-Darwin circuit in tute6.PRD, which should have values similar to those in Table 9.

Table 9. GRAFEX Frequency Table results for Manila-Darwin.

```
==============================================================================
ASAPS V5 GRAFEX FREQUENCY TABLE ---------------------------------
==============================================================================
Circuit 2: manila-darwin            Distance: 3198km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 160  340    T-index: 94
Rx: Darwin          -12.46  130.85   Path: Short Path
==============================================================================
First Mode: 1F  1-10 1E  0                Second Mode: 2F 13-26 2E  2
UT    UD     MUF    OWF   EMUF    ALF      UD     MUF    OWF   EMUF    ALF  UT
00   34.8   31.5   26.9    0.0   12.9     23.6   21.5   18.6   15.0    9.1  00
01   32.9   29.8   25.5    0.0   13.8     22.5   20.5   17.7   16.7    9.7  01
02   31.3   27.6   23.8    0.0   14.4     21.8   19.3   16.9   17.7   10.0  02
03   31.0   26.6   23.6    0.0   14.7     21.1   18.3   16.3   18.3   10.2  03
04   30.6   26.2   23.2    0.0   14.7     21.2   18.4   16.4   18.4   10.2  04
05   32.2   27.6   24.5    0.0   14.5     22.9   19.8   17.7   18.1   10.0  05
06   35.1   29.8   25.8    0.0   14.0     24.3   20.9   18.2   17.2    9.7  06
07   37.1   31.2   26.6    0.0   13.1     25.5   21.7   18.7   15.8    9.1  07
08   36.5   30.8   26.3    0.0   11.8     25.3   21.5   18.6   13.6    8.2  08
09   36.0   30.3   25.9    0.0    9.3     24.4   20.7   17.9    9.5    6.6  09
```

10	35.3	29.2	24.0	0.0	0.0	23.3	19.5	16.3	2.4	0.0	10
11	35.8	28.9	23.1	0.0	0.0	22.2	18.1	14.8	2.4	0.0	11
12	39.9	32.2	25.8	0.0	0.0	23.3	19.0	15.5	2.4	0.0	12
13	43.9	35.4	28.4	0.0	0.0	27.1	22.1	18.0	2.4	0.0	13
14	43.1	35.4	27.9	0.0	0.0	28.1	23.7	18.8	2.4	0.0	14
15	39.5	32.9	25.7	0.0	0.0	24.4	20.6	16.4	2.4	0.0	15
16	33.6	28.0	21.8	0.0	0.0	21.9	18.5	14.7	2.4	0.0	16
17	31.7	26.4	20.5	0.0	0.0	21.1	16.8	12.7	2.4	0.0	17
18	29.9	23.4	17.1	0.0	0.0	21.2	16.1	11.7	2.4	0.0	18
19	27.0	19.9	13.9	0.0	0.0	18.5	14.0	10.3	2.4	0.0	19
20	24.3	17.8	12.3	0.0	0.0	16.6	12.6	9.2	2.4	0.0	20
21	24.8	18.2	12.6	0.0	0.0	16.2	12.3	9.0	2.4	0.0	21
22	30.4	24.8	19.2	0.0	8.3	20.4	17.0	13.5	6.5	6.4	22
23	34.8	31.5	26.9	0.0	11.4	24.4	22.2	19.2	12.4	8.2	23

The bearing of the antenna in Manila should be near 160° while the bearing of the antenna in Darwin should be close to 340° for the greatest signal strength. The suggested take-off angles for propagation of the radio wave by the first F mode are 1 to 10°, for the second F mode, 13 to 26° and for the second E mode, 2°. The first E mode is unable to propagate due to the length of the circuit. The take-off angle for this mode is therefore shown as 0° and there are no EMUF values displayed.

Consider the antennas direct most of their energy into take-off angles around 5°. Most of the energy is likely to be directed into the first F and second E modes although, unless the antenna is highly directive, the radio wave is also likely to propagate via the second F mode. Therefore, fading is likely.

The information below for 00 UT is extracted from Table 9. The following discussion concerns the propagation of frequencies in the "maritime" set at this hour.

First Modes						Second Modes					
UT	UD	MUF	OWF	EMUF	ALF	UD	MUF	OWF	EMUF	ALF	UT
00	34.8	31.5	26.9	0.0	12.9	23.6	21.5	18.6	15.0	9.1	00

2.0, 4.0, 6.0 and 8.0 MHz are unlikely to propagate on the first F and second E and F modes since these frequencies are below the first mode ALF (12.9 MHz) and the second mode ALF (9.1 MHz). These frequencies are likely to be highly attenuated if used.

If 12.0 MHz is the operating frequency, it is likely this frequency will be highly attenuated on the first F mode since is lies below the first mode ALF (12.9 MHz). 12.0 MHz is likely to propagate more than 90% of the time (more than 27 days of the month at this hour) on the second F mode since it lies below the second mode OWF (18.6 MHz) and via the second E mode more than 50% of the time (more than 15 days of the month at this hour) since it is below the second mode EMUF (15.0 MHz). Therefore, fading is likely at 00 UT between the two second modes if the antennas allow both the second E and F modes to propagate.

16.0 MHz is likely to propagate more than 90% of the time (more than 27 days of the month at this hour) via the first F mode since it is lower than the first mode OWF (26.9 MHz). This frequency is below the second mode OWF (18.6 MHz) so may propagate more than 90% of the time via this mode. 16 MHz is above the second mode EMUF (15.0 MHz) and is likely to propagate less than 50% of the time via this mode. As a result, if the antenna allows propagation of all three modes, fading is likely much of the time, particularly between the two F modes.

22.0 MHz is below the first mode OWF (26.9 MHz) and is likely to propagate more than 90% of the time. This frequency is above the second mode MUF (21.5 MHz) and will propagate on this mode less than 50% of the time. 22 MHz is also well above the second mode EMUF and will propagate less than 50% of the time on the second E mode.

At 00 UT, providing energy can be directed into the first F mode, 22 MHz is likely to provide the best quality of communications since it is well above the first mode ALF and is the frequency least likely to propagate on the second E and F modes so reducing the likelihood of fading.

The information below is extracted from Table 9 (p. 73) for 09 UT.

```
    First Modes                                     Second Modes
UT    UD      MUF     OWF    EMUF     ALF       UD      MUF     OWF    EMUF     ALF   UT
09   36.0    30.3    25.9     0.0     9.3      24.4    20.7    17.9     9.5     6.6   09
```

2.0, 4.0 and 6.0 MHz are below the first and second mode ALFs and are likely to be highly attenuated resulting in low signal strength.

8.0 MHz is below the first mode ALF (9.3 MHz) so is likely to suffer attenuation on this mode. This frequency is above the second mode ALF (6.6 MHz) and below the second mode OWF (17.9 MHz) and second mode EMUF (9.5 MHz). Fading is therefore likely between the two second modes if the antennas allow both to propagate.

12.0 MHz is between the first mode OWF (25.9 MHz) and first mode ALF (9.3 MHz) and is likely therefore to propagate via this mode more than 90% of the time. This frequency is likely to propagate more than 90% of the time on the second F mode but less than 50% of the time on the second E mode. Fading is likely on this frequency between the first and second F modes much of the time, if the antennas allow.

16.0 MHz is also below the first and second mode OWFs resulting in possible propagation of both modes more than 90% of the time. Fading between these two modes is likely. This frequency is well above the second mode EMUF so propagation and therefore fading effects are unlikely due to this mode.

22.0 MHz is below the first mode OWF so should propagate via this mode more than 90% of the time. This frequency is above the second mode MUF and therefore is likely to propagate via this mode less than 50% of the time. Propagation on the second E mode is unlikely. Fading on this frequency is likely to be less than if 12.0 or 16.0 MHz were chosen.

4.11.2 GRAFEX frequency set test analysis

In the GRAFEX Frequency Set Test format, the frequency set specified in the default station configuration, here “maritime”, is tested over 24 hours where the number of hours for communications is specified in the *Prediction Details* dialogue under the *Frequency Set Selection/Testing* button.

View the *Verbose* report of the GRAFEX Frequency Set Test format of tute6.PRD. This report should look like Table 10.

Table 10. Full report of GRAFEX Frequency Set Test for Exercise 21**.**

```
===============================================================================
ASAPS V5 GRAFEX FREQUENCY SET TESTING --------------------------
===============================================================================
Frequency Set: maritime
Circuit:manila-ho chi minh 1644 km Bearings: 255 ,72 degrees

 F S T - Frequency Set:  07 frequencies
22.0, 16.0, 12.0, 8.0, 6.0, 4.0, 2.0 MHz
Main Mode = 1F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  2  2  2  1  1  1  1  2  2  2  3  5  5  5  5  5  5  5  4  4  3  2  3  2
All Modes
OCT 2008 T: 94  4  3  3  3  3  3  3  3  3  4  4  6  6  6  6  6  6  6  5  5  4  3  4  3
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
```



```
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode
%=propagation by some mode at least 50% of month  A=too near the ALF

Usability Summary (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
22.00  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
16.00  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  0  0
12.00  1  1  1  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1
08.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  0  1  1
06.00  0  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0
04.00  0  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0
02.00  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
.Availability =100.0%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
22.00  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
16.00  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  0  0
12.00  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1
08.00  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  1  1
06.00  1  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
04.00  0  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0
02.00  0  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0
.Availability =100.0% Score =    44.4

Circuit:manila-darwin 3198 km Bearings: 160 ,340 degrees

 F S T - Frequency Set:  07 frequencies
22.0, 16.0, 12.0, 8.0, 6.0, 4.0, 2.0 MHz
Main Mode = 2F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  2  2  2  2  2  2  2  2  2  3  6  5  5  6  6  6  5  5  4  4  4  4  2  2
All Modes
OCT 2008 T: 94  3  3  3  3  3  3  3  3  3  4  7  7  7  7  7  7  6  6  6  5  5  5  3  3
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode
%=propagation by some mode at least 50% of month  A=too near the ALF

Usability Summary (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
22.00  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
16.00  1  1  1  1  1  1  1  1  1  1  1  0  0  1  1  1  0  0  0  0  0  0  0  1
12.00  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  1  1
08.00  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0
06.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
04.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
02.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
.Availability =100.0%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
22.00  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  0  0  0  1
16.00  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1  1
12.00  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
08.00  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0
06.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
04.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
02.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
.Availability =100.0% Score =    63.4

.FST Network Results
Frequency Set:  22.0 16.0 12.0 8.0 6.0 4.0 2.0  MHz
.             Main Mode                 All Modes
Availability =  100.0%   Availability =  100.0%   Score =   107.8
===============================================================================
```

The *Verbose* report of this format displays the suitability of the frequency set specified in the default station configuration, “maritime”, for the number of hours, 24, chosen under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue.

The Manila-Ho Chi Minh circuit is 1,644 km in length. The main mode is the 1F and the other modes considered are the 1E, 1F, 2E and 2F.

The first part of the results for the Manila-Ho Chi Minh circuit show how many frequencies in the “maritime” frequency set are usable at each hour for the main mode and all modes (see Section 4.2.2 for usability rules). For example, two of the seven frequencies are usable on the main mode and four frequencies are usable on all modes at 00 UT. Below this, Usability Summaries indicate which frequencies are usable at each hour for this circuit. At 00 UT on the Ho Chi Minh circuit, 12.0 and 16.0 MHz are usable on the main mode and 6.0, 8.0, 12.0 and 16.0 MHz are usable when all modes are considered.

For circuits between 500 and 12,000 km in length, when the main mode is the first F mode (as is the case for the Manila-Ho Chi Minh circuit), Section 4.2.2 states that a frequency is usable if it lies between the main mode OWF and the larger of the main mode ALF and second mode EMUF.

At 06 UT on the Manila-Ho Chi Minh circuit, the OWF of the main mode (1F) is 18.0 MHz (Table 8, p. 70), the main mode ALF is 10.0 MHz and the second mode EMUF is 11.6 MHz. Because the second mode EMUF is larger than the main mode ALF, only frequencies from the “maritime” frequency set between the main mode OWF (18.0 MHz) and the second mode EMUF (11.6 MHz), are considered for usability. The only frequencies from the “maritime” set between these limits are 12.0 and 16.0 MHz. However, the Usability Summary for the main mode shows 16.0 MHz is the only frequency in the “maritime” frequency set usable on the main mode at 06 UT.

12.0 MHz is not considered usable since the relationship from Section 4.2.2:

100 * (frequency - bottom frequency) / (top frequency - bottom frequency)

is less than 10%. In this case, 12.0 MHz is not selected at 06 UT since

$$100 * (12.0 - 11.6) / (18.0 - 11.6) = 6.25\%$$

The availability of the main mode for the Manila to Ho Chi Minh circuit is 100% because there is at least one frequency available for use at each of the specified hours (here 24 hours).

For circuits between 500 and 12,000 km in length, a frequency is considered usable on all modes if it lies between the second mode ALF and the largest value of the first and second mode OWFs and EMUFs (Section 4.2.2). At 06 UT on the Manila-Ho Chi Minh circuit, the first mode OWF is 18.0 MHz, the first mode EMUF is 17.9 MHz, the second mode OWF is 12.8 MHz and the second mode EMUF is 11.6 MHz. The largest of these values is the first mode OWF, 18.0 MHz. Frequencies are therefore considered usable at 06 UT if they lie between 18.0 MHz and the second mode ALF, 5.7 MHz. Those frequencies from the “maritime” frequency set that lie between 18.0 MHz and 5.7 MHz are 6.0, 8.0, 12.0 and 16.0 MHz. As explained in Section 4.2.2, where:

100 * (frequency - bottom frequency) / (top frequency - bottom frequency)

is less than 10%, a frequency is not selected as usable. In this case 6.0 MHz is not selected since

$$100 * (6.0 - 5.7) / (18.0 - 5.7) = 2.44\%$$

which is less than 10%.

For all modes at 06 UT, the three usable frequencies are therefore 8.0, 12.0 and 16.0 MHz.

The availability for all modes is 100% because there is at least one frequency usable at each hour for the 24 hours.

The Manila-Ho Chi Minh score is 44.4.

The Manila-Darwin circuit is 3,198 km long so the main mode is the 2F and the 1F, 2E and 2F are considered for the all modes results.

At 06 UT on the Manila-Darwin circuit, two frequencies are usable on the main mode and three frequencies for all modes (Table 10, p. 75). From Section 4.2.2, a frequency is usable if it lies between the main mode ALF and the main mode OWF, when the main mode is the second F mode. For main mode usability on this circuit then, a frequency must lie between 18.2 MHz and 9.7 MHz at 06 UT. That is, 12.0 and 16.0 MHz are possibly usable. Both of these frequencies also satisfy the 10% relationship in Section 4.2.2 and hence are usable on the main mode at this hour as shown in the Usability Summary of Table 10 for the main mode of this circuit.

The range of frequencies considered for usability for all modes on a circuit of this length is between the second mode ALF (9.7 MHz) and the largest value of the first and second mode OWFs and EMUFs (25.8 MHz). The frequencies in the “maritime” frequency set that lie within this range are 12.0, 16.0 and 22.0 MHz. All satisfy the 10% relationship in Section 4.2.2 and are therefore usable at 06 UT when all modes (i.e. 1F, 2E and 2F) are considered, Table 10 (p. 75).

The availabilities of the main and all modes are both 100% for this circuit. The score is 63.4. This value is greater than the score for the Manila-Ho Chi Minh circuit and indicates the “maritime” frequency set is better suited to the Manila-Darwin circuit, for this particular month, T index and 24 hour communications.

The final part of the *Verbose* report displays the network results. The network availabilities are the averages of the main mode and all mode availabilities and the network score is the sum of the scores for all the circuits in the prediction file.

4.11.3 GRAFEX frequency selection analysis

The GRAFEX Frequency Selection format for this exercise has computed three frequency sets (containing 2 to 4 frequencies) for 24 hour communications where the number of frequency sets and hours for communications are specified in the *Prediction Details* dialogue under the *Frequency Set Selection/Testing* button.

View the *Verbose* report of the GRAFEX Frequency Selection format of tute6.PRD. This report should look like Table 11.

Table 11. Full report of GRAFEX Frequency Selection for Exercise 21.

```
================================================================================
ASAPS V5 GRAFEX FREQUENCY SET SELECTION --------------------------
================================================================================

  F S T - NETWORK FREQUENCY SELECTION RESULTS
Main mode All modes
.Avail.   Avail. Score  Frequencies
                        MHz
  87.5    93.8    17.2  16.80 9.00
  91.7    97.9    37.7  16.80 8.50
  91.7    97.9    36.2  16.80 8.00
  91.7    97.9    34.5  16.80 7.50
  91.7   100.0    43.8  16.80 7.00
  89.6   100.0    42.6  16.80 6.50
  89.6   100.0    41.1  16.80 6.00
  89.6   100.0    39.8  16.80 5.50
  89.6   100.0    38.6  16.80 5.00
--------------------------------------------------------------------------------
  91.7   100.0    43.8  16.80 7.00
Circuit:manila-ho chi minh 1644 km Bearings: 255 ,72 degrees

 F S T - Frequency Set:  02 frequencies
16.8, 7.0 MHz
Main Mode = 1F
```

```
.             00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.              |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  1  1  1  1  *  1  1  1  1  1  2  1  1  2  2  2  2  2  1  1  1  1  1  1
All Modes
OCT 2008 T: 94  2  2  2  2  1  1  2  2  2  2  2  1  1  2  2  2  2  2  1  1  1  1  1  1
.              |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.             00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode
%=propagation by some mode at least 50% of month  A=too near the ALF

Usability Summary (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
16.80  1  1  1  1  0  1  1  1  1  1  1  0  0  1  1  1  1  1  0  0  0  0  0  0
07.00  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
.Availability = 95.8%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
16.80  1  1  1  1  1  1  1  1  1  1  1  0  0  1  1  1  1  1  0  0  0  0  0  0
07.00  1  1  1  1  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
.Availability =100.0% Score =    20.7

Circuit:manila-darwin 3198 km Bearings: 160 ,340 degrees

 F S T - Frequency Set:  02 frequencies
16.8, 7.0 MHz
Main Mode = 2F
.             00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.              |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  1  1  1  *  *  1  1  1  1  1  1  1  1  2  2  1  1  1  1  1  1  1  *  1
All Modes
OCT 2008 T: 94  1  1  1  1  1  1  1  1  1  1  2  2  2  2  2  2  2  2  2  1  1  1  1  1
.              |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.             00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode
%=propagation by some mode at least 50% of month  A=too near the ALF

Usability Summary (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
16.80  1  1  1  0  0  1  1  1  1  1  0  0  0  1  1  0  0  0  0  0  0  0  0  1
07.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
.Availability = 87.5%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
16.80  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1  1
07.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
.Availability =100.0% Score =    23.0

.FST Network Results
Frequency Set:  16.8 7.0  MHz
.             Main Mode                 All Modes
Availability =   91.7%   Availability =  100.0%   Score =    43.8

 F S T - NETWORK FREQUENCY SELECTION RESULTS
Main mode All modes
.Avail.   Avail. Score  Frequencies
                        MHz
  97.9   100.0    71.2  17.90 14.45 7.00
  97.9   100.0    69.2  17.90 13.95 7.00
 100.0   100.0    68.6  17.90 13.45 7.00
 100.0   100.0    66.5  17.90 12.95 7.00
  95.8   100.0    66.6  17.90 12.45 7.00
  93.8   100.0    67.5  17.90 11.95 7.00
  93.8   100.0    66.7  17.90 11.45 7.00
  93.8   100.0    65.2  17.90 10.95 7.00
  83.3   100.0    63.2  17.90 10.45 7.00
  93.8    93.8    44.7  17.90 14.45 9.00
  97.9    97.9    65.2  17.90 14.45 8.50
  97.9    97.9    63.6  17.90 14.45 8.00
  97.9    97.9    62.0  17.90 14.45 7.50
  97.9   100.0    71.2  17.90 14.45 7.00
  97.9   100.0    70.0  17.90 14.45 6.50
```



```
  97.9   100.0    68.6  17.90 14.45 6.00
  97.9   100.0    67.2  17.90 14.45 5.50
  97.9   100.0    66.0  17.90 14.45 5.00
-------------------------------------------------------------------------------
  97.9   100.0    71.2  17.90 14.45 7.00
Circuit:manila-ho chi minh 1644 km Bearings: 255 ,72 degrees

 F S T - Frequency Set:  03 frequencies
17.9, 14.5, 7.0 MHz
Main Mode = 1F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  2  2  2  1  1  1  2  2  2  2  3  2  2  2  3  3  3  3  2  1  1  1  1  2
All Modes
OCT 2008 T: 94  3  3  3  3  2  2  3  3  3  3  3  2  2  2  3  3  3  3  2  1  1  1  1  2
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode
%=propagation by some mode at least 50% of month  A=too near the ALF

Usability Summary (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
17.90  1  1  1  0  0  0  1  1  1  1  1  0  0  0  1  1  1  1  0  0  0  0  0  0
14.45  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  1
07.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1
.Availability =100.0%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
17.90  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1  1  1  1  0  0  0  0  0  0
14.45  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  1
07.00  1  1  1  1  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
.Availability =100.0% Score =    34.2

Circuit:manila-darwin 3198 km Bearings: 160 ,340 degrees

 F S T - Frequency Set:  03 frequencies
17.9, 14.5, 7.0 MHz
Main Mode = 2F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  2  1  1  1  1  1  2  2  2  1  2  2  2  3  3  2  2  1  1  1  1  1  *  2
All Modes
OCT 2008 T: 94  2  2  2  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  2  1  1  1  2  2
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode
%=propagation by some mode at least 50% of month  A=too near the ALF

Usability Summary (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
17.90  1  0  0  0  0  0  1  1  1  0  0  0  0  1  1  0  0  0  0  0  0  0  0  1
14.45  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  0  0  0  1
07.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
.Availability = 95.8%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
17.90  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  1  1
14.45  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1  1
07.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
.Availability =100.0% Score =    37.0

.FST Network Results
Frequency Set:  17.9 14.5 7.0  MHz
.             Main Mode                 All Modes
Availability =   97.9%   Availability =  100.0%   Score =    71.2

 F S T - NETWORK FREQUENCY SELECTION RESULTS
Main mode All modes
.Avail.   Avail. Score  Frequencies
                        MHz
  95.8   100.0    91.7  18.40 16.60 10.80 7.00
```

```
 100.0   100.0    92.7  18.40 16.10 10.80 7.00
 100.0   100.0    92.8  18.40 15.60 10.80 7.00
 100.0   100.0    92.2  18.40 15.10 10.80 7.00
 100.0   100.0    90.9  18.40 14.60 10.80 7.00
 100.0   100.0    88.9  18.40 14.10 10.80 7.00
 100.0   100.0    87.9  18.40 13.60 10.80 7.00
 100.0   100.0    86.3  18.40 13.10 10.80 7.00
 100.0   100.0    85.6  18.40 12.60 10.80 7.00
 100.0   100.0    93.8  18.40 15.60 12.80 7.00
 100.0   100.0    96.5  18.40 15.60 12.30 7.00
 100.0   100.0    94.9  18.40 15.60 11.80 7.00
 100.0   100.0    94.1  18.40 15.60 11.30 7.00
 100.0   100.0    92.8  18.40 15.60 10.80 7.00
 100.0   100.0    91.0  18.40 15.60 10.30 7.00
 100.0   100.0    89.3  18.40 15.60 9.80 7.00
 100.0   100.0    88.6  18.40 15.60 9.30 7.00
 100.0   100.0    88.6  18.40 15.60 8.80 7.00
  93.8    93.8    69.9  18.40 15.60 12.30 9.00
  97.9    97.9    90.4  18.40 15.60 12.30 8.50
  97.9    97.9    88.9  18.40 15.60 12.30 8.00
  97.9    97.9    87.2  18.40 15.60 12.30 7.50
 100.0   100.0    96.5  18.40 15.60 12.30 7.00
 100.0   100.0    95.3  18.40 15.60 12.30 6.50
 100.0   100.0    93.8  18.40 15.60 12.30 6.00
 100.0   100.0    92.5  18.40 15.60 12.30 5.50
 100.0   100.0    91.3  18.40 15.60 12.30 5.00
--------------------------------------------------------------------------------
 100.0   100.0    96.5  18.40 15.60 12.30 7.00
Circuit:manila-ho chi minh 1644 km Bearings: 255 ,72 degrees

 F S T - Frequency Set:  04 frequencies
18.4, 15.6, 12.3, 7.0 MHz
Main Mode = 1F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  3  3  3  1  1  1  2  3  3  3  3  3  3  3  4  4  4  4  3  2  1  1  1  2
All Modes
OCT 2008 T: 94  4  4  4  3  3  3  3  4  4  4  3  3  3  3  4  4  4  4  3  2  1  1  1  2
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode
%=propagation by some mode at least 50% of month  A=too near the ALF

Usability Summary (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
18.40  1  1  1  0  0  0  0  1  1  1  0  0  0  0  1  1  1  1  0  0  0  0  0  0
15.60  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  0
12.30  1  1  1  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1
07.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1
.Availability =100.0%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
18.40  1  1  1  0  1  1  0  1  1  1  0  0  0  0  1  1  1  1  0  0  0  0  0  0
15.60  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  0
12.30  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1
07.00  1  1  1  1  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
.Availability =100.0% Score =    44.0

Circuit:manila-darwin 3198 km Bearings: 160 ,340 degrees

 F S T - Frequency Set:  04 frequencies
18.4, 15.6, 12.3, 7.0 MHz
Main Mode = 2F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  3  2  2  2  2  2  2  3  3  2  3  2  2  3  4  3  2  2  1  1  1  1  1  3
All Modes
OCT 2008 T: 94  3  3  3  3  3  3  3  3  3  3  4  4  4  4  4  4  4  4  3  2  2  2  3  3
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode
```



```
%=propagation by some mode at least 50% of month  A=too near the ALF

Usability Summary (Main Mode only)
FR      0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
18.40  1  0  0  0  0  0  0  1  1  0  0  0  0  0  1  0  0  0  0  0  0  0  0  1
15.60  1  1  1  1  1  1  1  1  1  1  1  0  0  1  1  1  0  0  0  0  0  0  0  1
12.30  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  1  1
07.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
.Availability =100.0%
Usability Summary (All Modes)
FR      0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
18.40  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  1  1
15.60  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  1  1
12.30  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
07.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0  0
.Availability =100.0% Score =    52.5

.FST Network Results
Frequency Set:  18.4 15.6 12.3 7.0  MHz
.             Main Mode                 All Modes
Availability =  100.0%   Availability =  100.0%   Score =    96.5
================================================================================
```

Under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue for this prediction, the whole 24 hours and a minimum of two and maximum of four frequencies were specified. Three frequency sets were computed, one set containing two frequencies, one set with three frequencies and the last set, four frequencies.

For each frequency set computed, the *Verbose* report of this format displays a list of frequencies tested in the selection process and the final set selected, the number of frequencies in the set that are usable at the specified hours for the main and all modes, Usability Summaries showing which frequencies from the selected set are usable at the specified hours for the main and all modes, the availabilities of the main mode and all modes and the score. Network availabilities and scores are also listed.

The following discussion concerns the selection of three frequencies at 09 UT in Table 11 (p. 78).

ASAPS lists the frequency sets tested, their availabilities and scores. The frequency set from the list with the highest score is selected as the best frequency set containing the required number of frequencies. ASAPS has selected as the best frequency set possible containing three frequencies for 24 hour communications between Manila and Ho Chi Minh, and Manila and Darwin in October with a T index of 94 as 7.00, 14.45 and 17.90 MHz.

At 09 UT, the Manila-Ho Chi Minh circuit has two frequencies usable on the main mode and three frequencies usable when all modes are considered. The Manila-Ho Chi Minh circuit is 1,644 km in length so that the main mode is the 1F. The 1E, 1F, 2E and 2F modes are considered in determining the results for all modes. For a circuit of this length, a frequency is considered for usability on the main mode if it lies between the first mode OWF and the larger of the first mode ALF or second mode EMUF (Section 4.2.2). At 09 UT, a frequency is possibly usable on the main mode if it lies between 19.4 and 8.2 MHz (Table 8, p. 70). Only the top two frequencies, 14.45 and 17.90 MHz, are usable on the main mode because they lie within the required range and satisfy the 10% rule (Section 4.2.2). When all modes are considered, a frequency must lie between the second mode ALF (4.6 MHz) and the largest value of the first and second mode OWFs and EMUFs (i.e., 19.4 MHz) at 09 UT to be considered for usability. All three frequencies (7.0, 14.45 and 17.9 MHz) are usable since they lie within this range and satisfy the 10% rule.

The availabilities of the main and all modes are both 100% on the Manila-Ho Chi Minh circuit since at least one frequency is available for use for each of the specified hours. The score for this circuit is 34.2.

The Manila-Darwin circuit is 3,198 km so that the main mode is the 2F. Modes considered when determining usability for all modes are the 1F, 2E and 2F. For a circuit of this length, a frequency must lie between the main mode ALF (6.6 MHz at 09 UT - Table 9, p. 73) and the main mode OWF (17.9 MHz) to be considered for usability on the main mode. All three frequencies lie within this range. However, 7.0 MHz is too close to the ALF to satisfy the 10% relationship in Section 4.2.2.

$$100 * (7.0 - 6.6) / (17.9 - 6.6) = 3.5\%$$

which is less than 10% and 17.9 MHz is not selected since it can only be assumed the OWF is actually slightly higher than 17.9 MHz and is rounded down to this value in Table 9.

For all modes, the range of usable frequencies is between 6.6 MHz and 25.9 MHz at 09 UT on the Manila-Darwin circuit (Table 9, p. 73). The three frequencies selected by ASAPS all lie within this range however, the 10% relationship in Section 4.2.2 must be checked first. For 7.0 MHz the relationship is:

$$100 * (7.0 - 6.6) / (25.9 - 6.6) = 2.1\%$$

which is less than 10%. The other two frequencies, 14.45 and 17.9 MHz satisfy the relationship and are therefore usable when all modes are considered.

The availability of the main mode of the Manila-Darwin circuit is 95.8% since at 22 UT, no frequency is considered usable on the main mode (i.e., 100 * 23 / 24). Since there is at least one frequency from the selected set available for all 24 hours when all modes are considered, the availability there is 100%.

The score for the Manila-Darwin circuit is 37.0. This is slightly higher than the score for the Manila-Ho Chi Minh circuit, indicating the quality of communications is likely to be slightly better with this frequency set on the Manila-Darwin circuit. In terms of availability though, the main mode is available for more hours on the Manila-Ho Chi Minh circuit.

The network availabilities for the three-frequency set are just the averages of the main and all mode availabilities for each circuit (e.g., (100 + 95.8) / 2 = 97.9% for the main mode and 100% for all modes). The network score for this frequency set is the sum of the scores for each circuit (i.e., 34.2 + 37.0 = 71.2).

The frequency set containing three frequencies selected by ASAPS was the set with the highest score. However, the list of frequency sets initially tested in the determination of the three-frequency set shows there are two frequency sets which have lower scores but higher main mode availabilities. These sets are 17.90, 13.45 and 7.00 MHz and 17.90, 12.95 and 7.00 MHz. The scores for these frequency sets are not significantly lower than the score for the selected frequency set so if availability of communications is important, it may be more appropriate to choose one of these frequency sets.

In this exercise, ASAPS was required to select three frequency sets. One set containing two frequencies, one containing three frequencies and one set containing four frequencies. The three frequency sets selected by ASAPS are: 7.00 and 16.80 MHz, 7.00, 14.45 and 17.90 MHz and 7.00, 12.30, 15.60 and 18.40 MHz. Which of the three frequency sets is best depends on whether just the number of hours in which communications are possible is important or whether the quality of communications is also important. In terms of availability, some hours may be more critical for communications than others so by viewing the Usability Summaries for each set, the operator is able to determine the best set. The Usability Summaries can also be used to determine the greatest number of frequencies available for use for the communication period since it may be important for the operator to have alternative frequencies.

It can be seen that the set containing four frequencies is likely to provide the best coverage over the 24 hours since it provides 100% availability for the main mode and all modes on both circuits and the best quality of communications as this frequency set has the highest score. The frequency set with the largest number of frequencies will usually provide the best availability and quality however, other factors such as the cost of obtaining use of frequencies and equipment will also be important.

Frequency sets that ASAPS selects can be compared with those tested. The GRAFEX Frequency Set Test results of the "maritime" frequency set for the same period on the same circuits are (Table 10, p. 75): Manila-Ho Chi Minh (main mode avail. = 100%, all mode avail. = 100%, score = 44.4) and Manila-Darwin (main mode avail. = 100%, all mode avail. = 100%, score = 63.4).

The results for the four-frequency set that ASAPS selected (Table 11, p. 78) are Manila-Ho Chi Minh (main mode avail. = 100%, all mode avail. = 100%, score = 44.0) and Manila-Darwin (main mode avail. = 100%, all mode avail. = 100%, score = 52.5).

If the operator is only interested in the number of hours of use (i.e., a low signal-to-noise threshold is acceptable), then both frequency sets provide 100% availability and the set ASAPS selected would be adequate. However, if the quality of communications is important, the "maritime" set has the largest score and the quality of communications would be slightly better with this set, particularly on the Manila-Darwin circuit. This is due to the larger number of frequencies in the "maritime" set likely to be closer to the OWF.

4.11.4 SNR frequency set test analysis

The SNR Frequency Set Test results are dependent upon the station parameter values specified in the default station configuration, unlike the GRAFEX Frequency Set Test results which are solely dependent on the frequencies being within a certain frequency range. The frequency set specified in the default station configuration, here "maritime", is tested for 24 hour communications where the number of hours required for communications was selected in the *Prediction Details* dialogue under the *Frequency Set Selection/Testing* button.

View the *Verbose* report of the SNR Frequency Set Test format of tute6.PRD. This report should look like Table 12.

Table 12. Full report of SNR Frequency Set Test for Exercise 21.

```
================================================================================
ASAPS V5 SNR FREQUENCY SET TESTING -------------------------
================================================================================
Frequency Set: maritime
Min.Angle: 2deg                  Noise:-150dBW/Hz CCIR
TxAntenna: WH35 V                RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
================================================================================
Circuit:manila-ho chi minh 1644 km Bearings: 255 ,72 degrees

.S.N.R - Frequency Set:  07 frequencies
22.0, 16.0, 12.0, 8.0, 6.0, 4.0, 2.0 MHz
Main Mode =1F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  3  3  1  1  1  1  1  2  3  3  3  5  5  4  5  5  5  5  4  4  3  2  3  3
All Modes
OCT 2008 T: 94  4  4  3  2  2  2  2  3  4  5  4  5  5  4  5  5  5  5  4  4  3  2  3  4
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode

Usability Summary 1F (Main Mode only)
FR      0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
22.00  1  1  0  0  0  0  0  0  1  1  0  0  0  0  1  1  1  1  0  0  0  0  0  0
```



```
16.00  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1
12.00  1  1  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  1
08.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1
06.00  0  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  0
04.00  0  0  0  0  0  0  0  0  0  0  0  1  1  0  0  0  0  0  0  0  0  0  1  0
02.00  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
.Availability =100.0%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
22.00  1  1  0  0  0  0  0  0  1  1  0  0  0  0  1  1  1  1  0  0  0  0  0  0
16.00  1  1  2  2  2  2  2  2  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1
12.00  3  3  2  2  2  2  2  3  3  3  2  2  2  2  2  2  2  2  2  1  1  0  0  1
08.00  3  2  1  0  0  0  0  1  2  3  3  2  2  2  2  2  2  2  2  2  1  1  1  3
06.00  0  0  0  0  0  0  0  0  0  1  2  2  2  2  2  2  2  2  2  2  2  2  2  2
04.00  0  0  0  0  0  0  0  0  0  0  0  1  1  0  0  0  0  0  0  0  0  0  2  0
02.00  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
.Availability = 100.0% Score =  24.2

Circuit:manila-darwin 3198 km Bearings: 160 ,340 degrees

.S.N.R - Frequency Set:  07 frequencies
22.0, 16.0, 12.0, 8.0, 6.0, 4.0, 2.0 MHz
Main Mode =2F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  2  2  1  1  1  1  1  2  2  3  4  4  4  5  5  4  4  3  3  2  2  3  3  3
All Modes
OCT 2008 T: 94  3  3  2  2  2  2  2  3  3  4  5  5  5  5  5  5  5  5  5  4  4  4  4  3
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode

Usability Summary 2F (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
22.00  0  0  0  0  0  0  0  0  0  0  0  0  0  1  1  0  0  0  0  0  0  0  0  1
16.00  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1  1
12.00  1  1  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
08.00  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0
06.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  0  0  0  0  1  0  0
04.00  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
02.00  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
.Availability =100.0%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
22.00  1  1  1  1  1  1  1  1  1  1  1  1  1  1  2  2  1  1  1  1  0  0  1  2
16.00  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  1  1  1  2  2
12.00  1  1  0  0  0  0  0  1  3  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2
08.00  0  0  0  0  0  0  0  0  0  1  2  2  2  2  2  2  2  2  2  2  2  2  1  0
06.00  0  0  0  0  0  0  0  0  0  0  2  2  2  2  2  2  2  1  1  1  1  2  0  0
04.00  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
02.00  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
.Availability = 100.0% Score =  19.6

.SNR FST Network Results
Frequency Set:  22.0 16.0 12.0 8.0 6.0 4.0 2.0  MHz
.             Main Mode                 All Modes
Availability =  100.0%   Availability =  100.0%   Score =   22.4
===============================================================================
```

Section 4.2.5 states that a frequency will be considered possibly usable on an F mode if it lies between the greater of the ALF and E-cutoff frequency, and the frequency specified by the Required % Days in the default station configuration. A frequency will be considered possibly usable on an E mode, if it lies between the ALF and the frequency specified by the Required % Days. In this exercise, the Required % Days is 50% so the upper limit is the MUF. If the frequency under examination lies between the MUF and the lower limit, its predicted signal-to-noise satisfies the Required S/N and its take-off angle satisfies the Min. Angle, the frequency is usable.

The E-cutoff frequency is somewhat higher than the EMUF of the next higher mode. Frequencies below the E-cutoff frequency are not considered for propagation on an F mode in the SNR formats because they are unlikely to penetrate the E region.

Consider the results for 09 UT in Table 12.

For the Manila-Ho Chi Minh circuit, the main mode is the 1F. The frequencies considered for usability on this mode will therefore lie between the first mode MUF and the larger of the first mode ALF and E-cutoff frequency. At 09 UT in Table 8 (p. 70), the first mode MUF is 22.7 MHz, the first mode ALF is 7.8 MHz and the second mode EMUF is 8.2 MHz. The second mode EMUF is greater than the first mode ALF and the second mode EMUF will be lower than the E-cutoff frequency. The limits of usable frequencies for the main mode at 09 UT are the MUF (22.7 MHz) and the E-cutoff frequency for the first F mode.

To determine which frequencies in the "maritime" frequency set are above the E-cutoff frequency, view the Field Strength prediction, tute6.FSH, by selecting *Predictions|View Predictions*, the file type *Field Strength files (*.FSH)* and selecting tute6.FSH. View a Field Strength Table format by pressing *View|New View|Field Strength Table*. Select any Field Strength Table format except the EPR or BUF formats by selecting *View* then the particular format. The different modes may be viewed by selecting *View|Next Mode* or using the ↑ ↓ keys while the different circuits may be viewed by selecting *View|Next Circuit* or using the ← → keys on the keyboard. Ensure the 1F mode of the Manila-Ho Chi Minh circuit is being viewed.

In the Field Strength Table formats (except the EPR and BUF), only those frequencies that lie below the UD (upper decile) and above the ALF or E-cutoff frequency (for F modes), whichever is the greater or ALF (for E modes), have values associated with them. Frequencies that are above the UD and below the ALF/E-cutoff frequency display the symbol "..". At 09 UT on the 1F mode for the Ho Chi Minh circuit, only 12.0, 16.0 and 22.0 MHz have values associated with them indicating these frequencies are greater than the E-cutoff frequency of the first mode.

ASAPS then determines whether the frequencies 12.0, 16.0 and 22.0 MHz satisfy the Required S/N (3 dB) and Min. Angle (2°).

View the Signal-to-Noise (SNR) format of tute6.FSH by pressing the "*s*" key on the keyboard or selecting *View|Signal-to-Noise*. Use the ↑ ↓ keys to view the different modes. Ensure the 1F mode results are displayed for the Ho Chi Minh circuit. Table 13 is an extract from the signal-to-noise results for the 1F mode at 09 UT for this circuit in tute6.FSH.

Table 13. Extract from signal-to-noise format of Field Strength prediction of Exercise 21.

```
=============================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
=============================================================================
Circuit 1: manila-ho chi minh        Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         SIGNAL/NOISE
=============================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09 22.7 19.4     34   32   ..   ..   ..   ..   27   29   33
=============================================================================
```

Table 13 shows the signal-to-noise values at 09 UT, based on the parameter values in the "new" station configuration. The Required S/N specified in the default station configuration was 3 dB, thus the predicted signal-to-noise values of all three frequencies satisfy the Required S/N.

Now view the Take-off Angle format of the Field Strength prediction, tute6.FSH, for the Manila-Ho Chi Minh circuit on the 1F mode by pressing “t” or selecting *View|Take-off Angle* when tute6.FSH is the current display. The predicted take-off angles for 12.0, 16.0 and 22.0 MHz at 09 UT are displayed in Table 14. The predicted take-off angles for these frequencies on the 1F mode satisfy the Min. Angle requirement of 2°.

Table 14. Extract from take-off angle format of Field Strength prediction of Exercise 21.

```
===============================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
===============================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         TAKEOFF ANGLE
===============================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09 22.7 19.4     23   21   ..   ..   ..   ..   20   20   22
===============================================================================
```

The frequencies 12.0, 16.0 and 22.0 MHz all lie between the first mode MUF and the E-cutoff frequency. These frequencies also satisfy the Required S/N and Min. Angle values that were specified in the “new” station configuration. Therefore, 12.0, 16.0 and 22.0 MHz are usable on the main mode of the Manila-Ho Chi Minh circuit at 09 UT in October, based on a T index of 94 as shown in the Usability Summary for the main mode of this circuit in Table 12 (p. 84).

The modes considered for all mode usability are the 1E, 1F, 2E and 2F on the Manila-Ho Chi Minh circuit. Again, a frequency may be usable on a particular mode if it lies between the frequency specified by the Required % Days for that hour and the greater of the ALF or E-cutoff frequency (for an F mode) or the ALF (for an E mode).

For the 1E mode, a frequency will possibly be usable at 09 UT if it lies between the EMUF (13.4 MHz) and the ALF (7.8 MHz) - see Table 8 (p. 70). The frequencies in the “maritime” set that lie in this range are 8.0 and 12.0 MHz.

Table 15 is a concatenation of extracts from the Field Strength file, tute6.FSH and displays the results for the 1E, 2F and 2E modes for the Signal-to-Noise and Take-off Angle formats.

Table 15. Extracts from signal-to-noise and take-off angle formats of the Field Strength prediction for Manila-Ho Chi Minh.

```
===============================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
===============================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000
================================================================================
Mode: 1E         SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09 13.3 12.6     18   19   ..   ..   ..   18   20   ..   ..

Mode: 1E         TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09 13.3 12.6      6    5   ..   ..   ..    3    4   ..   ..
===============================================================================
Mode: 2F         SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09 15.6 13.4     24   25   ..   ..    9   19   25   25   ..

Mode: 2F         TAKEOFF ANGLE
```



```
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09 15.6 13.4     43   40   ..   ..   41   39   39   43   ..
===============================================================================
Mode: 2E         SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09  8.2  7.8     10    9   ..   ..   -1   10   ..   ..   ..

Mode: 2E         TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09  8.2  7.8     16   15   ..   ..   12   15   ..   ..   ..
===============================================================================
```

The Required S/N is 3 dB and the Min. Angle is 2°. Both 8 and 12 MHz on the 1E mode satisfy the Required S/N and Min. Angle and are therefore usable at 09 UT.

The range of frequencies that may possibly be usable on the 2F mode at 09 UT is from the second mode MUF (15.6 MHz - Table 8, p. 70) down to the greater of the ALF (4.6 MHz) or E-cutoff frequency. To determine which frequencies in the “maritime” set lie above the higher of the second mode ALF and E-cutoff frequency for this mode, view the results for the 2F mode in Table 15. At 09 UT, the “..” symbol is displayed for 2.0 and 4.0 MHz so the greater of the ALF and E-cutoff frequency must lie between 4.0 MHz and 6.0 MHz. Therefore, the frequencies that may be usable on the 2F mode are 6.0, 8.0 and 12.0 MHz (16.0 and 22.0 MHz are above the MUF). These frequencies all meet the Required S/N (3 dB) and Min. Angle (2°) so are usable.

On the 2E mode, Table 8 (p. 70) shows the range of possibly usable frequencies is 4.6 MHz (ALF) to 8.2 MHz (EMUF); 6.0 and 8.0 MHz may therefore be usable. The results for the 2E mode in Table 15 show that while both frequencies meet the Min. Angle requirement of 2°, only 8 MHz meets the Required S/N of 3 dB. Hence, 8 MHz is the only frequency usable on the 2E mode.

Therefore, the frequencies usable when all modes are considered are those on the main mode (12.0, 16.0 and 22.0 MHz), 8.0 and 12.0 MHz on the 1E, 6.0, 8.0 and 12.0 MHz on the 2F and 8.0 MHz on the 2E mode. Th**e** Usability Summary in Table 12 (p. 84) for all modes for the Ho Chi Minh circuit shows 6.0, 8.0, 12.0, 16.0 and 22.0 MHz are the frequencies usable at 09 UT in October with a T index of 94.

Consider the Manila-Darwin circuit at 09 UT.

Table 12 (p. 84) shows the main mode for the Manila-Darwin circuit to be the 2F. The range of frequencies that may be usable on this mode at 09 UT is from the MUF (20.7 MHz - Table 9, p. 73) to the greater of the second mode ALF (6.6 MHz) or the E-cutoff frequency. The Field Strength prediction, tute6.FSH, will display the approximate lower limit for this circuit. Table 16 is a concatenation of extracts from the relevant Field Strength Table formats for the Manila-Darwin circuit in tute6.FSH at 09 UT. The results for the 2F mode show the maximum of the E-cutoff frequency or the ALF to be below 8.0 MHz. The frequencies that may possibly be usable on the 2F mode at 09 UT are 8.0, 12.0 and 16.0 MHz.

Table 16. Extracts from signal-to-noise and take-off angle formats of the Field Strength prediction for Manila-Darwin.

```
===============================================================================
ASAPS V5 FIELD STRENGTH TABLE ---------------------------------
===============================================================================
Circuit 2: manila-darwin            Distance: 3198km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 159  339    T-index: 94
Rx: Darwin         -12.47  130.85   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
===============================================================================
Mode: 1F         SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09 30.3 25.9     26   25   ..   ..   ..   ..   14   19   24
```

```
Mode: 1F          TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09 30.3 25.9      8    7   ..   ..   ..   ..    7    7    7
================================================================================
Mode: 2F          SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09 20.7 17.9     27   25   ..   ..   ..   13   19   23   28

Mode: 2F          TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09 20.7 17.9     24   22   ..   ..   ..   22   21   21   24
================================================================================
Mode: 2E          SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09  9.5  9.0     -1    0   ..   ..   ..    0   ..   ..   ..

Mode: 2E          TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
09  9.5  9.0      6    5   ..   ..   ..    4   ..   ..   ..
================================================================================
```

Table 16 shows that 8.0, 12.0 and 16.0 MHz on the 2F mode satisfy the Min. Angle of 2° and the Required S/N of 3 dB. Hence, the results in the main mode Usability Summary of the Manila-Darwin circuit in Table 12 (p. 84) at 09 UT.

The modes considered for all modes on the Manila-Darwin circuit are the main mode (2F), the 1F and 2E mode. Table 9 (p. 73) shows the upper limit for usability (the MUF in this case) on the 1F mode is 30.3 MHz with the lower limit being the greater of the ALF (9.3 MHz) or the E-cutoff frequency. The results for the 1F mode in Table 16 indicate the greater of the first mode ALF and the E-cutoff frequency for this mode is below 12.0 MHz. Therefore, the frequencies that may be usable are 12.0, 16.0 and 22.0 MHz. Table 16 shows these three frequencies have take-off angles greater than the Min. Angle requirement of 2° and predicted signal-to-noise levels that exceed the Required S/N of 3 dB.

On the 2E mode, Table 9 (p. 73) shows the range of frequencies that may be usable is from the EMUF (9.5 MHz) to the ALF (6.6 MHz); that is, only 8.0 MHz. In Table 16 it can be seen 8.0 MHz on the 2E mode does not meet the Required S/N of 3 dB and hence is not usable on this mode.

The frequencies usable when all modes are considered are 8.0, 12.0, 16.0 and 22.0 MHz for the Manila-Darwin circuit at 09 UT in October with a T index of 94 as shown in Table 12 (p. 84).

Table 12 displays the availabilities and score, respectively, for the Manila-Ho Chi Minh circuit as 100% (main mode), 100% (all modes) and 24.2. The availabilities and score, respectively, for the Manila-Darwin circuit are 100% (main mode), 100% (all modes) and 19.6. The “maritime” frequency set is usable on all hours on both circuits for the main mode and when all modes are considered. The Usability Summaries show 2.0 MHz is predicted never to be usable on either circuit based on the station parameter values specified and for October with T = 94. The results indicate a frequency set without 2 MHz is adequate. It may therefore be adequate to test a frequency set containing only 4.0, 6.0, 8.0, 12.0, 16.0 and 22.0 MHz.

4.11.5 SNR frequency selection analysis

View the *Verbose* report of the SNR Frequency Selection format of tute6.PRD. This report should look like Table 17. An SNR Frequency Selection has been computed for 24 hour communications and three frequency sets (containing 2 to 4 frequencies) as specified under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue for this exercise. The SNR Frequency Selection also uses the station parameter values (not the frequency set) specified in the default station configuration.

Table 17. Full report of SNR Frequency Selection for Exercise 21.

```
================================================================================
ASAPS V5 SNR FREQUENCY SET SELECTION -------------------------
================================================================================
Min.Angle: 2deg                   Noise:-150dBW/Hz CCIR
TxAntenna: WH35 V                 RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
================================================================================

  SNR NETWORK FREQUENCY SELECTION RESULTS
Main mode  All modes
.Avail.  Avail. Score  Frequencies
                 ~dB   MHz
  85.4   100.0   25.6  20.30 9.00
  85.4   100.0   25.5  20.30 8.80
  85.4   100.0   25.5  20.30 8.60
  85.4   100.0   25.4  20.30 8.40
  85.4   100.0   25.4  20.30 8.20
  85.4    95.8   25.4  20.30 8.00
  85.4    93.8   25.3  20.30 7.80
  85.4    93.8   25.3  20.30 7.60
  85.4    93.8   25.2  20.30 7.40
  83.3    93.8   25.2  20.30 7.20
  83.3    93.8   25.2  20.30 7.00
  83.3    93.8   25.1  20.30 6.80
  81.2    93.8   25.1  20.30 6.60
  81.2    93.8   25.1  20.30 6.40
  81.2    93.8   25.1  20.30 6.20
  81.2    93.8   25.0  20.30 6.00
  72.9    93.8   25.0  20.30 5.80
  70.8    89.6   25.0  20.30 5.60
  70.8    89.6   25.0  20.30 5.40
  70.8    89.6   25.0  20.30 5.20
  68.8    89.6   25.0  20.30 5.00
--------------------------------------------------------------------------------
  85.4   100.0   25.6  20.30 9.00
Circuit:manila-ho chi minh 1644 km Bearings: 255 ,72 degrees

.S.N.R - Frequency Set:  02 frequencies
20.3, 9.0 MHz
Main Mode =1F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  1  1  1  *  *  *  1  1  1  1  2  2  1  2  2  2  2  2  2  1  1  1  1  1
All Modes
OCT 2008 T: 94  2  2  2  1  1  1  2  2  2  2  2  2  1  2  2  2  2  2  2  1  1  1  1  1
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode

Usability Summary 1F (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
20.30  1  1  1  0  0  0  1  1  1  1  1  1  0  1  1  1  1  1  1  0  0  0  0  0
09.00  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
.Availability = 87.5%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
20.30  1  1  1  0  0  0  1  1  1  1  1  1  0  1  1  1  1  1  1  0  0  0  0  0
09.00  2  3  1  1  1  1  1  1  3  2  2  2  2  2  2  2  2  2  2  2  1  1  1  3
.Availability = 100.0% Score =  27.4

Circuit:manila-darwin 3198 km Bearings: 160 ,340 degrees

.S.N.R - Frequency Set:  02 frequencies
20.3, 9.0 MHz
Main Mode =2F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  1  1  *  *  *  *  1  1  1  2  1  1  1  2  2  2  1  1  1  1  1  1  1  1
All Modes
```

```
OCT 2008 T: 94  1  1  1  1  1  1  1  1  1  2  2  2  2  2  2  2  2  2  2  1  1  1  2  1
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode

Usability Summary 2F (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
20.30  1  1  0  0  0  0  1  1  1  1  0  0  0  1  1  1  0  0  0  0  0  0  0  1
09.00  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0
.Availability = 83.3%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
20.30  2  2  1  1  1  1  2  2  2  2  1  1  1  2  2  2  1  1  1  0  0  0  1  2
09.00  0  0  0  0  0  0  0  0  0  1  2  2  2  2  2  2  2  2  2  2  2  2  2  0
.Availability = 100.0% Score =  22.2

.SNR FST Network Results
Frequency Set:  20.3 9.0  MHz
.             Main Mode                 All Modes
Availability =   85.4%   Availability =  100.0%   Score =   25.6

  SNR NETWORK FREQUENCY SELECTION RESULTS
Main mode  All modes
.Avail.  Avail. Score  Frequencies
                ~dB   MHz
 100.0   100.0   25.8  21.50 16.25 7.00
 100.0   100.0   25.8  21.50 16.05 7.00
 100.0   100.0   25.7  21.50 15.85 7.00
 100.0   100.0   25.6  21.50 15.65 7.00
 100.0   100.0   25.5  21.50 15.45 7.00
 100.0   100.0   25.5  21.50 15.25 7.00
 100.0   100.0   25.4  21.50 15.05 7.00
 100.0   100.0   25.4  21.50 14.85 7.00
 100.0   100.0   25.3  21.50 14.65 7.00
 100.0   100.0   25.2  21.50 14.45 7.00
 100.0   100.0   25.2  21.50 14.25 7.00
 100.0   100.0   25.1  21.50 14.05 7.00
 100.0   100.0   25.1  21.50 13.85 7.00
 100.0   100.0   25.0  21.50 13.65 7.00
 100.0   100.0   25.0  21.50 13.45 7.00
 100.0   100.0   24.9  21.50 13.25 7.00
 100.0   100.0   24.9  21.50 13.05 7.00
 100.0   100.0   24.8  21.50 12.85 7.00
  91.7   100.0   24.8  21.50 12.65 7.00
  83.3   100.0   24.7  21.50 12.45 7.00
  83.3   100.0   24.6  21.50 12.25 7.00
 100.0   100.0   26.1  21.50 16.25 9.00
 100.0   100.0   26.0  21.50 16.25 8.80
 100.0   100.0   26.0  21.50 16.25 8.60
 100.0   100.0   26.0  21.50 16.25 8.40
 100.0   100.0   26.0  21.50 16.25 8.20
 100.0   100.0   25.9  21.50 16.25 8.00
 100.0   100.0   25.9  21.50 16.25 7.80
 100.0   100.0   25.9  21.50 16.25 7.60
 100.0   100.0   25.9  21.50 16.25 7.40
 100.0   100.0   25.8  21.50 16.25 7.20
 100.0   100.0   25.8  21.50 16.25 7.00
 100.0   100.0   25.8  21.50 16.25 6.80
 100.0   100.0   25.8  21.50 16.25 6.60
 100.0   100.0   25.8  21.50 16.25 6.40
 100.0   100.0   25.8  21.50 16.25 6.20
 100.0   100.0   25.8  21.50 16.25 6.00
  93.8   100.0   25.7  21.50 16.25 5.80
  93.8   100.0   25.7  21.50 16.25 5.60
  93.8   100.0   25.7  21.50 16.25 5.40
  93.8   100.0   25.7  21.50 16.25 5.20
  91.7   100.0   25.7  21.50 16.25 5.00
-----------------------------------------------------------------------------
 100.0   100.0   26.1  21.50 16.25 9.00
Circuit:manila-ho chi minh 1644 km Bearings: 255 ,72 degrees
```



```
.S.N.R - Frequency Set:  03 frequencies
21.5, 16.2, 9.0 MHz
Main Mode =1F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  2  2  2  1  1  1  1  2  2  2  3  2  2  2  3  3  3  3  3  2  1  1  1  2
All Modes
OCT 2008 T: 94  3  3  3  2  2  2  2  3  3  3  3  2  2  2  3  3  3  3  3  2  1  1  1  2
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode

Usability Summary 1F (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
21.50  1  1  1  0  0  0  0  1  1  1  1  0  0  0  1  1  1  1  1  0  0  0  0  0
16.25  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1
09.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1
.Availability =100.0%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
21.50  1  1  1  0  0  0  0  1  1  1  1  0  0  0  1  1  1  1  1  0  0  0  0  0
16.25  1  1  2  2  2  2  2  2  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1
09.00  2  3  1  1  1  1  1  1  3  2  2  2  2  2  2  2  2  2  2  2  1  1  1  3
.Availability = 100.0% Score =  27.8

Circuit:manila-darwin 3198 km Bearings: 160 ,340 degrees

.S.N.R - Frequency Set:  03 frequencies
21.5, 16.2, 9.0 MHz
Main Mode =2F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  2  1  1  1  1  1  1  2  2  2  2  2  2  3  3  2  2  2  1  1  1  1  2  2
All Modes
OCT 2008 T: 94  2  2  2  2  2  2  2  2  2  3  3  3  3  3  3  3  3  3  3  2  2  2  3  2
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode

Usability Summary 2F (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
21.50  1  0  0  0  0  0  0  1  1  0  0  0  0  1  1  0  0  0  0  0  0  0  0  1
16.25  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  1  1
09.00  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0
.Availability =100.0%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
21.50  2  1  1  1  1  1  1  2  2  1  1  1  1  2  2  1  1  1  1  0  0  0  1  2
16.25  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  1  1  1  1  1  2  2
09.00  0  0  0  0  0  0  0  0  1  2  2  2  2  2  2  2  2  2  2  2  2  2  2  0
.Availability = 100.0% Score =  22.9

.SNR FST Network Results
Frequency Set:  21.5 16.2 9.0  MHz
.             Main Mode                 All Modes
Availability =  100.0%   Availability =  100.0%   Score =   26.0

  SNR NETWORK FREQUENCY SELECTION RESULTS
Main mode  All modes
.Avail.  Avail. Score  Frequencies
                 ~dB   MHz
  93.8   100.0   25.3  21.80 18.87 11.93 7.00
  95.8   100.0   25.4  21.80 18.67 11.93 7.00
  95.8   100.0   25.3  21.80 18.47 11.93 7.00
 100.0   100.0   25.3  21.80 18.27 11.93 7.00
 100.0   100.0   25.4  21.80 18.07 11.93 7.00
 100.0   100.0   25.3  21.80 17.87 11.93 7.00
 100.0   100.0   25.4  21.80 17.67 11.93 7.00
 100.0   100.0   25.3  21.80 17.47 11.93 7.00
 100.0   100.0   25.3  21.80 17.27 11.93 7.00
 100.0   100.0   25.2  21.80 17.07 11.93 7.00
```

```
 100.0   100.0   25.2  21.80 16.87 11.93 7.00
 100.0   100.0   25.1  21.80 16.67 11.93 7.00
 100.0   100.0   25.0  21.80 16.47 11.93 7.00
 100.0   100.0   25.0  21.80 16.27 11.93 7.00
 100.0   100.0   24.9  21.80 16.07 11.93 7.00
 100.0   100.0   24.8  21.80 15.87 11.93 7.00
 100.0   100.0   24.8  21.80 15.67 11.93 7.00
 100.0   100.0   24.7  21.80 15.47 11.93 7.00
 100.0   100.0   24.7  21.80 15.27 11.93 7.00
 100.0   100.0   24.6  21.80 15.07 11.93 7.00
 100.0   100.0   24.6  21.80 14.87 11.93 7.00
 100.0   100.0   25.8  21.80 17.67 13.93 7.00
 100.0   100.0   25.7  21.80 17.67 13.73 7.00
 100.0   100.0   25.7  21.80 17.67 13.53 7.00
 100.0   100.0   25.6  21.80 17.67 13.33 7.00
 100.0   100.0   25.6  21.80 17.67 13.13 7.00
 100.0   100.0   25.6  21.80 17.67 12.93 7.00
 100.0   100.0   25.6  21.80 17.67 12.73 7.00
 100.0   100.0   25.5  21.80 17.67 12.53 7.00
 100.0   100.0   25.5  21.80 17.67 12.33 7.00
 100.0   100.0   25.4  21.80 17.67 12.13 7.00
 100.0   100.0   25.4  21.80 17.67 11.93 7.00
 100.0   100.0   25.3  21.80 17.67 11.73 7.00
 100.0   100.0   25.3  21.80 17.67 11.53 7.00
 100.0   100.0   25.3  21.80 17.67 11.33 7.00
 100.0   100.0   25.3  21.80 17.67 11.13 7.00
 100.0   100.0   25.3  21.80 17.67 10.93 7.00
 100.0   100.0   25.2  21.80 17.67 10.73 7.00
 100.0   100.0   25.2  21.80 17.67 10.53 7.00
 100.0   100.0   25.2  21.80 17.67 10.33 7.00
 100.0   100.0   25.2  21.80 17.67 10.13 7.00
 100.0   100.0   25.1  21.80 17.67 9.93 7.00
 100.0   100.0   25.9  21.80 17.67 13.93 9.00
 100.0   100.0   25.9  21.80 17.67 13.93 8.80
 100.0   100.0   25.9  21.80 17.67 13.93 8.60
 100.0   100.0   25.9  21.80 17.67 13.93 8.40
 100.0   100.0   25.9  21.80 17.67 13.93 8.20
 100.0   100.0   25.9  21.80 17.67 13.93 8.00
 100.0   100.0   25.8  21.80 17.67 13.93 7.80
 100.0   100.0   25.8  21.80 17.67 13.93 7.60
 100.0   100.0   25.8  21.80 17.67 13.93 7.40
 100.0   100.0   25.8  21.80 17.67 13.93 7.20
 100.0   100.0   25.8  21.80 17.67 13.93 7.00
 100.0   100.0   25.8  21.80 17.67 13.93 6.80
 100.0   100.0   25.7  21.80 17.67 13.93 6.60
 100.0   100.0   25.7  21.80 17.67 13.93 6.40
 100.0   100.0   25.7  21.80 17.67 13.93 6.20
  97.9   100.0   25.7  21.80 17.67 13.93 6.00
  97.9   100.0   25.7  21.80 17.67 13.93 5.80
  97.9   100.0   25.7  21.80 17.67 13.93 5.60
  97.9   100.0   25.7  21.80 17.67 13.93 5.40
  97.9   100.0   25.7  21.80 17.67 13.93 5.20
  95.8   100.0   25.7  21.80 17.67 13.93 5.00
-------------------------------------------------------------------------------
 100.0   100.0   25.9  21.80 17.67 13.93 9.00
Circuit:manila-ho chi minh 1644 km Bearings: 255 ,72 degrees

.S.N.R - Frequency Set:  04 frequencies
21.8, 17.7, 13.9, 9.0 MHz
Main Mode =1F
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  3  3  2  2  2  2  2  3  3  3  4  3  3  3  4  4  4  4  3  2  1  1  1  3
All Modes
OCT 2008 T: 94  4  4  3  3  3  3  3  4  4  4  4  3  3  3  4  4  4  4  3  2  1  1  1  3
.               |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.              00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode

Usability Summary 1F (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
```

```
21.80  1  1  0  0  0  0  0  1  1  1  1  0  0  0  1  1  1  1  0  0  0  0  0  0
17.67  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  1
13.93  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  1
09.00  0  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1
.Availability =100.0%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
21.80  1  1  0  0  0  0  0  1  1  1  1  0  0  0  1  1  1  1  0  0  0  0  0  0
17.67  1  1  1  2  2  2  2  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  1
13.93  2  3  3  3  2  2  3  3  3  2  2  2  2  2  2  2  2  2  1  1  0  0  0  1
09.00  2  3  1  1  1  1  1  1  3  2  2  2  2  2  2  2  2  2  2  2  1  1  1  3
.Availability = 100.0% Score =  27.6

Circuit:manila-darwin 3198 km Bearings: 160 ,340 degrees

.S.N.R - Frequency Set:  04 frequencies
21.8, 17.7, 13.9, 9.0 MHz
Main Mode =2F
.             00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
.              |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
OCT 2008 T: 94  2  2  2  2  2  2  2  2  2  3  3  3  3  4  4  3  3  2  2  2  1  1  2  3
All Modes
OCT 2008 T: 94  3  3  3  3  3  3  3  3  3  4  4  4  4  4  4  4  4  4  4  3  3  3  4  3
.              |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
.             00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
0=no propagation  #=number of available frequencies *=propagation by other than Main Mode

Usability Summary 2F (Main Mode only)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
21.80  0  0  0  0  0  0  0  0  0  0  0  0  0  1  1  0  0  0  0  0  0  0  0  1
17.67  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  0  0  0  0  1
13.93  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0  0  1  1
09.00  0  0  0  0  0  0  0  0  0  1  1  1  1  1  1  1  1  1  1  1  1  1  1  0
.Availability =100.0%
Usability Summary (All Modes)
FR     0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 UT
21.80  1  1  1  1  1  1  1  1  1  1  1  1  1  2  2  1  1  1  1  0  0  0  1  2
17.67  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  2  1  1  1  1  1  1  2
13.93  2  1  1  1  1  1  1  2  2  2  2  2  2  2  2  2  2  2  2  2  1  1  2  2
09.00  0  0  0  0  0  0  0  0  0  1  2  2  2  2  2  2  2  2  2  2  2  2  2  0
.Availability = 100.0% Score =  22.8

.SNR FST Network Results
Frequency Set:  21.8 17.7 13.9 9.0  MHz
.            Main Mode                All Modes
Availability =  100.0%   Availability =  100.0%   Score =   25.9
==========================================================================
```

The following discussion on usability relates to the SNR Frequency Selection information in Table 17 for a frequency set containing three frequencies.

Table 17 displays a list of frequency sets containing three frequencies that were considered in the determination of the best set. The frequency set with the highest score was selected as the best set. The best frequencies ASAPS computed are 9.00, 16.25, and 21.50 MHz. These frequencies were computed as providing the best overall signal-to-noise for the Manila-Ho Chi Minh and Manila-Darwin circuits in October with a T index of 94 for 24 hour communications.

A frequency is considered for usability (Section 4.2.5) if it lies between the highest frequency (specified by the Required % Days value in the default station configuration) for the particular mode and the greater of the ALF or E-cutoff frequency (for F modes) or just the ALF (for E modes). If a frequency lies between these limits and also satisfies the Required S/N and Min. Angle values specified in the default station configuration, the frequency is considered to be usable.

The E-cutoff frequency is somewhat higher than the EMUF of the next higher mode. Frequencies below the E-cutoff frequency are not considered for propagation on an F mode in the SNR formats because they are likely to be reflected by the E region.

The following discussion concerns the data for 09 UT.

The length of the Manila-Ho Chi Minh circuit is 1644 km. The 1F is the main mode and the 1E, 1F, 2E and 2F modes are considered for all mode usability on this circuit.

The Required % Days in the default station configuration was specified as 50%. At 09 UT on the Manila-Ho Chi Minh circuit, the main mode MUF is 22.7 MHz. The lower limit is the greater of the main mode ALF (7.8 MHz) and E-cutoff frequency.

To determine the frequencies greater than the E-cutoff frequency or ALF, the frequency set ASAPS has selected, 9.00, 16.25 and 21.50 MHz, could be entered into the Frequency Set database. With the “new” station configuration as the default, a prediction could then be computed for these two circuits, for October with a T index of 94, with this frequency set listed in the *Frequency Set* list box of the *Prediction Detail*s dialogue. The resulting Field Strength prediction could then be viewed to determine frequencies above the E-cutoff frequency and why some frequencies were only usable at certain hours. Table 18 displays the take-off angle and SNR formats of such a Field Strength prediction at 09 UT.

Table 18. Extracts from signal-to-noise and take-off angle formats of the Field Strength prediction for Exercise 21.

```
===============================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
===============================================================================
Circuit 1: manila-ho chi minh        Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:tute6         Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
===============================================================================
Mode: 1F         SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09 22.7 19.4     34   32   ..   30   33
Mode: 1F         TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09 22.7 19.4     23   21   ..   20   22
===============================================================================
Mode: 1E         SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09 13.3 12.6     18   19   19   ..   ..
Mode: 1E         TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09 13.3 12.6      6    5    3   ..   ..
===============================================================================
Mode: 2F         SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09 15.6 13.4     24   25   22   25   ..
Mode: 2F         TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09 15.6 13.4     43   40   39   43   ..
===============================================================================
Mode: 2E         SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09  8.2  7.8     10    9   ..   ..   ..
Mode: 2E         TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09  8.2  7.8     16   15   ..   ..   ..
===============================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
===============================================================================
Circuit 2: manila-darwin             Distance: 3198km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 159  339    T-index: 94
Rx: Darwin         -12.47   130.85   Path: Short Path      TxAntenna: WH35 V
FSet:tute6         Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
===============================================================================
```



```
Mode: 1F         SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09 30.3 25.9     26   25   ..   20   24
Mode: 1F         TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09 30.3 25.9      8    7   ..    7    7
================================================================================
Mode: 2F         SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09 20.7 17.9     27   25   14   24   28
Mode: 2F         TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09 20.7 17.9     24   22   21   21   24
================================================================================
Mode: 2E         SIGNAL/NOISE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09  9.5  9.0     -1    0    0   ..   ..
Mode: 2E         TAKEOFF ANGLE
UT  MUF  OWF   @MUF @OWF  9.0 16.2 21.5
09  9.5  9.0      6    5    5   ..   ..
================================================================================
```

Table 18 shows 9.0 MHz on the main mode (1F) of the Manila-Ho Chi Minh circuit has the ".." symbol associated with it, indicating this frequency is below the lower limit of the usable frequencies. Table 8 (p. 70) shows that the first mode ALF for this circuit is 7.8 MHz, hence 9.0 MHz must be below the E-cutoff frequency.

The frequencies 16.25 and 21.5 MHz lie below the MUF for the main mode on this circuit. In Table 18, these two frequencies satisfy the Required S/N (3 dB) and Min. Angle (2°) and are therefore usable on the main mode of the Manila-Ho Chi Minh circuit at 09 UT; see Table 17 (p. 90).

For usability on the 1E mode at 09 UT, a frequency must lie between the first mode ALF (7.8 MHz) and the first mode EMUF (13.4 MHz), see Table 8 (p. 70). 9.0 MHz lies within this range and from Table 18 also satisfies the Required S/N and Min. Angle values, so is usable on this mode.

For the 2F mode, frequencies must lie between the second mode MUF (15.6 MHz - Table 8, p. 70) and the greater of the second mode ALF (4.6 MHz) and the E-cutoff frequency. The E-cutoff frequency can be estimated from Table 18 for this mode and is below 9.0 MHz. Therefore, only 9.0 MHz is potentially usable on this mode (16.25 and 21.50 MHz are above the MUF). Table 18 shows 9.0 MHz satisfies the Required S/N and Min. Angle values of 3 dB and 2°, respectively, so is usable on this mode.

Frequencies that are potentially usable on the 2E mode must lie between the second mode ALF (4.6 MHz) and the second mode EMUF (8.2 MHz), see Table 8 (p. 70). No frequency from the selected set lies within this range.

All three frequencies are usable when all modes are considered; 9.00 MHz (1E, 2F), 16.25 MHz (1F) and 21.50 MHz (1F) on the Manila-Ho Chi Minh circuit at 09 UT as shown in Table 17 (p. 90).

The Manila-Darwin circuit is 3198 km. The main mode for a circuit of this length is the 2F and the modes considered for usability on all modes are the 1F, 2F and 2E.

The range of frequencies usable on the main mode (2F) for the Manila-Darwin circuit at 09 UT is from the second mode MUF (20.7 MHz - Table 9, p. 73) to the larger of the second mode ALF (6.6 MHz) or E-cutoff frequency. Table 18 shows for this circuit on the 2F mode, the larger of these two values is below 9.0 MHz so the frequencies that may be usable are 9.0 and 16.25 MHz. Both frequencies satisfy the Min. Angle and Required S/N requirements. As Table 17 (p. 90) shows, both 9.0 and 16.25 MHz are usable on the main mode at 09 UT for this circuit.

On the 1F mode, a frequency will be considered for usability if it lies between the first mode MUF (30.3 MHz - Table 9, p. 73) and the larger of the first mode ALF (9.3 MHz) and E-cutoff frequency.

Table 18 for this mode and circuit shows 9.0 MHz to be below the larger of the E-cutoff frequency and first mode ALF hence, 16.25 and 21.5 MHz are the only frequencies potentially usable on this mode. Table 18 also shows both these frequencies satisfy the Required S/N and Min. Angle values in the default station configuration, so both are usable on this mode.

On the 2E mode, a frequency may be usable if it lies between the EMUF (9.5 MHz - Table 9, p. 73) and ALF (6.6 MHz). Only 9.0 MHz may be usable on this mode. However, as Table 18 shows, while this frequency satisfies the Min. Angle, it does not satisfy the Required S/N of 3 dB. No frequencies are usable on this mode.

As the all mode Usability Summary for the Manila-Darwin circuit in Table 17 (p. 90) shows at 09 UT, all three frequencies are usable, 9.0 (2F), 16.25 MHz (1F, 2F) and 21.5 MHz (1F).

Both circuits have 100% availability for the main and all modes indicating at least one frequency is usable for each hour. The network availabilities and score for the three-frequency set are 100.0%, 100% and 26.0.

A comparison of the two-, three- and four-frequency sets ASAPS has computed in the SNR Frequency Selection of Table 17 (p. 90) shows the following results:

Two frequencies: 9.0 and 20.3 MHz

> Manila-Ho Chi Minh: main mode availability is 87.5% (outages 03-05 UT), all mode availability is 100.0% and score is 27.4.
>
> Manila-Darwin: main mode availability is 83.3% (outages 02-05 UT), all mode availability is 100.0% and score is 22.2.
>
> Network: main mode availability is 85.4%, all mode availability is 100.0% and score is 25.6.

Three frequencies: 9.0, 16.25 and 21.5 MHz

> Manila-Ho Chi Minh: main mode availability is 100%, all mode availability is 100% and score is 27.8.
>
> Manila-Darwin: main mode availability is 100.0%, all mode availability is 100% and score is 22.9.
>
> Network: main mode availability is 100.0%, all mode availability is 100% and score is 26.0.

Four frequencies: 9.0, 13.93, 17.67 and 21.8 MHz

> Manila-Ho Chi Minh: main mode availability is 100%, all mode availability is 100% and score is 27.6.
>
> Manila-Darwin: main mode availability is 100.0%, all mode availability is 100% and score is 22.8.
>
> Network: main mode availability is 100.0%, all mode availability is 100% and score is 25.9.

These results indicate the three and four-frequency sets are likely to provide the best overall communications with the least outages. The four-frequency set will provide greater redundancy in situations where there may be fading, interference or ionospheric conditions depart significantly from those predicted. The scores for the three-frequency set are greatest overall. The scores indicate the quality of communications may be slightly improved using the three-frequency set.

5. Field Strength predictions

Field Strength predictions supply detailed information about communications between two locations using the station parameter information specified in the Station Configurations database. The Field Strength prediction formats are useful when engineering circuits or determining deficiencies in existing circuits.

The following Field Strength prediction formats are computed:

- Take-off Angle
- Probability of Ionospheric Support
- Reflection Heights
- Antenna Gains
- All Noise
- Pathloss
- Noise_Pathloss
- Signal-to-Noise
- Field Strength
- Estimated Power Required (EPR)
- Noise Field Strength
- Best Usable Frequency (BUF)

These formats may be used to determine the best operating frequencies based on the parameters specified. Field Strength predictions may also be used as a diagnostic tool to optimise communications sites.

Field Strength prediction files have a ".FSH" extension.

The Field Strength prediction formats are dependent on the station parameter values specified in the station configuration. Table 19 displays which station parameters influence the Field Strength prediction formats. The parameters used in the computation of the Field Strength formats are displayed in the header section of the predictions. Ensure the parameter values are correct before using the predictions.

Table 19. Station parameters applicable to Field Strength prediction formats.

Prediction formats	Station parameters										
	Tx power	Antenna types	Freq. set	Man-made noise	Band-width	Required S/N	Min. take-off angle	Required % Days	Pol. coupling loss	Predict. confid. level	Atmos. noise model
Take-off angle			•								
Probability			•								
Reflection heights			•								

Prediction formats	Station parameters										
	Tx power	Antenna types	Freq. set	Man-made noise	Band-width	Required S/N	Min. take-off angle	Required % Days	Pol. coupling loss	Predict. confid. level	Atmos. noise model
Antenna gains		•	•								
All noise			•	•							•
Pathloss			•						•		
Noise_ pathloss			•	•					•	•	•
Signal-to-noise	•	•	•	•	•				•	•	•
Field strength	•	• (Tx only)	•						•		
Estimated power required		•	•	•	•	•	•	•	•	•	•
Noise field strength			•	•							•
BUF	•	•	•	•	•	•	•	•	•	•	•

5.1 Field strength prediction formats

In the Field Strength Table formats, two dots ".." may be displayed for some hours and frequencies. The ".." symbol is displayed for E modes when the frequency is above the propagation mode's UD or below the ALF. For F modes, the ".." symbol is displayed if the frequency is above the propagation mode's UD or below the ALF or E-cutoff frequency, whichever is the greater. Frequencies higher than the UD have less than 10% chance of propagating successfully, if the prediction is correct. Frequencies below the ALF are likely to be highly absorbed. For F region propagation, E-layer screening is taken into account and only those frequencies above the E-cutoff frequency are considered to propagate by the F region. The E-cutoff frequency is somewhat higher than the EMUF of the next mode. For example, if the F mode under consideration is the first F mode, the E-cutoff frequency will be somewhat higher than the second mode EMUF.

In the Field Strength Table formats, the MUF and OWF and the values of the format being viewed for the MUF and OWF are listed as well as the values for the frequencies in the specified set.

In the following sub-sections, the letter in parentheses in the heading is the hot key for viewing that particular format in the Field Strength Table in an open Field Strength prediction file. They may be entered as either lower case letters or as upper case letters when the caps lock key is activated.

A BUF Graph may also be viewed. More information on this graph can be found in Section 5.1.12.

Refer to Section 2.7 for information on station parameters.

5.1.1 Take-off angle (t)

The take-off or elevation angle is the vertical angle, in degrees, between the horizontal plane and normally the main lobe of the gain pattern of the antenna. This format displays the predicted optimum elevation angle for the particular propagation mode for each frequency in the specified set, the OWF and MUF. For a certain circuit length, usually the higher the frequency the greater the elevation angle, since higher frequencies penetrate further into the ionosphere. Generally, it can be considered that if the elevation angle and bearing for the maximum gain of the antenna are within 30° of the required take-off angle and circuit bearing given in the prediction, then the antenna is appropriate for the path. This may not be the case with directional antennas.

5.1.2 Probability of ionospheric support (p)

This format displays the probability of ionospheric support for the OWF, MUF and the frequencies in the specified frequency set. Note the probability of ionospheric support for the MUF and OWF are 50% and 90%, respectively (see Section 1.11). When frequencies are below the OWF and above the ALF or E-cutoff frequency, they are given a 99% support rating indicating they have a high probability of being reflected or supported by the ionosphere on that particular mode. Frequencies in the frequency set which are higher than the OWF have less than a 90% support rating because there is a greater chance of a radio wave penetrating the layer.

A 90% support rating for a frequency at a certain hour in a monthly prediction means communications on that frequency are likely to be successful 90% of the month at that particular hour on the particular propagation mode, if the prediction is correct. That is, about 27 days of the month at that hour and on the particular propagation mode, the frequency should be reflected by the ionosphere. For reliable operations, frequencies at or below the OWF are normally selected.

5.1.3 Reflection heights (h)

This format displays the expected virtual reflection height, in kilometres, of the OWF, MUF and the frequencies in the specified set. Generally, the greater the frequency the higher a radio wave travels into the ionosphere. The same frequency at a higher take-off angle will also penetrate further into the ionosphere. Reflection heights are not defined for district/NVIS circuits.

5.1.4 Antenna gains (g)

This format displays the combined transmitting and receiving antenna gains for the MUF, OWF and the frequencies in the set for the appropriate elevation angle (and bearing if 3D antennas are specified).

The antenna gains are expressed in dBi (decibels above isotropic; i.e., in dB relative to an isotropic antenna). See Section 2.5.1 for further information.

5.1.5 All noise (a)

This format displays the predicted total background noise as the combined median atmospheric, galactic and man-made noise power spectral density in dBW/Hz (decibels above one Watt for a one Hertz receiver bandwidth; that is, the reference power is 1 Watt) for the OWF, MUF and each of the frequencies in the specified frequency set.

The median combined noise at a particular frequency is calculated as the logarithmic sum of the three individual median noise levels:

$$N_t = 10 * \log_{10} (10^{(Na / 10)} + 10^{(Ng / 10)} + 10^{(Nm / 10)})$$

where: N_t = total noise in dBW/Hz
N_a = atmospheric noise in dBW/Hz

N_g = galactic noise in dBW/Hz
N_m = man-made noise in dBW/Hz

Because radio noise power is very much less than one watt, the more noise, the less negative the noise value. Therefore, if at some hour for a circuit the noise is -138 dB at 3.2 MHz and -146 dB at 6.5 MHz, then the lower frequency, 3.2 MHz, is noisier. Generally, noise is greater at lower frequencies, greater during the night and greater with larger bandwidths although there are anomalies due to location and season.

Man-made noise levels and the atmospheric noise model are specified in the default station configuration by the user (Sections 2.7.6 and 2.7.7). The galactic noise level is determined by the T index and the frequency.

The man-made noise at the receiver site, as specified in the default station configuration, is for a frequency of 3 MHz. Man-made noise is calculated for the frequencies in the specified set using the formula:

$$N_m = N_3 - [d * \log_{10} (f / 3)]$$

where: N_m = man-made noise density in dBW/Hz at a frequency of f MHz
N_3 = man-made noise density in dBW/Hz at 3 MHz (-100 to -204 if user specified, -130 ship, -140 city, -145 residential, -150 rural, -164 remote, -204 ignore)
d = 13.5 (ship), 27.7 (city, residential or rural), 28.0 (if user specified) or 28.6 (remote or quiet rural)
f = frequency in MHz

The contribution from atmospheric noise is dependent on which atmospheric noise model is specified in the default station configuration, either CCIR Report 322 (“World Distribution and Characteristics of Atmospheric Radio Noise”) (1963) or Recommendation ITU-R P.372-8 (“Radio Noise”) (2003).

Radio waves arriving at a receiver site from the galaxy constitute galactic or cosmic noise. The effect of galactic noise is dependent on the shielding effect of the ionosphere. The ionosphere generally shields the receiver from galactic noise on the frequencies below the extraordinary wave critical frequency for the F2 region.

The T index is used to predict the critical frequency reflected overhead at the receiver site.

Transmission frequencies below the critical frequency are shielded from galactic noise resulting in no galactic noise contribution to total noise for such frequencies. Frequencies above the critical frequency are not shielded from galactic noise.

The ITU 372 and CCIR 322 reports suggest slightly different formulas for median galactic noise levels in a one hertz bandwidth.

The ITU galactic noise formula is:

$$N_g = -152 - 23 * \log_{10} (f/3)$$

The CCIR galactic noise formula is:

$$N_g = -165 - 22.097 * \log_{10} (f/3)$$

where: N_g = galactic noise in dBW/Hz
f = frequency in MHz

The ITU formula is more conservative, resulting in slightly higher galactic noise values. The galactic noise component in ASAPS 5.3 is determined from the galactic noise formula discussed in

Recommendation ITU-R P.372-8 (“Radio Noise”) (2003). ASAPS implements the ITU galactic noise formula regardless of whether the user specifies the CCIR or ITU model for atmospheric noise in the default station configuration.

The noise power density values displayed in ASAPS are referenced to a one hertz bandwidth. For a bandwidth of *b* hertz, the all noise values should be increased by $10 * \log_{10} b$. Thus for a 1 kHz bandwidth, add 30 dB (i.e., $10 * \log_{10} (1000)$) to the all noise values.

Versions of ASAPS older than V5 used the upper decile (90%) values for the atmospheric, galactic and man-made noise to approximate “worst” case, which is helpful in planning. Although ASAPS 5 allows the user to vary the prediction confidence level anywhere between 1% and 99%, only median (50%) noise values are displayed in this format.

5.1.6 Pathloss or losses (l)

This format displays the predicted median (50%) pathloss between the output of the transmitting antenna and the input to the receiving antenna in dB for the MUF, OWF and each frequency in the specified set.

Pathloss is the ratio of the radio frequency power radiated to that available, between ideal loss-free isotropic transmitting and receiving antennas, which are in the same locations as the actual antennas. It is therefore independent of the antennas used.

$$\text{Pathloss (in dB)} = 10 * \log_{10} (\text{transmitted power / available power})$$

Alternatively, if the powers are measured in dBW or dBμ, then the pathloss is:

Pathloss (in dB) = (signal power at output to Tx antenna) - (signal power at input to Rx antenna)

Example:

A transmitter is located at point A and the receiver at point B. The transmitted power is 100 W while the available power is 0.5 nW (i.e., 0.5×10^{-9} W; nW = nanowatts) at 12 UT and 0.01 nW at 23 UT.

The pathloss in each case is:

$$\text{Pathloss (at 12 UT)} = 10 * \log_{10} (100 / 0.5\times10^{-9}) = 113 \text{ dB}$$
$$\text{Pathloss (at 23 UT)} = 10 * \log_{10} (100 / 0.01\times10^{-9}) = 130 \text{ dB}$$

The greater the pathloss value, the greater the losses on the circuit and the weaker the signal arriving at the receiving antenna. Therefore, more losses will occur at 23 UT on this circuit.

The strength of a radio signal diminishes as it propagates from the transmitting antenna, through the ionosphere. The phenomena which cause losses in signal strength include:

- Spatial attenuation (as a radio wave travels from the transmitting antenna it spreads out and the signal strength decreases; this loss is dependent upon the circuit length and frequency);
- Ionospheric absorption (radio waves are attenuated in the D and lower E regions; this loss is dependent on the operating frequency, state of the ionosphere and circuit’s length and location);
- Ground reflection loss (for multiple hop circuits the signal strength decreases each time a radio wave is reflected from the ground; this loss is dependent on the ground type at the ground reflection location(s));
- Polarisation coupling loss (at lower frequencies most of the radio wave energy may have been transferred into the extraordinary wave leading to a loss in signal strength - Section 2.7.13);
- Sporadic E obscuration loss (sporadic E may prevent a signal reaching the F layer; this loss is dependent on the frequency and circuit length);

- "Horizon focus" gain (not a loss but a gain due to the focussing effect of the curvatures of the Earth and ionosphere for radio waves of low elevation angles; this gain is dependent on the propagation mode and circuit length).

The pathloss is a summation of these losses and the horizon focus gain. The greatest losses are due to spatial attenuation and ionospheric absorption, although sometimes the polarisation coupling loss can be large. Pathloss is generally greater at lower frequencies during the day (because of ionospheric absorption) and at higher frequencies at night (because of greater spatial attenuation). Further, losses are usually greater during the day than at night on any particular frequency.

5.1.7 Noise_pathloss (n)

Noise_Pathloss (NP) is independent of the station configuration and may be used to derive estimates of either the transmission power required to provide a given grade of service or the grade of service for a particular transmitter power. It allows the ionosphere, which the user has no control over, to be separated from those areas of the circuit which can be adjusted such as transmitter power, antennas, signal-to-noise threshold, etc., so that the required grade of service can be achieved.

The Noise_Pathloss format displays the negative sum of the predicted median (50%) noise power density (All Noise format) plus the predicted median (50%) pathloss (Losses format) in dBW/Hz, adjusted for the prediction confidence level (Section 2.7.12) specified in the default station configuration. A prediction confidence level of 50% displays the combined median noise and median pathloss. Higher prediction confidence levels (greater than 50%) will result in lower noise_pathloss values which have higher probabilities of being achieved.

In versions older than ASAPS 5, the Noise_Pathloss format displayed the upper decile (90%) noise and the median pathloss which gave an approximate prediction confidence level of 82%. In ASAPS 5, the median noise and median pathloss are added then adjusted for the specified prediction confidence level.

When the noise and power are in units of watts, noise_pathloss can be determined from:

$$\begin{aligned} NP &= -\left[10 * \log_{10}(\text{all noise}) + 10 * \log_{10}(\text{trans. power / avail. power})\right] \\ &= -\left[10 * \log_{10}(\text{all noise * transmitted power / available power})\right] \end{aligned}$$

Or, when the noise and pathloss are converted to dB:

$$NP = -\left[\text{noise power density (dBW/Hz)} + \text{pathloss (dB)}\right]$$

The noise_pathloss power density values in ASAPS are referenced to a one hertz bandwidth. For a bandwidth of *b* hertz, the noise_pathloss values should be increased by $10 * \log_{10} b$. Thus for a 100 hertz bandwidth, add $10 * \log_{10} 100$ (i.e., 20 dB) to the noise_pathloss values.

Example:

With a prediction confidence level of 50%, what is the expected noise_pathloss for a particular frequency at a particular time and T index on a circuit if the median all noise is calculated as -163 dBW/Hz and the median pathloss is estimated to be 124 dB?

$$NP = -(-163 + 124) = 39 \text{ dBW/Hz}$$

In this example the all noise and pathloss values can be entered in the equation since the prediction confidence level is 50% which implies median values. This result indicates that at this particular hour, month and T index, 50% of actual measurements of noise_pathloss are likely to equal or exceed 39 dBW/Hz.

When the prediction confidence level is other than 50%, the median all noise and median pathloss are added as per the noise_pathloss equation and then adjusted for the specified prediction confidence level.

Now consider that for the same circuit, same time and T index with a prediction confidence level of 99%, the noise_pathloss is computed to be 11 dBW/Hz. This result indicates that almost all noise_pathloss measurements (99%) for this particular hour, month and T index will equal or exceed 11 dBW/Hz. In this case, by specifying a higher prediction confidence level, the communicator is indicating a lower grade of service is acceptable.

Better quality circuits have higher noise_pathloss (and signal-to-noise) values. A lower noise_pathloss value (and therefore lower signal-to-noise) is more easily achieved indicating the communicator is willing to accept poorer quality conditions to attain the required success rate (90% instead of say, 50%).

5.1.8 Signal-to-noise (s)

The Signal-to-Noise (SNR) format shows the predicted signal-to-noise power ratio in dB for the MUF, OWF and the frequencies in the set for the specified receiver bandwidth and specified prediction confidence level.

A minimum signal-to-noise ratio is required to maintain a desired grade of service (i.e., emission type, error rate, etc.) in the presence of noise, but in the absence of any other unwanted signals (i.e., interference). The signal-to-noise ratio, SNR, of the sky wave is given by:

$$\text{SNR} = \text{signal intensity} - \text{noise intensity}$$

where the intensities are expressed in units of either power (dBW) at the output of the receiving antenna or field strength (dBμV/m) at the input to the receiving antenna.

Signal-to-noise is dependent upon the transmitter power, combined antenna (transmitter and receiver) gain, receiver site noise, pathloss and receiver bandwidth and the prediction confidence level (see Section 2.7). The relationship between these parameters is:

$$P_t + G_a = \text{SNR} - \text{NP} + B$$

where:

P_t = input power to the transmitting antenna in dBW
G_a = combined antenna gain in the direction of propagation in dBi
SNR = signal-to-noise power ratio for a receiver of b hertz bandwidth in dB
NP = noise_pathloss for a receiver bandwidth of 1 hertz at the specified prediction confidence level in dBW/Hz
B = bandwidth in dBHz (10 * $\log_{10} b$, where *b* is the receiver bandwidth in hertz)

The SNR format may be used to determine a system's signal-to-noise threshold or required signal-to-noise.

Older versions than ASAPS 5 used upper decile (90%) noise and median (50%) pathloss values which resulted in signal-to-noise values based on a prediction confidence level of approximately 82%. In ASAPS 5, the noise_pathloss values are adjusted for the specified prediction confidence level which in turn adjusts the predicted signal-to-noise values for the same prediction confidence level. A higher prediction confidence level will result in lower predicted noise_pathloss and signal-to-noise values.

Example:

What is the predicted signal-to-noise for a particular frequency, time and T index if the input power to the transmitting antenna is 250 W, the combined antenna (receiver and transmitter) gain is -2 dBi, the receiver bandwidth is 3 kHz and the noise_pathloss on the circuit is 14 dBW/Hz for a prediction confidence level of 99%?

$$\begin{aligned} SNR &= P_t + G_a + NP - B \\ &= 10 * \log_{10}(250) + (-2) + 14 - [10 * \log_{10}(3000)] \\ &= 23.98 - 2 + 14 - 34.77 \\ &= 1.2 \text{ dB} \end{aligned}$$

This result indicates that almost all measurements of signal-to-noise (99% of them) are expected to equal or exceed 1.2 dB for this particular hour, month and T index.

Example:

Consider the same transmitter power, combined antenna gain and bandwidth as those in the example above for the same frequency, time and T index. In this case the prediction confidence level is 50%, resulting in a noise_pathloss value of 38 dBW/Hz.

$$\begin{aligned} SNR &= 10 * \log_{10}(250) + (-2) + 38 - [10 * \log_{10}(3000)] \\ &= 25.2 \text{ dB} \end{aligned}$$

This value indicates that half (50% prediction confidence level) of the signal-to-noise measurements taken at this particular hour, month and T index are likely to equal or exceed 25.2 dB.

The more positive the signal-to-noise value, the better the grade of service, because a more positive signal-to-noise value indicates large signal intensity and/or low noise intensity. The grade of service will be superior for the 50% prediction confidence level in the above examples but fewer actual measurements (about 50%) are likely to achieve or exceed a signal-to-noise of 25.2 dB. On the other hand, most measurements are likely to achieve or exceed a signal-to-noise of 1.2 dB but the grade of service or quality will be reduced when the prediction confidence level is higher.

5.1.9 Field strength (f)

This format displays the predicted root mean squared (rms) field strength or amplitude of the electric field component of the electromagnetic field at the input to the receiving antenna for each frequency in the specified set, as well as the OWF and MUF. The field strength is measured in dBμV/m (decibels above one microvolt per metre). The larger this value the greater the strength or amplitude of the signal received.

The field strength of a radio wave is dependent upon the transmitter frequency, the transmitter power, gain of the transmitting antenna in the direction of the propagation mode and the pathloss.

The field strength is calculated as:

$$\text{Field Strength} = 107.2 + 20 * \log_{10} f + P_t + G_t - L_b$$

where:

f = transmitter frequency in MHz

P_t = signal power in dBW at the input to the transmitting antenna

G_t = transmitting antenna gain in dBi for the frequency and elevation angle of the propagation mode

L_b = median pathloss for the mode in dB

Hence the field strength for a circuit using a frequency of 13 MHz, a transmitter power of 200 W with a transmitting antenna gain of 6 dBi for the required elevation angle and bearing and a pathloss of 122 dB is:

$$\begin{aligned}\text{Field Strength} &= 107.2 + 20 * \log_{10}(13) + 10 * \log_{10}(200 / 1) + 6 - 122 \\ &= 107.2 + 22.3 + 23.0 + 6 - 122 \\ &= 36.5 \text{ dB}\mu\text{V/m}\end{aligned}$$

If required, the field strength of the radio signal can be converted into a receiver input voltage. When the receiving antenna is highly directional so that only one propagation mode is detected, the receiver input voltage is:

$$V = E + G - 20 * \log_{10} f - L_c + 29.8$$

where:

V = receiver input voltage in dBμV
E = field strength at input to receiving antenna in dBμV/m
G = antenna gain for the elevation angle of the mode in dBi
f = operating frequency in MHz
L_c = antenna cable and mismatch losses in dB

However, most antennas receive several propagation modes simultaneously and so the receiver input voltage is a complicated combination of the contributions from each mode. These lead to uncertainties when making comparisons between predictions and measurements. The uncertainties can be reduced if the actual, not theoretical, antenna gain patterns are available.

5.1.10 Estimated Power Required (EPR) (e)

This format displays the estimated power required (EPR), in watts, to achieve the Required S/N specified in the station configuration using the selected antennas, receiver bandwidth and calculated noise_pathloss based on the specified prediction confidence level. The minimum take-off angle (Min. Angle) and percentage days of ionospheric support (Required % Days) specified in the default station configuration, must be met for a value to be calculated (Section 2.7).

The estimated power required is calculated using the equation for determining the signal-to-noise. That is:

$$EPR = SNR - NP + B - G_a$$

where:

EPR = estimated power required in dBW
SNR = required signal-to-noise in dB at the specified bandwidth
NP = noise_pathloss in dBW/Hz at the specified prediction confidence level for a receiver bandwidth of 1 Hz
B = bandwidth in dBHz (10 * log10 b, where b is the receiver bandwidth in Hz)
G_a = combined antenna gain in the direction of propagation in dBi

In earlier versions than ASAPS 5, the signal-to-noise and noise_pathloss were based on a prediction confidence level of approximately 82%. In ASAPS 5, these values are computed for the specified prediction confidence level in the default station configuration. A higher prediction confidence level results in lower predicted noise_pathloss values leading to greater power required to achieve the required signal-to-noise.

Example:

Determine the transmitter power required to attain a signal-to-noise of 3 dB for a particular frequency, hour, month and T index when the combined antenna gain is 6 dBi, the receiver bandwidth is 4 kHz and the noise_pathloss for a prediction confidence level of 99% is 12 dBW/Hz.

$$\begin{aligned} EPR &= 3 - 12 + 10 * \log_{10}(4000) - 6 \\ &= 21 \text{ dBW} \\ &= 10^{21/10} \quad \text{(converting from dBW to watts)} \\ &= 126.5 \text{ W} \end{aligned}$$

Now determine the EPR for the same circuit, time and T index when the prediction confidence level is 50% resulting in a NP of 40 dBW/Hz.

$$\begin{aligned} EPR &= 3 - 40 + 10 * \log_{10}(4000) - 6 \\ &= -6.98 \text{ dBW} \\ &= 10^{-6.98/10} = 0.2 \text{ W} \end{aligned}$$

When the prediction confidence level is higher (e.g., 99%), the predicted noise_pathloss levels are lower. If the Required S/N is to be met, the transmitter power must be increased.

5.1.11 Noise field strength (i)

This format displays the predicted amplitude or field strength of the noise at the input to the receiving antenna for the MUF, OWF and each frequency in the set. The noise field strength is measured in dBμV/m (dB above 1 μV/m). The more negative the value, the smaller the amplitude of the noise field strength at a particular frequency and the less affected by noise that frequency will be (that is, higher signal-to-noise).

5.1.12 Best Usable Frequency (BUF) (b)

This format displays the frequency with the highest predicted signal-to-noise value from any of the available propagation modes. The Required S/N, Min. Angle and Required % Days values that are specified in the default station configuration must be met (Section 2.7). Sometimes, no BUF is chosen for an hour because none of the frequency/mode combinations satisfy one or more of the Required S/N, Min. Angle or Required % Days values.

Because signal-to-noise is dependent upon transmitter power, receiver site noise, bandwidth, antenna types (gain), polarisation coupling loss algorithm and prediction confidence level, these parameters will also influence the best usable frequency chosen (Table 19, p. 98). Choice of frequencies is also important.

Factors such as antennas with good gain at the appropriate azimuths and bearings for the communication path, adequate transmitter power, low noise levels at the receiver site(s) and a reduced bandwidth will improve the signal-to-noise level. High prediction confidence levels result in lower predicted signal-to-noise values. Consequently, BUFs are less likely to be chosen with higher prediction confidence levels since the predicted signal-to-noise values are less likely to meet the Required S/N specified in the default station configuration.

The tabular BUF format lists, for each hour, the BUF, the propagation mode of the BUF, the probability of ionospheric support for the BUF, the BUF take-off angle, the noise field strength and signal-to-noise of the BUF. The OWF and MUF on the BUF mode and their signal-to-noise values are also displayed.

The BUF Graph format displays two bar graphs.

The top graph shows the BUF (bars – left axis indicates frequency in MHz) for each hour, its corresponding mode (bar pattern), OWF on the BUF mode (blue horizontal lines), MUF on the BUF mode (yellow horizontal lines), take-off angles for the BUF (blue diamonds – right axis indicates angles in degrees) and frequencies in the set (horizontal black dotted lines across the graph).

The top half of the lower graph displays the predicted signal-to-noise (in dB) at the BUF (bars) for the specified prediction confidence level, the BUF mode (bar pattern) and the signal-to-noise at the OWF (blue lines) and MUF (yellow lines) on the BUF mode for each hour, again for the specified prediction confidence level. The Required S/N specified in the default station configuration is displayed as a horizontal black line. The lower half of this graph displays the noise field strength in dBμV/m/Hz of the BUF. While both signal-to-noise and noise field strength can be positive or negative, signal-to-noise usually takes positive values and noise field strength takes negative values. The BUF will be less affected by noise the more negative the noise field strength.

Example:

A signal is likely to propagate via the 1F, 2F and 1E modes on a particular circuit. The frequency set contains the frequencies 6, 8 and 12 MHz. The following values are specified in the default station configuration:

1. Min. Angle = 15°
2. Required S/N = 6 dB
3. Required % Days = 90%

Table 20. Example of BUF selection.

	Modes								
	1F mode			2F mode			1E mode		
Frequency	6	8	12	6	8	12	6	8	12
TOA	**36**	**35**	38	**56**	**56**	59	12	-	-
SNR	**28**	**31**	38	**20**	**17**	10	6	-	-
Probability	**99**	**99**	67	**99**	**99**	13	99	-	-

Table 20 displays the predicted take-off angle (TOA), signal-to-noise (SNR) and probability of ionospheric support (probability) for the different frequency/mode combinations for the circuit at some hour. No values are shown for 8 and 12 MHz on the 1E mode because these frequencies are above the UD for this mode.

The minimum take-off angle (Min. Angle) of 15° is satisfied by all available frequency/mode combinations except the 6 MHz/1E mode combination. This frequency/mode combination therefore need not be considered further. The Required S/N of 6 dB is satisfied by the remainder of the frequency/mode combinations. The probability of ionospheric support is only satisfied by the following combinations: 6 MHz/1F, 8 MHz/1F, 6 MHz/2F and 8 MHz/2F.

The four frequency/mode combinations that satisfy all three requirements are displayed in bold type in Table 20.

The BUF will be that frequency/mode combination out of these four that has the highest signal-to-noise value. The BUF in this case is 8 MHz on the 1F mode, with a signal-to-noise of 31 dB.

Note that while the BUF meets the specifications (Required S/N of 6 dB, Min. Angle of 15° and Required % Days of 90%) there are three other frequency/mode combinations that also meet these specifications. This may also be the case in other circuits so that frequency/mode combinations other than the BUF could be used while still meeting the requirements, for example, if the BUF happens to be subject to interference.

5.2 Frequency set specification

Frequency sets for Field Strength predictions are specified in the *Prediction Details* dialogue. Table 21 lists the behaviour of ASAPS when choosing a frequency set for a Field Strength prediction containing only one circuit. Set A, set B or no frequency set “(NONE) GRAFEX” are the choices in the default station configuration and the *Frequency Set* list box of the *Prediction Details* dialogue.

Table 21. Frequency set specification in Field Strength predictions.

Frequency set in default station configuration	Frequency set specified in *Prediction Details* dialogue	Field Strength prediction produced?
Set A	Set A	Yes - Set A
Set A	(NONE) GRAFEX	No
Set A	Set B	Yes - Set B
(NONE) GRAFEX	Set A	Yes - Set A
(NONE) GRAFEX	(NONE) GRAFEX	No
(NONE) GRAFEX	Set B	Yes - Set B
Set B	Set A	Yes - Set A
Set B	(NONE) GRAFEX	No
Set B	Set B	Yes - Set B

Different circuits in a Field Strength prediction may use different frequency sets. However, if no frequency set is selected (that is, “(NONE) GRAFEX” is specified in the *Frequency Set* list box of the *Prediction Details* dialogue) for one or more of the circuits, then those circuits will be omitted from the resulting Field Strength prediction file. A GRAFEX prediction containing all the circuits is still produced using the frequency set chosen in the default station configuration.

If all circuits in a new Field Strength prediction are to use the same frequency set, select that frequency set when entering the details of the first prediction. If circuits in a Field Strength prediction are to use different frequency sets, choose the appropriate set from the *Frequency Set* list box in the *Prediction Details* dialogue when the details of each circuit are entered and before pressing *Add*.

The GRAFEX prediction associated with a Field Strength prediction is based on the frequency set specified in the default station configuration. If the Field Strength prediction contains only one circuit and the circuit in the associated GRAFEX prediction is to use the same frequency set, ensure the frequency set specified in the default station configuration is the same as that specified in the *Frequency Set* list box of the *Prediction Details* dialogue.

If there is more than one circuit in the Field Strength prediction and these circuits use different frequency sets, the circuits in the associated GRAFEX prediction will use the frequency set specified in the default station configuration. Consider the example where the “maritime” frequency set is specified in the default station configuration and the Field Strength prediction based on the default station configuration contains the circuits Singapore to Delhi and Melbourne to Perth using the “maritime” and “broadcast” frequency sets, respectively. The results of the associated GRAFEX prediction containing the two circuits Singapore to Delhi and Melbourne to Perth will be based on the “maritime” frequency set. To temporarily view the GRAFEX prediction results of the circuit Melbourne to Perth using the “broadcast” frequency set, press *View|Select Frequency Set* and change the frequency set to “broadcast”. Note that the results for both circuits will be based on the “broadcast” frequency set.

When an Area prediction is computed a Field Strength prediction is also computed for communications between the base and the gridpoints of the area. The Field Strength results are based the frequency set specified in the *Area Prediction details* dialogue.

5.3 Computing a Field Strength prediction

All circuits in a Field Strength prediction use the same information specified in the default station configuration, except for the frequency set. Frequency sets are selected in the *Prediction Details* dialogue. Circuits in a Field Strength prediction can use the same frequency set or different frequency sets.

Exercise 22. Viewing a Field Strength prediction

Change the default station configuration to “statute” and view the circuits of “tute1.FSH” in their different formats.

- Select ***Databases|Station configurations*** and ensure the **statute** station configuration is the default by clicking on the ***Set as default*** option button. Click on ***Add/Modify*** then ***Done***.
- A Field Strength prediction called **tute1.FSH** was computed when the GRAFEX prediction called **tute1.PRD** was produced in Exercise 12 (p. 60). To view **tute1.FSH** select ***Predictions|View Predictions*** and select the **Field Strength files (*.FSH)** file type of **tute1.FSH**.
- The BUF Graph is displayed. View the different circuits by pressing the ← → keys or pressing ***View|Next Circuit*** or ***View|Previous Circuit***.
- View the Field Strength Table formats by pressing ***View|New View|Field Strength Table***.
- View the different circuits by pressing the ← → keys on the keyboard or pressing ***View|Next Circuit*** or ***View|Previous Circuit***.
- The results for the different modes for each of the circuits (except in the BUF format) can be viewed by pressing the ↑ ↓ keys on the keyboard or ***View|Next Mode*** and ***View|Previous Mode***.
- To view other formats select ***View*** and the format. Alternatively, use the hot keys displayed in the ***View*** menu or indicated in parentheses after the sub-headings in Section 5.1.

Exercise 23. Producing a Field Strength prediction

Produce a Field Strength prediction for the following short path circuits for the current year and month, using the frequency set shown before each circuit. Call the prediction file "tute7".

Use the "test" station configuration which has the following parameters: Tx Power = 1000 W, Polarisation Coupling Loss = Full Calculation, Tx Antenna = Rx Antenna = HLP (Horizontal), Frequency Set = maritime, Man-made Noise = -145 dB, Bandwidth = 3000 Hz, Required S/N = 3 dB, Min. Angle = 2°, Required % Days = 90, Prediction Confidence Level = 50% and Atmospheric Noise = CCIR 322.

1. **tuteset: Berne (46.95° N, 7.42° E) to Lisbon (38.44° N, 9.08° W)**
2. **test: Ulaanbaatar (47.54° N, 106.52° E) to Lanzhou (36.01° N, 103.45° E)**
3. **long: Miami (25.77° N, 80.21° W) to Roseau (15.18° N, 61.23° W)**

- Select ***Databases|Station configurations*** to view the **Station Configuration** dialogue. Set up the **test** station configuration. Ensure this station configuration is selected as the default. Click on ***Add/Modify*** then ***Done***. Note that the associated GRAFEX prediction will use the frequency set selected in the default station configuration.
- Select ***Predictions|Do Prediction*** to display the **Prediction Details** dialogue. Enter the details of the first circuit, making sure the correct frequency set is selected from the **Frequency Set** list box. Press ***Add***.
- Repeat the above step for the other two circuits, then press ***Do Prediction***.
- When the **Save Prediction** dialogue is displayed, enter the name of the file **tute7**, then press ***Save***.
- Open **tute7.FSH** by selecting **tute7** in either the **BUF Graph** or **Field Strength Table** at the **Open** dialogue.
- If viewing the **BUF Graph**, display the results for the different circuits by using the ← → keys. Ensure the correct station parameters and frequency sets have been used.
- If viewing the **Field Strength Table**, display the results for the different circuits by pressing the ← → keys. Use the ↑ ↓ keys to view the data for different modes in each circuit. The hot keys displayed next to the different formats in the ***View*** menu may be used to access the tabular views.
- Note that while the **maritime** frequency set was specified in the default station configuration, each circuit uses the frequency set specified in the **Prediction Details** dialogue.

5.4 The View menu

Pressing *View|New View* when a Field Strength prediction is the active window allows the BUF Graph or one of the Field Strength Table formats to be viewed.

Some of the station parameters may be altered by clicking on *NewView|Station Parameters* which displays the *Station Configuration* dialogue. The *Frequency Set*, *ManMade Noise*, *Polarisation Coupling Loss* (and *antenna polarisations*), *Prediction Confidence Level* and *Atmospheric Noise* list boxes are deselected indicating they cannot be altered. By altering any of the parameters that are still active or choosing another station configuration then pressing *Update View|Yes*, the effect of the change may be seen. The change may be saved in the station configuration by then pressing *Add/Modify* then *Done*. Pressing *Cancel* will not save the change to the station configuration and the next format that is viewed in the prediction will revert to the original values.

The *Re-compute* option displays the *Prediction details* dialogue. Modifications can be made to the circuits in the prediction and either saved in a new file or existing file, including the currently viewed file, by overwriting.

If there are multiple circuits in the prediction then pressing either *Next Circuit* or *Previous Circuit* will display the next or previous circuit. Using the ← → keys also achieves this. If a tabular view is displayed in the active window clicking on *All Circuits* will display the results of all circuits for that format. Clicking on *All Circuits* again will revert to displaying the results for a single circuit.

If one of the tabular views is displayed in the active window a list of the formats appears in the View menu. Clicking on the required format will result in its display.

The *Next Mode* and *Previous Mode* options, only available when viewing Field Strength tables, will display one of the other modes for the format being view. The *All Modes* option will display the results of the format being viewed for all modes that were computed.

5.5 Re-computing a Field Strength prediction and global changes

Modifications to the date, index, circuit details and frequency sets of an existing Field Strength prediction file can be made. Changes can also be made to parameters under the *Frequency Set Selection/Testing* button which will be reflected in the associated GRAFEX prediction.

If the Field Strength prediction to be re-computed is not already open, select *Predictions|View Predictions* and select *Field Strength files (*.FSH)* and the file name from the *Open Prediction File* dialogue. Once the file is open, press *View|Re-compute* to display the *Prediction Details* dialogue.

If the Field Strength prediction is already open, view the prediction and select *View|Re-compute* to display the *Prediction Details* dialogue.

The *Global change* button in the *Prediction Details* dialogue allows the same changes to be made to the date, index and frequency set of all the circuits in a file. To ensure global changes are made, actively select the value required in the field to be altered even though the value required may already be displayed.

If it is required that all circuits in an existing Field Strength prediction file be re-computed to use the same information, click on the *Global change* button in the *Prediction Details* dialogue, make changes to the date, index, frequency set and press *Modify*. Remember to de-activate the *Global change* button to make changes to individual circuits.

Changes to the date, index, path type and other circuit details of a Field Strength prediction produce corresponding changes to the associated GRAFEX prediction. However, while any changes to the frequency sets used are reflected in the new Field Strength prediction file, all the circuits in the GRAFEX prediction file will use the frequency set specified in the default station configuration.

Exercise 24. Changing a frequency set in a Field Strength prediction

Change the frequency set the “Miami-Roseau” circuit in “tute7.FSH” uses to the “maritime” frequency set. Call the new prediction file “tute7”.

- If **tute7.FSH** is not open select ***Predictions|View Predictions*** and open the **Field Strength files (*.FSH)**, **tute7.FSH**.
- With **tute7.FSH** open, select ***View|Re-compute*** to display the **Prediction Details** dialogue.
- In the **Circuit #** drop-down list select the number that displays the **Miami-Roseau** circuit (**3**). Change the frequency set from **long** to **maritime**, click on ***Modify*** then ***Do Prediction***.

- The **Save Prediction** dialogue is now displayed. Enter **tute7** in the **File name** field then press ***Save*** to overwrite the old **tute7.FSH**.
- The **Open** dialogue is displayed. Select either the **Field Strength Table (*.FSH)** or **BUF Graph (*.FSH)** and open **tute7.FSH**. Ensure the **maritime** frequency is now used by the **Miami-Roseau** circuit prediction.

Exercise 25. Re-computing a Field Strength prediction with global changes

Using the "statute" station configuration, re-compute all the circuits in "tute1.FSH" to use the "maritime" frequency set. Change the month for the Arequipa district, Auckland-Limbunya and Yangon-Son Hai circuits to next month (and next year if next month is January). Call the new file "tute8". View the different formats in "tute8.FSH" and confirm the changes have been made.

- Ensure the **statute** station configuration is the default by selecting ***Databases|Station configurations*** and ticking the ***Set as default*** tick box when this station configuration is displayed. Press ***Add/Modify*** then ***Done***.
- If **tute1.FSH** is open, close all views of this file (this needs to be done to ensure when it is re-opened, it will use the **statute** station parameter values).
- Select ***Predictions|View Predictions***, select the **Field Strength files (*.FSH)** file type and open **tute1.FSH**.
- Select ***View|Re-compute***. The **Prediction Details** dialogue is displayed.
- Activate the global change button and change the frequency set to **maritime**. Press ***Modify*** and then click on the global change button to turn global changes off.
- Select the **Arequipa district** circuit from the **Circuit #** drop-down list (**2**). Make the change to the Arequipa circuit and press ***Modify***. Repeat for the other two circuits (circuits **4** and **6**).
- Click on ***Do Prediction***. The **Save Prediction** dialogue appears. Call the new prediction **tute8** and press ***Save***. The **Open** dialogue is displayed. At this stage only view the Field Strength Table

  formats so select ***Field Strength Table (*.FSH)*** in the **Files of type** list box, then open **tute8.FSH**.
- View the different circuits and verify the changes have been made. To view the other circuits in the file press the ← → buttons or select ***View|Next Circuit*** or ***Previous Circuit***.
- To view the other Field Strength Table formats select ***View*** from the menu bar and select the format you wish to view or use the hot keys. By pressing the "**a**" key on the keyboard for instance, you can view the **All Noise** format.
- To view the available modes for each circuit press the ↑ ↓ keys on the keyboard, or enter the letter "**d**" to view all the modes for each circuit.
- To view the BUF Graph, select ***View|New View|BUF Graph***. To return to viewing the Field Strength Table formats, select ***View|New View|Field Strength Table***.

5.6 Adding and deleting circuits in a Field Strength prediction

New circuits may be added to an existing Field Strength prediction file.

If the prediction file to be altered is already open and is the active window, select *View|Re-compute*.

If the file is not open, select *Predictions|View Predictions*. The *Open Prediction File* dialogue is displayed. In the *Files of type* list box, select *Field Strength files (*.FSH)* then the name of the file to be changed. Select *View|Re-compute*.

In the *Circuit #* field of the *Prediction Details* dialogue, select *(NEW)* and enter the details of the new circuit. Press *Add* then *Do Prediction* and save the new prediction file or overwrite an existing file.

To delete a circuit from an existing Field Strength prediction, display the prediction as above, select *View|Re-compute*, then in the *Circuit #* field select the number of the circuit to be deleted, its details will be displayed in the other fields, press *Delete* then *Do Prediction*. The associated GRAFEX prediction will also display the change.

Exercise 26. Adding a circuit to a Field Strength prediction

Add the short path circuit, Madrid (40.4° N, 3.68° W) to Paris (48.87° N, 2.32° E), for the current year and month to "tute8.FSH". Use the "tuteset" frequency set for this circuit. Replace "tute8.FSH" with the new prediction.

- The file **tute8.FSH** should be displayed from Exercise 25. If this is the case, select ***View|Re-compute***. The **Prediction Details** dialogue is displayed. However, if **tute8.FSH** is not open, press ***Predictions|View Predictions***. In the **Files of type** list box in the **Open Prediction File** dialogue select **Field Strength files (*.FSH)** and select **tute8.FSH**. The **Prediction Details** dialogue is displayed.
- Select **(NEW)** in the **Circuit #** drop-down list. Use the Tab key to move through the **Day**, **Month**, **Year** and **Index** fields and enter the details for the Circuit Name, Tx and Rx. Ensure the correct path type and the frequency set are used. Press ***Add*** then ***Do Prediction***. The **Save Prediction** dialogue is displayed.
- Call the file **tute8** then press ***Save***. Overwrite the existing **tute8.FSH**.
- The **Open** dialogue is now displayed. Open **tute8.FSH** in either the **BUF Graph** or **Field Strength Table** and confirm the new circuit has been added.

Exercise 27. Re-computing a Field Strength prediction

Re-compute "tute8.FSH" to produce a new Field Strength prediction with the following changes: add the new short path circuit Kelowna (49.53° N, 119.29° W) to Minot (48.14° N, 101.18° W) circuit. Change the T index to 10 and the month to the current month (and year) for all circuits. Use the "tuteset" frequency set for all circuits except Perugia-London "amateur" and Arequipa district "local". Change the Perugia-London long path to a short path circuit. Call the new prediction "tute9".

- View any format of **tute8.FSH**.
- Select ***View|Re-compute***. The **Prediction Details** dialogue is displayed.
- Click on the **Global change** box. Depending on what circuit is displayed, the month may be the current month or next month. Note that to ensure global changes are made the value required must be actively selected even though that value may be already displayed.

- Even if the month displayed in the **Month** list box is the current month, select it from the drop-down list to ensure the change is made. Repeat this procedure for the **Year** list box to ensure the current year is selected. Change the T index to **10** and the frequency set to **tuteset** (note that if **tuteset** is already displayed, actively select **tuteset** to ensure the change is made). Click on ***Modify*** then click in the **Global change** box to turn global changes off.
- In the **Circuit #** drop-down list, select the **Arequipa district** circuit (**2**). Change the frequency set to **local**. Click on ***Modify***.
- In the **Circuit #** drop-down list, select the **Perugia-London** circuit (**7**). Change the path type to **short** and the frequency set to **amateur**. Click on ***Modify***.
- In the **Circuit #** field select **(NEW)** and add the details of the new circuit. Check the current month, T = 10 and the **tuteset** frequency set are used. Click on ***Add*** then ***Do Prediction***.
- The **Save Prediction** dialogue is now displayed. Enter **tute9** as the name of the file and click on ***Save***.
- Open **tute9.FSH** in any of the Field Strength formats and ensure the changes have been made.

5.7 Producing a planning prediction

When communications are required over a long period, a planning prediction which encompasses the four seasons (March, June, September and December) and four levels of solar activity (T=0, 50, 100 and 150), to represent communications over a solar cycle, may be appropriate.

Planning predictions for a circuit or group of circuits may be combined in the same prediction file with normal predictions that cover a short period of time such as a month. For the planning prediction circuits only one frequency set may be used. Different frequency sets may be specified for individual circuits in the prediction. The frequency set displayed in the *Frequency Set* list box of the *Prediction Details* dialogue at the time the *Create a standard Sunspot cycle set of 16 Month/T indices* tick box is activated will be used in the planning prediction.

Planning predictions may also be computed during a re-compute of a Field Strength file. Planning predictions will be prepared for all circuits in the prediction file.

The two SNR formats of the associated GRAFEX prediction are based on station parameter information and may be helpful in either testing or selecting frequency sets for communications over such time periods.

Exercise 28. Producing a planning prediction

Using the "test" station configuration, produce a planning prediction for the circuits Berne-Lisbon and Ulaanbaatar-Lanzhou using the "beacon" frequency set. Include in the prediction file a prediction for, current month and year, Miami-Roseau using the "maritime" frequency set. Call the prediction "tute7".

- Select ***Databases|Station configurations*** to view the **Station Configuration** dialogue. Select the **test** station configuration. Ensure this station configuration is selected as the default. Click on ***Add/Modify*** then ***Done***.
- The three circuits were entered into the Circuits database in Exercise 23 (p. 111). Select ***Predictions|Do Prediction*** to display the **Prediction Details** dialogue. Enter the details for the **Berne-Lisbon** circuit. Press ***Add***.
- Enter the **Ulaanbaatar-Lanzhou** circuit, ensuring the **beacon** frequency set is specified. Press ***Add***.

- Select the ***Frequency Set Selection/Testing*** button and click on the ***Create a standard Sunspot cycle set of 16 Month/T indices***. A tick should now be displayed in the box. Press ***OK***. A dialogue should appear that asks the user to confirm whether 32 circuits or 2 sets of 16 month/T indices are required. Press ***OK***.
- Enter the details of the **Miami-Roseau** circuit. Ensure the **maritime** frequency set is specified. Press ***Add***.
- Press ***Do Prediction***.
- When the **Save Prediction** dialogue is displayed, select **tute7** from the list of files, then press ***Save***.
- Open **tute7.FSH** by selecting **tute7** in either the **BUF Graph** or **Field Strength Table** at the **Open** dialogue.
- When viewing the 33 circuits, note how the 16 **Berne-Lisbon** circuits and the 16 **Ulaanbaatar-Lanzhou** circuits are based on the **beacon** frequency set and the **Miami-Roseau** circuit is based on the **maritime** frequency set.

5.8 Changing station parameters

The station parameter values selected for a Field Strength prediction may not provide the best communications. If the capability exists to change parameter values, the performance may be improved. By altering a parameter in a station configuration, it can be seen how such a change is likely to affect a circuit's performance. Note that frequency sets for Field Strength predictions are altered in the *Prediction Details* dialogue, not in the station configuration, see Section 5.2. The frequency set specified in the default station configuration will be used by all circuits in the associated GRAFEX prediction.

If the Field Strength prediction file to be altered is not already open, select *Predictions|View Predictions*, choose *Field Strength files (*.FSH)* from the list of file types and open the required file. With the Field Strength prediction open, select *View|New View|Station Parameters*. The *Station Configuration* dialogue is displayed at this stage. Note that the *Polarisation* (only if the "Full Calculation" of the Polarisation Coupling Loss algorithm is selected), *Frequency Set*, *Man-made Noise*, *Polarisation Coupling Loss*, *Prediction Confidence Level* and *Atmospheric Noise* list boxes are de-activated, indicating these parameters cannot be altered.

The other parameters in the default station configuration can be changed or a different station configuration selected as the default. If a new station configuration is selected as the default, the values in the *Polarisation* (only if Polarisation Coupling Loss "Full Calculation" method selected), *Frequency Set*, *Man-made Noise*, *Polarisation Coupling Loss*, *Prediction Confidence Level* and *Atmospheric Noise* list boxes will change to display the values specified for that station configuration but the resulting prediction will continue to use the values specified in the station configuration that was used to originally compute the prediction.

If the "Full Calculation" polarisation coupling loss algorithm was originally used in the computation of the prediction, ensure that if the Tx and/or Rx antennas are altered, the antennas selected have the same polarisations as the original antennas.

If a new station configuration is selected, the *Set as default* tick box should be ticked before continuing.

Click on *Update View* to display the changes. At this stage the user can either press *Cancel* or *Done*. If *Cancel* is pressed, a temporary change is made to the current view of the Field Strength prediction. Displays of other circuits or modes or views of this prediction file are not altered. If

Done is selected, the change is saved to the Station Configurations database and all views of the currently displayed Field Strength prediction file and other Field Strength prediction files will reflect the change when another view/circuit/mode is displayed.

Note the effect of closing a Field Strength prediction or ASAPS itself. When an existing Field Strength prediction file is then opened, its results are based on the default station configuration values except the man-made noise, atmospheric noise, polarisation coupling loss (and antenna polarisations if the “Full Calculation” was used in the initial computation of the prediction) and the prediction confidence level. The prediction will use the frequency set selected in the *Prediction Details* dialogue at the time the prediction was computed.

If the values for man-made noise, atmospheric noise, prediction confidence level, polarisation coupling loss (and antenna polarisations when using the “Full Calculation”) need to be altered, change their values in the default station configuration (and any other parameters apart from the frequency set that need to be altered) by selecting *Databases|Station configurations*. With the Field Strength prediction open, select *View|Re-compute* and make any changes required, including changes to the frequency set. Produce either a new prediction file or overwrite an existing file. Note that the results of other predictions that are open will be now based on the new default station configuration. The current view of these files may not alter until another circuit/mode/format is displayed.

Exercise 29. Changing station parameters in a Field Strength prediction

View the effect on tute9.FSH of altering the default station configuration, “statute” so the Tx Power = 500 W, Tx Antenna = Rx Antenna = WH35 and the Min. Angle = 2°.

- Select ***Databases|Station configurations*** and ensure the **statute** station configuration is specified as the default.
- If **tute9.FSH** is not open, select ***Predictions|View Predictions*** and open the Field Strength file **tute9.FSH**. Otherwise just display this file in the active window.
- Select ***View|NewView|Station Parameters***, the **Station Configuration** dialogue appears. Change the Tx Power to **500**, the Tx and Rx Antennas to **WH35** and the Min. Angle to **2**°.
- Press ***Update View*** then ***Cancel***. This procedure updates the results of the current display but does not save the changes to the **statute** station configuration.
- View another circuit (← → keys) or mode (↑ ↓ keys) or view (hot keys). Note, the changes made using ***Update View|Cancel*** only changed the initial display. Other displays are based on a Tx power of 1000 W, the SLW Tx antenna and the 30° minimum angle. Further, when the circuit that was altered is viewed again, the results are displayed for the original station parameter values of **statute**.
- Select ***View|NewView|Station Parameters***, the **Station Configuration** dialogue appears. Change the Tx Power to **500**, the Tx and Rx Antennas to **WH35** and the Min. Angle to **2**°.
- Press ***Update View*** then ***Done***. This procedure updates the results of the current display and saves the changes to the **statute** station configuration.
- All views of the different circuits and modes now use the altered **statute** station configuration values.

Exercise 30. Station parameters and terminals

Consider the station parameters at Darwin are: Tx Power = 1000 W, Tx Antenna = Rx Antenna = HLP (Horizontal), Frequency Set = broadcast, Man-made Noise = -150 dBW/Hz, Bandwidth = 3000 Hz, Required S/N = 3 dB, Min. Angle = 10°, Required % Days = 90%, Polarisation Coupling Loss = Full Calculation, Prediction Confidence Level = 50%, Atmospheric Noise = CCIR 322.

The station parameters at Bangkok are: Tx Power = 750 W, Tx Antenna = Rx Antenna = SVM (Vertical), Frequency Set = broadcast, Man-made Noise = -145 dBW/Hz, Bandwidth = 2000 Hz, Required S/N = 1 dB, Min. Angle = 2°, Required % Days = 80%, Polarisation Coupling Loss = Full Calculation, Prediction Confidence Level = 50%, Atmospheric Noise = ITU 372-8.

Produce a Field Strength prediction called "tute10a" for communications from Darwin (12.47° S, 130.85° E) to Bangkok (13.75° N, 100.51° E), short path circuit for September with a T index of 80 (the year is irrelevant). Use the "broadcast" frequency set.

Also produce a Field Strength prediction called "tute10b" for communications from Bangkok to Darwin, short path for the same month, T index and frequency set.

- Because the station parameters are different at the two sites, produce two station configurations. Select ***Databases|Station configurations*** and set up the station configurations with the values below. The **broadcast** frequency set needn't be chosen here unless the GRAFEX formats of the prediction will be viewed since the frequency set(s) for circuits in a Field Strength prediction are specified in the **Prediction Details** dialogue.
- The station configuration for communications from Darwin to Bangkok should contain the following values: Tx Power = **1000** W, Tx Antenna = **HLP** (**Horizontal**), Rx Antenna = **SVM** (**Vertical**), Frequency Set = **broadcast**, Man-made Noise = **-145** dBW/Hz, Bandwidth = **2000** Hz, Required S/N = **1** dB, Min. Angle = **10**°, Required % Days = **80**%, Polarisation Coupling Loss = **Full Calculation**, Prediction Confidence Level = **50** %, Atmospheric Noise = ITU 372-8.
- The station configuration for communications from Bangkok to Darwin should contain the following parameters. Tx Power = **750** W, Tx Antenna = **SVM** (**Vertical**), Rx Antenna = **HLP** (**Horizontal**), Frequency Set = **broadcast**, Man-made Noise = **-150** dBW/Hz, Bandwidth = **3000** Hz, Required S/N = **3** dB, Min. Angle = **10**°, Required % Days = **90**%, Polarisation Coupling Loss = **Full Calculation**, Prediction Confidence Level = **50**%, Atmospheric Noise = CCIR 322.
- Select the station configuration for communications from **Darwin to Bangkok** as the default.
- Note that the man-made noise, atmospheric noise, SNR, reliability (Required % Days) and bandwidth are those at the receiver site. Note also the larger of the two minimum take-off angle values was selected for both station configurations. Even though the Bangkok antenna can transmit and receive energy down to 2°, the Darwin antenna can only transmit and receive signals above 10°. Hence, angles below 10° can be disregarded.
- Now select ***Predictions|Do Prediction*** and produce a prediction file containing the circuit **Darwin-Bangkok** for **September** with T = **80** and using the **broadcast** frequency set. Press ***Do Prediction*** and call the file **tute10a**.
- Open **tute10a.FSH** in the BUF Graph view. Select ***View|New View|Field Strength Table*** to access the tabular views and select ***View|All Parameters*** then ***View|All Modes*** to view all the data for **tute10a.FSH**.
- Select ***Databases|Station configurations*** and change the default station configuration to that for communications from **Bangkok to Darwin**. Ensure this configuration is set as the default.

- Select ***Predictions|Do Prediction*** and produce a prediction called **tute10b** for communications from **Bangkok-Darwin**, **September**, T = **80** using the **broadcast** frequency set.
- Open **tute10b.FSH** in the BUF Graph format. Select ***View|New View|Field Strength Table*** to display the Field Strength Table formats. Select ***View|All Parameters*** then ***View|All Modes*** to view all the data in the Field Strength Table.
- The reason **tute10a.FSH** (Darwin to Bangkok communications) was opened in the Field Strength Table showing all modes and all parameters as well as the BUF Graph is that if the views were changed or opened for this file after the default station configuration had been changed to that for communications from Bangkok to Darwin, the views would use the Bangkok to Darwin parameters. It was not strictly necessary to open **tute10b.FSH** (Bangkok to Darwin) in all formats and views since this circuit's station configuration is the default.
- Hence, when the different formats of Field Strength predictions are changed, they use the values in the default station configuration which may not necessarily be the required configuration.
- Note the two circuits were not included in one prediction file. This was because the parameters at the sites were different. It is preferable to use this method even when station parameters are the same since atmospheric noise will always vary from location to location.

5.9 Field Strength prediction analysis

Exercise 31. Field Strength prediction analysis

In Exercise 21 (p. 69), the "new" station configuration was entered in the Station Configurations database. The "new" station configuration has the following parameters: Tx Power = 1000 W, Polarisation Coupling Loss = Full Calculation, Tx Antenna = WH35 (Vertical), Rx antenna = WH35 (Vertical), Frequency Set = maritime, Man-made Noise = -150 dBW/Hz, Bandwidth = 3000 Hz, Required S/N = 3 dB, Min. Angle = 2°, Required % Days = 50%, Prediction Confidence Level = 50%, Atmospheric Noise = CCIR 322. Ensure this station configuration is selected as the default.

Produce a prediction for the short path circuit Manila (14.58° N, 120.98° E) to Ho Chi Minh (10.46° N, 106.43° E) using the "maritime" frequency set, in October with T = 94 (the year is irrelevant). Call the prediction file "tute11". Open the Field Strength Table (*.FSH) of "tute11".

- Select *Databases|Station configurations*. Display the **new** station configuration, ensure the parameter values are correct and a tick is displayed in the *Set as default* tick box. Press *Done*.
- Select *Predictions|Do Prediction* to display the **Prediction Details** dialogue. Enter the details for the circuit and ensure **maritime** is displayed in the *Frequency Set* list box.
- Press *Do Prediction* and in the *File name* field of the **Save Prediction** dialogue type **tute11**. Press *Save*. Select **tute11.FSH** in the **Field Strength Table (*.FSH)** file type from the **Open** dialogue.

The ASAPS excerpts below are extracted from the Field Strength Table formats of tute11.FSH, on the 1F mode for the hours 06, 12 and 23 UT. Table 8 (p. 70) or the GRAFEX Frequency Table format of the associated GRAFEX prediction, tute11.PRD, may be used in this analysis to obtain the relevant UD, EMUF and ALF data.

The probabilities for the UD, MUF, OWF and EMUF are 10, 50, 90 and 50%, respectively.

In the Field Strength Table formats, the ".." symbol is sometimes used. This symbol is used in F mode views if a particular frequency is above the UD for that particular mode or below the greater of the ALF or E-cutoff frequency. For E modes “..” is used where the frequency is below the ALF or above the UD for that particular E mode.

5.9.1 Probability (p)

Table 22. Extract of Probability of ionospheric support results for Exercise 31.

```
================================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
================================================================================
Circuit 1: manila-ho chi minh        Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         PROBABILITY
================================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
06 20.7 17.9     50   90   ..   ..   ..   ..   ..   99   30
12 19.9 16.0     50   90   99   99   99   99   99   90   25
23 18.1 15.4     50   90   ..   ..   ..   99   99   85   ..
================================================================================
```

At 06 UT, the GRAFEX Frequency Table format of tute11.PRD or Table 8 (p. 70) shows the first mode ALF is 10.0 MHz and the second mode EMUF is 11.6 MHz. The frequencies 2, 4, 6 and 8 MHz lie below the first mode ALF and are not considered; 12 MHz must be below the E-cutoff frequency since no values are displayed for its probability in Table 22. Frequencies below the 1F OWF (17.9 MHz) are given a 99% support rating, indicating they are highly likely to be supported or reflected from the F region of the ionosphere. 22 MHz lies above the MUF (20.7 MHz) and below the UD (24.4 MHz), so its support rating lies between 50% and 10% (Figure 1, p. 14) and is predicted to be 30%.

At 12 UT, the path through the ionosphere is in darkness and there is little ionospheric absorption and an insignificant E region (no ALF and low EMUF). Lower frequencies are now able to propagate. Table 22 shows the 1F OWF is 16.0 MHz and this frequency has a 90% support rating. All frequencies in the set below the OWF are given a 99% support rating. 22 MHz has a support rating of 25%, since it lies between the MUF (19.9 MHz) and the UD (24.6 MHz).

At 23 UT, the path through the ionosphere is again in daylight and the ALF and E-cutoff frequencies result in the lower frequencies being unsuitable. The first mode ALF is 6.0 MHz (Table 8), the second mode EMUF is 4.8 MHz and the OWF at this time is 15.4 MHz. Those frequencies above the ALF/E-cutoff frequency, whichever is the higher, and below the OWF are given a 99% support rating. 16 MHz is above the OWF so its support rating is below 90%. 22 MHz is not given a value, because it lies above the first mode UD which, as Table 8 or tute11.PRD show, is 20.0 MHz.

5.9.2 Reflection heights (h)

Table 23. Extract of virtual Reflection Heights for Exercise 31.

```
================================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
================================================================================
Circuit 1: manila-ho chi minh        Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         REFLECTION HEIGHTS
================================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
06 20.7 17.9    473  439   ..   ..   ..   ..   ..  422  473
```

```
12 19.9 16.0    406  356  308  314  321  328  342  356  406
23 18.1 15.4    305  280   ..   ..   ..  292  271  286   ..
================================================================================
```

These are estimates of the virtual reflection heights of the frequencies in the ionosphere. An undisturbed or quiet ionosphere is usually lower during the night, higher during the day and lowest around dawn (see Table 23 heights for 16 MHz for the three hours).

Generally, lower frequencies are reflected from lower in the ionosphere. However, occasionally there will be deviations during the daytime for a small group of frequencies around two to four MHz above the ALF. An example of this is 8 MHz at 23 UT (ALF is 6 MHz). This is due to the emergence of the F1 layer at the base of the F2 layer, which causes the retardation or slowing of the radio waves on these lower frequencies to be less than if the F layer were just one layer, leading to apparent higher reflection heights at 8 MHz than at 12 MHz, for instance.

5.9.3 Take-off angle (t)

Table 24. Extract of Take-off Angle results for Exercise 31.

```
================================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
================================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         TAKEOFF ANGLE
================================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
06 20.7 17.9     25   24   ..   ..   ..   ..   ..   23   25
12 19.9 16.0     22   19   16   17   17   18   18   19   22
23 18.1 15.4     16   15   ..   ..   ..   15   14   15   ..
================================================================================
```

Higher frequencies generally penetrate to higher altitudes in the ionosphere. The take-off angles of these frequencies consequently need to be larger so as to maintain circuit length. Take-off angles, therefore, generally increase with increasing frequency. Take-off angles vary throughout the day on particular frequencies because of changes in ionospheric reflection height.

5.9.4 Antenna gains (g)

Table 25. Extract of combined Antenna Gain for Exercise 31.

```
================================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
================================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         TX+RX ANTENNA GAIN
================================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
06 20.7 17.9     -8   -8   ..   ..   ..   ..   ..   -8   -8
12 19.9 16.0     -8   -8  -34  -22  -16   -9   -9   -8   -8
23 18.1 15.4    -10  -11   ..   ..   ..  -11  -11  -11   ..
================================================================================
```

The sum of the Tx and Rx antenna gains, at the appropriate elevation angle (and bearing for 3D antennas), are displayed for each supported frequency. The larger and more positive the gain value, the better the combined gain; the more negative the value, the poorer the gain. The combined antenna gain affects the strength of the signal and hence the signal-to-noise at the receiver and power required to achieve the Required S/N. Table 25 shows the gain of this particular antenna combination can be seen to generally improve with an increase in frequency at a particular hour (see 12 UT), although this antenna combination does not provide very good gain for this particular circuit. Viewing the gain pattern of the WH35 antenna in the Antennas database shows the gain improves with an increase in frequency, at least for frequencies lower than 8 MHz.

The gain for a particular frequency varies over the hours because of variations in the take-off angle due to changes in the reflection height of the ionosphere. The Antennas database also shows that, for a fixed frequency, the gain values for the WH35 antenna vary with take-off angle.

At 12 UT, the take-off angle for 16 MHz is 19° and the WH35 gain from the Antennas database is about -4 dBi for this frequency and take-off angle. The combined gain of the two antennas for this hour and frequency is therefore about -8 dBi (-4 + (-4)).

5.9.5 Pathloss (l)

Table 26. Extract of Pathloss predictions for Exercise 31.

```
================================================================================
ASAPS V5 FIELD STRENGTH TABLE -------------------------------
================================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         PATHLOSS
================================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
06 20.7 17.9    127  126   ..   ..   ..   ..   ..  126  127
12 19.9 16.0    125  122  114  114  115  117  120  122  125
23 18.1 15.4    123  122   ..   ..   ..  119  120  122   ..
================================================================================
```

Pathlosses are greater when the pathloss value is greater.

At all hours, Table 26 shows lower frequencies have fewer losses along the path. At 12 UT, the circuit is in darkness and absorption will be negligible at all frequencies. The losses due to spatial attenuation are dependent on the length of the circuit and it can be seen from the reflection heights at this hour that the lower frequencies are reflected from lower in the ionosphere. The lower frequencies therefore have shorter paths and suffer less spatial attenuation, leading to lower pathloss values.

When the circuit is in daylight at 06 and just at 23 UT, there will be greater ionospheric absorption at the lower frequencies, but the higher frequencies suffer greater spatial attenuation because of the greater distance travelled. At both hours, pathlosses are still less at the lower frequencies.

The pathloss also varies for the same frequency across the hours, mostly because of variations in ionospheric absorption and different distances the wave must travel due to changes in ionospheric reflection height. At 06 UT, 16 MHz suffers greater losses than at 12 or 23 UT. The GRAFEX prediction shows the ALF to be high at 06 UT, so compared to the other hours, ionospheric absorption is greatest then. The reflection height of 16 MHz is also highest at 06 UT, leading to greater spatial attenuation.

In some Field Strength predictions, the Pathloss format will show that, for a given daytime hour, pathlosses are greater at lower frequencies. This probably indicates losses due to ionospheric daytime absorption on the lower frequencies are greater than losses due to spatial attenuation on the higher frequencies.

On a particular circuit at a certain time and frequency, pathlosses will be greater for greater numbers of hops. Compare the pathlosses for the first and second modes at a particular time and frequency.

5.9.6 All noise (a)

Table 27. Extract of All Noise results for Exercise 31.

```
===============================================================================
ASAPS V5 FIELD STRENGTH TABLE ---------------------------------
===============================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         ALL NOISE
===============================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
06 20.7 17.9   -170 -167   ..   ..   ..   ..   .. -165 -171
12 19.9 16.0   -168 -164 -134 -144 -150 -153 -158 -164 -171
23 18.1 15.4   -171 -168   ..   ..   .. -156 -164 -169   ..
===============================================================================
```

The less negative the all noise value, the higher the noise level.

Generally, it is found that the noise level is greater on lower frequencies. This can be seen for any of the hours, Table 27. In ASAPS, man-made noise and galactic noise vary only with frequency, while atmospheric noise varies with frequency and time. In general, the noise level is greater during the night. The man-made and atmospheric noise parameters are specified in the station configuration.

5.9.7 Noise field strength (i)

Table 28. Extract of Noise Field Strength results for Exercise 31.

```
===============================================================================
ASAPS V5 FIELD STRENGTH TABLE ---------------------------------
===============================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         NOISE FIELD STRENGTH
===============================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
06 20.7 17.9    -36  -34   ..   ..   ..   ..   ..  -34  -37
12 19.9 16.0    -35  -32  -21  -25  -27  -28  -29  -32  -37
23 18.1 15.4    -39  -38   ..   ..   ..  -31  -35  -38   ..
===============================================================================
```

The less negative the value, the greater the noise field strength indicating higher noise levels.

Noise usually affects lower frequencies to a greater extent and for any hour the noise field strength or noise intensity is greater at the lower frequencies. Table 28 shows that on 16 MHz the noise field strength is greatest at 12 UT (early evening local time) and least at 23 UT (dawn) mostly resulting from variations in atmospheric noise levels.

5.9.8 Noise_pathloss (n)

Table 29. Extract of Noise_Pathloss results for Exercise 31.

```
===============================================================================
ASAPS V5 FIELD STRENGTH TABLE -------------------------------
===============================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         NOISE PATHLOSS
===============================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
06 20.7 17.9     42   40   ..   ..   ..   ..   ..   39   44
12 19.9 16.0     44   41   21   31   35   36   38   41   45
23 18.1 15.4     48   47   ..   ..   ..   37   44   47   ..
===============================================================================
```

Better or optimum ionospheric propagation conditions occur when noise_pathloss (NP) values are large (more positive).

Noise levels are usually greater at lower frequencies while pathlosses are often greater at higher frequencies in this prediction (Sections 5.9.5 and 5.9.6). The combination of these two parameters usually results in better propagation conditions at higher frequencies for any particular hour, at least in this prediction.

Table 29 shows that on 16 MHz, ionospheric propagation conditions are best at 23 UT and poorer at 06 UT for the three hours displayed. The All Noise format shows that, for 16 MHz, noise levels are lowest at 23 UT. The Pathloss format shows that, for 16 MHz, there are predicted to be fewer losses along the path at 23 UT compared to at 06 UT.

The noise_pathloss on 16 MHz is therefore less at 23 UT (larger NP value) compared with 06 UT.

5.9.9 Field strength (f)

Table 30. Extract of signal Field Strength results for Exercise 31.

```
===============================================================================
ASAPS V5 FIELD STRENGTH TABLE -------------------------------
===============================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         FIELD STRENGTH
===============================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
06 20.7 17.9     32   32   ..   ..   ..   ..   ..   31   33
12 19.9 16.0     35   35   13   25   30   34   34   35   35
23 18.1 15.4     34   34   ..   ..   ..   31   33   34   ..
===============================================================================
```

This format shows the intensity of the radio wave, with larger values indicating a stronger signal. The field strength is dependent upon the frequency, transmitter power, gain of the Tx antenna and pathlosses. Field strength will improve with increased transmitter power, better transmitting antenna gain, increased frequency and fewer pathlosses.

The Tx antenna is a WH35 in this case. The Antenna Gains format displays the combined gain of the transmitting and receiving antennas so the transmitting antenna gain pattern must be viewed in the Antennas database. For the take-off angles and frequencies in the example, the WH35 antenna generally has better gain with increasing frequency (at least up to 8 MHz after which it remains constant). The pathlosses in this example are actually less at the lower frequencies for all hours but overall field strength of the radio wave is greater at the higher frequencies.

Consider the results for 16 MHz at 12 and 23 UT, Table 30.

By interpolating between the antenna gain values of the WH35 antenna in the Antennas database at 16 MHz for take-off angles of 6° (-8 dBi) and 20° (-4 dBi), it can be seen that at 23 UT (15° take-off angle from Table 24, p. 121) the WH35 antenna gain is about -5 dBi while at 12 UT, the gain is approximately -4 dBi (take-off angle from Table 24 is 19°).

The predicted pathlosses at 12 and 23 UT on 16 MHz are the same, Table 26 (p. 122), and the transmitter power is the same. The slightly greater transmit antenna gain at 12 UT results in a slight improvement in the predicted field strength of the radio wave on 16 MHz at 12 UT.

At 12 UT on 16 MHz, the signal field strength (E) is approximately (Section 5.1.9):

$$\begin{aligned} E &= 107.2 + 20 * \log_{10}(f) + P_t + G_t - L_b \\ &= 107.2 + 20 * \log_{10}(16) + 10 * \log_{10}(1000) + (-4) - 122 \\ &= 107.2 + 24.1 + 30 - 4 - 122 \\ &= 35.3 \text{ dB}\mu\text{V/m} \end{aligned}$$

At 23 UT, the field strength of 16 MHz is approximately:

$$\begin{aligned} E &= 107.2 + 20 * \log_{10}(16) + 10 * \log_{10}(1000) + (-5) - 122 \\ &= 107.2 + 24.1 + 30 - 5 - 122 \\ &= 34.3 \text{ dB}\mu\text{V/m} \end{aligned}$$

5.9.10 Signal-to-noise (s)

Table 31. Extract of Signal-to-Noise results for Exercise 31.

```
================================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
================================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         SIGNAL/NOISE
================================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
06 20.7 17.9     30   27   ..   ..   ..   ..   ..   26   31
12 19.9 16.0     31   28  -18    4   14   22   24   28   32
23 18.1 15.4     33   31   ..   ..   ..   22   28   31   ..
================================================================================
```

A more positive signal-to-noise (SNR) value indicates a stronger signal compared to the noise level.

The predicted signal-to-noise is dependent on the transmitter power, combined antenna gain, noise_pathloss (and therefore the prediction confidence level) and receiver bandwidth (Table 19, p. 98). Assuming the transmitter power and receiver bandwidth are constant across all frequencies, then only the combined antenna gain and noise_pathloss variations need be considered. The Antenna Gains format shows the gain of the antennas generally improves with increasing frequency (see 12 UT, Table 25, p. 121). The Noise_Pathloss format combines the noise and pathlosses and this format shows less effect from noise and losses at higher frequencies (Table 29, p. 124). The better antenna gain and larger noise_pathloss values at the higher frequencies result in improved signal-to-noise values for these frequencies.

At 12 UT, 16 MHz has a signal-to-noise of (see Section 5.1.8):

$$
\begin{aligned}
SNR &= P_t + G_a + NP - B \\
&= 10 * \log_{10}(1000) + (-8) + 41 - 10 * \log_{10}(3000) \\
&= 30 - 8 + 41 - 34.77 \\
&= 28.23 \text{ dB}
\end{aligned}
$$

Table 31 shows the signal-to-noise for 16 MHz at 12 UT to be 28 dB.

Note that since the noise_pathloss has been adjusted for the specified prediction confidence level, the signal-to-noise values are appropriate for the specified prediction confidence level. Therefore, if the prediction was completely accurate, 50% (specified prediction confidence level) of the time at 12 UT in October with a T of 94, the actual signal-to-noise on 16 MHz will exceed the predicted signal-to-noise of 28 dB, based on the station parameter values for this exercise. The Required S/N is 3 dB so it is predicted the actual signal-to-noise will be well above this. In this case, the transmitter power, for instance, could be decreased and the threshold signal-to-noise of 3 dB still be satisfied.

5.9.11 Estimated power required (e)

Table 32. Extract of Estimated Power Required results for Exercise 31.

```
==============================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
==============================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Mode: 1F         ESTIMATED POWER REQUIRED
==============================================================================
UT  MUF  OWF   @MUF @OWF  2.0  4.0  6.0  8.0 12.0 16.0 22.0
06 20.7 17.9      2    4   ..   ..   ..   ..   ..    5   ..
12 19.9 16.0      2    3 >33k  773   71   12    8    3   ..
23 18.1 15.4      1    2   ..   ..   ..   13    3    1   ..
==============================================================================
```

This format estimates the transmitter power needed to achieve the Required S/N of 3 dB, specified in the default station configuration, “new”.

The Min. Angle of 2° and Required % Days of 50% must be satisfied for a value to be calculated. For instance, in Table 32, no value is given at 12 UT for 22 MHz. While the take-off angle (22°) satisfies the Min. Angle requirement, this frequency does not satisfy the specified Required % Days of 50%. The support for this frequency at 12 UT is only 25%, Table 22 (p. 120).

To achieve the Required S/N of 3 dB at 12 UT using 6 MHz, a transmitter power of only 71 watts (18.5 dBW) is predicted to be required, well below the 1000 W transmitter power specified. A transmitter power of 1000 W is predicted to actually provide a signal-to-noise of 14 dB (3 dB + 10* log10 (1000 / 71) = 14.5 dB), as displayed in Table 31 for this hour, frequency and prediction confidence level.

5.9.12 BUF (b)

This format examines the 28 frequency/mode combinations (seven frequencies, four modes, e.g., 12 MHz/2F mode) for this particular circuit and determines for each hour which frequency/mode combination satisfies the Required S/N, Min. Angle and Required % Days values and has the largest signal-to-noise. Note that if a BUF is selected, there may be other frequency/mode combinations that still satisfy the requirements and can be considered for use.

Table 34 (p. 128) lists the Probability, Take-off Angle and Signal-to-Noise format results for Exercise 31 at 06 UT. The three values that must be satisfied are Required % Days = 50%, Min. Angle = 2° and Required S/N = 3 dB that were specified in the station configuration "new".

Table 34 shows 6 and 8 MHz on the 2E mode do not meet the Required S/N and 12 MHz on this mode does not meet the required probability of ionospheric support. 22 MHz on the 1F mode also does not meet the required probability of ionospheric support. 16 MHz on the 2F mode does not meet the required probability of ionospheric support.

The frequency/mode combinations that satisfy all three requirements are 12 MHz/1E, 16 MHz/1E, 16 MHz/1F and 12 MHz/2F. Of these, the 16MHz/1F mode has the highest predicted signal-to-noise (26 dB) and hence is the BUF at 06 UT, Table 33. The other three combinations that satisfy the requirements may still be used and may be preferred if the BUF is affected by fading or interference.

Table 33. Extract of Best Usable Frequency (BUF) results for Exercise 31.

```
============================================================================
ASAPS V5 FIELD STRENGTH TABLE --------------------------------
===============================================================================
Circuit 1: manila-ho chi minh       Distance: 1644km      Date: October 2008
Tx: Manila          14.58   120.98   Bearings: 255  072    T-index: 94
Rx: ho chi minh     10.46   106.43   Path: Short Path      TxAntenna: WH35 V
FSet:maritime      Min.Angle: 2deg Noise:-150dBW/Hz CCIR   RxAntenna: WH35 V
Full PCLoss PredConf.50% Required S/N:3dB RxBW:3.0kHz    %Days:50  Power:1000 W
Modes: 1F 1E 2F 2E              BEST USABLE FREQUENCY
===============================================================================
UT   MODE PROB ANGLE  NOISE  S/N  SN@MUF SN@OWF   BUF     MUF   OWF
0600  1F   99    23    -34    26    30     27   16.000  20.7  17.9
1200  1F   90    19    -32    28    31     28   16.000  19.9  16.0
2300  1F   85    15    -38    31    33     31   16.000  18.1  15.4
```


Table 34. Selection of the BUF at 06 UT for Exercise 31.

Mode	Format	Frequency						
		2	4	6	8	12	16	22
1E	Probability					**99**	**99**	
	Take-off angle					**3**	**4**	
	Signal-to-noise					**15**	**17**	
2E	Probability			99	99	17		
	Take-off angle			12	12	16		
	Signal-to-noise			-25	-5	4		
1F	Probability						**99**	30
	Take-off angle						**23**	25
	Signal-to-noise						**26**	31
2F	Probability					**99**	16	
	Take-off angle					**44**	46	
	Signal-to-noise					**17**	18	

6. Area predictions

Area predictions provide information for sky wave communications between a location and anywhere within a nominated area. The Area prediction formats apply the parameter information specified in the Station Configurations database. The Area prediction also computes two surface wave formats.

The following Area prediction formats are available, in either graphical or tabular views:

- Best usable frequency (BUF)
- Maximum usable frequency (MUF) on the BUF mode
- Optimum working frequency (OWF) on the BUF mode
- Signal-to-noise at the BUF
- Signal-to-noise at the MUF on the BUF mode
- Signal-to-noise at the OWF on the BUF mode
- BUF mode
- Noise field strength at the BUF
- Probability of ionospheric support for the BUF
- Take off angle of the BUF
- Surface wave prediction
- Multi-surface prediction

Area prediction file names have a ".AHD" extension.

When entering the details for an Area prediction, the base need not be within the nominated area and may be specified as either the transmitter or receiver. Only one Area prediction can be performed per prediction file.

Area predictions are generated from many point-to-point circuits between the base and a set of gridpoint locations on a rectangular grid covering the area of interest. The number of circuits the programme calculates is determined by the resolution of the underlying grid, specified when entering the details of the area in the Areas of Interest database. The more rows and columns entered, the greater the resolution of the prediction, but the longer the computation time. See Section 2.6 for information on the area of interest.

GRAFEX and Field Strength predictions are automatically produced when Area predictions are computed. The Area and Field Strength predictions will be based on the frequency set specified in the *Frequency Set* list box of the *Area Prediction details* dialogue while the GRAFEX prediction results will be based on the frequency set specified in the default station configuration. If no frequency set is specified in the default station configuration, some of the GRAFEX formats will not be produced (GRAFEX Frequency Plan Table, GRAFEX Frequency Plan Graph, GRAFEX Frequency Set Test and SNR Frequency Set Test).

Area predictions employ the station parameters specified in the Station Configurations database. Table 35 (p. 130) indicates which station parameters are applicable to the Area prediction formats. The station parameters used in the computation of a particular format are displayed in the header section of the graphical and tabular results. The parameter values in the header should be checked for accuracy before the predictions results are used.

Table 35. Station parameters applicable to Area prediction formats.

Station parameters	Prediction format							
	BUF	Signal-to-noise	Modes	Noise field strength	Probability	Take-off angle	Surface wave	Multi-surface
Frequency set or frequency	●	●	●	●	●	●	●	●
Tx power	●	●	●				●	●
Man-made noise	●	●	●	●			●	●
Atmos. noise	●	●	●	●			●	●
Bandwidth	●	●	●				●	●
Antennas	●		●				●	●
Min. take-off angle	●		●					
Required % days	●		●					
Required S/N	●		●				●	●
Pol. coupling loss	●	●	●					
Predict. confid. level	●	●	●				●	●
Ground type							●	
Sea state loss							●	●

6.1 The Area prediction formats

The following sub-sections describe the Area prediction formats. The letters in parentheses in the sub-headings indicate hot keys to display the formats. These may be entered as either lower case letters or as upper case letters when the Caps Lock key on the keyboard is activated.

6.1.1 The BUF (b)

This format displays the frequency/mode combination at each gridpoint that has the largest signal-to-noise value of the frequency/mode combinations that satisfy the Min. Angle, Required % Days and Required S/N parameters specified in the default station configuration. In locations where there is no BUF, the Area prediction graph will be uncoloured while three dots "…" will be displayed at the gridpoints in the Area prediction table. This means that at that hour and gridpoint, none of the frequency/mode combinations meet one or more of the three parameter values that need to be satisfied (Required S/N, Required % Days and Min. Angle).

The Modes format displays the mode on which the BUF occurs at each gridpoint.

The BUF is mode-dependent so the frequency that is the BUF may not necessarily meet the system parameters on other modes. Note, there may be other frequency/mode combinations that, while not selected as the BUF, still satisfy the Required S/N, Required % Days and Min. Angle values specified in the default station configuration. Refer to Section 5.1.12 for further details.

6.1.2 MUF on the BUF mode (m)

This format displays the MUF (the frequency with a 50% probability of support) on the propagation mode selected for the BUF at each gridpoint. For example, if at a particular gridpoint, the BUF occurs on the 2F mode at a particular hour, this format displays the MUF on the 2F mode for that hour at that gridpoint. Locations where there is no BUF are uncoloured in this format's Area prediction graph or display the "…" symbol in the Area prediction table.

6.1.3 OWF on the BUF mode (o)

This format displays the OWF (the frequency with a 90% probability of support) on the mode selected for the BUF at each gridpoint. Hence, if the BUF for some hour occurred on the 1F mode at certain gridpoints within the area, then ASAPS will display the OWFs for the 1F mode for that hour at those gridpoints. Locations where there is no BUF are uncoloured in the Area prediction graph or display the "…" symbol in the Area prediction table.

6.1.4 Signal-to-noise at the BUF (x), MUF (y) and OWF (z)

These three formats display the predicted signal-to-noise for the BUF or the predicted signal-to-noise for the MUF or OWF, on the BUF mode based on the specified prediction confidence level. For example, if the BUF occurs on the 2F mode for some particular hour and gridpoint, the S/N @ OWF format will display the signal-to-noise for the OWF at that hour on the 2F mode at that gridpoint. The signal-to-noise values displayed for the BUFs in the S/N @ BUF format will be equal to or greater than the Required S/N specified in the default station configuration. The signal-to-noise values displayed in the S/N @ MUF and S/N @ OWF do not necessarily meet the Required S/N value.

If there is no BUF at a particular gridpoint and hour, the "…" symbol will be displayed in the Area prediction table and in the Area prediction graph, the area will be uncoloured.

The signal-to-noise values computed are based on the prediction confidence level specified in the default station configuration. The BUF and the mode on which the BUF occurs may vary depending on the prediction confidence level specified.

A higher prediction confidence level leads to lower predicted signal-to-noise values so it is less likely the predicted signal-to-noise values will achieve the Required S/N. This usually results in a smaller area of coverage. Hence, a higher prediction confidence level such as 90% should be considered when engineering communication links or for worst case scenarios. At other times a 50% prediction confidence level is adequate. See Section 2.7.12 for more information on the prediction confidence level. Refer to Section 5.1.8 for signal-to-noise details.

6.1.5 BUF mode (d)

This format displays the propagation mode of the BUF at each gridpoint. Uncoloured areas and the "…" symbol on the Area prediction graph and Area prediction table respectively, indicate there is no BUF at that hour and gridpoint. The modes considered in the determination of the BUF depend on the distance between the gridpoint and the base. Table 1 (p. 11) displays the modes considered for circuits of varying length.

6.1.6 Noise field strength at the BUF (n)

This format displays the amplitude of the noise in dBμV/m at the input to the receiving antenna for the BUF. Uncoloured areas in the Area prediction graph and the "…" symbol in the Area prediction table indicate no BUF at that gridpoint. See Section 5.1.11 for more information.

6.1.7 Probability of support at the BUF (p)

This format displays the probability of ionospheric support for the BUF. Since the Required % Days specified in the default station configuration must be met for a BUF to be selected, the probability values will be equal to or greater than this specified value. A BUF that is below the OWF displays a 99% support rating.

If there is no BUF at a location, the "…" symbol will be displayed in the Area prediction table and the area will be uncoloured in the Area prediction graph. See Section 5.1.2 for more information.

6.1.8 Take-off angle at the BUF (t)

This format displays the take-off angle for the BUF, which will be greater than or equal to the specified Min. Angle value in the default station configuration. At gridpoints where there is no BUF, the Area prediction table will display the "…" symbol and the Area prediction graph will be uncoloured. Section 5.1.1 provides further details.

6.1.9 Surface wave prediction (s)

This format displays the predicted ranges of the frequencies in the specified set as they travel over the specified ground type. The predicted range of a frequency is determined by its signal-to-noise satisfying the required signal-to-noise value. At gridpoints where the signal-to-noise values of none of the frequencies meet the required signal-to-noise, the Area prediction table will display the "…" symbol and the Area prediction graph will be uncoloured.

The station configuration parameters used in the computation of this prediction format are displayed in Table 35 (p. 130).

The frequency set is specified in the *Frequency Set* list box of the *Area Prediction details* dialogue. Refer to Section 2.4 for the range of frequencies that may be used in this format. The antenna details, ground type, sea state (for frequencies greater than 2,000 kHz when sea water is the specified ground type) and inclusion or otherwise of atmospheric noise in the computation are specified under the *Surface Wave Parameters* button in the *Area Prediction details* dialogue (Section 3.3.6). The transmitter power, man-made noise category, atmospheric noise model, receiver bandwidth, required signal-to-noise and prediction confidence level are specified in the default station configuration prior to performing the prediction.

The most appropriate atmospheric noise model for the computation is dependent on the communication region; see Section 2.7.7 for further information. Man-made and atmospheric noise components can be exluded from the surface wave computation (Sections 3.3.6.7 and 2.7.6). It is suggested atmospheric and man-made noise should normally be included in the computation. Note that excluding man-made noise will result in the man-made noise component also being excluded from the multi-surface and sky wave computations of the Area prediction and the Field Strength prediction. Galactic noise cannot be excluded and will be included in the computation for any frequency above the vertical incidence penetration frequency (fxF2) at the base.

In the *Area Prediction details* dialogue the base may be specified as either the transmitter or receiver. Changing the base from transmitter to receiver and vice versa has no effect on this particular Area prediction format. When atmospheric noise is included in the computation, the atmospheric noise level at a particular time is the value determined from the appropriate model at the base.

While the Surface Wave graph displays land masses, the surface wave computation is based only on the one ground type specified in the *Surface Wave Parameters* dialogue of the *Area Prediction details* dialogue. That is, at all locations between the base and the gridpoints of the specified area, the ground type is the same. Further, topography is not included in the computation.

The surface wave range calculation can only be computed from the Area prediction graph. Therefore, to view the surface wave range data in the tabular format, firstly view a graph of any of the Area prediction formats, compute the Surface Wave format (press "*s*" or select *View|Surface Wave*), then return to viewing the Area prediction table using *View|New View|Area Prediction Table*.

An increase in receiver bandwidth and/or noise level will decrease the predicted signal-to-noise ratio of the surface wave and result in decreased range. The type of ground also affects the detectable range of the surface wave; sea water is optimum for surface wave propagation. A greater transmitter power will increase signal strength and predicted signal-to-noise values. The suite of frequencies selected for surface wave propagation also affects the prediction results. Lower frequencies suffer less attenuation across the ground than higher frequencies. A larger required signal-to-noise value implies a superior grade of service or better quality signal. Increasing the required signal-to-noise value is likely to reduce the number of frequencies that satisfy the required signal-to-noise. The prediction confidence level alters the predicted signal-to-noise values computed. A lower prediction confidence level results in higher predicted signal-to-noise values. There is then a greater chance that a frequency's predicted signal-to-noise ratio will meet or exceed the required signal-to-noise.

Note that changing parameter values using *View|New View|Station Parameters* does not alter the data displayed but will result in changes to data displayed for the sky wave formats. To re-compute a Surface Wave format, press *Databases|Station configurations*, select the appropriate station configuration or change parameters then select *View|Re-compute*, alter any details as required in the *Area Prediction details* dialogue and produce a new prediction.

6.1.10 Multi-surface prediction (q)

This format displays predicted signal-to-noise values for a specified frequency propagating via the surface wave across different ground types. At gridpoints where the predicted signal-to-noise of the surface wave is below the required signal-to-noise, the Area prediction table will display the "…" symbol and the Area prediction graph will be uncoloured.

The multi-surface prediction is computed using the semi-empirical method by Millington [1949] to calculate the field strength of the surface wave over multiple ground types as described in CCIR Recommendation 368-5, Annex II - Application to Mixed Paths ("Propagation in Non-Ionized Media" 1986 Volume V).

In this format the Earth's surface is divided into 259,200 segments, each with the dimensions of 0.5 degrees latitude and 0.5 degrees longitude. Each segment is one of four ground types; ice (-10 degrees Celsius), sea ice (-1 degree Celsius), sea water or dry land. The permittivities and conductivities of these ground types are the same as those specified under the *Surface Wave Parameters* button; topography is not considered.

The parameters in the default station configuration used in the computation of this prediction format are displayed in Table 35 (p. 130).

The frequency, antenna details, sea state (for frequencies greater than 2,000 kHz) and inclusion or otherwise of atmospheric noise in the computation are specified under the *Surface Wave Parameters* button in the *Area Prediction details* dialogue (Section 3.3.6). The transmitter power, man-made noise category, atmospheric noise model, receiver bandwidth, required signal-to-noise and prediction confidence level are specified in the default station configuration.

The most appropriate atmospheric noise model for the computation is dependent on the communication region; see Section 2.7.7 for further information. The user may choose to exclude man-made and atmospheric noise from this computation (Sections 3.3.6.7 and 2.7.6). It is suggested atmospheric and man-made noise should normally be included in the computation. Galactic noise cannot be excluded and will be included in the computation if the specified frequency is above the vertical incidence penetration frequency (fxF2) at the receiver site.

In the *Area Prediction details* dialogue the base may be specified as either the transmitter or receiver. If the base is specified as the transmitter, parameters used in the multi-surface computation other than transmitter power, pertain to the gridpoints in the designated area; see Table 2 (p. 30). If the base is specified as the receiver, these station parameters pertain to the base and the gridpoints in the area are used as the transmitter locations in the computation.

The Multi-surface format can only be computed from the Area prediction graph by pressing "*q*" or selecting *View|Multi-Surface*. The multi-surface computation can be time consuming so the user is asked for confirmation of the calculation. If viewing the Area prediction file in the tabular format, return to viewing an Area prediction graph before attempting the multi-surface computation. Once computed, the Multi-surface format may be viewed as a table, *View|New View|Area Prediction Table*.

A larger transmitter power, smaller receiver bandwidth, lower man-made noise levels and lower prediction confidence level will increase the predicted signal-to-noise levels of the surface wave and may increase its area of coverage.

The required signal-to-noise value specified in the default station configuration is likely to alter the coverage of the surface wave. A frequency's area coverage should decrease with higher required signal-to-noise levels.

Relevant station parameters to this format may only be altered by re-computing a prediction. This is achieved by selecting *Databases|Station configurations* and changing the parameters as required. Then select *View|Re-compute*, alter any values here that may be required and produce a prediction.

Note that changing parameter values using *View|New View|Station Parameters* does not alter the data displayed but will cause the sky wave formats of the area prediction to be re-computed. To re-compute the Multi-surface format, press *Databases|Station configurations*, select the appropriate station configuration or change parameters then select *View|Re-compute*, alter any details in the *Area Prediction details* dialogue and produce a new prediction.

6.2 Frequency set specification

Only one Area prediction is permitted per file. The frequency set is specified in the *Frequency Set* list box of the *Area Prediction details* dialogue which is accessed by selecting *Predictions|Do Area Prediction*. This frequency set is used to compute the results of the sky wave formats and the Surface Wave format of an Area prediction. Table 36 highlights this point; the default station configuration uses Set A, Set B or no frequency set (that is, "(NONE) GRAFEX") while the frequency set specified in the *Area Prediction details* dialogue is either Set A or Set B.

Table 36. Frequency set specification in Area predictions.

Frequency set specified in default station configuration	Frequency set specified in *Area Prediction details* dialogue	Frequency set used in Area prediction
Set A	Set A	Set A
Set A	Set B	Set B

Frequency set specified in default station configuration	Frequency set specified in *Area Prediction details* dialogue	Frequency set used in Area prediction
(NONE) GRAFEX	Set A	Set A
(NONE) GRAFEX	Set B	Set B
Set B	Set A	Set A
Set B	Set B	Set B

The Multi-surface format of an Area prediction uses the frequency specified in the *Multi-Surface Frequency* box in the *Surface Wave Parameters* dialogue which is accessed from the *Area Prediction details* dialogue (Section 3.3.6.8).

GRAFEX and Field Strength predictions are automatically computed when an Area prediction is prepared.

The results for all circuits in the Field Strength prediction will be based on the same frequency set as the Area prediction.

The results for all circuits in the GRAFEX prediction will be based on the frequency set specified in the default station configuration.

To ensure all three prediction files used the same frequency set, specify the same frequency set in the default station configuration and the *Frequency Set* list box of the *Area Prediction details* dialogue.

6.3 Computing an Area prediction

Table 2 (p. 30) displays which station configuration parameters apply to the transmitter and receiver. Note that the Tx/Rx Antennas, Min. Angle, Required % Days, Prediction Confidence Level and Polarisation Coupling Loss parameters do not apply to the Surface Wave and Multi-surface formats.

Care should be taken to use the correct station configuration parameters for the correct terminal of a circuit. For example, if the station parameters for the base are different from those of locations within the designated area and two-way communications are required, then two station configurations will be necessary, one station configuration for communications from the base to the area and the other for communications from the area to the base. Two Area prediction files will also be required, one where the base is selected as the transmitter and the other where the base is selected as the receiver. Then, when computing and viewing the two Area predictions, it is imperative to have the appropriate station configuration set as the default.

The base station in an Area prediction may be specified as either a transmitter (Tx) or receiver (Rx) in the *Area Prediction details* dialogue for all formats.

In the *Area Prediction details* dialogue, the user has the option to include atmospheric noise in the Surface Wave and Multi-surface formats by ticking the *Atmospheric noise* box under the *Surface Wave Parameters* button (Section 3.3.6.7). This affects a frequency's predicted signal-to-noise value at a location, particularly if the man-made noise level is low.

If the *Atmospheric noise* box is not ticked, atmospheric noise is not included in the computation of the Surface Wave and Multi-surface formats. Surface Wave format predictions where the base is the transmitter and where the base is the receiver will be the same (as long as other parameter values are the same for both communication directions) when no atmospheric noise is included.

When the *Atmospheric noise* button is ticked, atmospheric noise is included in the Surface Wave and Multi-surface format computations. While the area of interest used in these computations is likely to be small so maximum detail is displayed, the variability in atmospheric noise within the area may be considerable. For the Surface Wave format, the base should be specified correctly (Tx or Rx). If the Surface Wave format is required for two-way communications, two separate Area prediction files should be computed. The first prediction file should be computed for communications from the base to the area (base as transmitter) and the second prediction file should be computed for communications from the area to the base (base as receiver), ensuring the correct station parameters are used for each prediction file.

The sky wave prediction formats always include atmospheric noise. If the base and locations within the designated area have the same station parameters, then one prediction may be computed to approximate expected conditions. However, because atmospheric noise varies from location to location, it may be preferable to compute two Area predictions, one where the base is the transmitter and the other where the base is the receiver. When the base is specified as the transmitter, the total noise is calculated at each of the gridpoints. If the base is the receiver, the total noise is calculated at the base only.

Exercise 32. Computing an Area prediction

Ensure the “statute” station configuration is selected as the default and that it has the following values. Tx Power = 1000 W, Polarisation Coupling Loss = Full Calculation, Tx Antenna = SLW (Vertical), Rx Antenna = WH35 (Vertical), Frequency Set = tuteset, Man-made Noise = -150 dBW/Hz, Bandwidth = 3000 Hz, Required S/N = 3 dB, Min. Angle = 30°, Required % Days = 90%, Prediction Confidence Level = 90% and Atmospheric Noise = CCIR 322.

Compute an Area prediction for the current month and year for one-way, short path communications from Tokyo (35.70° N, 139.77° E) to the “austasia” area using the “broadcast” frequency set. Produce a surface wave range calculation over sea water using two metre vertical monopole antennas at ground level with 80% efficiency, a sea state loss = 10 knots and including atmospheric noise. Also produce a multi-surface computation for the same ground wave antennas using a frequency of 1200 kHz. Call the Area prediction “tute12a”.

Also compute for the current month and year, a short path Area prediction from the “southern africa” area (5° to 35° south and 10° to 50° east, grid resolution of 5° in latitude and 5° in longitude) to Beira (19.82° S, 34.87° E) using the “test” frequency set (Exercise 5, p. 22) and the “tute” station configuration (parameter values given below). Produce a surface wave prediction over moist ground using the same antennas as those in the Tokyo to austasia prediction and including atmospheric noise.

The station parameters for the “tute” station configuration are: Tx Power = 500 W, Polarisation Coupling Loss = Full Calculation, Tx Antenna = HLP (Horizontal), Rx Antenna = HLP (Horizontal), Frequency Set = amateur, Man-made Noise = -145 dBW/Hz, Bandwidth = 2000 Hz, Required S/N = 1 dB, Min. Angle = 2°, Required % Days = 75%, Prediction Confidence Level = 50% and Atmospheric Noise = ITU 372-8.

Call this Area prediction file “tute12b”.

- Select ***Databases|Station configurations***. Confirm the **statute** station configuration is selected as the default and the values for the parameters are as shown above. Unless the GRAFEX prediction file produced in conjunction with this Area prediction file is to be used, it really is irrelevant which frequency set is specified in the default station configuration since the Area and associated Field Strength predictions use the frequency set specified in the **Area Prediction details** dialogue.
- Select ***Predictions|Do Area Prediction***. The **Area Prediction details** dialogue is displayed. Use the **Tab** key to enter the default date and index values and enter a name in the **Name** field if desired or leave blank. If the **Name** field is left blank, ASAPS will provide a name based on the base name and area of interest. Enter the base as **Tokyo** and select the base as **Tx** (i.e., transmitter). Enter the area of interest as **austasia** from the **Area of interest** list box. Ensure **Short** is displayed in the **Path** list box and select the **broadcast** frequency set in the **Frequency Set** list box.
- Click on the ***Surface Wave Parameters*** button and select the surface type as **Sea Water**, sea state loss as **State 2**, Tx and Rx antennas as **Vertical Monopole**, of length **2 m**, height as **0 m**, efficiency as **80%**, ensure the **Atmospheric noise** box is ticked and enter **1200** in the **Multi-Surface Frequency (kHz)** field. Press ***OK*** then press ***Do Prediction***.
- At the **Save Prediction** dialogue, enter the name of the Area prediction file, **tute12a**, and press ***Open***. When the **Open Prediction File** dialogue appears, open **tute12a.AHD**. The Area prediction graph for the BUF format is displayed.
- The Area prediction graph for different hours can be viewed by using the ↑↓ keys. To view the different area formats, select ***View*** and then the format required or use the hot keys displayed next to each format in the ***View*** menu or shown in the sub-sections in Section 6.1. Note the frequency set used in the prediction. Regions of the Area prediction graph for sky wave communications may be devoid of colour. This occurs when no frequency satisfies the selection criteria for the BUF at those gridpoints.
- To view the surface wave prediction, ensure the window containing the Area prediction graph is active. Select ***View|Surface Wave*** or press the "***s***" key. ASAPS asks the user to confirm if the surface wave prediction is to be computed, since this may take some time to complete. Press ***OK*** to compute the surface wave prediction or ***Cancel*** to abandon the calculation. If ***Cancel*** is pressed, the surface wave prediction can be computed and viewed later, if desired. Regions of the surface wave coverage graph may be devoid of colour. This occurs when the Required S/N specified in the default station configuration cannot be attained by any of the frequencies in the specified set at those locations.
- To view the multi-surface prediction, again ensure an Area prediction graph window for this prediction file is active. Select ***View|Multi-Surface*** or press the "***q***" key. The programme will then request confirmation to continue with the computation. Press ***OK*** to continue or ***Cancel*** to desert the calculation. Regions of the multi-surface graph may be devoid of colour. This occurs when the Required S/N specified in the default station configuration is higher than the predicted signal-to-noise at a gridpoint.
- Select ***Databases|Station configurations*** and enter the details of the **tute** station configuration. Ensure this station configuration is set as the default.

- Select ***Predictions|Do Area Prediction*** and ensure the **test** frequency set is specified in the **Frequency Set** list box. Enter **Beira** in the **Base** list box of the **Area Prediction details** dialogue. If **Beira** does not exist in the Terminals database, click on the button with three dots in the **Base** group box and enter the location of **Beira** in the **Terminals** dialogue. Press ***Add/Modify*** then ***Done***. This will save **Beira** in the Terminals database. Ensure **Rx** is specified in the **Base is** list box.
- View the **Area of interest** drop-down list and determine if the **southern africa** area exists. Regardless of whether it does exist, click on the button with three dots in the **Area of interest** group box. This displays the **Area of interest** dialogue. If the **southern africa** area does exist in the database, check its bounds and required numbers of rows and columns.
- If the area does not exist, enter the data for the **southern africa** area. To calculate the number of rows and columns for the **southern africa** area, see Section 2.6. The values to enter for the **# of Rows** and **# of Columns** fields are **7** and **9**, respectively. When all data for this area have been added press ***Add/Modify*** then ***Done***.
- At the **Area Prediction details** dialogue, ensure **southern africa** is the selected area of interest, check the path type and select the **test** frequency set in the **Frequency Set** list box.
- Under the ***Surface Wave Parameters*** button, change the surface type to **moist ground** and press ***OK***. Back at the **Area Prediction details** dialogue, press ***Do Prediction***.
- At the **Save Prediction** dialogue, enter the name of the Area prediction file, **tute12b**, and press ***Open***.
- When the **Open Prediction File** dialogue displays, open **tute12b.AHD**. View the different hours using the ↑↓ keys. View the different Area Prediction formats by selecting ***View*** and then the name of the required format, or use the hot keys.
- Note that it is the frequency set specified in the **Area Prediction details** dialogue that is used in the Area prediction. This is not necessarily the set specified in the default station configuration. Note that if the multi-surface computation was attempted, the format was cancelled because the base was specified as the receiver.

6.4 The View menu

When an Area prediction is displayed in the active window clicking on *View|New View* allows switching between the graph and table views. The *Station Parameters* option displays the *Station Configuration* dialogue. The *Frequency Set*, *ManMade Noise*, *Polarisation Coupling Loss*, *Prediction Confidence Level*, *Atmospheric Noise* and possibly the polarisations of the antennas will be deselected – it is not possible to alter these parameters. For the other parameters that are still active, changes may be made to the default station configuration or a new default station configuration selected. As long as the *Set as default* tick box has a tick displayed, the selected station configuration parameters will be used when the *Update View* button is pressed. There is then the option of *Cancel* or *Done* in the *Station Configuration* dialogue. Pressing *Cancel* does not save the changes made to the Station Configurations database. Pressing *Done* will save any changes. Regardless, of which option is used, other formats of the prediction will be based on the changes, saved or otherwise, made to the Station Configurations database until changes are again made in the same manner or the Area prediction is closed.

The *Re-compute* option displays the *Area Prediction details* dialogue. The prediction may be modified and the new prediction can either be saved to a new file or an existing file may be overwritten, including the current file.

The various Area prediction formats are listed in the *View* menu and may be displayed by clicking on the desired format. Alternatively, use the hot keys displayed next to the formats in the *View* menu or shown in parentheses in the sub-section headings in Section 6.1. The *All Parameters* option is only usable when the active window displays an Area prediction table format. The twelve formats (ten if the surface wave range and multi-surface predictions have not been computed) are displayed in one long table.

The *Next Hour* and *Previous Hour* options scroll through the 24 hours. If viewing the formats as tables there is also an *All Hours* option which displays the results for the 24 hours.

When viewing an Area prediction graph, the status bar at the bottom of ASAPS displays the cursor's latitude, longitude and the data for the format being viewed. Note however, that the Area prediction table displays the data more accurately.

Exercise 33. The View menu

View the Area prediction table formats of the Area predictions "tute12a" or "tute12b".

- With either **tute12a.AHD** or **tute12b.AHD** as the current display, press ***View|New View|Area Prediction Table*** and view the formats by way of the hot keys or by selecting the format required from the ***View*** drop-down menu.
- Compare the values given in the Area prediction tables with those shown on the Area prediction graphs. In most cases, the Area prediction tables provide more precise information.
- The "…" symbol may be displayed at gridpoints in the Area prediction tables. In the surface wave coverage table (note that to view the surface wave coverage table, view any Area prediction graph, press "***s***" or select ***View|Surface Wave***, then select ***View|New View|Area Prediction Table***) this symbol indicates the Required S/N specified in the default station configuration is not attainable at those locations for any of the frequencies in the specified set. The "…"symbol in the multi-surface prediction indicates that the required signal-to-noise is not attainable at that gridpoint for the specified frequency. For the other formats, the "…" symbol indicates none of the frequencies in the specified set satisfy the selection criteria for the BUF at those gridpoints.

6.5 Re-computing an Area prediction

When viewing an Area prediction, the *Re-compute* option in the *View* menu allows changes to be made to the date, index, area of interest, base, frequency set (frequency in Multi-surface format), path type and surface wave parameters. If the default station configuration has been changed before selecting the *Re-compute* option, all the parameter values in the new default station configuration will also be used in computing the new prediction. This prediction can then either be saved to a new file or an existing Area prediction file can be overwritten.

Exercise 34. Re-computing an Area prediction

Change the transmitter site in "tute12a.AHD" (i.e., the "Tokyo" to "austasia" Area prediction) to "Kudat" (6.53° N, 116.46° E). Also change the frequency set for this prediction to "maritime" (2, 4, 6, 8, 12, 16, 22 MHz). Change the sea state loss to "none". Save the new prediction file as "tute13". Use the "statute" station configuration in the computation.

- Select ***Databases|Station configurations*** and ensure the **statute** station configuration is the default. The **tute** station configuration is currently the default station configuration. If **statute** is not specified as the default, the re-computation will use the **tute** station configuration values.

- If **tute12a.AHD** is not open, select ***Predictions|View Predictions*** and from the **Area Predictions (*.AHD)** file types, select **tute12a.AHD**. Note the surface wave prediction in this case would be based on moist ground as specified for **tute12b.AHD** when **tute12a.AHD** is opened. Since a re-computation of **tute12a.AHD** is to be performed, it is not necessary to change this parameter in the **Area Prediction details** dialogue before opening **tute12a.AHD**.
- Otherwise, just display **tute12a.AHD** in any format.
- With **tute12a.AHD** as the current display, select ***View|Re-compute***. The **Area Prediction details** dialogue is displayed.
- Enter **Kudat** in the **Base** list box and press the **Enter** or **spacebar** key on the keyboard. If the **Lat.** and **Long.** fields display values, verify they are correct. If the **Lat.** and **Long.** fields are empty or the values displayed in them are incorrect, click on the button with three dots in the **Base** group box. The **Terminals** dialogue will be displayed. Enter the details for **Kudat**, press ***Add/Modify*** then ***Done***.
- Change the name of the prediction in the **Name** box to **Kudat to austasia**, otherwise **Tokyo to austasia** will be used and may lead to confusion.
- Change the frequency set in the **Frequency Set** list box to **maritime**, change the **Surface Type** to **Sea Water** and the **Sea State Loss** to **None** under the ***Surface Wave Parameters*** button, ensure the other parameters are correct from Exercise 32 (p. 136), click ***OK*** then ***Do Prediction***.
- The **Save Prediction** dialogue is displayed. Call the file **tute13** then press ***Open***.
- The **Open Prediction File** dialogue is displayed. Select **tute13.AHD** and press ***Open***.
- View **tute13.AHD** and confirm the changes made have been used in the prediction.

6.6 Changing station parameters

The parameters specified in the default station configuration, apart from the frequency set, are used in the computation of an Area prediction. The frequency set used in the sky wave and Surface Wave formats of an Area prediction, is specified in the *Area Prediction details* dialogue. The frequency used in the calculation of the Multi-surface format, is specified under the *Surface Wave Parameters* button, in the *Area Prediction details* dialogue.

If Area prediction files are closed and the default station configuration is not that originally used to compute an Area prediction, existing Area prediction files that are re-opened will use most of the station parameter values in the new default station configuration, EXCEPT for the following:

1. Frequency set;
2. Man-made noise;
3. Atmospheric noise model;
4. Polarisation coupling loss algorithm and hence the antenna polarisations;
5. Prediction confidence level.

The Area prediction formats will use the values of these parameters that were specified in the original default station configuration. Note not all formats use all the parameters. However, in the Surface Wave and Multi-surface formats if the *Atmospheric noise* tick box under the *Surface Wave Parameters* button in the *Area Prediction details* dialogue is not ticked when the Area prediction file is re-opened, atmospheric noise will not be included.

When ASAPS is closed and then re-opened previously computed Area prediction files may be viewed. There is an error in the programme that causes incorrect computation of the Surface Wave and Multi-surface formats even though values in the *Surface Wave Parameters* dialogue may have been altered to those originally specified before opening the file. When the Surface Wave and Multi-surface formats are of particular interest, compute the prediction again if ASAPS has been closed. For the sky wave formats, opening a previously computed prediction will produce the same results as those computed before ASAPS was closed provided the correct station configuration is set as the default before opening the prediction.

The frequency set used in the sky wave and Surface Wave formats when re-opening an Area prediction will be that specified in the *Area Prediction details* dialogue when the prediction was originally computed.

To alter the frequency set the sky wave and Surface Wave formats in an existing Area prediction use, open the prediction, select *View|Re-compute*, change the frequency set and any other details in the *Area Prediction details* dialogue, then either save the prediction to a new file or overwrite an existing file.

To alter the man-made noise, atmospheric noise model, polarisation coupling loss (and antenna polarisation if using the *Full Calculation*) and prediction confidence level, change these parameters and any others to those required in the Station Configurations database and set the altered station configuration as the default. If the Area prediction is not open, open and display it. Select *View|Re-compute*, change any values in the *Area Prediction details* dialogue if required and press *Do Prediction*. At this stage either a new Area prediction file can be produced or an existing one, including that being re-computed, can be overwritten.

If it is necessary the values of parameters in the station configuration other than the man-made noise, atmospheric noise model, polarisation coupling loss algorithm (and hence antenna polarisations) and prediction confidence level be altered, open the prediction and select *View|New View|Station Parameters*. Change the values of the parameters (note that if another station configuration is selected then the *Set as default* tick box must be ticked in order to effect the change) and then click *Update View*. The prediction will now reflect the new values specified. At this stage either the *Cancel* button or the *Done* button can be pressed. If the *Cancel* button is pressed, the changes made to the station configuration will not be saved; if the *Done* button is pressed, the changes will be saved and this station configuration will be set as the default.

If an Area prediction file has been opened using a station configuration other than that used to initially compute the prediction, and it is required that the prediction be viewed using the initial station configuration, select *View|New View|Station Parameters*, specify the correct station configuration, set this configuration as the default (this must be done to effect the change), press *Update View* and then either *Cancel* or *Done*. If *Cancel* is pressed, the station configuration will not be set as the default; if *Done* is pressed, this station configuration will become the default.

To display the same Area prediction for two or more different station configurations at the same time, open the file using one station configuration, select *Databases|Station configurations* and alter the values of the parameters as required or choose a new station configuration. Produce a new prediction from *Predictions|Do Area Prediction* or *View|Re-compute*, selecting the appropriate frequency set and call the prediction file another name. The two predictions can now be compared.

Note that if the “Full Calculation” of the polarisation coupling loss algorithm is used, the antenna polarisations are required to be specified. It is therefore important, when changing the station configuration used by an Area prediction, to ensure that new antennas have the same polarisations as the antennas originally used to produce the prediction. If different antenna polarisations are required then alter the station configuration and produce a new prediction.

If either the Field Strength or GRAFEX prediction files associated with the Area prediction file being viewed are open, they are unaffected by the *Update View|Cancel* process. However, if *Update View|Done* is selected, the GRAFEX SNR formats and Field Strength views will also reflect the changes when a new format is viewed.

Exercise 35. Altering station parameters

Determine whether decreasing the Min. Angle in the "statute" station configuration to 5° increases the area coverage of the BUF in the Area prediction "tute13.AHD". Save this change to the "statute" station configuration.

- If **tute13.AHD** is not open, select ***Predictions|View Predictions***, select the **Area Predictions (*.AHD)** file type and open **tute13.AHD**. In this case, the default station configuration is **statute** from Exercise 34 which was used to produce **tute13.AHD**. If another station configuration was the default, it would be necessary to change the default to **statute** before opening **tute13.AHD**.
- With **tute13.AHD** displayed in any format, press ***View|New View|Station Parameters*** to view the **Station Configuration** dialogue. Change the **Min. Angle** value to **5** then press ***Update View***, answer ***Yes*** and press ***Done***. Pressing ***Done*** rather than ***Cancel*** saves the change to the default station configuration, **statute**.
- The area of coverage should have increased because determination of the BUF relies partly on the take-off angle. In general, the greater the minimum take-off angle (Min. Angle), Required S/N or probability of ionospheric support (Required % Days), the less area coverage is to be expected.
- Note that this change only affects the Area prediction file that is currently being viewed. Other Area prediction files that are open are not affected by the change.

Exercise 36. Altering station parameters and re-computing an Area prediction

Alter the station parameters used in "tute12b.AHD" to the following: Tx Power = 750 W, Tx/Rx Antenna = VLP (Vertical), Man-made Noise = -150 dBW/Hz, Bandwidth = 3000 Hz, Required S/N = 2 dB, Min. Angle = 3°, Required % Days = 50, Polarisation Coupling Loss = Full Calculation, Prediction Confidence Level = 50% and Atmospheric Noise = ITU 372-8.

Re-compute "tute12b.AHD" for next month (and next year if current month is December) using the "broadcast" frequency set with the following surface wave parameters: moist ground using 2 metre vertical dipoles at ground level with 100% efficiency, including atmospheric noise and a multi-surface frequency = 1300 kHz. Call the new file "tute14".

- If **tute12b.AHD** is not open, select ***Predictions|View Predictions*** and open the file. It doesn't matter at this stage that the station configuration selected as the default is not that originally used to produce **tute12b.AHD** since changes are to be made.
- Select ***Databases|Station configurations*** and change the values in **tute** to those required. Ensure the **tute** station configuration is specified as the default. Select ***Add/Modify*** then ***Done***.
- Select ***View|Re-compute***. The **Area Prediction details** dialogue is displayed. Change the month, frequency set and surface wave parameters.
- Press ***Do Prediction*** and save the file as **tute14** in the **Save Prediction** dialogue. When the **Open Prediction File** dialogue is displayed select **tute14.AHD**.
- Verify the changes have been made from the parameters used in the **tute12b.AHD**.

6.7 Area prediction analysis

Exercise 37. Area prediction analysis

One-way, short path communications between 23 and 04 UT using the maritime frequency set or another more suitable set containing seven frequencies, are required from Manila to locations in the area called “asia1” bounded by 15° N to 5° S and 105° E to 125° E (gridpoints every 2° latitude and longitude, 11 rows and 11 columns) in October with T = 94.

The station parameters are: Tx Power = 1000 W, Polarisation Coupling Loss = Full Calculation, Tx Antenna = Rx Antenna = HLP (Horizontal), Frequency Set = maritime, Man-made Noise = -145 dBW/Hz, Bandwidth = 3000 Hz, Required S/N = 3 dB, Min. Angle = 5°, Required % Days = 75%, Prediction Confidence Level = 90% and Atmospheric Noise = ITU 372-8.

Use the following surface wave parameters in the prediction: Surface Type = sea water, Sea State Loss = none, Tx Antenna = Rx Antenna = vertical monopole, length = 10 m, height = 0 m, efficiency = 100%, include atmospheric noise and multi-surface frequency = 1100 kHz.

Produce an Area prediction called “tute15” for these communications.

- Select ***Predictions|Do Prediction*** and under the ***Frequency Set Selection/Testing*** button tick the hours from **23** to **04** UT and enter the minimum and maximum number of frequencies as **7** and **7**, respectively. Press ***OK*** then ***Cancel*** at the **Prediction Details** dialogue. This action has no effect on the resulting Area prediction, **tute15.AHD**, but is required for Exercise 38 (p. 166) where the associated GRAFEX prediction, **tute15.PRD**, is viewed.
- Set up the station configuration from ***Databases|Station configurations*** and set it as the default. It is not necessary to select the **maritime** frequency set in this default station configuration when just viewing the resulting Area prediction since the frequency set an Area prediction uses is specified in the **Area Prediction details** dialogue. However, it is necessary the **maritime** frequency set be specified in this default station configuration if the associated GRAFEX prediction is to use this frequency set. The associated GRAFEX prediction will be discussed in Exercise 38.
- Produce the Area prediction, ***Predictions|Do Area Prediction***. Ensure the correct values (Manila is the Tx) are entered and surface wave parameters above are specified under the ***Surface Wave Parameters*** button. Call the file **tute15**.
- Open the Area prediction **tute15.AHD**.

6.7.1 Best Usable Frequency (BUF) (b)

The following analysis concerns the Area prediction results from Exercise 37 for 00 UT only.

This format displays the frequency at each gridpoint that has the highest signal-to-noise of those frequency/mode combinations that satisfy the required signal-to-noise, minimum take-off angle and probability of ionospheric support values specified in the default station configuration. If one or more of these three parameters is not satisfied at a particular gridpoint by all frequency/mode combinations, the "…" symbol will be displayed at that gridpoint in the Area prediction table. In the Area prediction graph, the area near the gridpoint will be uncoloured.

In Table 37 and Figure 3, the BUF is 16 MHz at the gridpoint, 5° N, 115° E. That is, 16 MHz has the highest signal-to-noise value of any of the "maritime" frequencies that satisfy the required signal-to-noise (3 dB), minimum take-off angle (5°) and probability of ionospheric support (75%) parameters specified in the default station configuration at this gridpoint.

16 MHz is the BUF at 5° N, 115° E on a particular mode (see Section 6.7.2). View the Modes format (*d*) to determine on which mode 16 MHz is selected as the BUF. Other frequency/mode combinations may satisfy the required signal-to-noise, minimum take-off angle and probability of ionospheric support values that were specified in the default station configuration. However, 16 MHz on the 1F mode has the highest signal-to-noise. To examine the signal-to-noise, take-off angle and probability values of the frequencies in the "maritime" set for different modes, the associated Field Strength prediction tute15.FSH should be viewed (select *Predictions|View Predictions* and select the *Field Strength files (*.FSH)* file type).

The Field Strength prediction, tute15.FSH (and GRAFEX prediction, tute15.PRD), will contain as many circuits as gridpoints used in the Area prediction. In tute15, the GRAFEX and Field Strength predictions will both contain 121 circuits (11 rows, 11 columns in the "asia1" area of interest). The circuits display information for communications from the base, Manila, to each gridpoint. Ensure that when studying the associated GRAFEX and Field Strength predictions, the correct circuit is viewed. Circuit 61 in the GRAFEX and Field Strength files associated with tute15.AHD contains information for communications from Manila to 5° N, 115° E. To view the GRAFEX prediction of tute15, select *Predictions|View Predictions* and select the *GRAFEX Predictions (*.PRD)* file type.

Table 37. Extract of Best Usable Frequency (BUF) results for Exercise 37.

```
==============================================================================
ASAPS V5 AREA PREDICTION ------------------------------------- 24 Oct 2008
================================================================================
Area 1: Manila to asia1                                     Date: October 2008
Tx: Manila           14.58   120.98                         T-index: 94
FSet: maritime       Min.Angle:  5deg  Path: Short Path     TxAntenna: HLP H
BandWidth: 3.0kHz    Noise:-145dBW/Hz Atm.ITU               RxAntenna: HLP H
Full PCLoss    PredConf.90%  Required S/N:3dB    %Days:75   Power:1000 W
    Best Usable Frequency    UT 00
================================================================================
```

lat/lon	105.00	107.00	109.00	111.00	113.00	115.00	117.00	119.00	121.00	123.00	125.00
15.00	22.000	16.000	16.000	16.000	12.000	12.000	8.000	6.000	6.000	6.000	8.000
13.00	22.000	16.000	16.000	16.000	12.000	12.000	8.000	8.000	6.000	8.000	8.000
11.00	22.000	16.000	16.000	16.000	12.000	12.000	12.000	8.000	8.000	8.000	12.000
9.00	22.000	22.000	16.000	16.000	16.000	12.000	12.000	12.000	12.000	12.000	12.000
7.00	22.000	22.000	16.000	16.000	16.000	16.000	12.000	12.000	12.000	12.000	12.000
5.00	12.000	22.000	22.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000
3.00	16.000	22.000	22.000	22.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000
1.00	16.000	16.000	22.000	22.000	22.000	22.000	16.000	16.000	16.000	16.000	16.000
-1.00	16.000	16.000	16.000	22.000	22.000	22.000	22.000	22.000	22.000	22.000	22.000
-3.00	16.000	16.000	16.000	22.000	22.000	22.000	22.000	22.000	22.000	22.000	22.000
-5.00	16.000	16.000	16.000	16.000	22.000	22.000	22.000	22.000	22.000	22.000	22.000

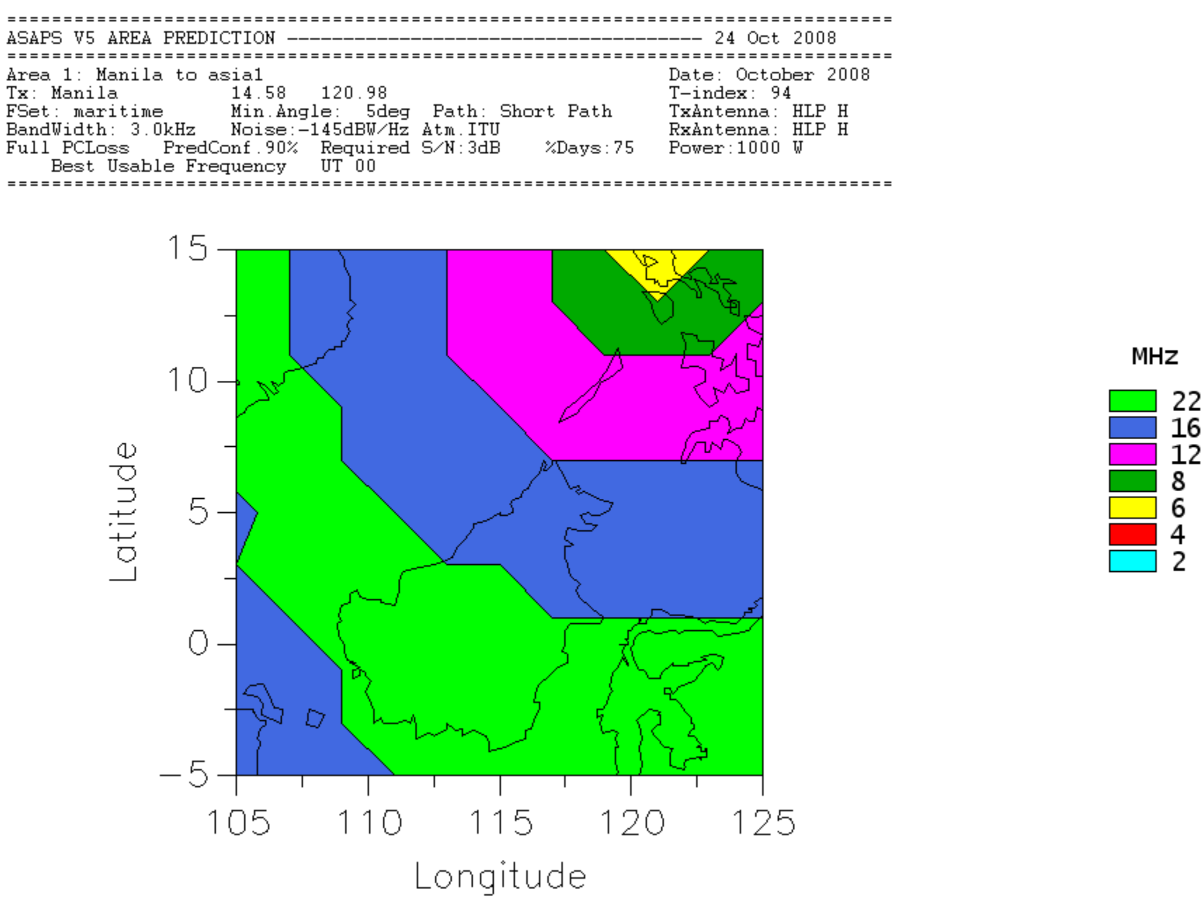

Figure 3. BUF at 00 UT for Exercise 37.

6.7.2 Propagation mode of the BUF (d)

The following analysis concerns the Area prediction results from Exercise 37 for 00 UT only.

Table 38 and Figure 4 display the propagation modes on which the BUFs occur at the gridpoints in the specified area. It can be seen that at the gridpoint, 5° N, 115° E, the BUF mode is the 1F (the BUF at this location is 16 MHz). Note that 16 MHz is only the BUF on the 1F mode at this particular gridpoint. 16 MHz may propagate from Manila to this gridpoint on other modes achieving the required signal-to-noise, but 16 MHz on these other modes will have lower signal-to-noise values. At 00 UT, other frequency/mode combinations may also propagate from Manila to this gridpoint, satisfying the required signal-to-noise, probability of ionospheric support and minimum take-off angle values, but they will also have lower signal-to-noise values than 16 MHz propagating on the 1F mode. The associated Field Strength prediction file, tute15.FSH, can be viewed to obtain more information concerning other frequency/mode combinations that may meet the three requirements (see the Probability, Take-off Angle and Signal-to-Noise formats for the different modes of tute15.FSH).

Table 38. BUF propagation mode results at 00 UT for Exercise 37.

```
================================================================================
ASAPS V5 AREA PREDICTION ------------------------------------- 24 Oct 2008
================================================================================
Area 1: Manila to asia1                                      Date: October 2008
Tx: Manila          14.58   120.98                           T-index: 94
FSet: maritime      Min.Angle:  5deg  Path: Short Path       TxAntenna: HLP H
BandWidth: 3.0kHz   Noise:-145dBW/Hz Atm.ITU                 RxAntenna: HLP H
Full PCLoss    PredConf.90%  Required S/N:3dB    %Days:75    Power:1000 W
                 BUF Mode    UT 00
================================================================================
```

lat/lon	105.00	107.00	109.00	111.00	113.00	115.00	117.00	119.00	121.00	123.00	125.00
15.00	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F
13.00	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F
11.00	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F
9.00	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F
7.00	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F
5.00	1E	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F
3.00	2F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F
1.00	2F	2F	1F	1F	1F	1F	1F	1F	1F	1F	1F
-1.00	2F	2F	2F	1F	1F	1F	1F	1F	1F	1F	1F
-3.00	2F	2F	2F	1F	1F	1F	1F	1F	1F	1F	1F
-5.00	2F	2F	2F	2F	1F	1F	1F	1F	1F	1F	1F

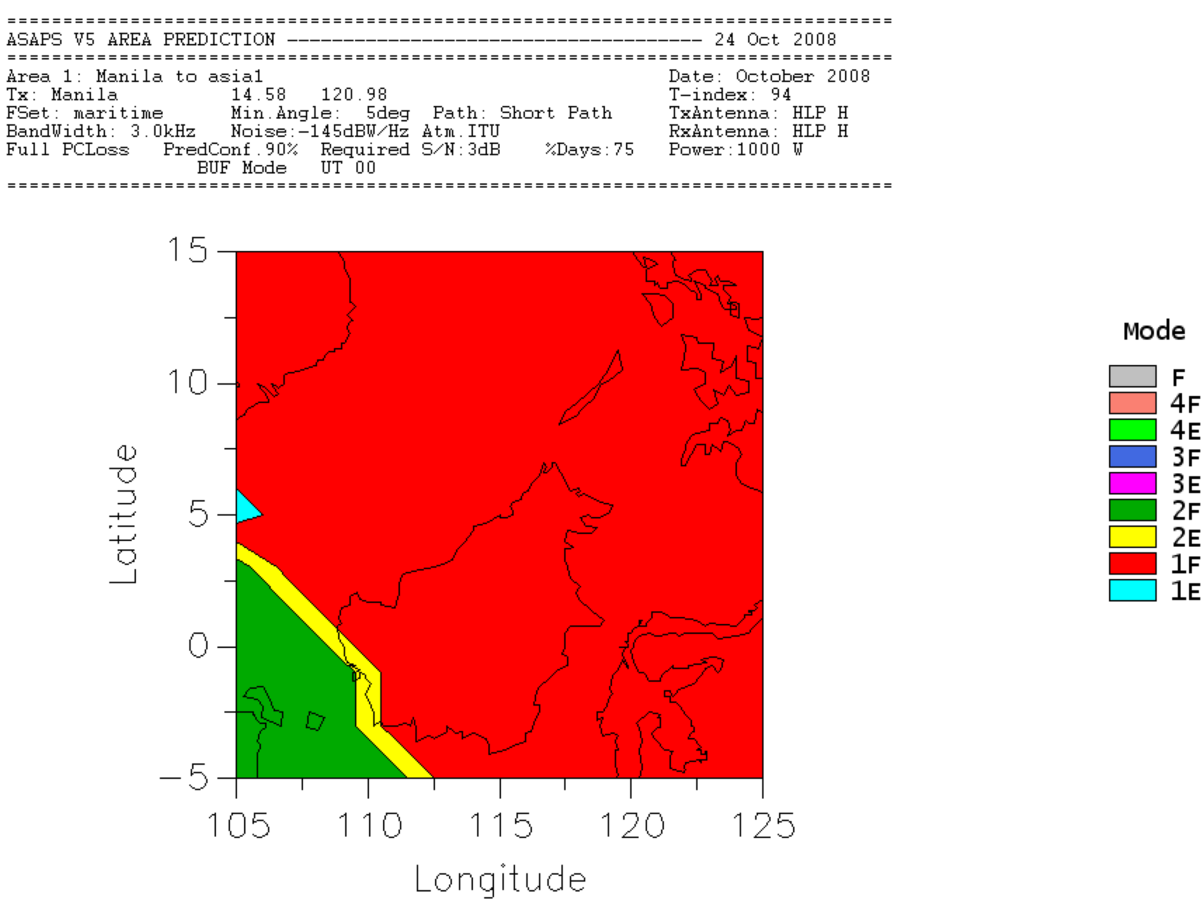

Figure 4. Propagation mode of the BUF at 00 UT for Exercise 37.

6.7.3 OWF on the BUF mode (o) and MUF on the BUF mode (m)

The following analysis concerns the Area prediction results from Exercise 37 for 00 UT only.

This format displays the OWF on the BUF mode, that is, the frequency that should be supported 90% of the time for a particular hour and location. At gridpoint (5° N, 115° E), the BUF mode at 00 UT is the 1F mode (Table 38, p. 147). Therefore, the OWF on the 1F mode is displayed at 5° N, 115° E in Table 39 and Figure 5.

The OWFs for the different modes, including any E modes, are listed in the tabular views of the corresponding Field Strength prediction, tute15.FSH.

From Figure 5, the OWF on the BUF mode for communications from Manila to gridpoint, 5° N, 115° E, looks to be between 17 and 19 MHz at 00 UT. Table 39 indicates that at 00 UT, the OWF on the 1F mode at 5° N, 115° E is 17.1 MHz. That is, a radio wave propagating from Manila to 5° N, 115° E on a frequency of 17.1 MHz via the 1F mode should be supported for 90% of the duration of the prediction (i.e., for the month of October with T = 94) at 00 UT, if the prediction is correct. The BUF at 5° N, 115° E at 00 UT is 16 MHz which is below the OWF of 17.1 MHz. Therefore, 16 MHz is likely to propagate successfully more than 90% of the time, if the prediction is correct.

The MUF on the BUF mode (*m*) displays the frequency that is likely to propagate, on the BUF mode, successfully 50% of the time at that hour for communications from Manila to a gridpoint. The MUF displayed at a particular gridpoint will be the MUF that occurs on the BUF mode. For example at 5° S, 111° E, the BUF mode from Table 38 (p. 147) is the 2F. The frequency displayed in the MUF on the BUF mode at this gridpoint will be the MUF for the 2F mode, which is 18 MHz.

Table 39. OWF on the BUF propagation mode at 00 UT for Exercise 37.

```
=================================================================================
ASAPS V5 AREA PREDICTION ------------------------------------- 24 Oct 2008
=================================================================================
Area 1: Manila to asia1                                          Date: October 2008
Tx: Manila            14.58    120.98                            T-index: 94
FSet: maritime        Min.Angle:   5deg  Path: Short Path        TxAntenna: HLP H
BandWidth: 3.0kHz     Noise:-145dBW/Hz Atm.ITU                   RxAntenna: HLP H
Full PCLoss     PredConf.90%  Required S/N:3dB     %Days:75      Power:1000 W
          OWF on BUF Mode     UT 00
=================================================================================
```

lat/lon	105.00	107.00	109.00	111.00	113.00	115.00	117.00	119.00	121.00	123.00	125.00
15.00	20.5	19.0	17.3	15.1	13.4	12.1	10.9	10.3	9.9	10.4	11.2
13.00	21.0	19.1	17.3	15.6	13.9	12.2	11.0	10.6	10.2	10.7	11.3
11.00	21.5	19.5	17.9	16.1	14.4	13.0	12.0	11.2	11.1	11.4	12.2
9.00	21.9	20.4	18.8	17.0	15.3	14.1	13.1	12.4	12.2	12.5	13.1
7.00	22.7	21.3	19.7	18.5	16.7	15.4	14.6	13.9	13.9	13.9	14.6
5.00	14.2	22.0	20.9	19.3	18.4	17.1	16.2	15.8	15.4	15.8	16.1
3.00	15.0	22.9	21.9	20.8	19.5	18.6	17.8	17.3	17.3	17.2	17.5
1.00	15.3	14.9	22.8	21.6	21.0	20.2	19.3	18.9	18.8	19.0	18.9
-1.00	16.0	15.2	14.8	22.8	22.2	21.4	21.0	20.6	20.5	20.4	20.7
-3.00	16.4	16.0	15.6	23.8	23.2	22.6	22.2	21.8	21.7	21.6	21.8
-5.00	17.3	16.9	15.9	15.5	24.1	23.5	23.2	23.2	23.1	23.0	23.0

```
=================================================================================
```

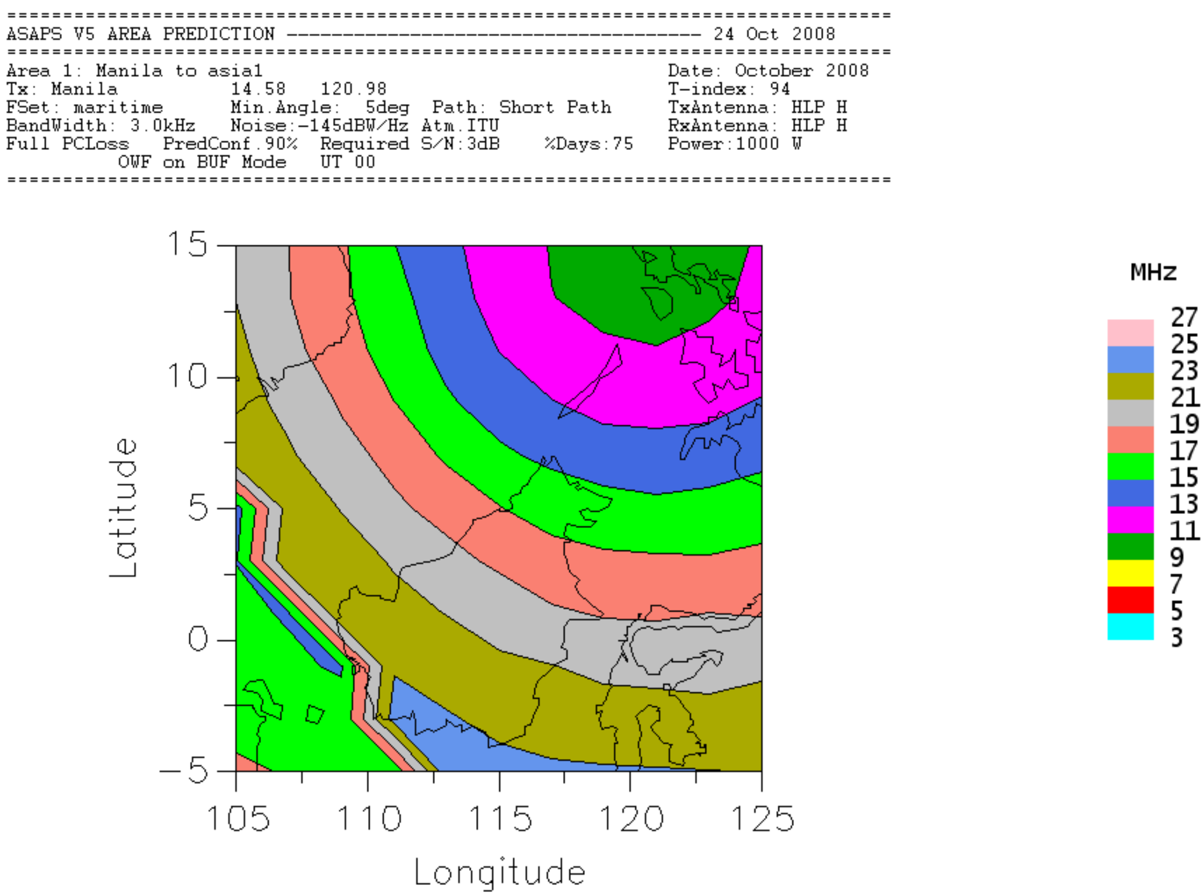

Figure 5. OWF on the BUF mode at 00 UT for Exercise 37.

6.7.4 Signal-to-noise at the BUF (x)

The following analysis concerns the Area prediction results from Exercise 37 for 00 UT only.

This format displays the predicted signal-to-noise values, in decibels, of the BUF for the specified receiver bandwidth and prediction confidence level. Figure 6 shows the predicted signal-to-noise for the BUF (16 MHz) at 5° N, 115° E at 00 UT lies between 38 and 41 dB. From Table 40, the predicted signal-to-noise at 5° N, 115° E for this hour is 39 dB. This predicted value is well above the Required S/N of 3 dB that was specified in the default station configuration.

The signal-to-noise values displayed in the SNR @ BUF, SNR @ MUF and SNR @ OWF formats are based on the prediction confidence level specified in the default station configuration. When the prediction confidence level is higher, the predicted signal-to-noise values are lower. Therefore, the less likely a frequency/mode combination's signal-to-noise will meet the Required S/N. The predicted area of coverage is then likely to be smaller than if a lower prediction confidence level was specified.

At 5° N, 115° E, it is expected 90% (the specified prediction confidence level) of all measurements of signal-to-noise at this hour for this particular month and index will exceed a signal-to-noise of 39 dB, based on the values of the parameters in the default station configuration. This is well above the Required S/N of 3 dB (specified in the default station configuration) so that even for worst case, communications at 16 MHz on the 1F mode should be successful most of the time from Manila to this gridpoint.

The SNR @ MUF (*y*) format displays the predicted signal-to-noise of the MUF for the mode selected as the BUF mode. For example, at 5° N, 115° E, Table 38 (p. 147) shows the BUF mode to be the 1F at 00 UT. The SNR @ MUF format will then display the predicted signal-to-noise of the MUF, 20 MHz, for the 1F mode for communications from Manila to this gridpoint, 40 dB.

The SNR @ OWF (*z*) format displays the predicted signal-to-noise of the OWF on the mode selected for the BUF. At 5° N, 115° E the OWF on the BUF mode is 17.1 MHz which has a signal-to-noise of 41 dB on the BUF mode (1F).

Table 40. BUF signal-to-noise at 00 UT for Exercise 37.

```
================================================================================
ASAPS V5 AREA PREDICTION ------------------------------------- 24 Oct 2008
================================================================================
Area 1: Manila to asia1                                     Date: October 2008
Tx: Manila          14.58   120.98                          T-index: 94
FSet: maritime      Min.Angle:  5deg  Path: Short Path      TxAntenna: HLP H
BandWidth: 3.0kHz   Noise:-145dBW/Hz Atm.ITU                RxAntenna: HLP H
Full PCLoss     PredConf.90%  Required S/N:3dB    %Days:75   Power:1000 W
                 S/N @ BUF    UT 00
================================================================================
```

lat/lon	105.00	107.00	109.00	111.00	113.00	115.00	117.00	119.00	121.00	123.00	125.00
15.00	35	36	41	39	40	40	36	31	27	32	36
13.00	34	35	40	40	40	40	37	32	30	33	37
11.00	34	34	39	39	39	40	39	35	35	36	39
9.00	33	36	37	40	39	39	39	39	40	40	40
7.00	31	35	35	39	39	39	38	39	40	39	39
5.00	31	33	36	36	39	39	39	38	39	39	38
3.00	32	31	33	36	35	38	39	39	39	39	38
1.00	32	31	31	33	35	38	35	36	38	37	36
-1.00	31	31	31	30	32	34	35	36	37	37	36
-3.00	31	31	31	28	29	31	32	32	33	33	32
-5.00	30	31	26	26	27	28	29	29	30	30	29

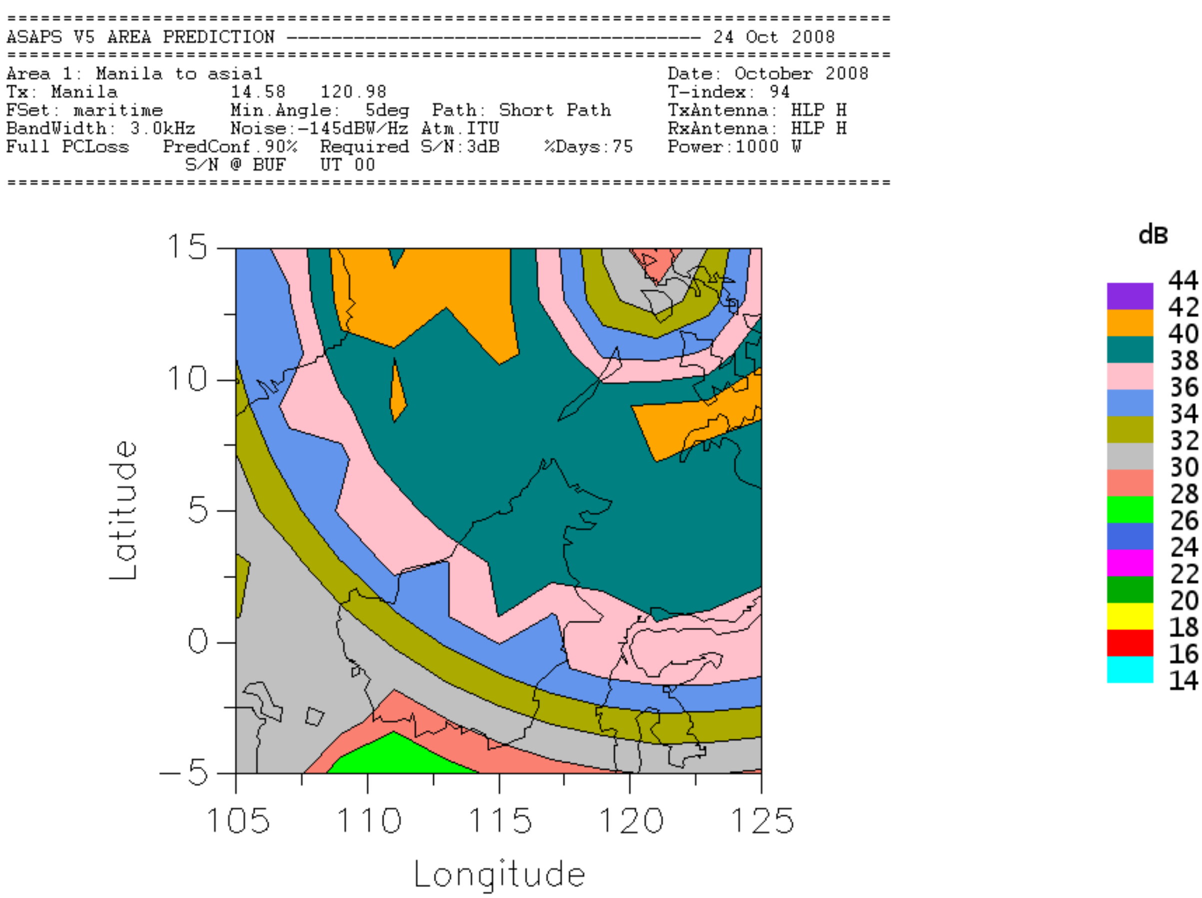

Figure 6. Signal-to-noise on the BUF at 00 UT for Exercise 37.

6.7.5 Noise field strength at the BUF (n)

The following analysis concerns the Area prediction results from Exercise 37 for 00 UT only.

This format displays the amplitude or field strength of the noise at the input to the receiving antenna for the BUF, in dBµV/m (Section 5.1.11). The noise at a receiver site is a combination of atmospheric, galactic and man-made noise (see Section 5.1.5). The man-made noise is the same at all gridpoints in the area and is based on the value specified in the default station configuration. Galactic and atmospheric noise levels vary with location. The variations in noise field strength for an Area prediction are therefore the result of the three noise contributions and the BUF, since noise levels are generally higher at lower frequencies.

Table 41 and Figure 7 show the noise field strength is greatest (less negative values indicate greater noise levels) near the transmitter site, Manila, which is located at 14.58° N, 120.98° E, then decreases with increasing path length until locations are reached where the noise field strength increases again. A study of the BUF format shows the BUFs are lower nearer Manila, increase to 22 MHz at greater distances then decrease to 16 MHz at the furthest gridpoints. This Area prediction format is thus reflecting the relationship between frequency and noise field strength.

Table 41. Noise field strength on the BUF and BUF mode at 00 UT for Exercise 37.

```
================================================================================
ASAPS V5 AREA PREDICTION ------------------------------------- 24 Oct 2008
================================================================================
Area 1: Manila to asia1                                        Date: October 2008
Tx: Manila           14.58   120.98                            T-index: 94
FSet: maritime       Min.Angle:  5deg  Path: Short Path        TxAntenna: HLP H
BandWidth: 3.0kHz    Noise:-145dBW/Hz Atm.ITU                  RxAntenna: HLP H
Full PCLoss    PredConf.90%  Required S/N:3dB    %Days:75      Power:1000 W
Noise field strength @ BUF    UT 00
================================================================================
```

lat/lon	105.00	107.00	109.00	111.00	113.00	115.00	117.00	119.00	121.00	123.00	125.00
15.00	-34	-32	-32	-32	-30	-30	-28	-28	-29	-29	-30
13.00	-34	-32	-32	-32	-30	-29	-28	-28	-29	-30	-30
11.00	-34	-32	-32	-32	-29	-29	-29	-28	-29	-30	-30
9.00	-34	-34	-32	-32	-31	-29	-29	-29	-30	-30	-30
7.00	-34	-34	-32	-32	-32	-31	-29	-29	-30	-30	-30
5.00	-30	-34	-34	-32	-32	-32	-31	-31	-32	-32	-32
3.00	-32	-34	-34	-34	-32	-32	-31	-31	-32	-32	-32
1.00	-32	-32	-34	-34	-34	-34	-32	-31	-32	-32	-32
-1.00	-32	-32	-32	-34	-34	-34	-34	-34	-34	-34	-34
-3.00	-32	-32	-32	-34	-34	-34	-34	-34	-34	-34	-34
-5.00	-32	-32	-32	-32	-34	-34	-34	-34	-34	-34	-34

```
================================================================================
ASAPS V5 AREA PREDICTION ------------------------------------- 24 Oct 2008
================================================================================
Area 1: Manila to asia1                                        Date: October 2008
Tx: Manila           14.58   120.98                            T-index: 94
FSet: maritime       Min.Angle:  5deg  Path: Short Path        TxAntenna: HLP H
BandWidth: 3.0kHz    Noise:-145dBW/Hz Atm.ITU                  RxAntenna: HLP H
Full PCLoss    PredConf.90%  Required S/N:3dB    %Days:75      Power:1000 W
Noise field strength @ BUF    UT 00
================================================================================
```

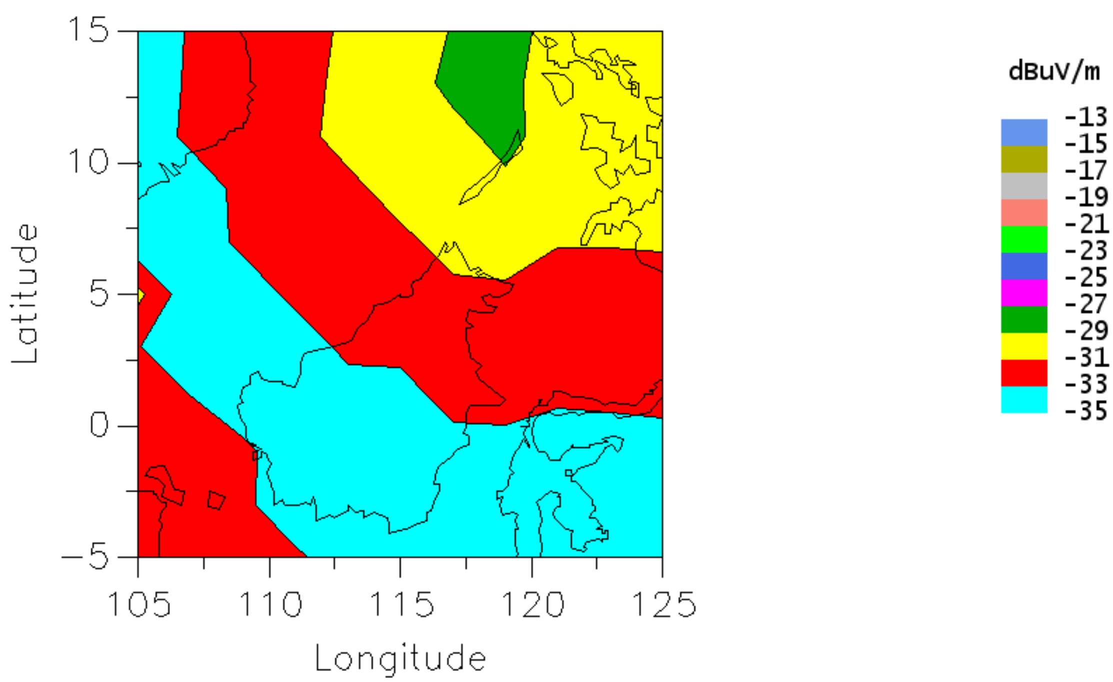

Figure 7. Noise field strength on the BUF at 00 UT for Exercise 37.

6.7.6 Probability of the BUF (p)

The following analysis concerns the Area prediction results from Exercise 37 for 00 UT only.

This format displays the probability of ionospheric support for those frequency/mode combinations selected as the BUFs. Table 38 (p. 147) displays the modes on which the BUFs occur. In this exercise, the Required % Days specified in the default station configuration was 75%. That is, a frequency selected as the BUF for a certain hour at a particular gridpoint may actually be higher than the OWF, which has a probability of ionospheric support of 90%, but lower than the MUF which has a support rating of 50%. Frequencies lower than an OWF that are chosen as the BUF are given a 99% support rating.

From Table 42 and Figure 8, there is a 99% probability of the BUF (16 MHz on the 1F mode, see Table 37, p. 145 and Table 38, p. 147) being supported by the ionosphere when the radio wave propagates from Manila to gridpoint 5° N, 115° E. This indicates the BUF is lower than the OWF at this gridpoint since the OWF has a 90% chance of support (at this location the OWF is 17.1 MHz, Table 39, p. 149). Therefore, at 00 UT, 16 MHz will be reflected from the ionosphere more than 90% (27 days) of the month, if the prediction is correct.

At 1° N, 115° E, the probability of the BUF being supported by the ionosphere is 75%. That is, the BUF is higher than the OWF and lower than the MUF at this particular location. The BUF format in Table 37 (p. 145) shows the BUF at this location to be 22 MHz (on the 1F mode, Table 38, p. 147). The OWF on the BUF format (Table 39, p. 149) indicates the OWF at 1° N, 115° E is 20.2 MHz and the MUF on the BUF format shows the MUF at this gridpoint to be 23.6 MHz.

Table 42. Probability of ionospheric support of the BUF at 00 UT for Exercise 37.

```
==============================================================================
ASAPS V5 AREA PREDICTION ------------------------------------ 24 Oct 2008
==============================================================================
Area 1: Manila to asia1                                      Date: October 2008
Tx: Manila          14.58   120.98                           T-index: 94
FSet: maritime      Min.Angle:  5deg  Path: Short Path       TxAntenna: HLP H
BandWidth: 3.0kHz   Noise:-145dBW/Hz Atm.ITU                 RxAntenna: HLP H
Full PCLoss   PredConf.90%  Required S/N:3dB    %Days:75     Power:1000 W
        Probability @ BUF   UT 00
==============================================================================
```

lat/lon	105.00	107.00	109.00	111.00	113.00	115.00	117.00	119.00	121.00	123.00	125.00
15.00	79	99	99	81	99	99	99	99	99	99	99
13.00	83	99	99	86	99	99	99	99	99	99	99
11.00	87	99	99	99	99	99	99	99	99	99	99
9.00	89	78	99	99	83	99	99	99	99	99	99
7.00	99	85	99	99	99	84	99	99	99	99	99
5.00	99	89	83	99	99	99	99	88	84	88	99
3.00	79	99	89	81	99	99	99	99	99	99	99
1.00	82	77	99	88	83	75	99	99	99	99	99
-1.00	99	82	77	99	99	86	83	80	79	78	80
-3.00	99	99	86	99	99	99	99	88	88	87	89
-5.00	99	99	89	85	99	99	99	99	99	99	99

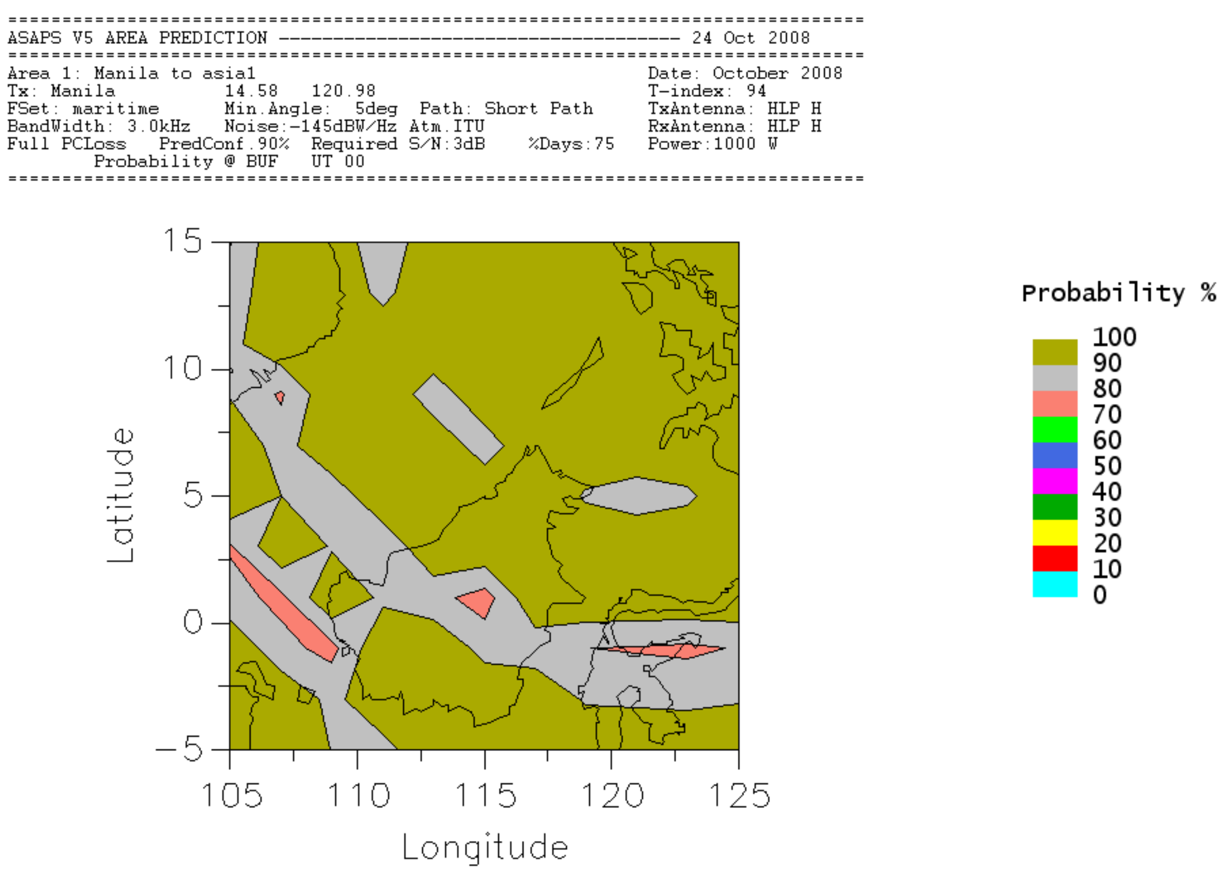

Figure 8. Probability of ionospheric support for the BUF at 00 UT for Exercise 37.

6.7.7 Take-off angle of the BUF (t)

The following analysis concerns the Area prediction results from Exercise 37 for 00 UT only.

This format displays the predicted elevation angle of the BUF.

From Figure 9, the take-off angle for the BUF (16 MHz) at 00 UT via the BUF mode (1F) from Manila to 5° N, 115° E is between 19 and 26°. Table 43 shows the take-off angle to be 22° at this gridpoint.

Both Table 43 and Figure 9 show the take-off angles to decrease with increasing path length, before increasing then decreasing again (from Manila to south-west). Table 38 (p. 147) and Figure 4 (p. 147) show the BUF propagation mode changes from the 1F closer to Manila, to the 2F at longer distances. As the circuit length increases on the 1F mode, the take-off angles decrease. For the Horizontal Log Periodic antennas, the gain drops off rapidly at the lower angles, so the preferred propagation mode for longer distances switches to the 2F mode, which has a take-off angle much closer to the angle of maximum gain of the antenna. Hence, the take-off angle for the BUF increases to higher values at the mode transition distance, but then decreases again as the path continues to lengthen.

Table 43. Predicted launch angles for the BUF on the BUF mode at 00 UT for Exercise 37.

```
================================================================================
ASAPS V5 AREA PREDICTION ------------------------------------- 24 Oct 2008
================================================================================
Area 1: Manila to asia1                                      Date: October 2008
Tx: Manila           14.58   120.98                          T-index: 94
FSet: maritime       Min.Angle:   5deg  Path: Short Path     TxAntenna: HLP H
BandWidth: 3.0kHz    Noise:-145dBW/Hz Atm.ITU                RxAntenna: HLP H
Full PCLoss    PredConf.90%  Required S/N:3dB    %Days:75    Power:1000 W
     Take-off Angle @ BUF    UT 00
================================================================================
```

lat/lon	105.00	107.00	109.00	111.00	113.00	115.00	117.00	119.00	121.00	123.00	125.00
15.00	14	16	20	26	31	40	52	68	90	69	52
13.00	14	16	20	25	30	39	50	64	73	64	51
11.00	13	15	19	24	28	35	44	51	55	52	45
9.00	13	16	18	21	27	31	36	41	43	42	37
7.00	11	14	16	19	23	28	30	33	34	33	31
5.00	26	13	15	17	20	22	25	28	29	28	27
3.00	26	11	13	16	17	19	21	22	23	23	22
1.00	24	27	11	13	16	18	17	18	19	19	18
-1.00	22	25	27	11	13	14	16	17	17	17	17
-3.00	20	22	24	9	11	12	13	14	14	14	14
-5.00	18	20	22	24	9	10	10	11	11	11	11

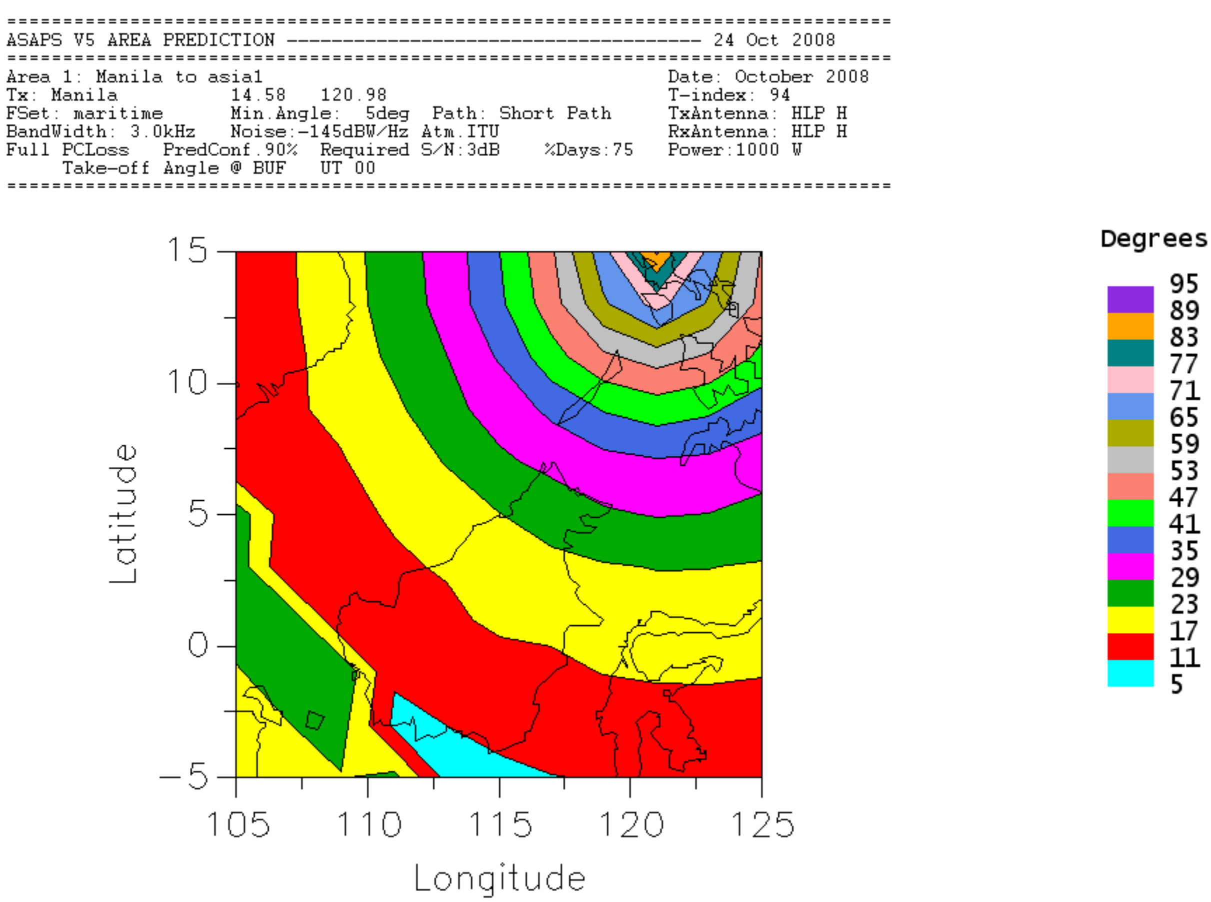

Figure 9. Take-off angle of the BUF at 00 UT for Exercise 37.

6.7.8 Surface wave prediction (s)

The following analysis concerns the Area prediction results from Exercise 37 for 00 UT only.

In general, lower frequencies propagate to greater distances across the Earth's surface. The surface wave coverage prediction can be considered a map where the range of the lowest frequency is laid down first and higher frequencies have their ranges successively laid on top. The result is that the ranges of the lower frequencies are obscured closer to the base by the ranges of the higher frequencies.

A frequency's predicted signal-to-noise at a gridpoint must meet the required signal-to-noise specified in the default station configuration. Those areas on an Area prediction graph that are not coloured indicate the signal-to-noise ratios of all frequencies in the specified frequency set do not meet the required signal-to-noise. The Area prediction table of the surface wave coverage will display "…" at gridpoints where the required signal-to-noise is not met be any frequency in the set.

Figure 10 and Table 44 show the surface wave coverage for Exercise 37 is restricted to the north-east corner of the area of interest. None of the frequencies in the "maritime" frequency set are predicted to propagate via the surface wave from Manila to 5° N, 115° E with a signal-to-noise value of at least 3 dB. This is because the surface wave is normally restricted to a few hundred kilometres over sea water (as is the case in this exercise), or a few tens of kilometres over land. Note the surface wave coverage prediction was computed for propagation over sea water.

Table 44 shows that all frequencies in the "maritime" frequency set will propagate via the surface wave from Manila to 13° N, 121° E, satisfying the required signal-to-noise. The range of the frequencies decreases dramatically as the distance from Manila increases. Only 2, 4, 6 and 8 MHz are predicted to propagate to 13° N, 125° E; 2, 4 and 6 MHz are predicted to propagate to 11° N, 125° E and only 2 MHz propagates to 11° N, 115° E with the required signal-to-noise.

The areas of coverage of the lower frequencies are more obvious if the area of interest is reduced in size and the grid resolution is increased from 5° to 1° separation in latitude and longitude, as in Table 45 and Figure 11 (both on p. 160).

In this exercise, Manila was specified as the transmitter. That is, the Surface Wave format is applicable for one-way communications from Manila to locations in the area. If communications were required from locations within the area to Manila, ideally another prediction should be computed where Manila is specified as the receiver. This is because the atmospheric noise at each of the gridpoints and the base are likely to be different. A comparison of the two predictions may show similar results in the Surface Wave format, particularly if the man-made noise is high, as is the case in this exercise. However, when man-made noise is low, there are likely to be distinct differences in the range of the surface wave between two such predictions.

Table 44. Predicted highest frequency propagating via the surface wave from Manila and achieving the required signal-to-noise at 00 UT.

ASAPS V5 AREA PREDICTION ------------------------------------

Area 1: Manila to asia1 Date: October 2008
Tx: Manila 14.58 120.98 T-index: 94
FSet: maritime TxAntenna: Vert. Monopole RxAntenna: Vert. Monopole
BandWidth: 3.0kHz Noise:-145dBW/Hz Atm.ITU Sea:Calm Power:1000 W
Required S/N:3dB PredConf.90% Permittivity=80.000, Conductivity=5.00000 S/m
Surface Wave UT 00

lat/lon	105.00	107.00	109.00	111.00	113.00	115.00	117.00	119.00	121.00	123.00	125.00
15.00	...	...	...	...	...	4.000	12.000	22.000	22.000	22.000	8.000
13.00	...	...	...	...	...	4.000	8.000	16.000	22.000	16.000	8.000
11.00	...	...	...	...	...	2.000	6.000	8.000	12.000	8.000	6.000
9.00	...	...	...	...	...	...	2.000	4.000	4.000	4.000	2.000
7.00	...	...	...	...	...	...	...	...	...	...	...
5.00	...	...	...	...	...	...	...	...	...	...	...
3.00	...	...	...	...	...	...	...	...	...	...	...
1.00	...	...	...	...	...	...	...	...	...	...	...
-1.00	...	...	...	...	...	...	...	...	...	...	...
-3.00	...	...	...	...	...	...	...	...	...	...	...
-5.00	...	...	...	...	...	...	...	...	...	...	...

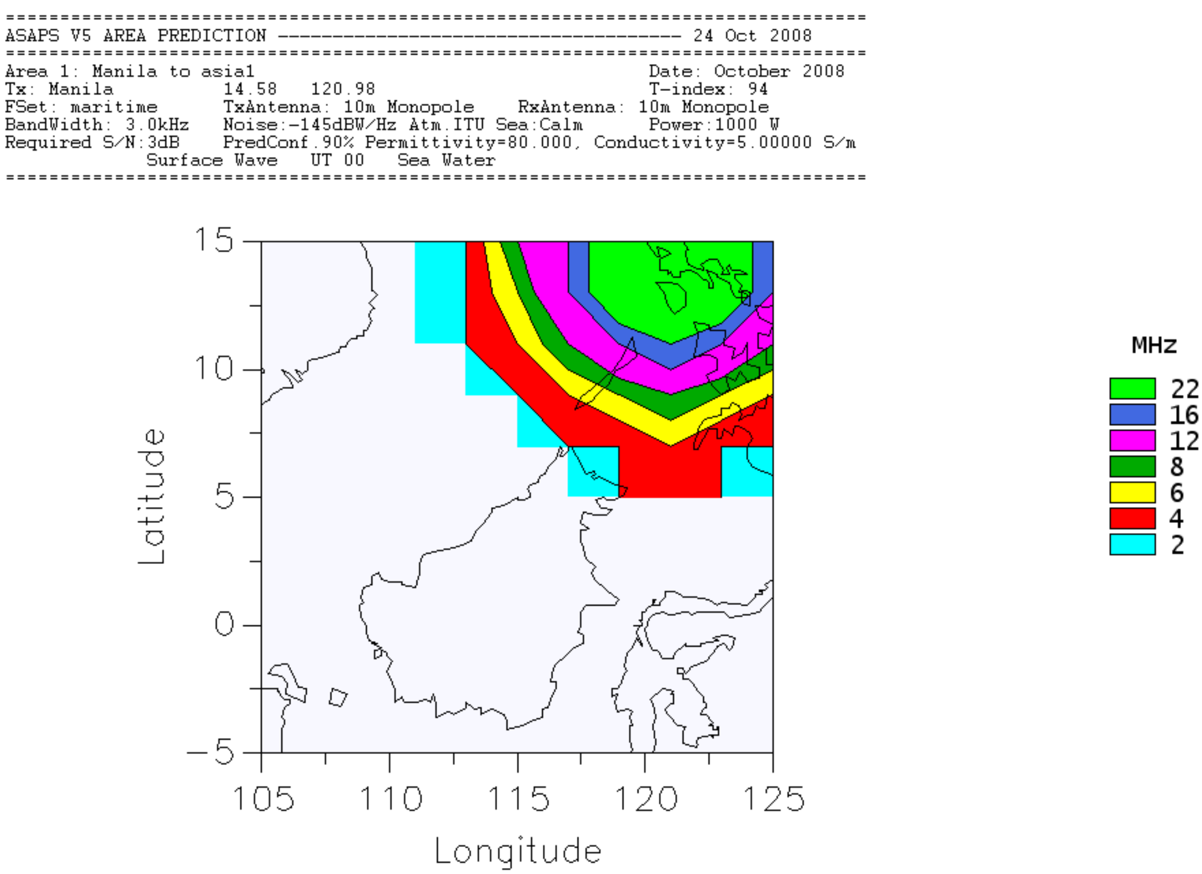

Figure 10. Surface wave graph at 00 UT for Exercise 37.

Table 45. Higher area resolution surface wave results at 00 UT for Exercise 37.

```
==============================================================================
ASAPS V5 AREA PREDICTION -----------------------------------
==============================================================================
Area 1: Manila to asia2                                    Date: October 2008
Tx: Manila           14.58   120.98                        T-index: 94
FSet: maritime       TxAntenna: Vert. Monopole    RxAntenna: Vert. Monopole
BandWidth: 3.0kHz    Noise:-145dBW/Hz Atm.ITU Sea:Calm       Power:1000 W
Required S/N:3dB     PredConf.90% Permittivity=80.000, Conductivity=5.00000 S/m
             Surface Wave    UT 00
==============================================================================
```

lat/lon	115.00	116.00	117.00	118.00	119.00	120.00	121.00	122.00	123.00	124.00	125.00
15.00	4.000	8.000	12.000	16.000	22.000	22.000	22.000	22.000	22.000	16.000	8.000
14.00	4.000	8.000	8.000	16.000	22.000	22.000	22.000	22.000	22.000	16.000	8.000
13.00	4.000	6.000	8.000	12.000	16.000	22.000	22.000	22.000	16.000	12.000	8.000
12.00	2.000	6.000	8.000	8.000	16.000	16.000	16.000	16.000	12.000	8.000	8.000
11.00	2.000	4.000	6.000	8.000	8.000	12.000	12.000	12.000	8.000	8.000	6.000
10.00	...	2.000	4.000	6.000	6.000	8.000	8.000	8.000	6.000	6.000	4.000
9.00	...	...	2.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	2.000
8.00	...	...	...	...	2.000	2.000	2.000	2.000	2.000	...	...
7.00	...	...	...	...	...	...	...	...	...	...	...

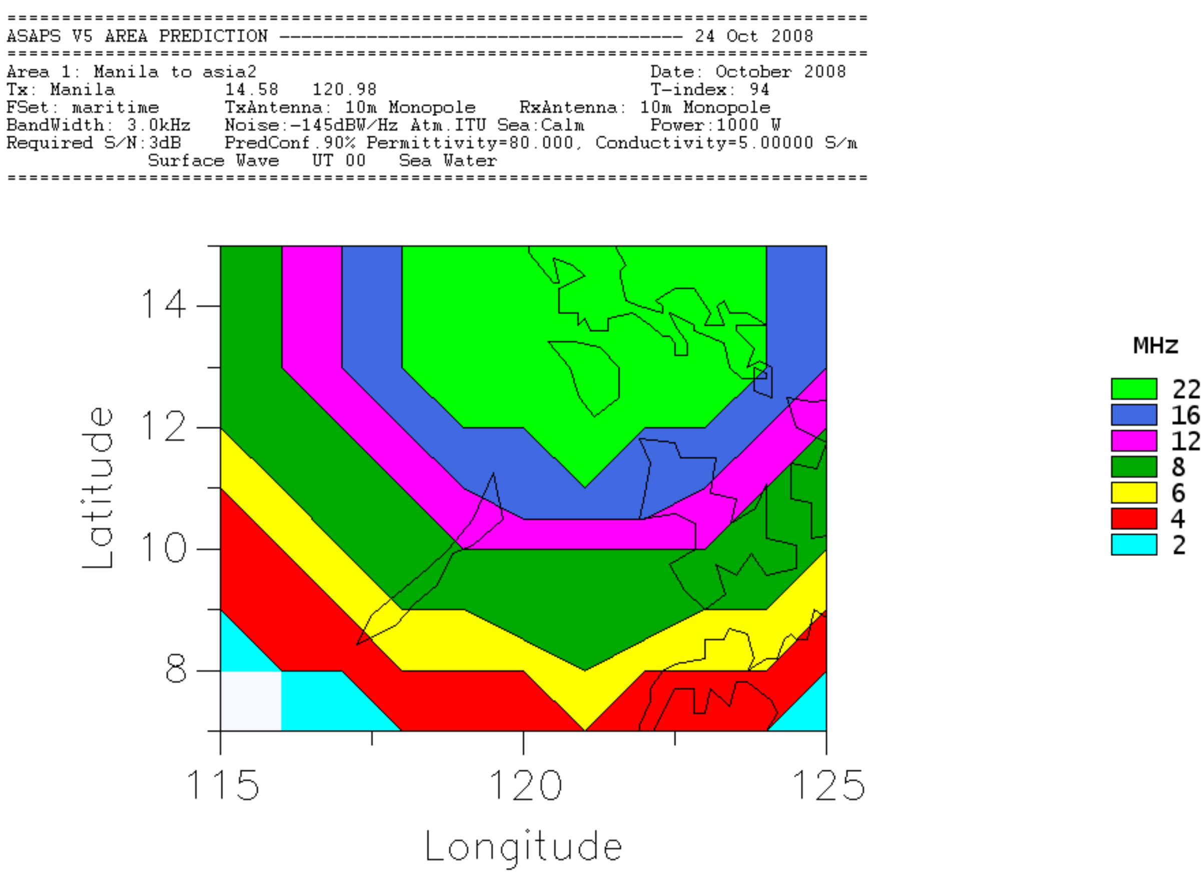

Figure 11. Higher resolution of surface wave coverage at 00 UT in Exercise 37.

6.7.9 Multi-surface prediction (q)

The following analysis concerns the Area prediction results from Exercise 37 for 00 UT only.

The Multi-surface format displays the predicted signal-to-noise of the specified frequency, here 1100 kHz, over the ground types appropriate for the area selected.

Those areas in an Area prediction graph that are not coloured indicate the predicted signal-to-noise ratio of the frequency is below the required signal-to-noise value specified in the default station configuration. The Area prediction table of the surface wave coverage will display "…" at a gridpoint where the frequency's predicted signal-to-noise is less than the required signal-to-noise.

The Area prediction graph in Figure 12 shows 1100 kHz is not predicted to be detected at the required signal-to-noise level of 3 dB at 5° N, 115° E. The Area prediction table in Table 46 shows the "…" symbol at that gridpoint. However, at 13° N, 119° E the signal-to-noise of the surface wave travelling from Manila over multiple ground types is predicted to be between 5 and 7 dB in the Area prediction graph. The Area prediction table shows the predicted signal-to-noise to be 5 dB at this gridpoint.

Greater detail of the range of the surface wave travelling over various ground types is obtained when the area of interest is decreased and the number of gridpoints is increased; see Table 47 and Figure 13 (both on p. 163).

Table 46. Predicted signal-to-noise for surface wave propagation from Manila at 00 UT over multiple surface types in Exercise 37.

```
================================================================================
ASAPS V5 AREA PREDICTION ------------------------------------- 24 Oct 2008
================================================================================
Area 1: Manila to asia1                                     Date: October 2008
Tx: Manila           14.58   120.98                         T-index: 94
Frequency=1.100MHz  TxAntenna: 10m Monopole    RxAntenna: 10m Monopole
BandWidth: 3.0kHz   Noise:-145dBW/Hz Atm.ITU Sea:Calm       Power:1000 W
Required S/N:3dB    PredConf.90%
            Multi-Surface   UT 00
================================================================================
```

lat/lon	105.00	107.00	109.00	111.00	113.00	115.00	117.00	119.00	121.00	123.00	125.00
15.00	...	...	...	...	...	...	4	16	12	15	4
13.00	...	...	...	...	...	...	...	10	11	10	...
11.00	...	...	...	...	...	...	...	...	4	...	...
9.00	...	...	...	...	...	...	...	...	...	...	...
7.00	...	...	...	...	...	...	...	...	...	...	...
5.00	...	...	...	...	...	...	...	...	...	...	...
3.00	...	...	...	...	...	...	...	...	...	...	...
1.00	...	...	...	...	...	...	...	...	...	...	...
-1.00	...	...	...	...	...	...	...	...	...	...	...
-3.00	...	...	...	...	...	...	...	...	...	...	...
-5.00	...	...	...	...	...	...	...	...	...	...	...


```
================================================================================
ASAPS V5 AREA PREDICTION ------------------------------------- 24 Oct 2008
================================================================================
Area 1: Manila to asia1                                     Date: October 2008
Tx: Manila           14.58   120.98                         T-index: 94
Frequency=1.100MHz  TxAntenna: 10m Monopole    RxAntenna: 10m Monopole
BandWidth: 3.0kHz   Noise:-145dBW/Hz Atm.ITU Sea:Calm       Power:1000 W
Required S/N:3dB    PredConf.90%
            Multi-Surface   UT 00
================================================================================
```


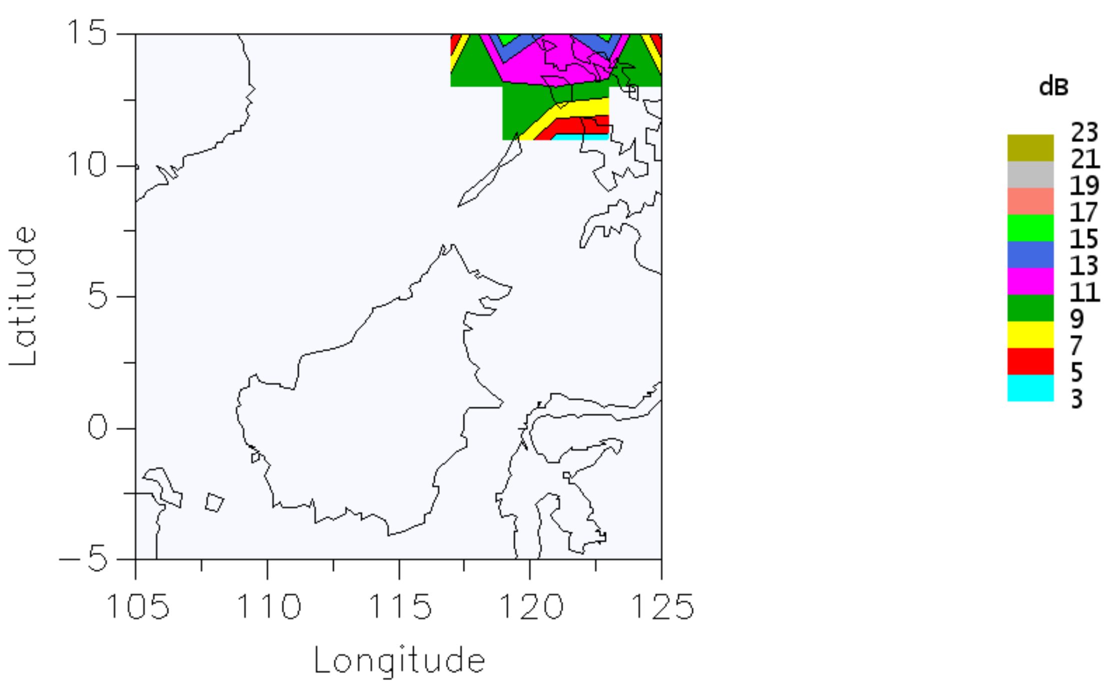

Figure 12. Multi-surface graph at 00 UT for Exercise 37.

Table 47. Higher resolution of multi-surface signal-to-noise at 00 UT for Exercise 37

```
================================================================================
ASAPS V5 AREA PREDICTION ------------------------------------- 24 Oct 2008
================================================================================
Area 1: Manila to asia3                                     Date: October 2008
Tx: Manila          14.58   120.98                          T-index: 94
Frequency=1.100MHz  TxAntenna: 10m Monopole    RxAntenna: 10m Monopole
BandWidth: 3.0kHz   Noise:-145dBW/Hz Atm.ITU Sea:Calm       Power:1000 W
Required S/N:3dB    PredConf.90%
            Multi-Surface   UT 00
================================================================================
```

lat/lon	118.00	118.50	119.00	119.50	120.00	120.50	121.00	121.50	122.00	122.50	123.00	123.50	124.00
15.00	10	13	16	19	23	12	12	11	22	19	15	12	7
14.50	10	13	16	19	23	12	12	11	22	19	15	12	7
14.00	7	13	16	19	23	23	12	22	22	...	...	...	...
13.50	7	10	13	16	19	19	23	12	19	16	...	...	...
13.00	7	10	10	13	16	11	11	10	10	13	10	...	...
12.50	4	7	10	10	13	9	9	8	8	5	10	7	...
12.00	5	5	8	8	11	7	6	...	5	5	7	4	4
11.50	...	5	5	5	8	4	4	...	...	...	...	...	...
11.00	...	...	...	5	...	...	4	...	...	...	...	...	...

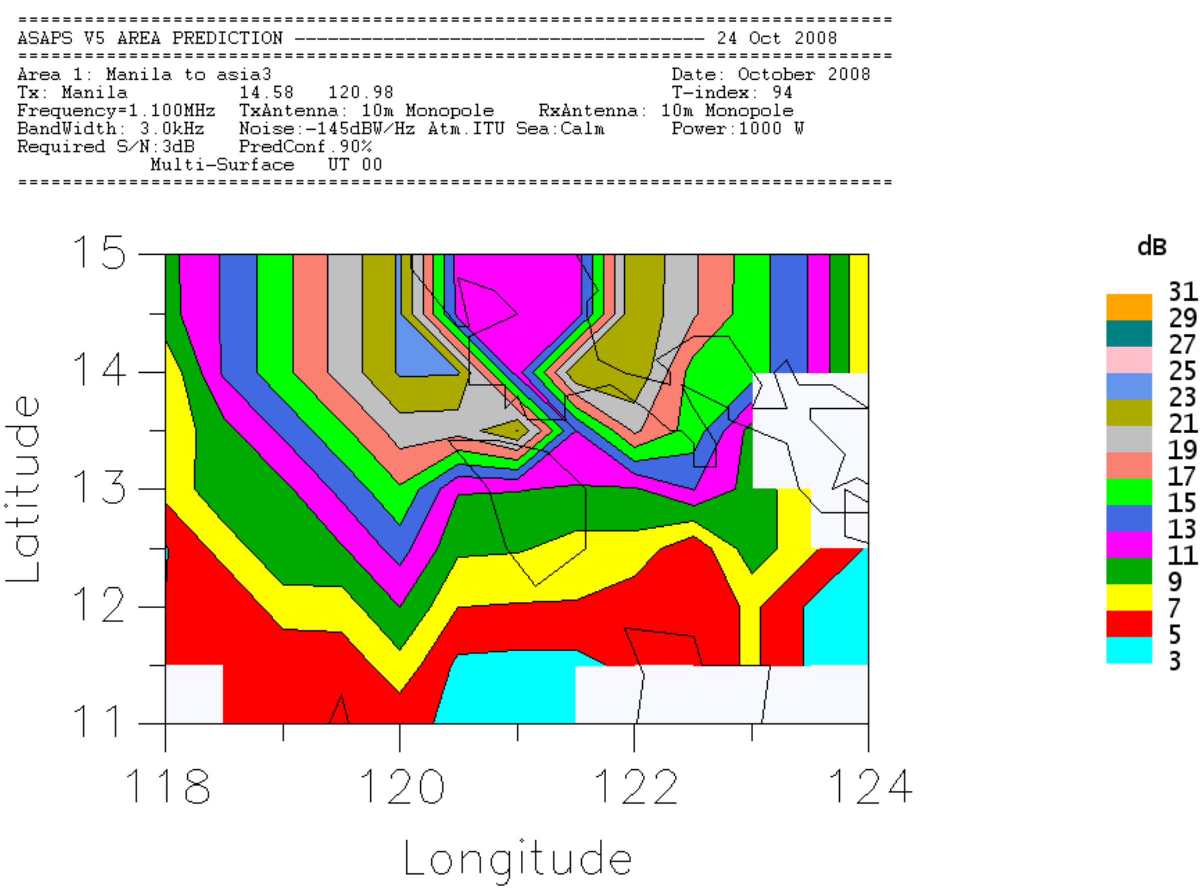

Figure 13. Higher resolution of the multi-surface graph at 00 UT for Exercise 37.

6.8 The associated GRAFEX and Field Strength predictions

The GRAFEX and Field Strength predictions associated with an Area prediction contain a number of point-to-point circuit predictions based on how many rows and columns are specified for the area of interest.

The gridpoint numbering scheme for Area predictions is shown in Figure 14, that is, the gridpoints are numbered from left to right and top to bottom. A base is also shown located within the grid of Figure 14, although for Area predictions, the base does not have to be located within the specified area of interest. The GRAFEX and Field Strength predictions associated with the Area prediction in Figure 14 will each contain 30 circuits. The first circuit will be for the path between Base and gridpoint 1, the next circuit will be for communications between Base and gridpoint 2, and so on up to the last circuit, Base to gridpoint 30.

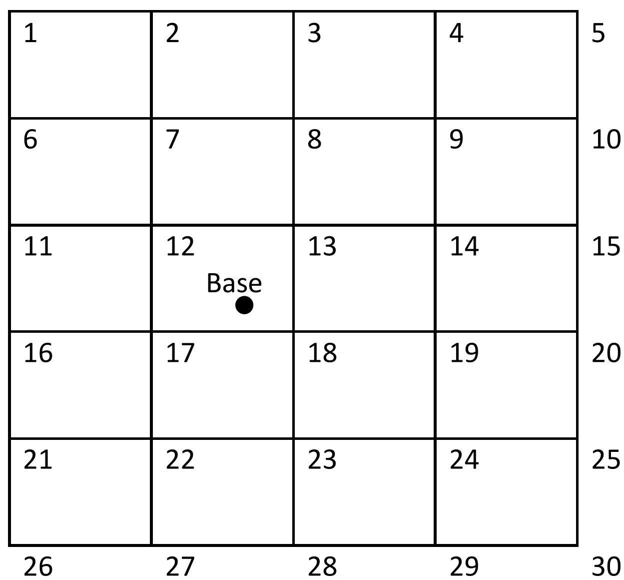

Figure 14. Numbering system for gridpoints used to generate the circuits in GRAFEX and Field Strength predictions associated with an Area prediction.

The GRAFEX and Field Strength files have the same name as the Area prediction file, but with different extensions, that is, *.PRD for GRAFEX, *.FSH for Field Strength, and *.AHD for Area. To view the GRAFEX and Field Strength predictions, select *Predictions|View Predictions*, specify the required file type then select the file.

All the circuits in a GRAFEX prediction file associated with an Area prediction file use the same frequency set which is the frequency set specified in the default station configuration. The frequency set an Area prediction uses is specified in the *Area Prediction details* dialogue (the associated Field Strength prediction will use the same frequency set). If the frequency set specified in the *Area Prediction details* dialogue is different to the frequency set specified in the default station configuration, the frequency set the GRAFEX prediction uses will be different to that the Area and Field Strength predictions use. To ensure the GRAFEX and Area predictions (and Field Strength prediction) use the same frequency set, specify the same frequency set in the *Area Prediction details* dialogue and the default station configuration.

If a frequency set is not specified in the default station configuration, that is, “(NONE) GRAFEX” is selected, the GRAFEX Freq Plan Table, GRAFEX Freq Plan Graph, GRAFEX Frequency Set Test and SNR Frequency Set Test formats will not be produced for the Area prediction circuits.

To produce the GRAFEX Frequency Set Test and SNR Frequency Set Test formats of the GRAFEX prediction associated with an Area prediction, a frequency set must be specified in the default station configuration and at least one hour selected under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue. Each time ASAPS is opened, the default number of hours under the *Frequency Set Selection/Testing* button is the whole 24 hours. If it is required that either of these formats be produced using a different range of hours, first change the range of hours under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue, cancel out of the *Prediction Details* dialogue, then produce the Area prediction from the *Area Prediction details* dialogue in the usual manner.

The GRAFEX Frequency Selection and SNR Frequency Selection formats of a GRAFEX prediction associated with an Area prediction require at least one hour to be selected, and a minimum and maximum number of frequencies be chosen under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue. Each time ASAPS is opened, the default number of hours is the whole 24 hours and the default minimum and maximum number of frequencies is 3 and 5, respectively. If it is desired the GRAFEX Frequency Selection and SNR Frequency Selection formats of the GRAFEX prediction file associated with an Area prediction file use values other than these defaults, first alter them under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue, cancel out of the *Prediction Details* dialogue, then produce the Area prediction in the usual manner from the *Area Prediction details* dialogue.

Note that once the range of hours and minimum and maximum number of frequencies have been changed in the *Prediction Details* dialogue, the change remains effective and will be used by all predictions computed or opened, until ASAPS is closed or different values are selected. Also, changes made to these values while a GRAFEX prediction is opened will be reflected in views that are opened after the change.

The greater the number of rows and columns in an area of interest (more gridpoints), the longer the computation time of the GRAFEX and SNR Frequency Selection and Frequency Set Test formats in a GRAFEX prediction (particularly the SNR Frequency Selection format). As an example, a SNR Frequency Selection computation containing 128 circuits for three frequency sets took 16 minutes to display the *Concise* report when tested using 2.3 GHz CPU, 512 MB RAM and the Windows XP operating system. It then took another 16 minutes to compute and display the results for the *Verbose* report. Computation times will be even longer when 3D antennas are used. Note that the GRAFEX and SNR Frequency Selection and Frequency Set Test formats are not computed if no hours are selected under the *Frequency Set Selection/Testing* button in the *Prediction Details* dialogue at the time the Area prediction is computed or opened.

If the frequency set for an Area prediction is altered in the *Area Prediction details* dialogue when re-computing, the associated Field Strength prediction of the new Area prediction will use the new frequency set. However, the associated GRAFEX prediction will continue to use the frequency set specified in the default station configuration. To ensure the associated GRAFEX prediction of a re-computed Area prediction uses the same frequency set, select *Databases|Station configurations* and change the frequency set in the default station configuration to the frequency set that will be used in the re-computation of the Area prediction. Then, with the Area prediction to be re-computed displayed, select *View|Re-compute* and make the required changes in the *Area Prediction details* dialogue, ensuring the frequency set selected is the same as that specified in the default station configuration. The resulting Area, Field Strength and GRAFEX predictions will now use the same frequency set.

Exercise 38. Viewing the GRAFEX and Field Strength files associated with an Area prediction

View the GRAFEX and Field Strength predictions associated with the Area prediction, "tute15.AHD" computed in Exercise 37. Compare the results of the SNR Frequency Set Test and SNR Frequency Selection formats of tute15.PRD.

- Select ***Predictions|View Predictions***, choose **GRAFEX Predictions (*.PRD)** in the **Files of type** list box and open **tute15.PRD**.
- Under ***View|New View***, view the GRAFEX Table, GRAFEX Graph, GRAFEX Frequency Table and GRAFEX Frequency Plan Table/Graph formats. Note the frequency set used in the GRAFEX Graph and GRAFEX Frequency Plan Table/Graph formats. The **maritime** frequency set should be used since it was specified in the default station configuration.
- Use the ← → keys to move through the circuits and note the total number of circuits. The total number of circuits should be 121 since 11 rows and 11 columns were specified for the **asia1** area.
- Now view the GRAFEX and SNR Frequency Set Test and Frequency Selection formats (the SNR Frequency Selection format may take some minutes to compute the results). The SNR formats will be based on the values in the default station configuration. The GRAFEX and SNR Frequency Set Test formats test the **maritime** frequency set between **23** and **04** UT. The GRAFEX Frequency Set Test format simply tests whether each frequency in the **maritime** set lies between the upper and lower frequencies based on the rules set out in Section 4.2.2. The SNR Frequency Set Test format tests the **maritime** frequency set for usability based on the station parameter values in the default station configuration, Section 4.2.5.
- The GRAFEX and SNR Frequency Selection formats produce one frequency set which contains seven frequencies for communications from **Manila** to locations within the **asia1** area for the five hours (**23 to 04** UT). The number of hours and minimum and maximum number of frequency sets were specified in Exercise 37.
- The GRAFEX Frequency Selection format selects the frequencies 8.9, 10.43, 11.47, 13.5, 15.53, 17.57 and 20.6 MHz for communications from **Manila** to the **asia1** area during **23-04** UT in **October** with T = **94**. These results are based only on ionospheric support. The network results for this frequency set are: main mode avail. = 99.6%, all mode avail. = 99.6% and score = 1825.2.
- The GRAFEX Frequency Set Test format tests the **maritime** frequency set over the same time period. The results for the **maritime** set are: main mode avail. = 96.8%, all mode avail. = 100% and score = 968.7.
- A comparison of the network results for the GRAFEX Frequency Selection and GRAFEX Frequency Set Test formats indicates better quality communications using the frequency set selected by ASAPS (higher score). On the frequency set selected by ASAPS, there are also fewer outages on the main mode but slightly more outages when all modes are considered. Some circuits may be more important than others and a detailed study of the verbose results will reveal when outages are likely to occur on certain circuits.
- The SNR Frequency Selection format selects 10.4, 10.96, 11.52, 13.88, 16.04, 18.4 and 22.56 MHz as the best frequencies for communications from **Manila** to the **asia1** area during **23-04** UT in **October** with T = **94**. The network results for this frequency set are: main mode avail. = 98.6%, all mode avail. = 98.6% and score = 20.6.

- The SNR Frequency Set Test format tests the **maritime** frequency set for communications from **Manila** to the **asia1** area during **23-04** UT in **October** with T = **94**. The network results for the **maritime** frequency set are: main mode avail. = 99.7%, all mode avail. = 100% and score = 11.0. The Usability Summaries for the 121 circuits in the SNR Frequency Set Test format *Verbose* report, show the lower frequencies, particularly 2.0 and 4.0 MHz, in the **maritime** set are rarely used. The availabilities for the **maritime** set and the selected frequency set are comparable.
- Select ***Predictions|View Predictions***, choose the **Field Strength files (*.FSH)** file type and open **tute15.FSH**.
- Use the ← → keys to move through the circuits. Select ***View|New View|Field Strength Table*** to view the Field Strength tables.
- Note the frequency set used for each of the 121 circuits.

Exercise 39. Viewing the GRAFEX file associated with an Area prediction

Short path sky wave communications are required between Kudat (6.53° N, 116.46° E) and ships located in the area called "asia4" bounded by 15° N to 10° S and 100° E to 125° E (gridpoints every 5° latitude and longitude). Produce three frequency sets containing 2, 3 and 4 frequencies for 24 hour communications for the current month and T index. Compare the results for these frequency sets with the results based on the "test" frequency set (5.143, 9.858 and 13.544 MHz). Save the prediction to "tute16".

- This exercise requires the GRAFEX or SNR Frequency Selection/Set Test formats of a GRAFEX prediction be produced.
- Since no station parameter details have been given, one can assume that only a GRAFEX Frequency Selection and GRAFEX Frequency Set Test are required. Hence, any station configuration could be selected as the default because the exercise is not concerned with the actual Area prediction, the results of which are based on the values specified in the default station configuration. However, the exercise requires a comparison of the results the frequency sets ASAPS selects in the GRAFEX Frequency Selection and the **test** frequency set being tested in the GRAFEX Frequency Set Test. Therefore, the frequency set specified in the default station configuration should be **test** since the GRAFEX Frequency Set Test format will be based on the frequency set specified in the default station configuration.
- Select ***Databases|Station configurations*** and specify the **test** frequency set in the default station configuration. Press ***Add/Modify*** then ***Done***.
- Select ***Predictions|Do Prediction*** to view the **Prediction Details** dialogue. Under the ***Frequency Set Selection/Testing*** button, select the whole **24** hours and the minimum (**2**) and maximum (**4**) number of frequencies. Press ***OK*** then ***Cancel*** at the **Prediction Details** dialogue.
- Select ***Predictions|Do Area Prediction***. The **Area Prediction details** dialogue is displayed.

- Enter the details for the current month. Enter the base as **Kudat**. If **Kudat** does not exist in the Terminals database, press the button with three dots in the **Base** group box and enter **Kudat** in the database. In the **Base is** list box choose either **Tx** or **Rx**. Note that if only the GRAFEX Frequency Set Test or GRAFEX Frequency Selection formats are to be viewed, it is irrelevant whether Tx or Rx is chosen in the **Base is** list box, because these formats test only ionospheric support and not the values of the station parameters. However, if the SNR Frequency Set Test or SNR Frequency Selection formats were required, it would be important to choose the correct option since these formats do use the station parameters. See Table 2 (p. 30) for the transmiiter and receiver parameters.
- At this stage **asia4** has not been entered in the Areas of Interest database. In the **Area of interest** group box press the "**…**" button to display the **Area of interest** dialogue. Enter the details for the **asia4** area; **6** rows and **6** columns are required based on the resolution.
- The frequency set displayed in the **Frequency Set** list box is that specified in the default station configuration and should be **test**. Because the Area and Field Strength files will not be used in this exercise, it is irrelevant which frequency set is specified in the **Area Prediction details** dialogue.
- Press ***Do Prediction*** and save the prediction to **tute16**.
- In the **Open Prediction File** dialogue, choose the **GRAFEX Predictions (*.PRD)** file type and open **tute16.PRD**.
- Select ***View|New View|GRAFEX Frequency Selection*** to view the *Concise* report on the selected frequency sets.
- Select ***View|Verbose*** (or ***ctrl+c***) to view the more detailed *Verbose* report.
- The GRAFEX Frequency Selection format displays three frequency sets, one containing two frequencies, one containing three and one containing four frequencies that have been computed by ASAPS to provide the best communications between **Kudat** and sites within the **asia4** area for all **24** hours.
- Select ***View|New View|GRAFEX Frequency Set Test***. The *Concise* report displays the results for **24** hour communications between Kudat and the gridpoints in the asia1 area of interest using the **test** frequency set. Select ***View|Verbose*** (or ***ctrl+c***) to view the extended report.
- Compare the *Verbose* report results of the frequency sets ASAPS has selected with the results for the **test** frequency set.
- This exercise shows that by producing an Area prediction, the user can compute frequency sets based only on ionospheric conditions for communications between a base and locations within the chosen area.
- This procedure may be a more efficient way of producing the GRAFEX and SNR Frequency Selection or Frequency Set Test formats when there are large numbers of circuits involved.