

Libra

**Radio Signal Strength
Survey Tool**

User Guide and Reference Manual



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Disclaimer

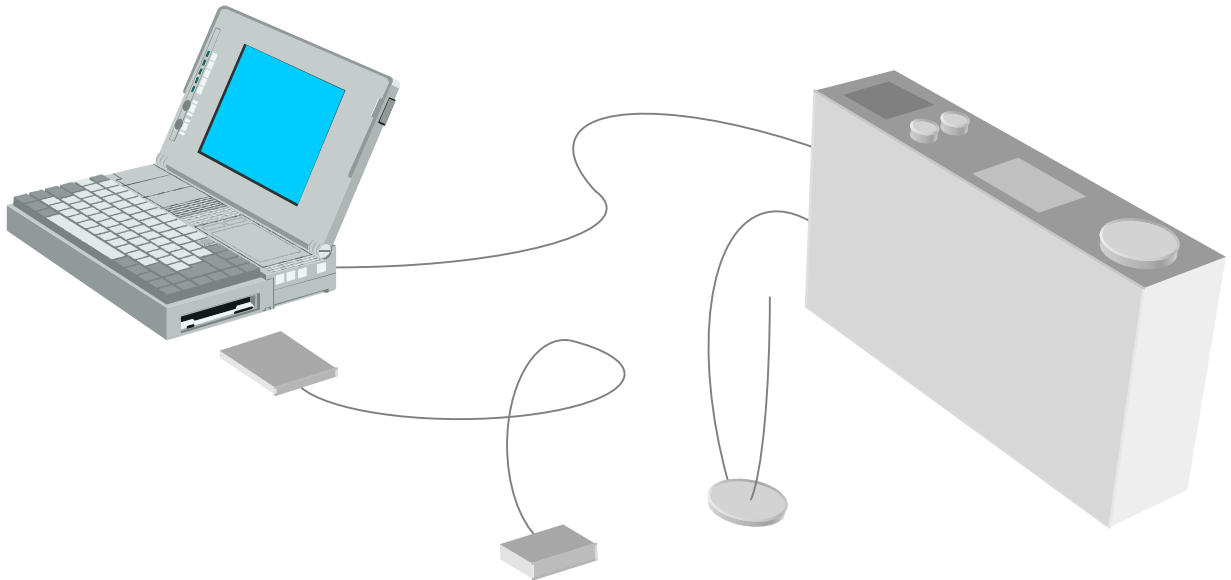
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1 Introduction

1.1 General

Libra provides the system planner with the ability to survey radio coverage simply and accurately. Powerful and flexible functions provide a number of ways to produce easily understood coverage maps. The diagram below shows the extent of the survey system and the interconnections:



Libra uses an innovative method to measure sample gap distances accurately therefore making the use of a cumbersome wheel transducer unnecessary. In addition Libra analysis software is geared towards the needs of the planner working on a system comprising many base radio sites and allows the "What if...?" questions to be answered easily.

Libra splits into two modes of operation: Surveying and Analysis. During surveying Libra logs data in real time from the measuring receiver to record statistically valid signal strength data in a user-friendly way. After the survey Libra takes the raw survey data files and analyses them to produce maps of the coverage

One of the fundamental principles of Libra operation is the use of sitemames rather than frequencies to identify sets of survey data. The real benefit of this comes during the analysis when complete sets of data for each site can be included or excluded from the analysis without having to worry about the actual survey frequency even if different frequencies were used to survey a site on different occasions.

Another powerful feature is the ability to survey an area a second time and merge the two sets of data to form a single set to be used in normal analysis. This is particularly useful if a fill-in site is identified and has to be surveyed over the cross-over area previously surveyed from the main site to make sure there is now continuous coverage. Similarly it is sometimes only possible to survey a network of sites one at a time because of limited survey frequencies or transmitters. This technique allows each site to be surveyed and the cross-over areas to be merged to form a single data file to make it look as though the two sites were actually surveyed at the same time. The only limitation in this technique is that the second survey must follow the same route as the original survey.

1.2 Key steps in performing a survey

The following steps summarise the general approach to carrying out a survey:

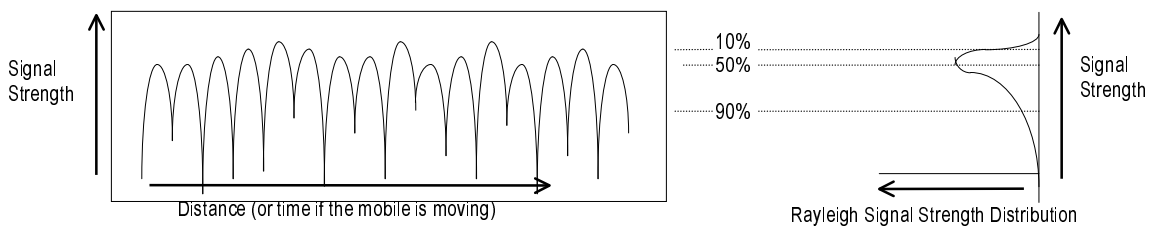
- 1 Determine the sample gap distance, the minimum number of samples required per sample gap distance and the % confidence levels required.
- 2 Determine which areas need to be surveyed and those areas which need to be surveyed from more than one radio site.
- 3 Carry out the survey if necessary using temporary transmitters at low power (enter a MISC GAIN correction factor). Keep a note of the routes taken for those areas that may have to be surveyed a second time. Try to break the area to be surveyed into a number of smaller routes of around 40km maximum. This has the advantage of saving data into a number of small files rather than one large file thus reducing the possibility of losing data in the event of a problem.
- 4 Carry out any second surveys (e.g. from another site if only 1 survey frequency is available).
- 5 Use the Merge facility to merge any data files for routes that were surveyed twice from different sites (removing the original data files once merged).
- 6 Set the signal strength threshold levels.
- 7 Display the survey map and graph on screen.

One of the most frequent problems when surveying a multiple site radio system is the creation of a Composite coverage map where a site has not been surveyed over a wide enough area so that coverage actually appears poorer than it really is. This is difficult to spot in a Composite coverage map but re-analysing the data as a Most Likely Server analysis often shows up the problem very clearly with routes being displayed in an obviously wrong colour. The only remedy is to go and carry out some more field surveys and then merge the new data with the existing.

2 Technical Background

2.1 Statistically valid surveying

Radio signals very rarely travel from a base station to a mobile by a single direct route. In all practical situations signals bounce off hills and buildings and arrive at the receiver from different directions after taking many different routes. This situation causes the phenomenon of Rayleigh or fast fading and produces deep random fades at roughly half-wavelength intervals so that by just moving, say, 1m a receiver might experience a 20dB change in signal strength. To make matters worse the pattern of fading is not constant and constantly varies with local conditions such as vehicles moving nearby, trees moving or weather conditions changing. Even if the measuring equipment is sufficiently fast to detect every fade in the coverage the conditions that created the fade will have changed and mean that it is impossible to repeat the measurement. This obviously makes it very difficult to produce repeatable, meaningful results from a survey if single, spot readings are taken. The diagram below illustrates a typical received signal and how this produces a Rayleigh distribution:

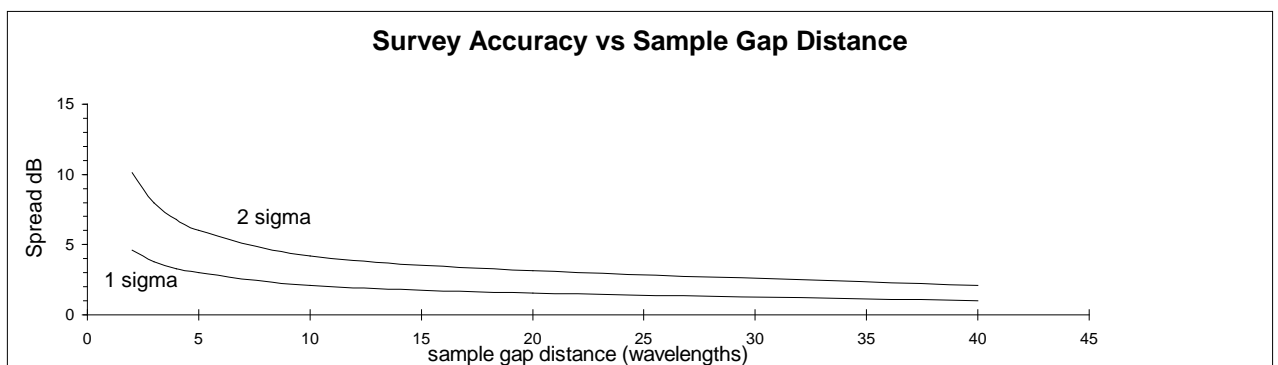


However although individual fades will be constantly changing, the general picture over a small area will remain the same, therefore it is possible to use statistical methods to indicate the signal strength and to allow for the range of actual signal strengths that may be experienced at a location. The signal strengths are in a Rayleigh distribution which is asymmetric, i.e. the mean or average signal strength is not the same as the median or middle value of the range of signal strengths. This means that it is best to use the concept of percentage confidence levels to indicate the signal strength, and a standard approach would be to say:

“There is a 90% probability of receiving at least 20dB μ V at this location”

2.2 Sample Gap Distance

The problem of how to measure the signal strength level while taking into account the unpredictability of the fading is achieved in practice by taking many spot samples over an area and then calculating the 50% or 90% level for the entire area. The area must be large enough area to ensure that individual fades are not affecting the result but small enough to ensure that local conditions do not change. W.C.Y. Lee has shown that the size of the area (also known as the sample gap distance) effects the accuracy as shown below:



This graph shows that, for example, measuring the median signal strength with a sample gap distance of 40 wavelengths will give a 95% probability (2 sigma) of a measurement being within 2.1dB of the true median and a 68% probability (1 sigma) of it being within 1.0dB. This is the inherent inaccuracy caused by an unpredictable fading signal superimposed on the background median signal strength.

There is little improvement in accuracy by choosing sample gap distances greater than about 40 wavelengths while below 20 wavelengths the uncertainty spread starts to increase rapidly. Therefore a measurement interval of 40 wavelengths is a good compromise between the result being affected by individual fades by using too small a distance, and smoothing out the long-term fading by using too large a distance. A sample gap distance of 40 wavelengths corresponds to the following distances for the frequencies shown:

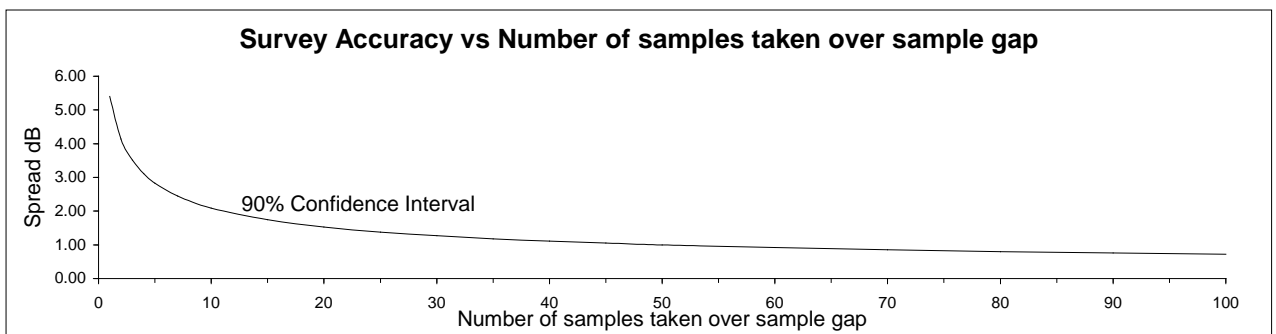
150MHz	-	80m
450MHz	-	27m
900MHz	-	13m

In general the sample gap distance should be kept below about 100m to avoid changes in terrain affecting the median signal level.

2.3 Sampling rate

However a further problem remains as to how many spot samples must be taken over this sampling distance to calculate the signal strength at a particular percentage level. If too few samples are taken then the calculation will be inaccurate, while the receiver scan speed sets an upper limit to how many samples can be taken at a given vehicle speed and sampling distance.

Further criteria developed by W.C.Y. Lee show that, not surprisingly, the more samples that are taken the more accurate the result is with the following theoretical figures:



This graph shows that, for example, taking 50 samples over the sample gap will give a 90% probability of the measurement being within 1.0dB of the true median.

As long as a reasonable number of samples are taken over an appropriate sampling distance (by not driving the survey vehicle too fast) then the results obtained will be valid and, most importantly, will be repeatable as the effect of individual fades are not affecting the results. Note also that taking more than about 50 samples over a sample gap distance does not significantly improve the accuracy although it does no harm.

Libra allows you record up to 3 different percentage levels during a survey and these 3 sets of files are then available in the analysis software with the level being selected in the Select data dialog box. In general when performing a survey of wanted coverage it is usual to use confidence figures of 90% or more at the minimum usable signal strength. If performing a survey of unwanted or interfering signals then it would be more appropriate to use a figure of 10% or less as even small levels of interference are troublesome. A confidence level of 50% might be appropriate if producing a surveyed coverage map to compare with a computer coverage prediction.

2.4 Sample gap distance measurement

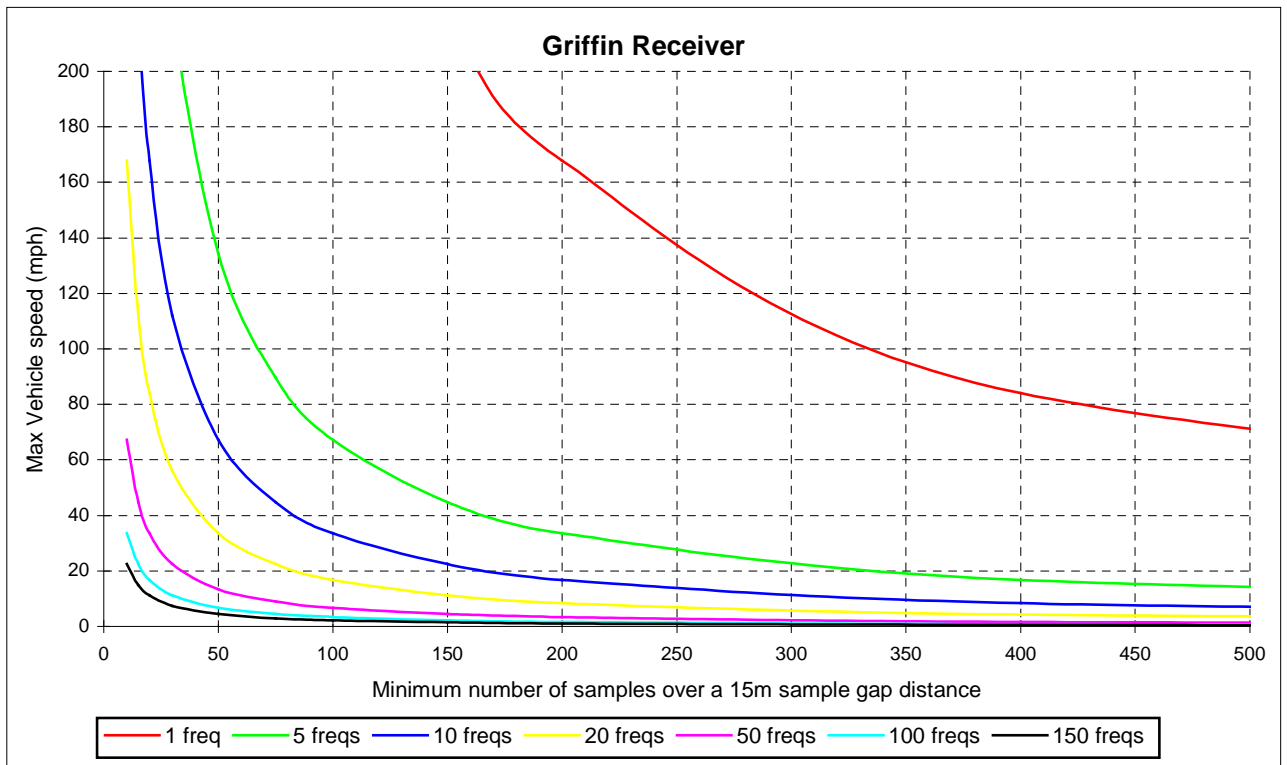
The previous section has explained the importance of the sample gap distance but in practice the ability to measure distances in a vehicle has always proved difficult. The standard solution has been to use a wheel transducer which is accurate but cumbersome and only fits a limited number of vehicles. Libra uses an innovative technique to generate accurate sample gap distances using GPS alone and with no additional attachments to the vehicle thus allowing Libra to be used in any kind of vehicle, e.g. a boat or train.

This technique is based on a fundamental property of GPS whereby although the absolute position at any given time is only accurate to, say, 100m the change in position error over time is relatively slow. For a vehicle moving at 30mph it is now possible to measure out a sample gap with an error of less than 1m and indeed over time the errors tend to cancel out anyway to produce repeatable measurements.

In general the larger the sample gap the more samples will be gathered for a given vehicle speed therefore reducing the statistical uncertainty however if the sample gap distance is too great then the statistical uncertainty will start to rise again as local variations in the mean signal strength will not be detected.

2.4.1 Griffin Receiver

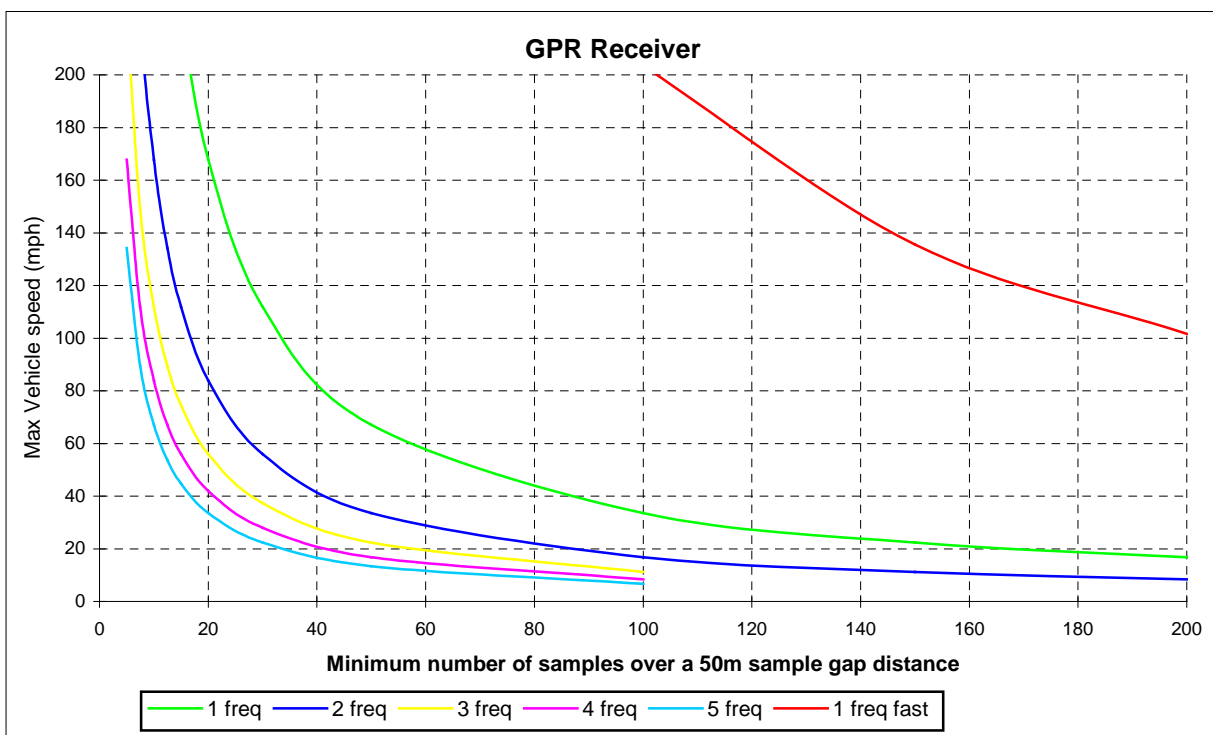
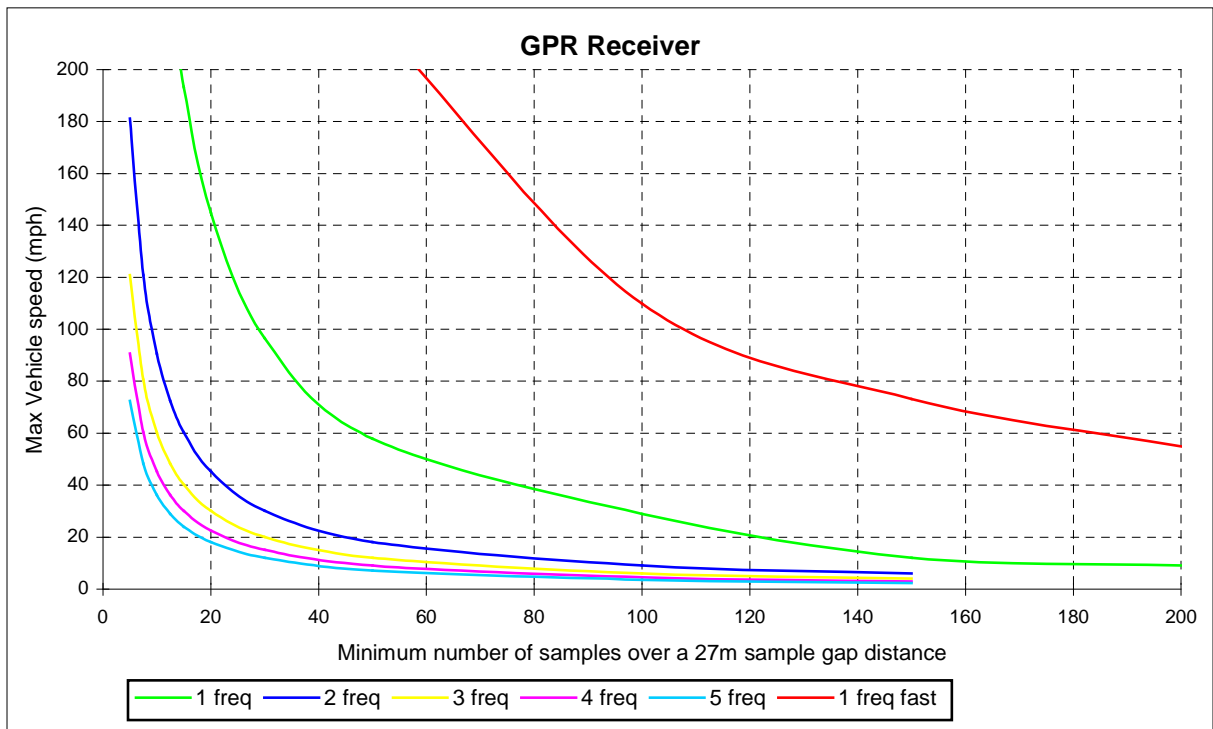
The Willtek Griffin receiver can produce signal strength samples every 1msec when scanning multiple frequencies and is able to scan up to 150 frequencies during a survey. This fast scan speed is only likely to limit maximum vehicle speed when large numbers of frequencies are being surveyed with small sample gaps as shown in the following graph:



2.4.2 GPR Receiver

The Chase (Willtek) GPR receiver can produce signal strength samples every 33msec when scanning more than 1 frequency or every 22msec if just monitoring a single frequency. In addition there is a special fast mode available when monitoring a single frequency that takes samples every 5.5msec – this is equivalent to a sample every 1cm at 40mph.

The receiver scanning speed, combined with the number of frequencies being monitored, the sample gap distance and the minimum number of samples required over the sampling distance, all affect the maximum vehicle speed. This is shown in the two graphs below at two different sample gap distances of 27m and 50m.



3 General Operation

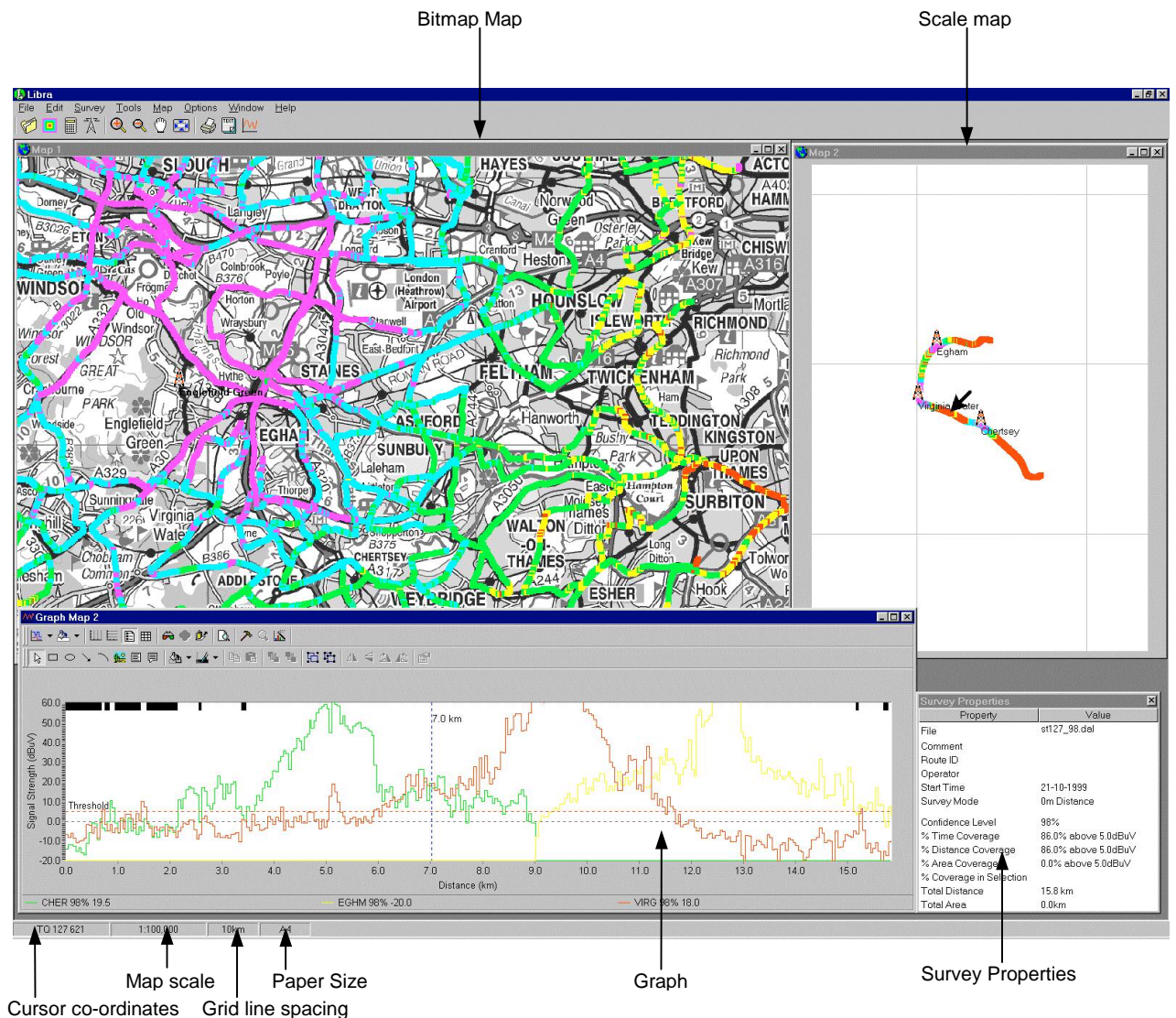
3.1 Overview

Libra runs under Microsoft Windows. You should be familiar with the Windows interface in order to use it successfully. The remainder of this manual assumes prior knowledge of the use of Windows menu commands and dialog boxes.

Libra can display survey data on either a bitmap background or as a scale map which may be printed at a precise scale for laying over paper maps. Multiple map windows (up to 16) can be open at the same time showing the same or different survey data.

The status bar at the bottom of the screen shows the current cursor co-ordinate and for scale maps it also shows the current paper size, grid spacing and map scale. Click on any of these to change the setting.

The initial Libra screen shows a map with no survey data. If any map tiles have been specified then the initial map is a bitmap type otherwise it is a scale map. To analyse and display survey data, files must firstly be selected using the menu option File: Select Data... or clicking the toolbar button.



3.2 Toolbar

The Toolbar is displayed across the top of the application window below the menu bar. The toolbar provides quick mouse access to many of the menu options. Some toolbar buttons will appear dimmed and will not have any effect until another action has been completed that makes the button relevant.

Click**To**

Select data files or sites to be displayed



Set the signal strength threshold ranges and colours



Set the analysis mode for multi-site files, either Composite Coverage or Most Likely Server



Specify the site data (names and coordinates) to be displayed



Zoom out



Zoom in



Pan map



Centre the survey data in the map window at the current level of zoom



Print the current survey map or graph



Export survey data to another application



Display graph for current map data

To include text labels on the toolbar buttons, right-click on the toolbar and select the 'Labels' option.

Export data to Clipboard

Select menu option Edit: Copy to copy the current map or graph to the Windows clipboard to allow it to be pasted as a picture into other applications. Graphs may also be copied as a Metafile, text data or OLE object.

3.3 Map Commands

Map commands are available from the main menu or by clicking on the map with the right mouse button or by clicking on the relevant button on the toolbar.

To open new map windows use menu option Window: New Map: and select either bitmap or scale. To change the title of a map window use menu option Window: Set Title.



Centre

Centre the survey data in the map window at the current level of zoom



Zoom In, Zoom Out, Zoom Out Full

Bitmap maps are zoomed in or out by a factor of 1.5 from the current zoom level while scale maps are zoomed in or out to the next standard map scale.

A bitmap map may be zoomed out to the extent of the current map tiles by selecting "Zoom Out Full" from the menu.

Bitmap maps may also be zoomed to a specific rectangle by clicking and holding on a point on the map and dragging the mouse to create a rectangle. The map window will then zoom to display this area.

A scale map may be zoomed to a specific scale by clicking on the scale box on the status bar at the bottom of the screen and selecting the appropriate scale from the pop-up menu. Note that scale maps are based on the current printer paper size and orientation, therefore to view a larger area at a given scale you must select a larger paper size using Printer Setup.



Panning the display

The survey map can be panned by clicking on the pan button, selecting "Pan" from the menu or right mouse clicking on the map and selecting "Pan" from the pop-up menu or by simply holding the shift key. Click on a point on the map and drag it to a new point within the limits of the display area. As the map is being dragged the map will move to show the relative position to the existing map.

The map may also be panned using the scrollbars on the side of the map window. These may be enabled or disabled by selecting the "Show Scrollbars" option on the "Map" menu.

Colours

Bitmap map images may be adjusted using the following options under the Colours menu option:

Set Greyscale: convert the current map tiles to grey scale to make it easier to see the colour survey data.

Set default: return the current map tiles back to the original colours.

Make Lighter: make the current map tiles lighter in colour.

Make Darker: make the current map tiles darker in colour.

4 Survey

4.1 Overview

Before surveying using Libra you should create a "Survey Profile" that contains all of the information required every time a survey of a particular system is carried out such as frequencies, receiver configuration and sampling mode. Once a Survey Profile has been created then further surveys of the same system can be carried out without having to change the Survey profile each time. This option is selected from the main menu "Survey | Configure..." and is explained in section 4.2.

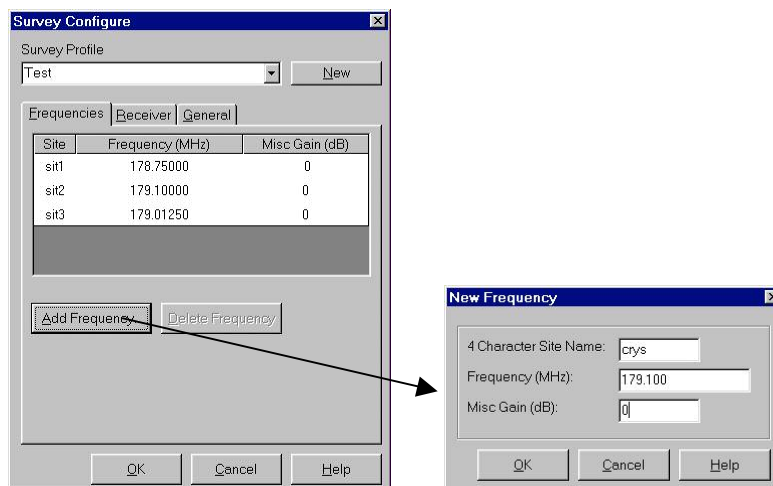
Once a Survey Profile has been created the survey may be started from the main menu "Survey | Start" and is explained in section 4.3.

4.2 Survey Configure

This dialog box allows you to create and edit Survey Profiles

Different Survey Profiles may be selected using the "Survey Profile" box and created initially using the "New" button and then entering the name of the new profile.

4.2.1 Frequencies



The "Frequencies" tab of the Survey Configure box shows the list of frequencies to be surveyed up to a maximum of 5 for the GPR receiver and 150 for the griffin receiver. New frequencies may be added by clicking the "Add Frequency" button and entering the following parameters:

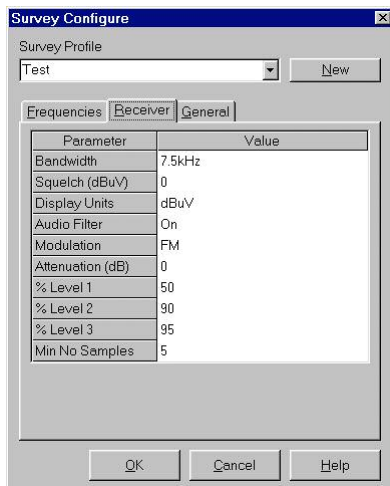
4 character site name: used to identify the source of the signal, usually an abbreviation of the site name. The analysis software uses this, not the frequency, to identify data surveyed from the same site.

Frequency (MHz): The frequency being surveyed. Must be between 10MHz and 10GHz.

Misc Gain (dB): added to all measured signal values, usually used to allow for any difference in the test conditions compared to normal conditions, e.g. a low power test transmitter.

Once entered, details may be edited by clicking on the value in the table and directly changing it, or by clicking the "Delete Frequency" button which will delete the entire line and shift up all the subsequent entries in the frequency table.

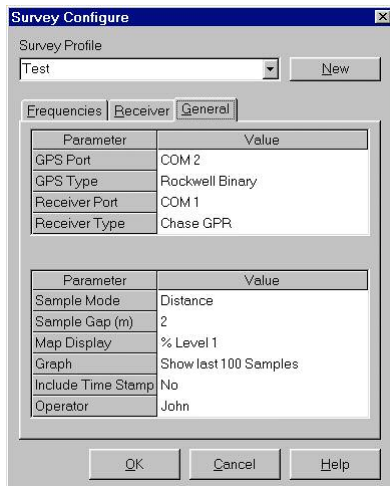
4.2.2 Receiver Parameters



Use the "Receiver" tab of the Survey Configure box to set the various receiver parameters as follows:

- Bandwidth:** Select the receiver IF bandwidth from 7.5kHz, 15kHz or 120kHz.
- Noise Filter:** (Griffin Receiver only) Select whether a 12.5kHz low pass filter is included prior to the analogue to digital converter
- Modulation:** (GPR receiver only) Select the modulation type: AM or FM.
- Attenuation:** Select the attenuation level:
- % Level:** This option determines what statistical analysis is applied to the samples collected over the sample gap. Select the % confidence value from the list:
- Average (Mean)
 - 50% (Median)
 - 90%
 - 95%
 - 98%
 - 99%
 - Other... Selecting this option allows a custom % value between 1 and 99
- Min No of Samples:** Enter a value for the minimum number of samples that must be taken over a sample gap distance for each frequency. If during the survey less than this number are taken (because the vehicle is driven too fast) then a warning message is displayed.

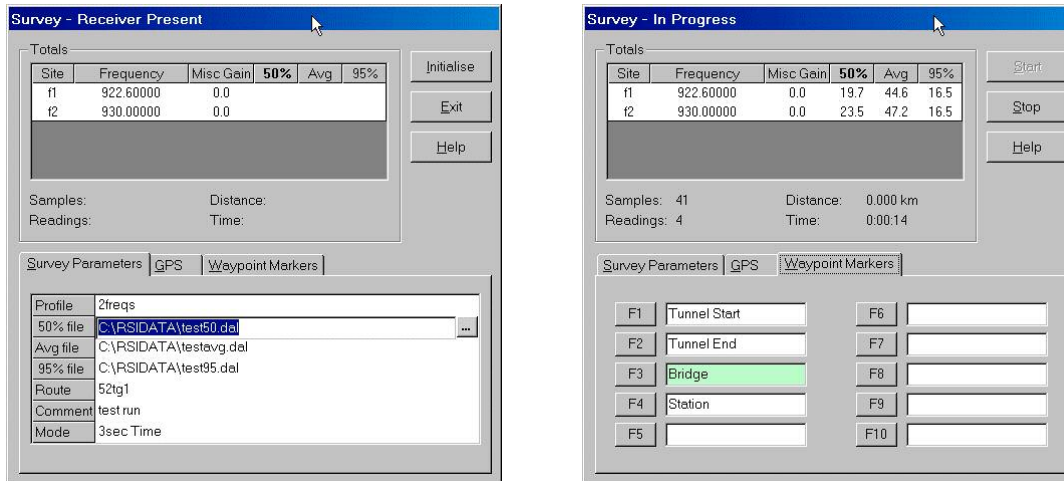
4.2.3 General Parameters



Use the "General" tab of the Survey Configure box to set the general survey parameters as follows:

- GPS Port:** Select the appropriate COM port from the drop down list of available ports.
- GPS Type:** Select from "Rockwell Binary" or "NMEA" at 4800 or 9600 rates. Note that the CRUX GPS PCMCIA card requires "NMEA 4800".
- When using the time sample mode it is possible to select 'not used' for GPS type as time sampling will often be at a fixed location where GPS data is not required.
- Receiver Port:** Select the appropriate COM port from the drop down list of available ports.
- Receiver Type:** Select the appropriate receiver type.
- Sample Mode:** Select either "distance" or "time" sampling. The units shown for "Sample Gap" will then change between metres or seconds respectively. Typically distance sampling will be used for vehicle based surveys while time sampling would be used for stationary monitoring of frequencies over a long period.
- Sample Gap:** Distance sampling: enter the sample gap distance in metres, typically between 10m and 100m.
Time sampling: enter the sample gap time in seconds.
- Map Display:** Select which % Confidence level entered on the "Receiver" tab should be displayed on the map and graph during a survey.
- Graph:** Select how many samples the graph should display during a survey.
- Include Time Stamp:** Select whether time stamps should be saved in the data file at the specified time intervals. This is particularly intended for use with time sampled surveys and will display the time stamps on the graph to indicate actual time rather than elapsed time.
- Operator:** Enter the name of the survey engineer.

4.3 Survey



To carry out a survey follow the following steps:

- 1 Select the relevant survey profile if it is not already selected.
- 2 Libra will check to see if the receiver is connected and indicate either 'Receiver Present' if all is OK or 'No Communication With Receiver' if there is a problem. If this occurs then check the following:
 - the receiver is powered up and can be controlled from the front panel
 - the receiver comms parameters are set to:
 - GPR: 9600 baud, 1 stop bit, no parity
 - Griffin: 57600 baud
 - the comms cable is connected to the correct PC comms port
- 3 Enter the data file name for at least one of the % levels. The file names must be different for each level.
- 4 Fill in the 'Route' and 'Comment' fields as appropriate - these are free-format text fields.
- 5 Check the 'Auto Centre Map' option on the GPS tab if you wish the map to pan automatically whenever the current location moves out of the map area - this ensures that the map always shows the local area during surveying. GPS information is displayed on the GPS tab.
- 6 You will then be able to click the 'Initialise' button as long as:
 - the receiver is present
 - you have GPS lock if surveying using distance sample mode
 - you have entered at least one data file name

This will then cause the receiver to self-calibrate on each of the survey frequencies. When this is complete the graph will appear and the 'Start' button may be clicked to start the survey. During a survey the following parameters are displayed:

Samples	- the number of instantaneous samples used to calculate the last reading
Readings	- a reading is taken each time the sample gap criteria is met, e.g. every 50m or 5 sec.
Distance	- the total distance since the start
Time	- the total time since the start

Results are displayed on the Graph & Map for the selected % level as indicated by the bold % level caption in the totals box.

To finish the survey, click the "Stop" button.

Note: If the GPS unit loses NAV mode due to poor satellite visibility then it drops back into ACQ mode and valid position information is no longer available. In this situation the software assumes that the vehicle is continuing to travel at the same speed and takes signal readings accordingly. When GPS NAV mode is regained the software takes the last good position and the first good position after the outage and spreads the data along a straight line between these two points. This technique has proved to be remarkably good

at producing accurate smooth vehicle tracks even in dense urban areas. Normally this condition only lasts for a few seconds and the “Estimating Position” warning can be ignored.

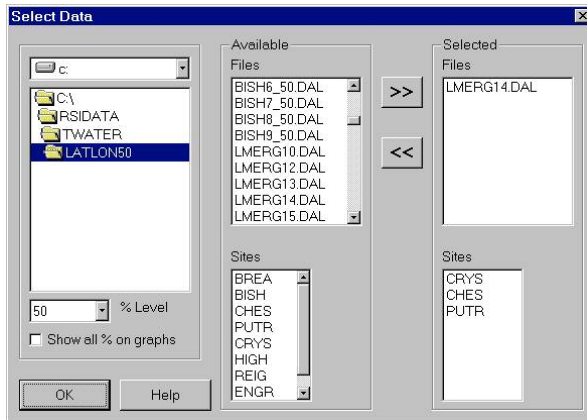
Waypoint Markers

During a survey it is possible to add waypoints to the survey data which are then displayed on the graph and map as short text labels. Usually waypoints are used to indicate geographical features or events during the survey that might not be obvious during the analysis, e.g. tunnels or bridges.

During the survey, click on the 'Waypoints Markers' tab and fill in the text fields in any order with text labels that may be needed – some of the waypoint labels already have default text but these may be changed. When the event occurs then click on the relevant button or press the associated Function Key on the keyboard (F1 to F10). The waypoint label will then change to green indicating that Libra is waiting for the next sample gap. Once the sample gap occurs then the waypoint text will be added to the survey data and the waypoint label colours returns to normal.

5 Analysis

5.1 Select data files or sites



This dialog box allows the user to select survey data files for display either by selecting the sites of interest or the files of interest. This is a very powerful method for showing, for example, the coverage of just one site when the original survey covered many sites or alternatively for showing the effect of different combinations of sites perhaps for assessing the effect of losing the coverage from one site.

Sites and files are selected from the Available Sites and Available Files boxes by double clicking on the site or file name. It will then be copied to the Selected Sites or Selected Files boxes unless it has already been selected. Sites and files in the Selected Sites or Selected Files boxes may be deselected by double clicking on them.

Multiple sites or files may be selected or deselected by highlighting them with the mouse together with the SHIFT and CTRL keys. Clicking the >> or << buttons moves the selected files or sites.

Selecting one or more sites of interest will automatically select those files with data on the selected sites. Similarly, selecting a file will also show those sites which it contains data on. In general it is usually easiest to select the sites of interest and then deselect any files which you may not want to include.

Only files with data for the same percentage level as the Percentage Level selector are listed. Changing the percentage level automatically lists any files in the directory with data for that level.

Normally files will contain data for only one percentage level, however if a file has been merged so that it contains data for several percentage levels then selecting the "Show all % on graphs" check box will allow a graph to display all of the percentage levels. See the section on Merge for information on merging files with different percentage levels.

Maps can only ever display data for one percentage level.

5.2 Analysis Type



Where there is survey data from more than one base station site the coverage map can be displayed either as:

Composite Coverage

Showing the level received from the strongest base station. This is used to show gaps in system coverage where an additional site may be needed. Different colours represent different signal strength levels.

or

Most Likely Server

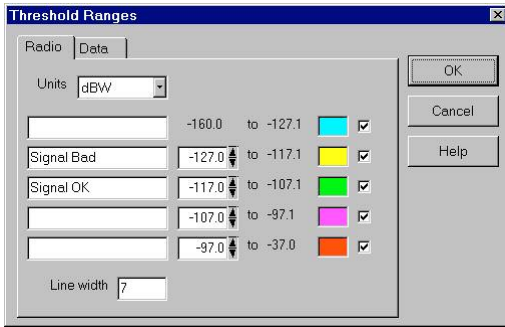
Showing which base station is providing the strongest signal. This is used to show the area that each site serves and is often useful for system sizing and traffic analysis as well as highlighting boundaries between sites for checking site or cell voting. Different colours represent the coverage areas of different sites.

Selecting Most Likely Server enables the Minimum Level field. Any signals below this level will be displayed in black on the map as it is assumed that no site can provide adequate coverage.

5.3



Threshold Ranges



Libra uses colour coded maps where the colour represents a different range of signal levels. Before displaying survey data the ranges must be set to levels that are relevant for your system. Note that any changes made in this dialog box are only implemented when next updating the map display.

Different threshold ranges may be specified for signal strength values and data values. Select the appropriate tab for the type of data currently selected.

To set the ranges..

- 1 Select the Units that the ranges are to be specified in. The values for the range limits will automatically adjust to sensible values for the units selected.
- 2 If field strength is selected then it will also be necessary to enter a Field Strength factor. This is a factor that relates the measured signal strength which is dependent on the survey antenna to the Field Strength which is antenna independent. An equation that is often used for a 1/4 wave whip antenna is:

$$\text{Field Strength [dBuV/m]} = \text{Signal Strength [dBuV]} + \text{factor}$$

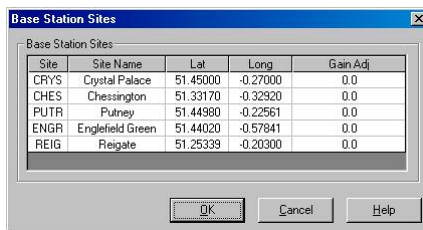
$$\text{factor} = 20\log(f) - 33.58 \quad (f \text{ is frequency in MHz})$$

For example:	frequency = 85MHz	factor = 5.0
	frequency = 140MHz	factor = 9.3
	frequency = 175MHz	factor = 11.3
	frequency = 450MHz	factor = 19.5

- 3 Select which ranges you wish to be displayed by clicking the relevant check-box. This allows you, for example, to highlight just those areas with poor signal strength by only selecting one range. Ranges which are not selected are shown with no colour and the text dimmed.
- 4 Set the range limits either by entering a number in the relevant box or using the spin controls. The higher range values will automatically adjust if you enter a figure in a lower range that is bigger than a figure in a higher range.
- 5 Enter any free format text such as "Unusable" or "Marginal" in the text boxes for each range. This text will be displayed on any printout and helps to make the coverage map more meaningful.
- 6 The colours displayed for each threshold can be changed by clicking on the colour and selecting a colour from the standard Windows colour selection box.

Line Width – Enter the width in pixels for the colour markers displayed on the map.

5.4 Base Station Sites



Radio Site locations can be identified on the coverage map using this dialog box. In addition it is possible to change the site colours for Most Likely Server maps (as set in the analysis type dialog box). Note that any changes made in this dialog box are only implemented when next updating the map display.

To display site markers on coverage maps

Enter or change data for a site by clicking on the appropriate field and typing in the data. Pressing return or clicking on another field updates the data in the list.

- 1 Site name - The site data list contains the abbreviated names of the selected sites in the left column. Enter the full name for this site in the site name column.
- 2 X and Y fields (Lat and Long) - Enter the coordinates for the site location. Note that site locations are always entered in the units currently selected and that X and Y coordinates are in units of metres and must include the 100km digit, e.g. TQ 123 456 would be entered as 51230 14560.
- 3 Gain Adj - Enter a correction value that will be added to all of the signal strength values for that site. This is different to the misc gain factor entered in the survey software at survey time which only applies to a single survey file. In general the gain adjust factor would be used for "what if..?" analysis such as seeing the effect of reducing the power of a single site while the misc gain factor would be used to allow for test conditions such as the survey signal being a different power to the actual transmitter.

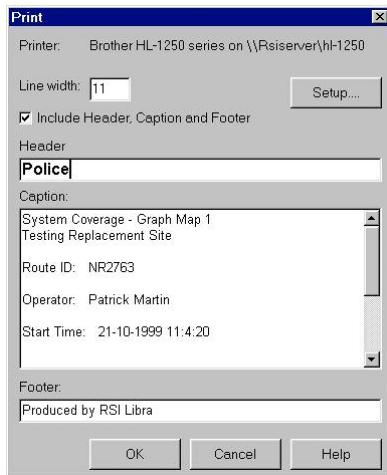
To change the colours for Most Likely Base sites

If Most Likely Base analysis has been selected then the site abbreviated names will be shown in the default colours that will be used. It is sometimes useful to change these colours particularly if there are many sites and two adjacent sites have been given the same default colour.

- 1 Click on the coloured abbreviated site name on the data entry. A colour selection box will be displayed showing the available colours.
- 3 Click on the desired colour and click "OK". The abbreviated site name will now be shown in the new colour.

These colours are also used by the graph when displaying data for each site.

5.6 Print Survey



Libra will print bitmap and scale maps to any standard Windows printer. Scale maps are printed to a precise scale and will appear as previewed in the map window. Bitmap maps are printed so that the current map image fills the paper size and are not printed to any particular scale.

Printer

The current printer is displayed. Click on the Printer Setup button to change the current printer. If the paper size or orientation is changed then the screen should be updated before printing to confirm exactly what will be printed.

Header, Caption & Footer

These are free format text lines that will be displayed next to the printed map or graph. Initially these fields are set with appropriate data from the survey properties form but this may be changed as required.

Line Width

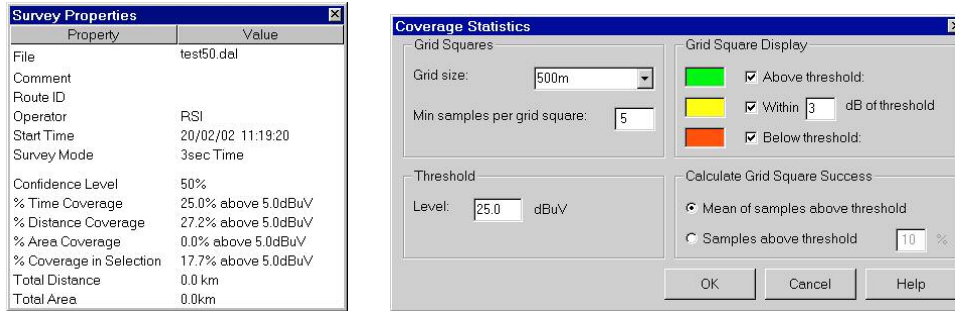
Enter a number to specify how large the printer will print the colour lines. A value of 15 is typical but this may need experimentation depending on the printer and map scale.

Printer Setup

The standard Windows Printer Setup dialog box allows you to set the various printer parameters.

Scale maps are based on the current printer paper size and orientation, therefore to view a larger area at a given scale you must select a larger paper size. The screen display will then reflect these selections when next updating the map display and will show exactly what will be printed.

5.7 Statistical Analysis



Libra includes statistical analysis functions for calculating the percentage of coverage above a threshold level. The results of the analysis are displayed in the "Survey Properties" form together with data for 'Comment', 'Route ID', 'Operator' and 'Start Time' for each file. As these properties may be different for each file the form allows the relevant file to be selected by clicking on the file name and selecting from the list.

The survey properties form shows the following statistics calculated for all of the data on the current map:

% Distance Coverage

Calculated as the distance above the threshold level. Note that this parameter does not allow for the geographical spread of survey data so that, for example, if one road is surveyed many times within a survey the % distance figure will be weighted towards the results for that road. This shortcoming is largely overcome by the % area figure.

% Area Coverage

The calculation of area coverage is configured from the "Coverage Statistics" form. The entire survey area is divided into grid squares sized according to the 'Grid Size' selection, i.e. 100m, 200m, 250m, 500m or 1000m. To ensure statistical validity grid squares are only included in calculation if the number of readings taken in it exceed the number set for the 'Min samples per grid square' parameter.

For those grid squares meeting this initial criteria the success criteria is then calculated according to the selection, i.e. either whether the mean of all samples in the grid square exceeds the threshold level or whether a specific percentage of samples in the grid square exceed the threshold level.

Grid squares are then coloured according to the 'Grid Square Display' setting. Colours are configurable by clicking on the colour and may be disabled completely by selecting the check boxes accordingly.

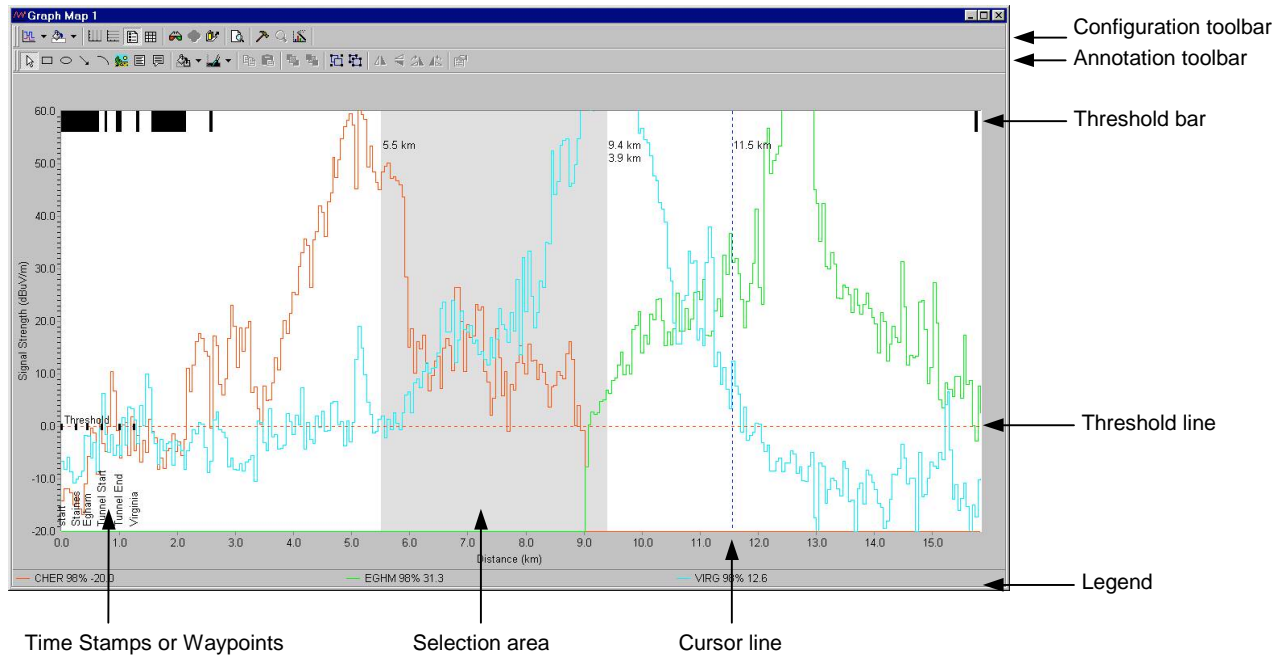
The final % area calculation is calculated as the number of successful grid squares divided by the total number of grid squares. Note that no attempt is made to determine if the total area has been surveyed sufficiently - this will have to be assessed manually by seeing how many squares are coloured in the area of interest and if necessary carrying out more surveys until the entire area has been surveyed in enough detail.

% Coverage in Selection

This figure is for the area selected in the graph (see section 4.11).

Total Distance, Total Area

5.8 Display Graph



Each map window has an associated graph window that may be displayed by clicking the Graph button. The signal strength is displayed for each site selected in the colour that would be used for a Most likely Base type map.

Graph properties such as colours, axis scaling and grid lines may be changed using the appropriate button on the Configuration toolbar or by clicking the right mouse button on the relevant part of the graph. Alternatively most aspects of the graph may be changed from the 'Configure' button on the graph toolbar. The 'Set as Default' option on this menu sets all of the current settings as the start up default.

Annotations such as text comments or diagrams may be added to the graph using the Annotation toolbar.

Zoom

To zoom the graph view in to show more detail, highlight the section to be zoomed using the mouse while holding the mouse button down. The graph will then zoom into this section and may be scrolled left or right using the scrollbar on the bottom of the graph. The zoom mode may be cancelled by clicking the 'Cancel Zoom' button on the toolbar.

Threshold line and bar

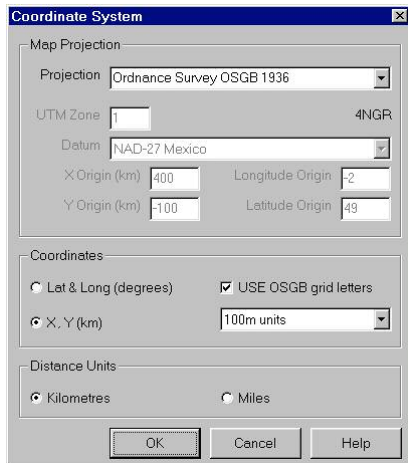
The value of the threshold line is set from the statistics configuration dialog box and is used to calculate the percentage coverage figure displayed in the status line at the bottom of the screen. The threshold bar at the top of the graph gives an instant view of where the signal exceeds the threshold line.

Cursor and Reference lines

The cursor line tracks the position of the mouse as it is moved over the graph. The current distance is shown at the top of the cursor line while the relevant signal values are shown for each site in the Legend box at the bottom of the graph. In addition, as the mouse is moved over the graph, an arrow is displayed on the map window indicating the location of the cursor position.

If the mouse button is clicked a reference line is created and the cursor line then includes a figure for the distance from the reference line. Clicking the graph again creates a 'Selected Section' highlighted in grey for which coverage statistics are shown in the Survey Properties form. Clicking the graph a third time resets the selection area and reference line.

5.9 Coordinate System



This dialog box allows survey maps to be displayed and printed in the most appropriate projection.

Map Projection

The Map Projection should be set to the appropriate type for the maps used. If selecting Gaussian or UTM then the zone number should also be entered. Selecting UTN Custom allows a Transverse Mercator projection to be specified using the following parameters:

Map Datum - GPS coordinates are referenced to the WGS-84 map datum and must be converted to whatever map datum you are using by selecting the datum from the list. Selecting the wrong datum could lead to errors of up to several hundred metres.

Longitude Origin - The line of longitude which is taken to be parallel with the Cartesian grid. UK Ordnance Survey default = -2 deg (ie 2 deg West).

Latitude Origin - The line of latitude which crosses the Longitude Origin at the same point as the Cartesian X axis origin. UK Ordnance Survey default = 49 deg (ie 49 deg North).

X Origin - The value of the Cartesian X axis at the intersection of the Longitude Origin and Latitude Origin. UK Ordnance Survey default = 400km

Y Origin - The value of the Cartesian Y axis at the intersection of the Longitude Origin and Latitude Origin. UK Ordnance Survey default = -100km

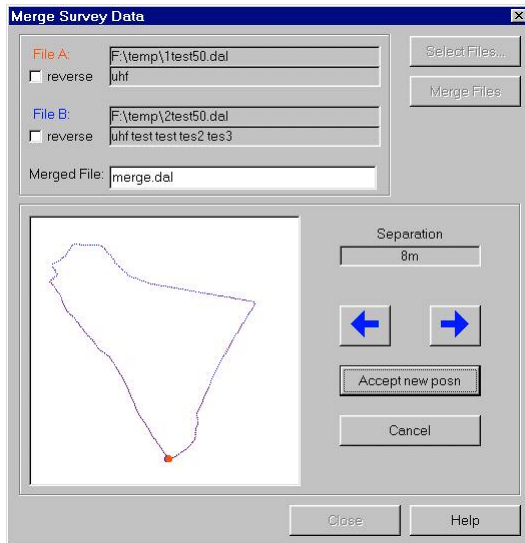
Coordinates

Used to set the type of coordinates used by Libra to display cursor and site location and grid lines and may be latitude and longitude or X and Y grid. The resolution for X and Y grid can also be set together with the option to use 2 letter codes for the 100km squares - as used for OSGB National Grid (only valid if grid has been selected).

Distance Units

This option sets the units to be used for the total survey distance displayed on the status line plus the Graph X axis units. This option may also be set by clicking on the total survey distance shown in the status line.

5.10 Merge Files



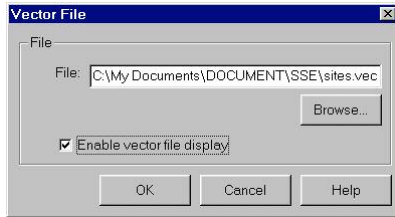
When surveying a network of radio sites it is vital that all sites that could cover an area are surveyed to produce a valid composite coverage map. This means surveying a number of sites for each route which Libra is perfectly capable of doing. However a practical problem often encountered is the lack of different frequencies for each site to produce a separate signal. Libra overcomes this problem by allowing a route to be surveyed as many times as necessary to obtain data for each site and then merging the separate data files to produce a single data file equivalent to surveying all of the sites in one go. The main limitation to this technique is that each site must be surveyed along exactly the same route and in the same direction.

The Merge dialog box allows you to select 2 data files that will be merged together to form a single data file. Problems with GPS inaccuracy are taken into account with a sophisticated algorithm ensuring that points from each file are correctly merged.

To merge two files

- 1 Click on the "Select Files.." button and select the 2 files to be merged from the normal file selection box. The files must contain data on no more than 10 sites otherwise an error occurs. The two files are displayed as red and blue routes on the map box to allow a visual confirmation that they contain data on the same route. If the files contain significantly different numbers of data values then a warning box is displayed.
- 2 Enter the new filename in the "Merged File:" box. A check is made to ensure that existing files are not overwritten.
- 3 Click on the "Merge Files" button. The software attempts to find waypoints in each file that correspond to the same location and marks these waypoints with red and blue markers. An info box informs you of the distance between the waypoints and if you agree that they represent the same point then click the "Yes" button. If they do not appear to be for the same location then click on the "No" button. You are then given the opportunity to adjust the waypoints manually.
- 4 If you select the manual waypoint adjustment then new buttons appear below the map display. Clicking on the left and right arrows moves the blue waypoint marker to other locations. If you can find a location for the blue marker that you believe corresponds with the red marker then click on the "OK" button otherwise click on the "Cancel" button to abort the use of that particular red waypoint.
- 5 If the software identifies more red waypoints then steps 3 and 4 above are repeated. The general aim is to select as many pairs of red and blue waypoints that correspond to the same location in order to improve the accuracy of the merge process.
- 6 When the final waypoint has been displayed the software draws the newly merged file in black based on the waypoint matching. If the new route is clearly incorrect then a poor choice of waypoint matches has been made and you should re-merge the file using a different combination of waypoints.

5.11 Vector File



Libra will display user-defined vector graphics superimposed on top of the map background to assist with the interpretation of survey data, typically showing user boundaries or other borders. The vector graphics are defined in a text file with the following format:

General: - Text file with each line terminated with <CR><LF>
 - File has a .vec extension
 - each line contains a definition for a line, text, point or rectangle as defined below:

Syntax: *Type, MapProjection, X1, Y1[,X2, Y2], Param1, Param2, Param3*

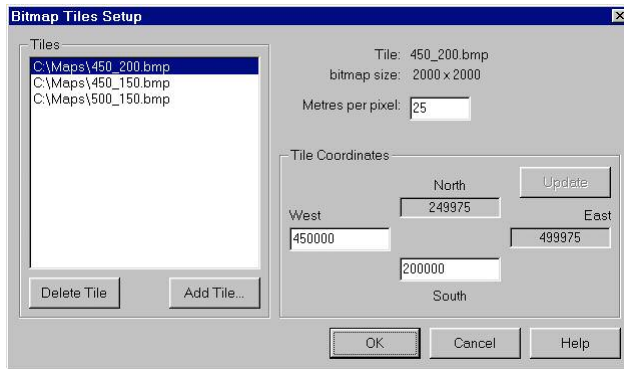
Where the parts have these definitions:

Type The vector type which may be: "line", "text", "point", "rectangle"
MapProjection The Libra map projection code (see the 'Coordinate System' dialog box)
X1, Y1 X and Y Coordinates in the local map projection units
X2, Y2 X and Y Coordinates in the local map projection units
Param1 Line width in pixels or free format text for the text vector type
Param2 Line colour as defined below or font size for the text vector type
Param3 Not Used

Examples:

```
line,4NGR,335600,950900,306300,955100,2,12,1
point,4NGR,367100,859900,10,12,1
rectangle,4NGR,335600,950900,306300,955100,2,12
text,4NGR,100000,1030000,Network Boundary,10
```

5.12 Bitmap Tile Setup



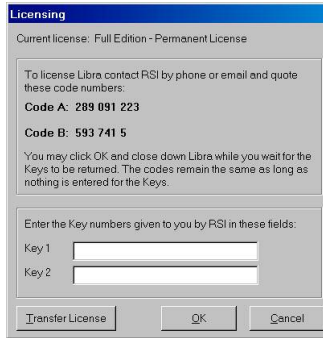
Libra will display survey results on a map taken from a standard .BMP file. When dealing with very large map areas it is probably quicker to split the area into tiles of approximately 2000 x 2000 pixels (typically equivalent to 50km x 50km for a 1:250,000 based map) so that Libra only has to manipulate the tiles that are currently within the map window. Libra only loads individual tiles into memory once they are actually needed and once they have been loaded they do not need to be loaded from disk again therefore speeding up the map redraw process.

This dialog box allows the bitmap tiles to be specified together with their coordinates. Each map tile should be a standard 256 colour Windows bitmap.

Tiles may be added to the list by clicking the "Add Tile..." button and selecting the new bitmap file. Enter the coordinate for the bottom left hand corner in the "West" and "South" boxes in units of metres and enter the appropriate value in the "Metres per pixel" box then click the "Update" button. The top right hand corner coordinate is shown in the "North" and "East" boxes and the map tile is added to the list.

Tiles may be deleted from the list by selecting the tile and clicking on the "Delete Tile" button.

5.13 Licensing



Libra software must be licensed before it may be used. If the software is currently unlicensed then all menu options and toolbar buttons will be disabled except the 'Licensing' option on the 'Help' menu.

The license may be one of the following:

Full Edition

Analysis Only – survey mode disabled

Each of the above may be a 'Permanent License' or a 'Temporary License' with an expiry date.

To request a new License from RSI, quote the 'Code A' and 'Code B' numbers by email or phone. Enter the numbers returned to you in the 'Key 1' and 'Key 2' boxes. If using email then it is possible to close down Libra between sending the Codes and receiving the Keys as long as no numbers are entered into the Key boxes – any number entered will be taken as an attempt to validate the codes and if wrong will reset the codes.

To transfer a license from one PC to another, click the 'Transfer License' button and follow the instructions. You will need to transfer a small file between the two PCs using a disk, network cable or USB pendrive.

6 Survey Data File Format

The survey data file is in the following format:

- General:
- Text file with each line terminated with <CR><LF>
 - File may contain data for a maximum of 10 sites
 - Each file has an 8 line header followed by a variable number of data lines
 - Survey data values, frequencies & gain factors are always in the same order as the first line listing the site names

PUTR HIGH	← 4 character site reference for each site surveyed separated by space
90	← percentage confidence level for the file
Testing new site	← description or comments
05-JAN-95 13:30:21	← date & time of survey
5m Distance	← survey sampling mode
NR2763	← route reference or description
John Smith	← operator Name
0085.3625 +00.00086.7250 +00.0	← frequency & miscellaneous gain for each site (in same order as sites)
51.504797 -0.226227 26.7 10.3	← Latitude & Longitude in decimal degrees, signal strength in dB μ V for each site
51.505164 -0.226718 26.7 10.3	
51.505440 -0.227139 26.7 10.3	
51.505768 -0.227991 26.8 11.3	
.	
.	
51.505962 -0.228920 27.5 10.5	
51.506155 -0.229777 28.0 10.4	
51.506303 -0.230636 29.6 13.4	
51.506405 -0.231497 30.6 13.1	
51.506464 -0.232431 30.7 12.4	
51.506478 -0.233367 30.9 13.9	
51.506536 -0.234229 30.9 14.7	
51.506596 -0.235236 26.1 15.0	
51.506656 -0.236170 26.7 13.9	

7 Installation

7.1 Hardware

The Chase GPR receiver is connected to the 9 pin COM1 serial port connector on the PC using the serial cable. Note that the receiver requires a separate 12V DC supply. If required the receiver can be connected to any other standard serial port up to COM16.

The GPS PCMCIA card is plugged into one of the PCMCIA slots on the PC with the GPS antenna positioned on the roof of the vehicle so that it has an unobstructed view of the entire sky. Note that the PC supplies power to the PC card automatically. The software drivers must be installed in accordance with the GPS card instructions so that the GPS card is available as any serial port up to COM16.

Note:

- 1 On some PC's the GPS card is found to work more reliably in one PCMCIA socket than the other - some experimentation may be needed.
- 2 It may be necessary to disable other applications that may be running such as FAX or mobile phone synchronisation software or infra red ports which may be trying to access the COM ports.

7.2 Software

If a previous version of Libra is installed then this should first be un-installed using the "Add/Remove Software" option in the Windows Control Panel.

Install Libra from the CD-ROM - this will run automatically. Note that you may need to disable anti-virus software.

Libra may then be accessed from the normal Windows Start menu.