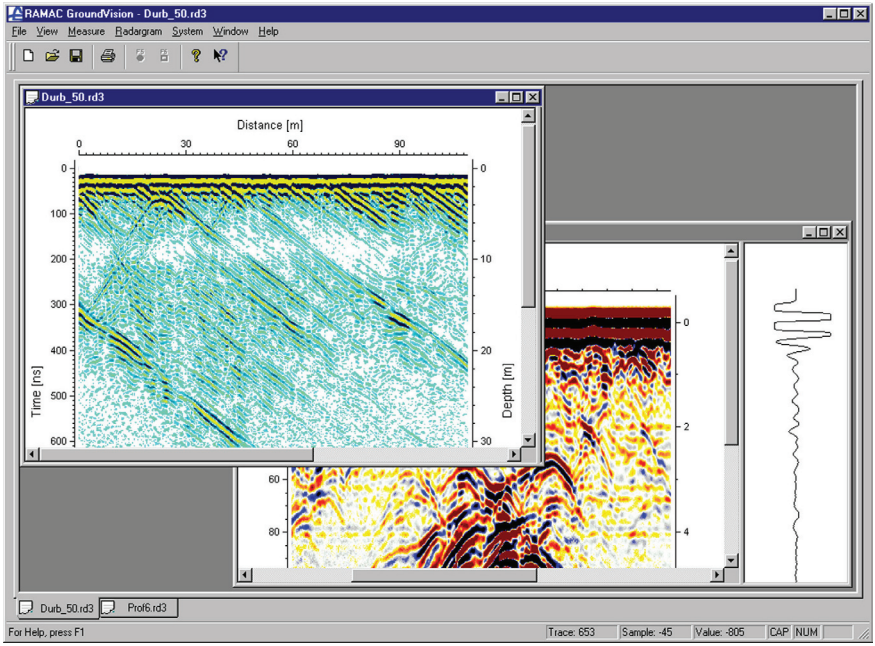
GroundVision Software



Operating Manual v. 1.4

19-001005

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1 Introduction

GroundVision™ is the data acquisition software dedicated to MALÅ GPR Systems. GroundVision can acquire data from MALÅ ProEx or X3M systems. As a Windows™ based software; GroundVision gives you an easy-to-use user interface, file management, printing and other key features. Each measurement and associated settings are stored in files. Filtering can be performed with the measurement or as post-processing. GroundVision software supports both GPS logging and multiple markers during measurement. All radargrams can be printed as such, or post processed by further software.

System requirements:

WINDOWS 95, 98, ME, 2000, NT or XP

- 100MHz Pentium processor
- 32MB of RAM
- 30MB free hard disk space
- 800x600 screen resolution
- ECP parallel port (IEEE 1284) for optimal data acquisition performance

1.1 Installation

The GroundVision Software is delivered to you on an installation CD. It contains a set of program files that will be installed once you run the **Setup.exe** file. The latest version of GroundVision is always available to download from the web site http://www.malags.com/

When you double click on the setup file (either from the installation CD or from the downloaded file) you will enter an installation wizard that will guide you through the rest of the installation process.

Note! If you are doing an upgrade installation of GroundVision it is recommended to uninstall the previous version of GroundVision first. This can be done easiest from the Windows Control Panel, Add/Remove programs.

1.2 User interface

The user interface of Ground Vision is following the standard of many other windows based programs. It supports multiple documents and multiple views of same document. Printing as well as window managing is quite similar and follow standard windows commands.

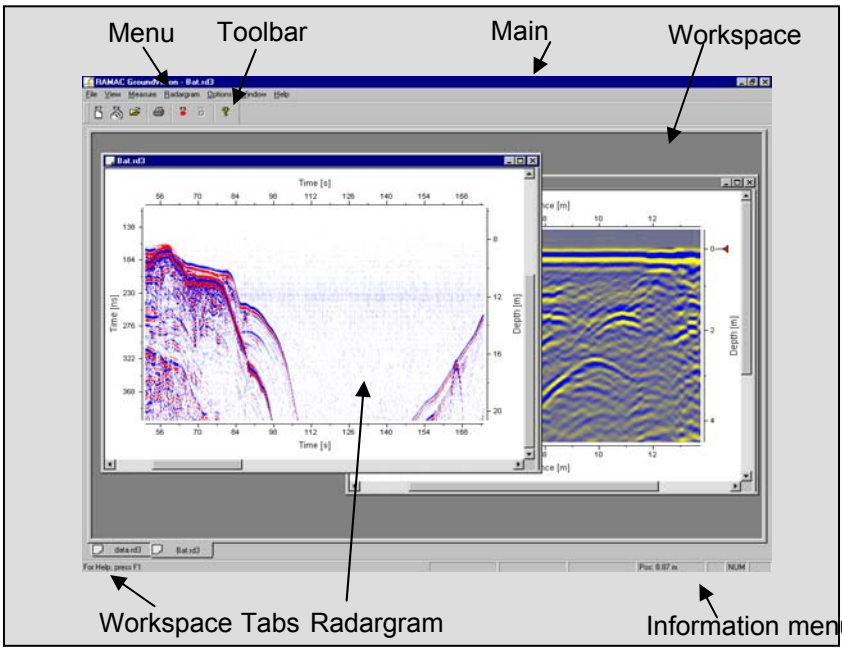


Fig. 1.1 GroundVision main window with two separate files opened.

1.2.1 Main Window

This can also be called the application window. This window holds the application's (GroundVision's) menu, information menu, toolbar, workspace, and the radargram windows. The main window can be minimized, maximized, or resized to any size by the user.

1.2.2 Workspace

One can say that the workspace is the area managed by the user. The main window determines the size of the workspace. The user can manipulate the radargram and trace view windows size and position inside the workspace. As help there

are workspace tabs, which keep track of the different windows and show which one is active.

1.2.3 Menu

The content of the menus varies depending on whether a file is open or not. All choices that are not available are gray.

1.2.4 Toolbar

The toolbar holds all the buttons. A toolbar button is a “shortcut” to a menu command, i.e. every button corresponds to a menu choice. If a button is grayed out that menu alternative is not available. Choosing *Customize Toolbar* under *Options* in the menu can customize the toolbar.

1.2.5 Radargram

The radargram is the image generated by the measured radar data. If the amount of data is larger than the window size, scrollbars are used to scroll the image, both horizontally and vertically. A mouse left click at a certain trace in the radargram shows that trace in the trace view. A mouse right click shows a popup menu containing the radargram specific commands. When the mouse pointer is moved across the radargram the information menu shows the actual trace number, sample number, depth/time and position/time.

1.2.6 Trace View

The trace view displays a trace, which is determined by the user. When scrolling the trace view the trace displays to the left in the radargram. The trace view is toggled On/Off from the keyboard with the *T* key. It can also be resized horizontally to

any size using the mouse. Choose *Trace Window* under *Window* in the menu and move the mouse, a left click determines the size.

1.3 File format

When measuring with Ground Vision two files are generated, one data file (.rd3) and one header file (.rad). The data file is a 16-bit binary file and contains the sample values. The header file is a text file and contains measurement specific information. Never edit and save the information in the header file that can cause errors in the file information and give corrupt data. MALÅ GPR data files acquired from the DOS program GPR.EXE can also be plotted, filtered and printed with GroundVision. If files are to be copied to or from another computer or disc it is important that both the data file (.rd3) and the header file (.rad) are copied.

GroundVision also generates other file types if save filter settings, palette, GPS and markers are enabled. A list of all file types follows:

.RD3	16-bit binary data file
.RAD	Header information file
.COR	Coordinate file acquired from a GPS
.MKN	File with markers 1-9 with color codes and names
.MRK	Marker file generated by the X3MCorder
.FIL	Saved filter parameters
.PAL	Saved palette settings
.MCH	Multi Channel information file

2 Quick start

This chapter deals with the most essential steps for making, viewing, and printing a radar image. Follow the five quick steps below and most of the basic functionality of GroundVision is covered. More detailed descriptions can be found in Chapter 3.

2.1 Power ON

First, make sure that the hardware is connected correctly and power is on. The circle of the *Start F5* button in the tool bar of GroundVision shall be red to indicate a correct power on and working communication with the control unit (or X3M/X3MCorder). If the circle is not red, press the auto-detect key in the toolbar *F9*, the circle shall become red within 5 seconds otherwise either of an ECP communication failure, incorrect cable connections or power failure has occurred.

2.2 New measurement

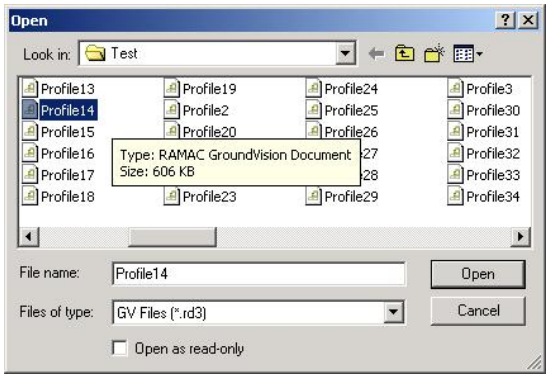
In order to make a new single channel measurement chose *New Single channel measurement* under *File* in the menu (Ctrl N) or the *Start F5* key. In the "New Profile" dialog following specify the desired filename,

directory, antenna and trigger (See also detailed information in chapter 3). Press *Start Measurement* (Ctrl M) and the measurement begin.

Stop the measurement by clicking the *Stop (F6)* button in the toolbar or choose *Stop* under *Measurement* in the menu. When a measurement is stopped the radargram is scrolled to display the beginning of the file.

2.3 View a measured file

To open a file, choose *Open* (Ctrl O) under *File* in the menu or click the *Open file button* in the toolbar. This displays an ordinary Windows "open file dialog" in which the user specifies the file to open.



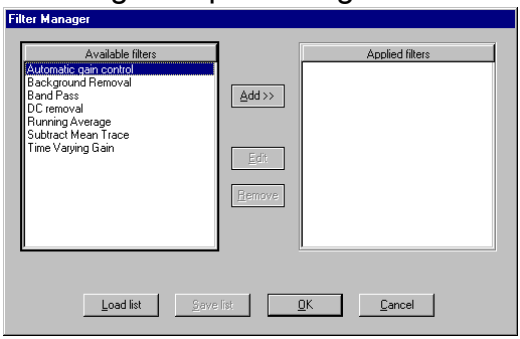
When a file is opened the horizontal scrolling position is zero, i.e. the first trace are shown to the left in the radargram. Likewise the vertical scrolling position is also zero, i.e. the first samples are shown in the top of the radargram. Use the windows scrollbars or the arrow keys to navigate through the radargram.

2.4 Apply filters

Start by choosing *Filter* under *Radargram* in the menu or right click in the radargram and choose *Filter* or press the *F* key.

This activates the “Filter Manager”. To the left, there is a list of available filters and to the right the list of the applied filters is shown.

The functionality of the Filter Manager is quite straightforward. Choose a filter and click either the *Add* or the *Remove* button and the chosen filter will be either removed or applied. It is also possible to double click the filter to be added. By “drag and drop” the order of the filters in the *Applied list* can be altered without removing and applying. The most common filters to use are DC Filter and Time Gain Filter.



There is an option to disable all filters. This is done by selecting the *Disable Filters* command from the *Radargram* menu. This command is also activated with the shortcut key Ctrl F.

Note! On start-up, GroundVision loads the previous applied filters automatically.

2.5 Change the palette

Start by choosing *Palette* under *Radargram* in the menu or right click in the radargram and choose *Palette* in the popup menu or press the *P* key. This activates the “Palette Manager”. The palette has 30 colors and three levels of resolution.

Double clicking on a specific "color box" opens a Windows color dialog and a new color can be chosen.

One single click on a color box makes it activate for interpolating colors. Another single click on the same color box deactivates it. When interpolating the palette it's recalculated depending on the colors in the active color boxes. *OK* closes the "Palette Manager" and applies the palette to the radargram.

Note! On start-up, GroundVision loads the previous used palette automatically.

2.6 Print

To print a radargram click on the *Print* button in the toolbar or chose *Print* in the *File* menu. A standard Windows print dialog will appear in which the printer to use and pages can be altered. The default settings are the same as the default print settings for your Windows operating system. Clicking *OK* prints the radargram with the actual settings. The printout can also be inspected prior to printout with the *Print Preview* in the *File* menu. A *Print Setup* function is also available in the *File* menu. A standard Windows print setup dialog will appear in which the printer, paper, and format can be altered.

Note! A windows printer driver must be installed for the *Print Preview* function to work.

3 Detailed instructions

3.1 Files and radargrams

The technique used when managing the files and the radargrams in Ground Vision is very similar to any other Windows program. Every radargram opens in its own window, which the user can maximize, minimize, and resize using the standard Windows commands. No data is changed in the data file (.rd3) when the file is open for viewing. By this reason there is no need for saving when the file is closed.

3.1.1 View several files at the same time

Viewing several files at the same time is simple. Just open the files separately and Ground Vision will keep track of which file corresponds to which radargram. In the bottom of the main window there are tabs showing which radargram is active (the one that is protruded).

Each radargram has its own palette, scale settings, and filter list. If the user wants to change these setting for a specified radargram it must first be activated.

3.1.2 Manage multiple views of same file

To create a second radargram for a file already opened chose *New Window* under *Window* in the menu. Ground Vision treats these windows as if they were individual files and the user can manage them accordingly.

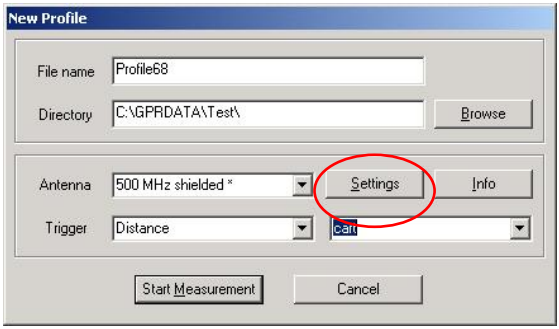
3.1.3 Handle the trace window

In all radargram windows, there is a so-called *Trace Window* that shows a single trace. By clicking on the radargram the user determines which trace to be shown. Toggle (turn on/off) the trace window by pressing *T* on the keyboard. The trace window can also be activated either from the *View* menu or the *Window* menu. By doing this, the size (width) of the window is set by moving the mouse pointer and activated with the left mouse key.

3.2 Measuring issues

3.2.1 Change the measurement settings

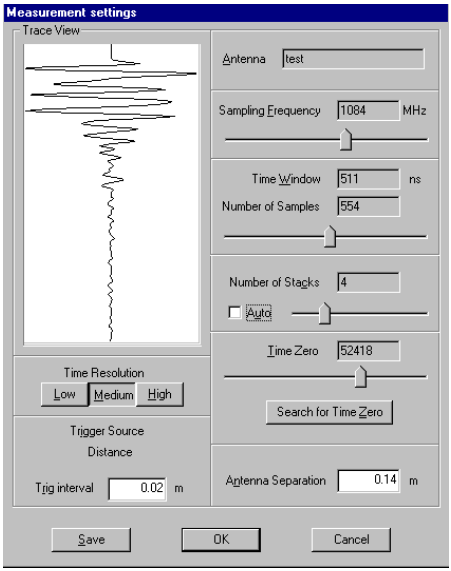
In order to view or change the measurement settings, click the *Settings* button in the "New Profile" dialog.



All measurement specific settings can be viewed and manipulated in the "Measurement settings" dialog. The trace view displays a trace measured with the actual parameters and is updated for every change. All controls can be managed both with the keyboard and the mouse.

Adjusting the Sampling Frequency and/or the Number of Samples controls the **Time Window**.

Sampling Frequency shall be set to approximately 10 times the antenna frequency. If the trace view only displays a straight line, make sure that the transmitter is turned on and is correctly connected. Does not that help, try the *Search for Time Zero* button.

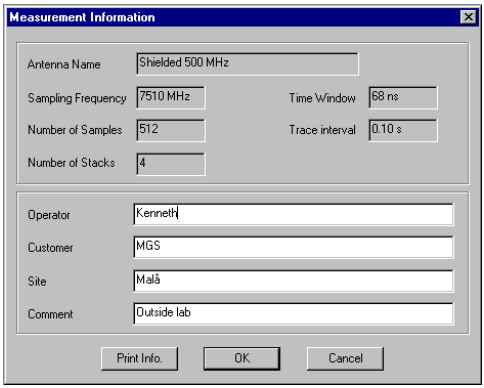


Number of Samples shall be set to a value near 500 for the best performance. A higher number increase the total measured time window but slow down the measuring speed and creates larger data files.

Alter the **Trig Interval** if the default settings are not appropriate (see also Chapter 3.7.1 for more information on encoders). Make sure that the *Antenna Separation* is correct. Otherwise, the calculation of the zero for the vertical scale will be incorrect.

The **Auto stacking** option is enabled by checking the *Auto* check box to the left of the *Number of stacks* slider in the *Measurement settings dialog* (see figure 2.3). When automatic stacking is enabled then the radar system automatically performs as many stacks as possible for each trace. In practice this means that the number of stacks will decrease if the antenna is moved faster, and increase if the antenna is moved slower.

3.2.2 Edit the measurement information



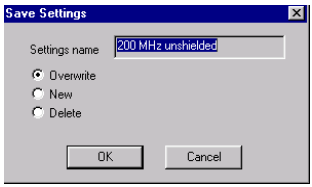
There are two ways to bring up the *Measurement Information* dialog. Either when a new measurement is started or by selecting *Measurement Info* under *View* in the menu.

Only the white areas allow typing/editing. When desired editing has been made *OK* saves the new information in the header file (.rad).

Note! Never open the header file in any word processor or editor! The file might be corrupted.

Clicking the Print Info button prints the information on the default printer with the printer default settings. How to change the printer and its settings is described in below.

3.2.3 Define, save, and delete antenna settings



In the parameter dialog there is a Save button which leads to the Save Settings dialog. It is through this dialog the antenna parameters can be overwritten, new antennas can be defined, and antennas can be deleted.

Choose the desired option (Overwrite, New, and Delete) and click the OK button. The new settings are now either saved or deleted in the control unit memory.

3.2.4 Continue with an existing measurement

First, check that the control unit and the antenna is correctly connected and switched on. Then open the file to be continued and start the measurement. When the measurement is started, the radargram is automatically continued where the previous data was ended.

3.2.5 Apply filters during measurement

Filters can be applied during measurement. However, the filter manager is not accessible during measurement. In order to add or remove filters or alter the settings of applied filters the user must do the following:

1. Stop the measurement (*F6-key*).
2. Apply filters
3. Restart the measurement (*F5-key*).

The data shown in the radargram is now filtered and the incoming data during measurement will be filtered before shown on the display.

Note that filtering during measurement increases the workload on the PC. The acquisition speed while heavy filtering is applied is much correlated to the power of the PC. When the power of the PC is the limiting factor, vertical fields without data may occur in the radargram.

Note! Applied filters only affects the view on the display, the raw data is always kept unaffected.

3.2.6 Change the palette when measuring

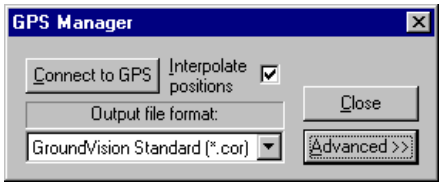
The user can define any palette and use it during measurement. However, the palette cannot be altered when

measuring. If the palette is to be changed or altered when measuring the procedure is the same as for the filters.

3.2.7 GPS Support

GroundVision supports logging of GPS data during measurement. The result of such a measurement is a GPS log file (*.cor, *.wsk or *.utm, see *File Format* below) in which GPS data are written together with the corresponding trace number. GroundVision can read GPS data from any GPS receiver that supports output of data with the NMEA or TSIP communication protocols. The GPS receiver should be connected to the serial port of the laptop. In order to make the GPS Manager visible chose *GPS* under *View* in the main menu. This menu alternative toggles the GPS Manager On/Off.

When first shown the GPS manager window gives access to basic options only. To access the advanced options just press the *Advanced* button. Pressing it again will close the *Advanced* section of the dialog.



Basic options

Connect to GPS

Press this button to activate the communication with the GPS receiver. If there is no contact make sure that the communications settings (see below) match those of the GPS receiver.

Interpolate positions

Due to the low position update rate of many GPS receivers there are often several traces with exactly the same position in

the GPS data file created by GroundVision. When the Interpolate positions checkbox is checked this staircased appearance is removed by interpolating between positions in the data file. This procedure will give best results if the radar unit is moved with constant velocity.

Output file format
Use this selection box to choose between the four different position output formats supported by GroundVision: GroundVision Standard (*.cor), WSKTRANS (*.fri), UTM coordinates (*.utm) and Local coordinates (*.lcf).
The option Local coordinates supports GPS systems which directly can send transformed coordinates (with an extended NMEA-protocol).

Advanced options
The advanced options are all communications settings. Normally the default settings should work but if there is no contact with the GPS receiver use these options to make sure that the communications settings match those of the receiver.

Baud rate, Parity, Data bits, and Stop bits
These are serial port communication settings, which must match those of the GPS receiver.

Com. Port
This setting determines witch serial port on the computer to use for the GPS receiver. The default selection is the first serial port (COM 1).

Protocol
Selects witch communication protocol to use. NMEA (0183) is a standard protocol that should work with most GPS receivers. TSIP is a protocol supported by Trimble GPS units. The default selection is NMEA.

Output file formats

When a new measurement is started a GPS data file is created in the same directory as the files containing GPR data. The file name of the GPS data file is the same as for the GPR data with a different file extension. During measurement the GPS data file is continuously updated to minimize data loss in occasion of a crash. When measuring multiple channels one GPS data file is created for each channel.

GroundVision Standard

This data file format contains the following information: trace number, date, latitude, longitude, height above mean sea level, and HDOP. HDOP is a theoretical measure of the accuracy in the horizontal coordinates based on the positions of the available GPS satellites. A lower value indicates better accuracy. The date and time is expressed in Greenwich time zone. The following is an excerpt of a *.cor file (Trace# date time latitude N longitude E “height above MSL” M HDOP):

105 2000-9-13 11:9:33 65.18164955141 N 18.75051193218 W 357.26 M 1.454542
106 2000-9-13 11:9:34 65.18164955141 N 18.75051193218 W 357.26 M 1.454657
107 2000-9-13 11:9:35 65.18164955141 N 18.75051193218 W 357.26 M 1.454898

WSKTRANS

This is a special data format suited for the WSKTRANS coordinate transformation software made by “Statens kartverk in Norway”. The first line is a header required by WSKTRANS. The file format is defined s:a

EU89-Geodetisk,P,G,HE
“Trace #” latitude longitude “height above ellipsoid”

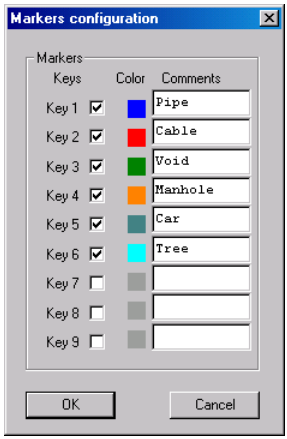
UTM-coordinates
This file format contains coordinates in the global UTM system. The coordinates are calculated from the GPS data using Redfearn's formulas on the WGS84 ellipsoid. The file format is defined as:

"Trace #" northing easting "height above MSL" "UTM zone"

3.2.8 Markers

GroundVision supports a multiple marker function during measurement. Up to 9 markers of different type and color can be configured in the marker dialog.

The Markers configuration dialog is opened from the options pull-down menu in the main window. All the boxes in this window will be empty the first time GroundVision is started. The 9 numerical keys 1-9 on the keyboard are predefined as marker keys. Each key needs to be enabled by checking the white box to the right of each key number. A new color can be selected by a double click on the color box. Any comment for each marker type can be entered in the comments field.



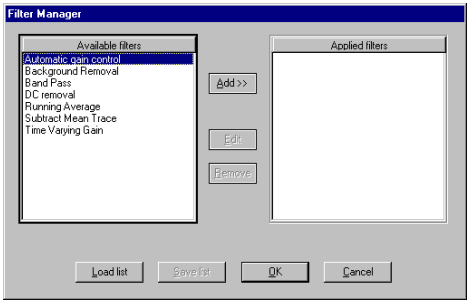
A new marker file with the extension .MKN is generated if any marker keys are pressed during measurement. The marker file is a text file. The first 9 lines contain information about the marker settings. Following in the file there is 2 columns with trace number and marker type for all the markers from the measurement.

3.3 Filtering

To be able to apply filters at least one file must be open. The filter commands are only valid for the active radargram. Much of the functionality described in the topics below is for mouse usage. However, the keyboard can be used in many of these cases. Use the *Tab* on the keyboard to move the input focus between functions and press the *Spacebar* instead of clicking the mouse.

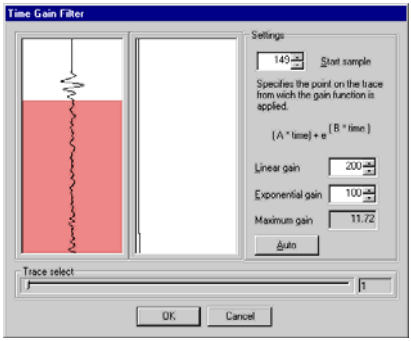
3.3.1 Apply and remove filters

Start by choosing *Filter* under *Radargram* in the menu or right click in the radargram and choose *Filter* in the popup menu. This activates the *Filter Manager*. To the left, there is a list of available filters and to the right; there is a list of the applied filters.



The functionality of the *Filter Manager* is quite straightforward. Choose a filter and click either the *Apply* or the *Remove* button and the chosen filter will be either removed or applied. You can also apply a filter by pressing the *A* or *space key* and remove a filter by pressing the *R* or *delete keys*, or you can both apply and remove by holding down the mouse button and dragging the filter to the list of available filters. By “drag and drop function” the order of the filters in the *Applied list* can be altered without removing and applying.

When a filter is being applied, a filter-settings dialog appears. Each type of filter has its own settings dialog with the specific parameters. The trace window is common to all filter settings dialogs. It displays the trace chosen with the Trace Control with filters applied, including the previous filters from the *applied list*.



Double clicking on a filter in the *applied list* brings up the filter's settings dialog where the filter parameters can be altered. There is an option to disable all filters. To do this select *Disable Filters* from the *Radargram* menu or press the shortcut Ctrl+F.

3.3.2 Decide what filter to use

There is no simple answer to that question. A filter very useful for some applications can be useless in others. Depending on the application and the quality of the radar image a range of different filters can be applied. The knowledge and experience of the user often determines the time it takes to produce a useful image. A general recommendation is to start with *DC Filter* and *Time Gain Filter*, after that perhaps a frequency filter or background removal filter is needed. A detailed description of the filters is found in Appendix 1.

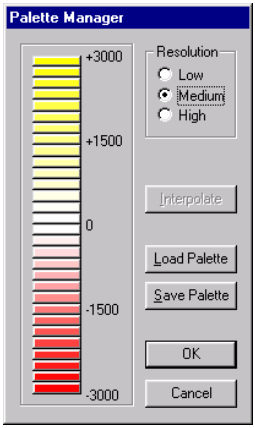
3.4 Palette issues

To be able to view, alter, load, and save the palette at least one file must be open. The palette commands are only valid

for the active radargram. Much of the functionality described in the topics below is for mouse usage. However, the keyboard can be used in many of these cases. Use the *Tab* on the keyboard to move the input focus between functions and press the *Spacebar* instead of clicking the mouse. On start-up Ground Vision always defaults to the last used palette.

3.4.1 Change the palette

Start by choosing *Palette* under *Radargram* in the menu or right click in the radargram and choose *Palette* in the popup menu. This activates the *Palette Manager*. The palette has 30 colors and three levels of resolution.



Double clicking on a specific "colour box" opens a Windows color dialog and a new color can be chosen.

One single click on a "color box" makes it activated, which means that it will be used when interpolating the palette. Another single click on the same "color box" deactivates it. When interpolating the palette is recalculated depending on the colours in the activated "colour boxes". *OK* closes the *Palette Manager* and applies the new palette to the radargram.

3.4.2 Save a palette

To save a palette click the *Save Palette* button and a standard Windows save dialog will appear. Choose directory in which the palette is to be saved, type in a file name, and click the *OK* button. The palette will now be saved in the specified directory with the file extension ".pal".

3.4.3 Load a palette

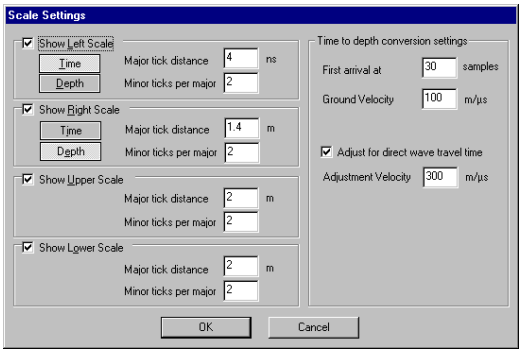
To open a saved palette click the *Open Palette* button and a standard Windows open dialog will appear. Select the palette file to be opened and click the *OK* button. The palette is now loaded into the *Palette Manager*.

3.5 Scales

To be able to view and alter the scale settings at least one file must be open. The scale settings are only valid for the active radargram. Much of the functionality described in the topics below is for mouse usage. However, the keyboard can be used in many of these cases. Use the *Tab* on the keyboard to move the input focus between functions and press the *Spacebar* instead of clicking the mouse.

3.5.1 Show or hide scales

Start by choosing *Scales* under *Radargram* in the menu or right click in the radargram and choose *Scales* in the popup menu. This activates the *Scale Settings* dialog. This dialog is divided into four groups of controls, one for each scale (Left, Right, Upper, and Lower). In the upper left corner in all the groups, there is a check box that is checked if the scale is shown in the radargram. The user can show (or hide) all the scales by checking (or unchecking) these checkboxes.



Once the settings are satisfactory click the *OK* button and radargram will display the new scales.

3.5.2 Alter length scale settings

The two groups of controls at the bottom of the *Scale Settings* dialog are the ones containing the upper and lower length scale settings. By manipulating the values for the major and minor ticks the appearance of the length scales are altered. The labels are shown for every major tick.

3.5.3 Alter depth scale settings

The two groups of controls at the top of the *Scale Settings* dialog are the ones containing the left and right scale settings. The *First Arrival* value is used to calculate the scale zero (see 3.5.4) and is in number of samples. A red marker is shown in the scale at the first arrival.

The scale can either show the depth or the time, altered by clicking the *Time* or *Depth* buttons in the *Scale Settings* dialog. The depth is calculated using the *Ground Velocity*, which is to be entered as m/μs.

By manipulating the values for the major and minor ticks the appearance of the depth/time scales are altered. The labels are shown for every major tick.

3.5.4 Adjust for first arrival travel time

Due to antenna separation, the wave traveling from the transmitter directly to the receiver (the direct wave) is received some time after the actual transmission. This means that the transmitted pulse has already penetrated the medium a certain distance before the direct wave is received. The result of this is that the depth scale zero must be corrected to be accurate.

The zero for the depth scale is calculated using the first arrival value, the antenna separation, and the first arrival adjustment velocity. The adjustment velocity can be set to any value. Practically however, it can be the ground velocity, the air velocity, or anything in between depending on the antenna configuration.

3.6 Printing

3.6.1 Print a radargram

To print a radargram click on the *Print* button in the toolbar or chose *Print* in *File* menu. A standard Windows print dialog will appear in which the printer to use and pages can be altered. The default settings are the same as the default print settings for your Windows operating system. Clicking *OK* prints the radargram with the actual settings.

3.6.2 Choose the printer

There are two ways of changing the printer. If the printer is to be changed just for the actual printing job it can be done in the Windows print dialog that appear when printing (see 3.6.1). If one wants to print several radargrams on a printer other than the default, that printer can be chosen as default (see 3.6.3).

3.6.3 Alter the printer settings

To alter the default printer settings in Ground Vision chose *Print Setup* in the *File* menu. A standard Windows print setup dialog will appear in which the printer, paper, and format can be altered. Clicking *OK* makes the settings default for future print jobs. Note that these settings are not saved and will not be the same if restarting Ground Vision.

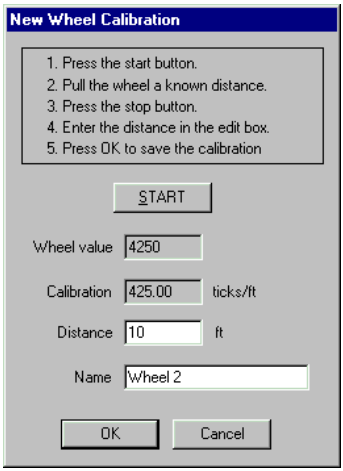
3.6.4 Use the print preview

The print preview functionality is similar to Microsoft Word. Chose *Print Preview* in the *File* menu and the radargram will be displayed as if it were to be printed. The print preview uses the default printer settings. To change the appearance of the radargram in the print preview mode, change the default printer settings (see 3.6.3). When done viewing the radargram in print preview mode, click on the *Close* button.

3.7 System settings

3.7.1 Perform a wheel calibration

Note! The precision of the encoder wheel is not infinite and depending on several factors as; the measurement surface, the pressure applied on the wheel and possible wear. If you are unsure of the encoder wheel precision a re-calibration should be made.



Start with connecting the control unit and the wheel to calibrate, switch the control unit on. Choose *New Wheel Calibration* under *Options* in the menu and the *New Wheel Calibration* dialog will appear,

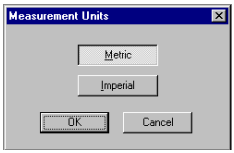
Follow the instructions in the dialog (the *START* button will turn into a *STOP* button when the calibration is started). Type the desired name of the calibration in the *Name* edit box. *OK* saves the new wheel calibration in the control unit memory.

3.7.2 Delete an old wheel calibration

Start with connecting the control unit and switch it on. Choose *Remove Wheel Calibration* under *Options* in the menu and the remove calibration dialog will appear. The dialog contains a list of the entire wheel calibrations saved in the control unit memory.

To delete a calibration, mark it and click the *Remove* button. This removes the calibration from the control unit memory. Note that there is no *Undo* command. Once deleted it is gone.

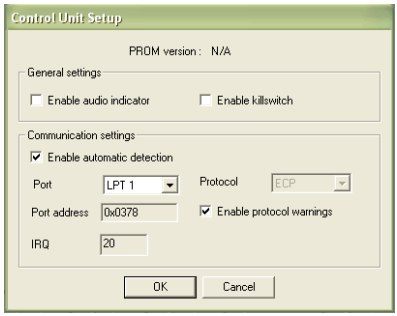
3.7.3 Choose Measurement Units



Choose *Measurement Units* under *Options* and the Measurement Units dialog will appear. Select the unit you wish to use and then press the *OK* button to confirm.

3.7.4 Change Control Unit Setup

The *Control Unit Setup* dialog is divided into three areas. The first area shows the current version of the control unit PROM. If the control unit is disabled or communication doesn't work, the PROM version will be shown as N/A[1].



The second area is for general settings with two checkbox. The first is for enable or disable the audio device on the CUII or the X3MCorder. If it is enabled, the control unit will give an audio signal at each measured trace.

[1] This will also happen if another port protocol than ECP is used with PROM versions prior to 104

The second checkbox enables or disables a kill switch function when using the High Frequency antennas (1.2 and 1.6 GHz, US models only). If it is enabled measurements can only be carried out if the kill switch button on the antenna is pressed down. The measurements will continue for 8 seconds when the button is released, and the stop. More information is found in the Operating Manual for the High frequency antennas.

The third group in the Control Unit Setup is the communication settings how communication is performed between the PC and the control unit. As default, automatic detection of port and protocol settings is enabled. This means that when the program is started, the PC will try to detect the best settings for this computer. By disabling automatic detection, the application can be forced to skip the detection phase upon startup and instead use settings selected by the user. This can be useful if the settings are already known or if the application has problem with automatic detection. If the automatic detection is disabled, the settings should be set to match the current port configuration, which can be found by examining the information available in the computer's control panel. Please note that some of the settings will be disabled depending on the system; for instance, under Windows NT the IRQ setting is disabled since this information is provided by the system. At present, two communication protocols are available: *SPP* [2] and *ECP*.

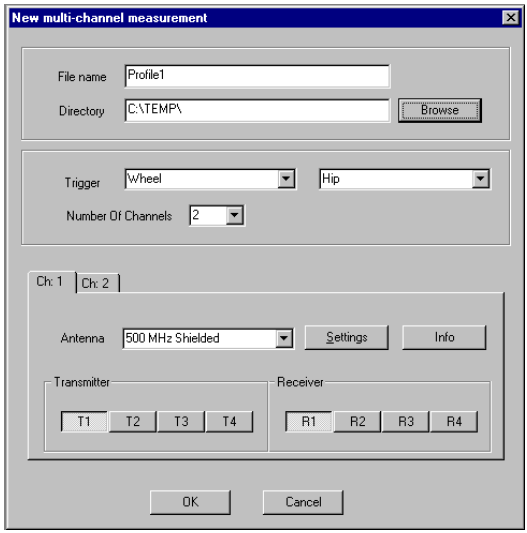
To get highest performance the parallel port should be configured as **ECP**. Port configuration is usually changed in the computers BIOS settings; the manual for your computer will tell you how to do this. For further information also see the *Parallel port configuration guide* of this manual.

[2] Known also as *standard, simple* or *compatible* mode.

4 Multi channel measurements

4.1 New measurement

Compared with single channel measurements, the biggest difference in GroundVision when you are doing Multi channel measurements is the dialog you will encounter when choosing a New Multi channel measurement (F8). Filename, directory, trigger and trigger source are chosen the same way as when doing a single channel measurement. The user decides the number of data channels in the “Number Of Channels” box, (1-16). For every channel a new flap that contains the settings for each channel is shown. Antenna, Settings and Info works as in the single mode.



The user has to define the transmitter and receiver for each antenna. All 4 transmitters and receivers are shown even if all data channels are not chosen. The settings parameters can be set individual in each of the new channels. When pressing OK a new radargram is for each of the channels is shown. To start the multi channel measurement press the “REC-button” (F5)

or choose Rec in the Measure menu. This gives you the possibility to arrange the windows before you start. (After the measurement is started the windows are locked in position.)

4.2 Files associated with MC

When performing a Multi channel measurement GroundVision creates a data file (.rd3) and a header file (.rad) for each channel. A Multi channel file (.mch), which contains the common information for the measurement, is also created. The mch- file gets the name that the user writes in the “New Multi channel measurement” dialog. The .rd3 and .rad files get the same name plus a prefix (a number) that reflects the affiliated channel

Example: The user writes filename MCprofil11 and the number of channels is 3.
The following files are then generated:

- MCProfile1.mch
- MCProfile1_1.rd3 , MCProfile1_1.rad
- MCProfile1_2.rd3 , MCProfile1_2.rad
- MCProfile1_3.rd3, MCProfile1_3.rad

*.cor and *.mrk files separate for every channel

The user can open a Multi channel measurement by choosing File type “GV MC files” in the menu “File open”. If a Multi channel file is opened a radargram for each channel is created. The Multi channel –info, -data and -header file must all been saved in the same folder.

5 Parallel Port Configuration Guide

Before installing the GroundVision application to your computer, you should first make sure that your system is configured correctly. To do this, it is advised that you follow the procedure described below. If you already have installed the application but find that data acquisition is not working properly, you should also follow this guideline.

Note! You must have administrative privileges on your computer to be able to perform some of the described operations. Also note that at some point you may be asked to input your Windows installation CD-ROM; before you begin, you should first locate it.

5.1 Check BIOS settings

Start your computer and enter the BIOS setup; for information on how to do this on your system, consult your computer's reference manual. Find the section containing port settings; on most systems this is found under *Peripheral Devices*. Make sure that the parallel port is set to ECP mode. Although not necessary, if the BIOS allow changing the port address and IRQ for the port it is recommended that one of the following configurations are used:

Table 2-1. Recommended port settings

Port Address	Interrupt Request (IRQ)
0x0378	7
0x0278	5

5.2 Check port type[3]

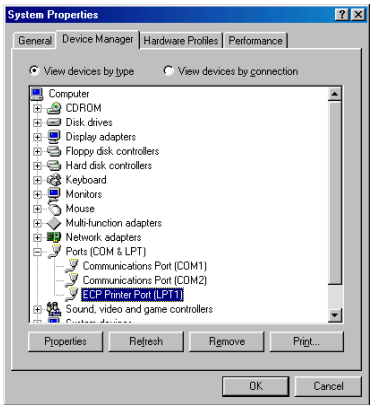
Now, you should start Windows and open the device manager. The device manager can be found as follows:

5.2.1 Windows 9x and Me

Select *Settings -> Control Panel* in the *Start* menu to open up the control panel. Then, double-click on the *System* icon in the control panel to open the system properties dialog. In the dialog, select the *Device Manager* tab.

5.2.2 Windows 2000 and XP

Select *Settings -> Control Panel* in the *Start* menu to open up the control panel. Then, open the system properties dialog by double-clicking on the *System* icon in the control panel. In the dialog, select the *Hardware* tab and then press the *Device Manager* button.



Double-click on *Ports (COM & LPT)*; under this branch you should now see an entry marked *ECP Printer Port*.

If there is no such node, your system is not aware of the parallel port. In this case, you should perform the following steps:

1. In the control panel, run *Add New Hardware*. The computer should after an initial search report that it found an ECP printer port; if it doesn't, press *Next* to proceed.

[3] This step doesn't need to be performed for Windows NT

2. When asked if Windows should search for the new hardware, you should select *No* and then press *Next* to proceed.
3. You will now be presented to a list of available hardware types; select *Ports (COM & LPT)* and press *Next* to proceed.
4. A list will show available drivers for the COM and LPT ports. Select *ECP Printer Port* and then press *Next.*

The system will now install the selected driver; you can later verify this by looking in the device manager. If you see a node but it is marked *Printer Port*, the system has found the port but incorrectly identified it as a standard (non-ECP) parallel port. In this case you should try to change the driver by performing the following steps:

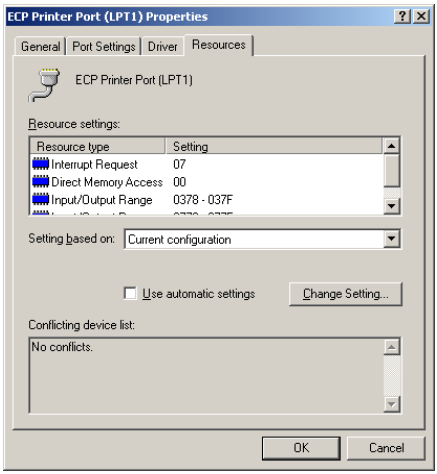
1. Double-click on the *Printer Port* node; this will open up the printer port properties dialog.
2. Select the *Driver* tab and then press the *Update Driver…* button. You should now see a list of alternative drivers for the port.
3. Select *ECP Printer Port* and then press *OK*.

The system will now replace the current driver with the ECP printer port driver; you can later verify this by looking in the device manager.

5.3 Check port configuration[1]

Now we are ready to check the configuration for the port. To do this, enter the device manager and double-click on *ECP Printer Port* to open the printer port properties dialog.

To view the port configuration, click on the *Resources* tab. You should now be able to read the port settings. If the current resource settings don't include an interrupt request, you should try to select one of the other configurations available in the configuration drop down list. If you are using Window 9x/Me, you will first have to disable *Use automatic settings* to be able to perform this operation. Make sure that the selected configuration matches your BIOS settings. Verify that the conflicting device list shows no conflicts. If it does, then you should try to resolve the reported conflicts either by changing the resources for this port or by changing the settings for another device. If you have to change the IRQ for the port in order to avoid conflicts, you should do this in your BIOS; see the first step in this guideline.



[1] This step doesn't need to be performed for Windows NT

5.3.1 Windows 2000 and XP specific issues

In order to make the port work as expected under Windows 2000 and XP, some additional steps have to be performed. Click on the *Port Settings* tab.

As filter resource method, you should select *Use any interrupt assigned to the port*. You should also check the *Enable legacy Plug and Play detection* check box.

5.4 Install software

When the steps above have been performed, it's finally time to install the software; to do this, just run the *setup.exe* for the installation and follow the online directions.

5.4.1 Windows 2000 and XP specific issues

If the software was installed before changing the port configurations, then you should at this stage run *Parallel Port Information Update*, which is located in the *Start* menu under *MALÅ Geoscience -> GroundVision.* After doing this, you should then restart the computer before running GroundVision.

6 Trouble shooting

6.1 Communication

6.1.1 Communication isn't working

Possible causes:

- Invalid BIOS settings
- Invalid communication settings
- Another device driver blocks access to the port
- Hardware problems
- The port doesn't support interrupts

6.1.1.1 Solution

Step 1
Check connections and verify that the control unit is switched on and working properly. You should also check that the parallel port is properly identified by the operative system and not conflicting with another device; for information on how to do this, read your Windows manual.

Step 2
Start GroundVision and select *Control Unit* Setup in the *Options* menu. Enable automatic detection or set communications to match the settings found in the control panel and then restart the computer.

Step 3
If communications still isn't working, check the parallel port's BIOS settings; the parallel port should be set to use either

SPP (compatible) or ECP mode[4]. It is also recommended that the port be set to use port address 0x0378, IRQ 7.
After startup, if the ECP mode has been selected in BIOS and this is a Windows 95/98 system the parallel port should now be identified as an ECP printer port in the device manager. If this is not the case, the port should be removed from the device manager and the computer restarted; the operating system should now identify the port as ECP and install the correct port driver.

Step 4
By now, you should at least have SPP communication up and running; if this isn't the case, the most probable cause is that another device driver is blocking the port or using the port incorrectly. If you use an external device like a CD-writer or a ZIP-driver or if you have a hardware dongle, you should try disabling or temporarily removing the driver for this device.

Step 5
If you've come this far and still haven't got communications up and running, you should try using another computer to verify that the control unit is working properly. If this is the case, then it is possible that the parallel port is faulty on your computer.

6.1.2 Communication is only working in SPP mode

Check the parallel port's BIOS settings; the parallel port should be set to use either SPP (compatible) or ECP[5] mode. It is also recommended that the port be set to use port address 0x0378, IRQ 7.

After startup, if the ECP mode has been selected in BIOS and this is a Windows 95/98 system the parallel port should now be identified as an ECP printer port in the device manager. If

[4] Control units with PROM versions prior to ver.104 only support communication through ECP.
[5] Control units with PROM versions prior to ver.104 only support communication trough ECP.

this is not the case, the port should be removed from the device manager and the computer restarted; the operating system should now identify the port as ECP and install the correct port driver.

6.1.3 The parallell port is configured for ECP, but the application reports SPP

6.1.3.1 Possible cause

This can happen if another device driver is blocking or making improper use of the parallel port resources. Under Windows NT, it will also sometimes happen if the application is started when the control unit is disabled or disconnected.

6.1.3.2 Solution

First, make sure that you have not explicitly set the protocol to SPP by selecting *Control Unit Setup* in the *Options* menu.
If you're using Windows NT, then you should try exiting and restarting the application with the control unit connected and active. If the program still reports SPP, the probable cause is interference from another driver. Otherwise, you should explicitly set the protocol to ECP in the *Control Unit Setup* dialog to make sure the right protocol is selected.[6]
You should at least have SPP communication up and running; if this isn't the case, the most probable cause is that another device driver is blocking the port or using the port incorrectly. If you use an external device like a CD-writer or a ZIP-driver or if you have a hardware dongle, you should try disabling or temporarily removing the driver for this device.

- **"Communication with the control unit failed! Please check connections/ battery and retry."** No communication with the control unit.

[6] This is a known problem with the current NT driver.

- **"No response from receiver. Please check power and connections, then restart the control unit."** Communication with the control unit but no response from the receiver.

6.2 EEPROM

- **"Unable to access the EEPROM! Please contact support."** GroundVision can not access memory in control unit. Change battery and retry, if no change contact support.
- **"Unable to add parameters to EEPROM. Please restart Ground Vision and reset the control unit"** GroundVision cannot access memory in control unit. Change battery and retry.
- **"Unable to delete settings from EEPROM. Please restart Ground Vision and reset the control unit"** GroundVision can not access memory in control unit. Change battery and retry.
- **"Unable to write settings to EEPROM.Please restart Ground Vision and reset the control unit"** GroundVision cannot access memory in control unit. Change battery and retry.

6.3 Wheel calibration

- **"The wheel calibration list is full! Remove wheel calibrations before adding another."** The control unit memory is limited. If the area dedicated for wheel calibrations is full this error message occur. Remove unused wheel calibration and try again.

- **"Wheel calibration distance is too short."** In order to make a proper wheel calibration a quite large distance should be used. Redo the calibration over a longer distance.

6.4 Multichannel

- **Unrecoverable internal error in multi channel routine."** Multi channel info is corrupt. Check ".mch" file, restart and try again. If the problem persists reinstall GroundVision.
- **"No response from channel number …"** GroundVision has no contact with the receiver specified for the channel in question. Check that the settings are proper, check batteries and connections and try again.

6.5 File handling

- **"It is not possible to continue on a measurement performed with the DOS acquisition software"** Due to differences in file formats of measurements done with the DOS acquisition software (GPR.EXE), these files cannot be continued for measurement in GroundVision. All files from GPR.EXE can still be displayed, filtered and printed in GroundVision.

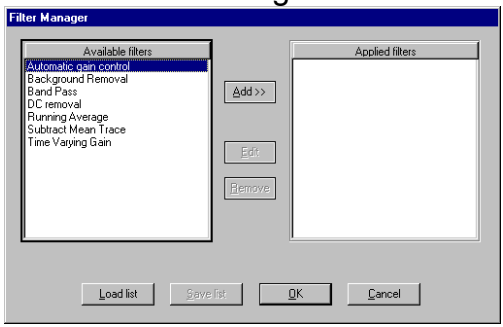
7 List of key-words

Sample	In order to collect and store GPR data the electromagnetic waveform has to be digitized. A sample is the digital amplitude value of the waveform at a specific time.
Trace	Several samples collected during a certain time interval generate a digitized image of the waveform, also known as a trace.
Sampling freq.	The interval in which samples is taken over the trace length. A higher sampling frequency gives a shorter time window.
Stacks	The number of stacks is equal to the number of times that each sample is measured and averaged over.
Direct wave	The part of the transmitted energy that travels the shortest distance between the transmitter and receiver.
First arrival	The user must set the first arrival value in order to show correct scaling. Normally it is set to the sample number that corresponds to the Direct Wave.
Time window	Defines the total trace length in time. Can be recalculated to a depth value if the ground velocity is known.
Ground velocity	The velocity (moving speed) of the electromagnetic wave in the ground. Different velocities are corresponding to different soil/ground types.
Travel time	The time elapsed between when the signal is transmitted and when it reaches the receiver.

Appendix 1

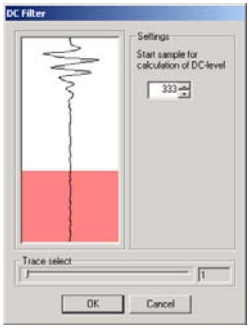
1.1 Available filters

This appendix covers the available filters in the Ground Vision filter manager. The filters that have settings that need to be set have a dialog connected to them. This dialog can be called from the *Filter Manager* and is shown in each filter description. Common to all filter dialogs is the trace window that shows the filtered trace. The trace window is updated when there is a change in the filter settings. The dialogs can be handled with both mouse and keyboard.



1.2 DC-Filter

There is often a constant offset in the amplitude of the registered trace, this is known as the DC level or the DC offset. This filter removes the DC component from the data. The DC component is individually calculated and removed for each trace.

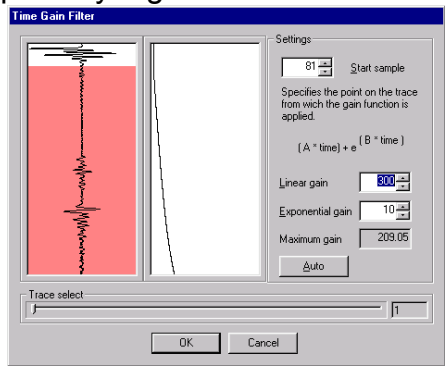


In the dialog (to the right) the sample interval on which the DC component is calculated is specified. The end sample is always the last sample in each trace and

the start sample is set using the spin button. The sample interval is shown as a red area at the bottom of the trace. The start position can also be selected by clicking in the trace window with the mouse pointer.

1.3 Time-Gain Filter

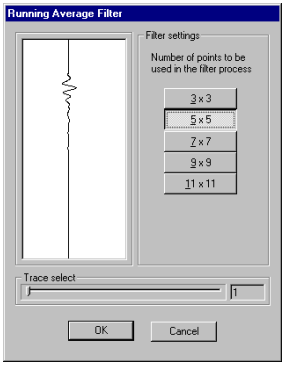
The Time-Gain filter applies a time-varying gain to compensate for amplitude loss due to spreading and attenuation. The trace is multiplied by a gain function combining linear and an exponential gain, with coefficients set by the user. It also has an Auto button which when pressed calculates and suggests filter coefficients. In the Time-Gain dialog (to the right), there is one trace window and one gain window. The trace window shows a filtered trace and the gain window shows the gain function applied. The red part of the trace window indicates the part of the trace that is filtered. The filter settings are altered by using the spin buttons or by entering a value from the keyboard.



The following keyboard shortcuts are also available:

l – increase linear gain factor
Control + l – decrease linear gain factor
e – increase exponential gain factor
Control + e – decrease linear gain factor

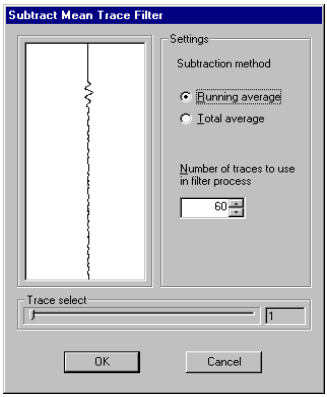
1.4 Running Average Filter



The running average filter smoothes the radargram by replacing each sample with the mean value calculated from all samples in a window centered on the active sample. The larger this window (or averaging mask) the more extreme becomes the smoothing effect.

Select the size of the averaging mask. The numerical keys 3,5,7,9 and 1 are mapped as shortcuts to the available settings. The trace view will be updated to reflect the changes in the settings.

1.5 Subtract mean trace



This filter is used to remove horizontal and nearly horizontal features in the radargram by subtracting a calculated mean trace from all traces The running average version subtracts a mean trace calculated in a window centred at the trace to be filtered. The size of this window is selected by the *Number of traces to use in filter process* edit box. The Total average method calculates the means trace as the means of the whole data file.

Subtraction method; the mean trace to be subtracted from the data can be calculated in two different ways, either as the mean of the whole data set or as the mean over a window centred around the trace to be filtered.

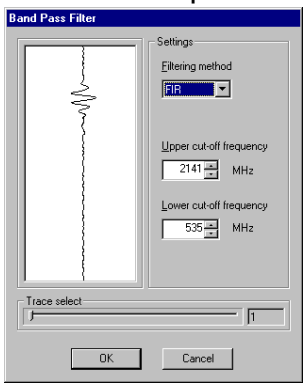
Number of traces to use determines the number of traces to be averaged in the calculation of the mean trace to be subtracted.

The following keyboard shortcuts are available:

n – increase *Number of traces to use in filter process*
control + n – decrease *Number of traces to use in filter process*

1.6 Band pass filter

Band pass filters are used to remove unwanted frequencies from the traces. Frequencies below the lower cut-off frequency and above the upper cut-off frequency are attenuated.

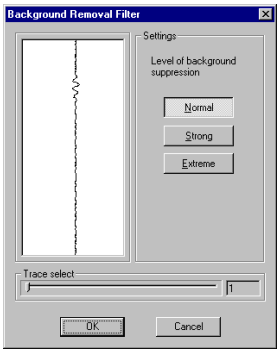


The band pass filter dialog is used to adjust the settings for band pass filters applied to the data. Both FIR (finite impulse response) and IIR (infinite impulse response) filters are available. FIR-filters are slower but generally provide better results. The upper and lower cut-off frequencies define the boundaries of the pass-band of the filter.
Filtering method selects between (FIR) and (IIR) filters. IIR filters are also known as recursive filters.
Upper cut-off frequency defines the highest frequency that is passed through the filter without attenuation, and *Lower cut-off frequency* defines the lowest frequency.

The following keyboard shortcuts are available:

u – increase upper cut-off frequency
control + u – decrease upper cut-off frequency
l – increase lower cut-off frequency
control + l – decrease lower cut-off frequency

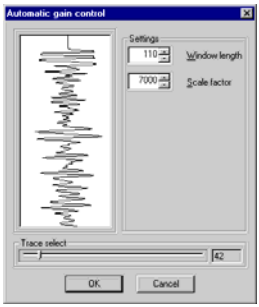
1.7 Background removal filter



This filter removes horizontal features or almost horizontal features from the data by applying a horizontal spatial high pass filter. The effect of the filter is similar to that of the running subtract mean trace filter. Going from the Normal to the Extreme setting has the effect of removing progressively more sloping events.
The three settings Normal, Strong and Extreme, corresponds to normalized cut-off frequencies (frequency divided by the sampling frequency) of 0.01, 0.025 and 0.05, respectively.

Note that during measurement a less powerful filtering algorithm has to be used (not phase compensated). Therefore there will be a slight difference in the appearance of the radargram during measurement and during viewing of recorded data.

1.8 Automatic gain control

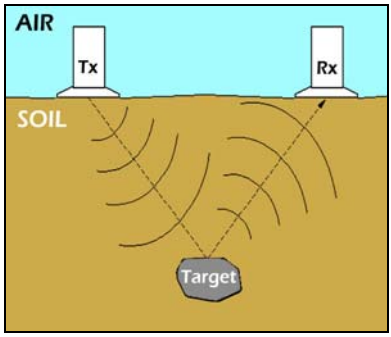


This filter attempts to adjust the gain of each trace by equalizing the mean amplitudes observed in a sliding time window. A short window gives a more pronounced effect, the extreme of which would a one-sample window, which would cause all amplitudes to be equal. The other extreme would be a time window of the same length as the trace. This would have no effect on the trace. After equalization a constant multiplier is applied to the trace to make the resulting amplitudes reasonable.

Appendix 2

2.1 GPR, Principle

Radar is, in principle, related to reflection seismic methods. A transmitter (Tx) emits a signal into the surface of investigation. The back reflected signal is detected and registered by a receiver (Rx). In contrast to seismic methods, radar instruments uses electromagnetic waves instead of acoustic waves.



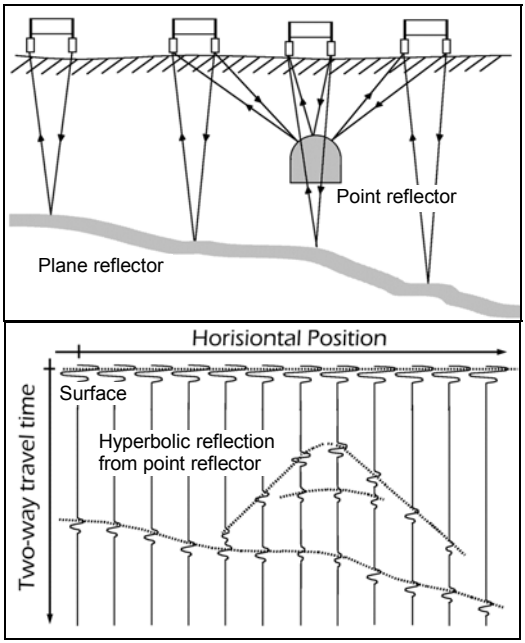
EM-waves will not penetrate as deep as acoustic waves but will result in much higher resolution maps. Targets with a contrast in electrical impedance to the surrounding media will be registered and detected. Therefore, surface radar instruments are primarily used for detection and localization of metallic and non-metallic targets down to an approximate depth of 30 m.

2.2 Measurement basics

The MALÅ control unit continuously emits signals into the media of investigation. The number of scans per length or time unit is set in the software. Normally, acquisition is performed in profiles on top of the surface of the media. Results of the survey can, instantaneously, be viewed on the laptop

computer controlling the measurement. Ground Vision allows real time filtering during measurement.

Point reflectors will, due to spherical dispersion, be registered as hyperbolas, whilst plane reflectors will maintain their natural form. The lateral and vertical resolution of the results varies between 0.01-1.0 meters, depending on the choice of antenna frequency. Higher antenna frequency gives higher resolution, but less penetration, and vice versa.



Appendix 3

3.1 Velocities in Certain Medias

The following table gives approximate values for ε_r (relative permittivity) and the resulting velocities for a number of medias. ε_r varies greatly with the water content in the medium. The larger value given for a velocity applies to a more unsaturated media.

Medium	**ε_r**	**Velocity [m/µs]**
Air	1	300
Fresh water	81	33
Limestone	7 - 16	75 - 113
Granite	5 - 7	113 - 134
Schist	5 - 15	77 - 134
Concrete	4 - 10	95 - 150
Clay	4 - 16	74 - 150
Silt	9 - 23	63 - 100
Sand	4 - 30	55 - 150
Moraine	9 - 25	60 - 100
Ice	3 - 4	150 - 173
Permafrost	4 - 8	106 - 150

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