

# Operating Manual v. 2.1

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# Table of Contents

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<b>1 Introduction</b>	<b>5</b>
1.1 Installation and Communication	6
1.2 User interface	6
1.3 File format	9
<b>2 Quick start</b>	<b>10</b>
2.1 Power ON	10
2.2 Select Measurement Settings	10
2.3 Start and stop a measurement	11
2.4 View a measured file	11
2.5 Apply filters	12
2.6 Change the palette	12
2.7 Use Contrast	13
2.8 Print	13
<b>3 Detailed instructions – Files and Measurements</b>	<b>14</b>
3.1 Files and radargrams	14
3.2 Measuring issues	14

<b>4 Detailed instructions - GPS</b>	<b>21</b>
4.1 GPS Support	21
<b>5 Detailed instructions – Markers, Filtering, Palette</b>	<b>24</b>
5.1 Markers	24
5.2 Filtering	24
5.3 Palette issues	26
5.4 Scales	27
5.5 Printing	28
<b>6 System settings</b>	<b>29</b>
6.1 Perform a wheel calibration	29
6.2 Choose Measurement Units	30
6.3 Change Hardware Setup	30
<b>7 Trouble shooting</b>	<b>31</b>
7.1 Wheel calibration	31
<b>Appendix 1 Filters</b>	<b>32</b>
<b>Appendix 2 GPS measurements</b>	<b>38</b>

# 1 Introduction

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MALÅ GroundVision is the data acquisition software dedicated to MALÅ GPR systems. GroundVision 2.0 can acquire data from the MALÅ ProEx and X3M control units with Ethernet communication. 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.



We at MALÅ Geoscience welcome comments from you concerning your experiences in using this equipment, as well as your impressions of this manual. Please take the time to read through the assembly instructions carefully and address any questions or suggestions to the following:

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# 1.1 Installation and Communication

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.

System requirements: Windows 95, 98, ME, 2000, NT or XP and Ethernet communication.

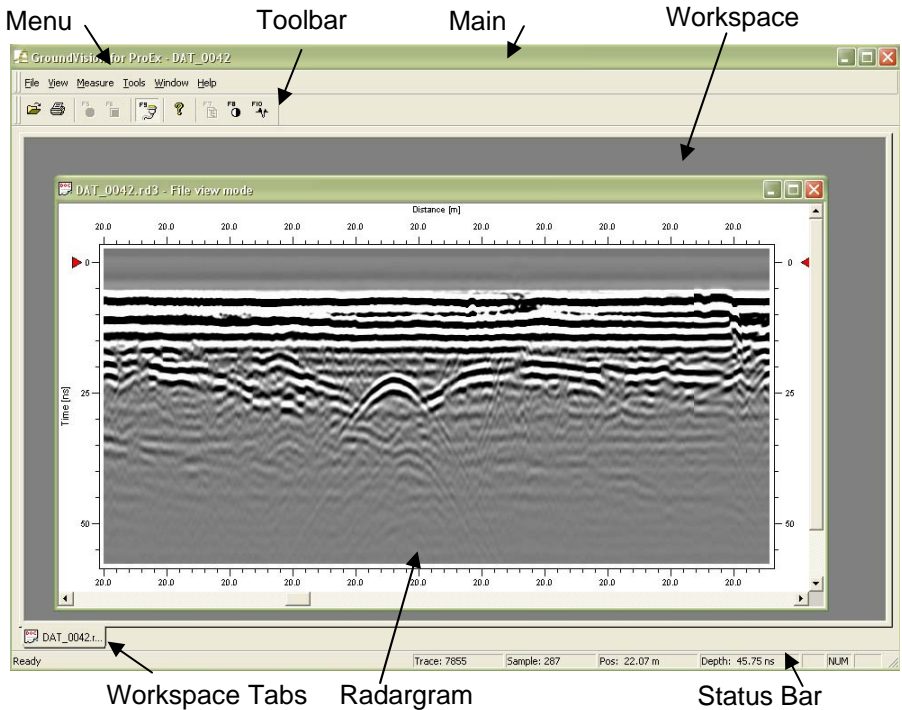
To make the communication run between the Control unit and the computer used, start up Ground Vision and go to the Tools menu -> Hardware setup.

In the Hardware Setup window (see Chapter 6.3), the setting on how communication is performed between the PC and the control unit is made. In the Ethernet interface drop-down-menu the available Ethernet-interfaces are seen. Choose the standard, most often a Generic VPN.

The communication between the PC and the ProEx or the X3M control unit will work only with Ethernet on wire.

# 1.2 User interface

The user interface of GroundVision is following the standard of many other windows based programs. Printing as well as window managing is quite similar and follow standard windows commands.



**Fig. 1.1** GroundVision main window with a radargram opened.

### 1.2.1 Main Window

This can also be called the application window. This window holds the application's (GroundVision's) menu, status bar, 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.

### 1.2.3 Menu

The content of the menus varies depending on whether a file is open or not or if the program is in measuring mode. All choices that are not available are grey.

### 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 greyed out that menu alternative is not available.

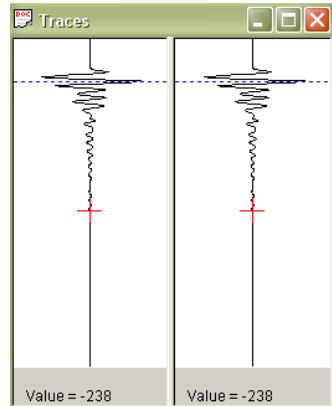
### 1.2.5 Radargram

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 single trace, which is determined by position of the mouse cursor over the radargram. In data collection mode the trace window always shows the last incoming trace. The trace view is toggled On/Off from the keyboard with the *F10* key or opened by choosing *Trace Window* under the *View menu*.

When measuring in multi-channel mode with the ProEX, there will be one trace view for each active channel.





## 1.3 File format

When measuring with GroundVision 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. 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 colour codes and names
.fil	Saved filter parameters
.pal	Saved palette settings

### **Note!**

When working with several antennas and extension modules (the different slots) with the ProEx control unit, the name for the files generated will follow this convention:

If the file name is set to PROF the file names generated by ProEx will be PROF\_nnn\_SC (.rad, .rd3, .add) and PROF\_nnn\_S (.mrk).

nnn is a automatically given number

S gives the slot the data belongs to, A to H

C gives the channel, 1 for internal Tx and 2 for external Tx.

The file **PROF\_0042\_B1.rd3** is accordingly radar data from slot B, internal Tx.

## 2 Quick start

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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 to 5.

### 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 (the ProEx or X3M with Ethernet).

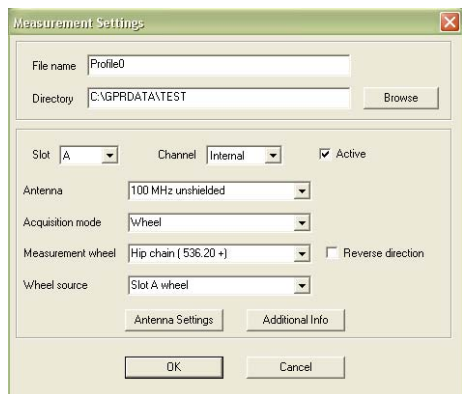


If the circle is not red, press the auto-detect key in the toolbar *F9*, the circle shall become red within 5 seconds otherwise a communication failure, incorrect cable connections or power failure has occurred.

### 2.2 Select Measurement Settings

Chose *Measurement Settings* under in the *Measure* menu or right-click on the channel to use in the Channel navigator to access the measurement settings dialog. Here the desired filename, directory, antenna and trigger can be chosen.

Detailed data collection settings are found in the Antenna Settings dialog opened by pressing the *Antenna Settings* button.



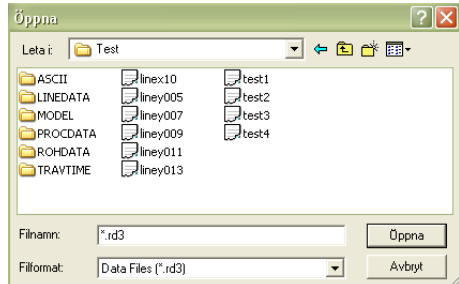
## 2.3 Start and stop a measurement

Click on the start button on the toolbar, press *F5* on the keyboard or select *Start* from the *Measure* menu to start a measurement with the selected settings. To stop the measurement, click on the stop button, press *F6* or select *Stop* from the *Measure* menu.

In distance triggering mode a new trace is collected every time the wheel or hip-chain has moved a distance interval as set in the Antenna Settings dialog. Time triggering mode works in the same way, using the elapsed time and the time interval to determine when to collect a new trace. In keyboard triggering mode one trace is collected every time the *Enter* button on the keyboard is pressed.

## 2.4 View a measured file

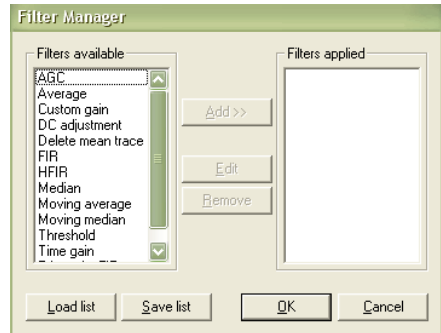
To open a file, choose *Open* (Ctrl O) under *File* in the menu or click the *Open file button* in the toolbar. This displays an ordinary Windows "open file dialog" in which the user specifies the file to open.



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.

## 2.5 Apply filters

Start by choosing *Filter Manager* under *View* in the menu or right click in the radargram and choose *Edit Filter List* 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.

The filters applied can be turned OFF and ON by pressing  in the toolbar.

## 2.6 Change the palette

Start by choosing *Palette Manager* under *View* in the menu or right click in the radargram and choose *Change Palette* in the popup menu or press the *P* key. This activates the “Palette Manager”.

Double clicking on a specific "color box" opens a Windows color dialog and a new color can be chosen. One single right-click on a color box makes it activate for interpolating colors (indicated by a red frame around the colour box). Another single right-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.

## 2.7 Use Contrast

The Contrast Control is found in the *View* menu, the *Toolbar* or by pressing *F8*, and it is used to increase the contrast of the different radargram views. The effect of changing the contrast is, somewhat similar to a change in the gain function, but much easier and faster to do.



## 2.8 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 – Files and Measurements

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## 3.1 Files and radargrams

The technique used when managing the files and the radargrams in GroundVision 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. For this reason there is no need for saving when the file is closed.

### 3.1.1 Handle the trace window

The *Trace Window* shows a number of panels with a single trace in each. There is one panel for every active channel. The position of the mouse cursor over the radargram determines which trace is shown. Toggle (turn on/off) the trace window by pressing *T* on the keyboard, clicking the trace window button on the toolbar or select *Trace Window* from the *View* menu.

## 3.2 Measuring issues

To start a measurement the communication between the PC and the ProEx or X3M has to be functioning. If the button F5 is red the measurement can start. Otherwise F9 can be used to connect the PC to the control unit. During measurement the F6 button is used to stop a profile. It can be started again by pressing F5.



**Note!** If a profile is closed it cannot be restarted again.

### 3.2.1 Start a measurement and change the settings

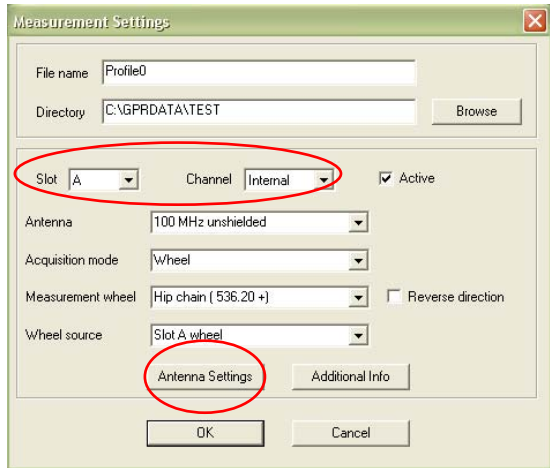
A measurement is carried out with the following steps:

1. Make the correct settings for the antennas used
2. Start the measurements F5
3. Stop the measurements F6
4. If a new profile is started with the same settings, go to 2, otherwise 1.

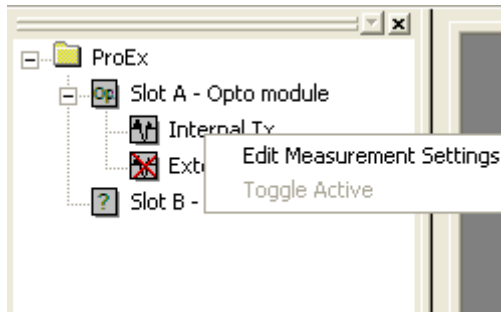
The file name is given in the *Measurement settings* dialog, and also the directory where to save it. Observe that the file name will be automatically extended according to the convention in Chapter 1.3. Choose the correct antenna, acquisition mode measurement wheel (more information in Chapter 6.1).

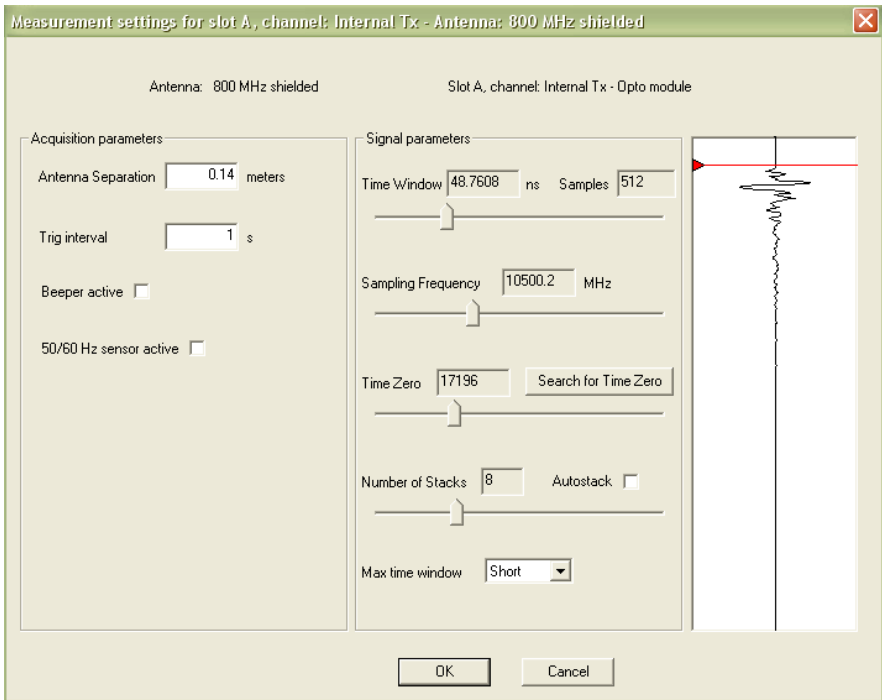
In order to view or change the measurement settings, click the *Antenna Settings* button in the *Measurement settings* dialog. See below.

The antenna settings are changed for the Slot and Channel viewed In the example at right Slot A and Channel Internal. **Note!** These options are **only** available for the ProEx control unit.

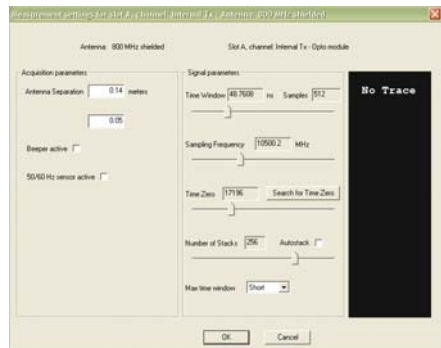


If the Channel navigator is opened (F8 or under the View menu) the settings for the different antennas connected can be changed by first marking the antenna to change and then by right-click on the same and choose the option *Edit Measurement settings*. This opens the same settings dialog as explained above and viewed below





If there is something wrong in the communication, for instance for the transmitter antenna, the trace will not be viewed, instead the trace window will be black as seen to the right.



All measurement specific settings can be viewed and manipulated in the *Antenna 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. In the header of the dialog the antenna changed are seen as a description of the slot and the channel.



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

**Sampling Frequency** shall be set to approximately 10 to 12 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.

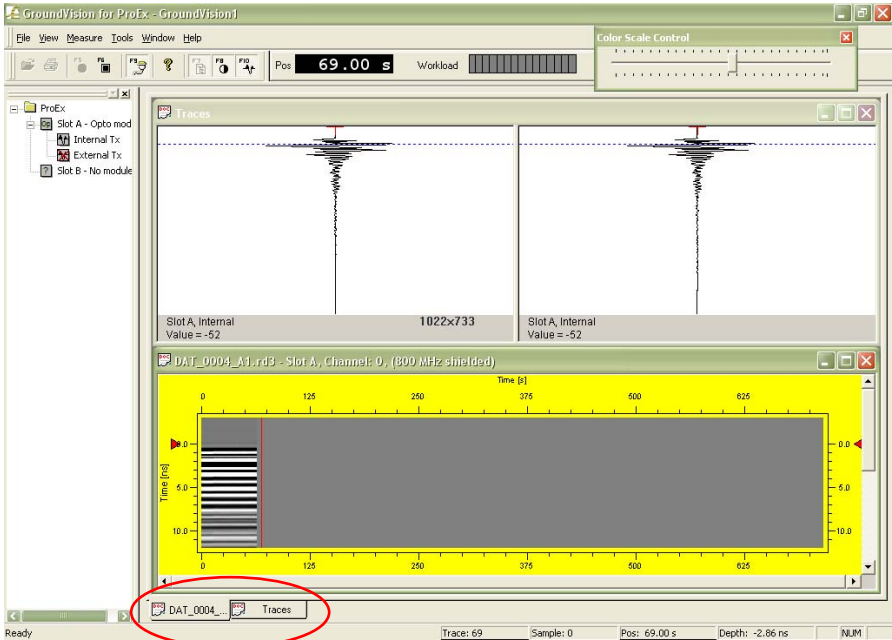
Alter the **Trig Interval (Point distance)** if the default settings are not appropriate. Make sure that the *Antenna Separation* is correct. Otherwise, the calculation of the zero for the vertical scale will be incorrect.

The **Auto stacking** option is enabled by checking the *Auto* check box to the right of the *Number of stacks*. 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.

If the option **Beeper** is ticked, a beep will be given for each measurement.

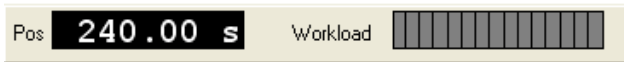
When the **50/60 MHz sensor** is active EM data from the HF antennas with EM option will be collected. See also Operating Manual för HF antennas.

In active mode, when the ProEx or X3M with Ethernet connection and GroundVision are collecting data the radargram screen is yellow; otherwise the radargram window is white. An example of GroundVision for ProEx in active mode is shown below.



When using several antennas only one radargram is shown at the time. To select which data to show just click on the channel you want to activate in the Channel navigator (F7), right-click and choose *Toggle active*.

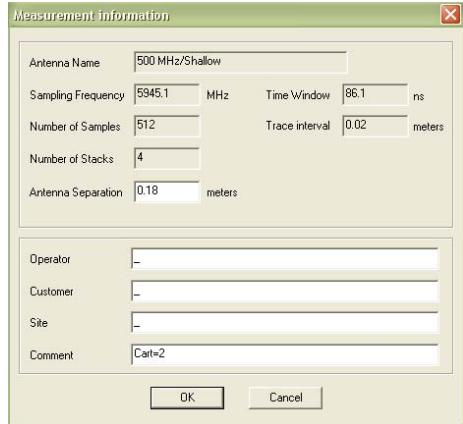
In the main menu the position is of the profile is viewed, together with the workload indicator. This should not go up to red more than occasionally, to give data of good quality.



### 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 Information* 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).



The *Measurement Information* dialog box contains the following fields:

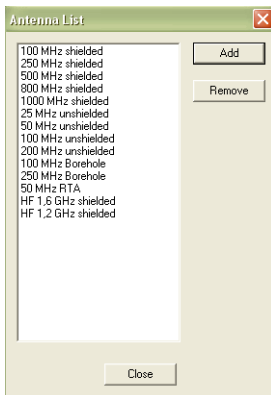
Antenna Name	500 MHz/Shallow		
Sampling Frequency	5345.1 MHz	Time Window	86.1 ns
Number of Samples	512	Trace interval	0.02 meters
Number of Stacks	4		
Antenna Separation	0.18 meters		
Operator	-		
Customer	-		
Site	-		
Comment	Call=2		

Buttons: *OK*, *Cancel*

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

### 3.2.3 Define, save, and delete antenna settings

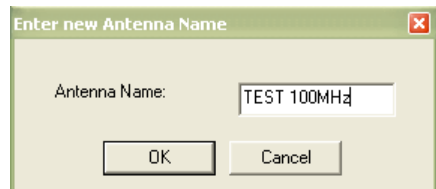
As changes has been made in the *Antenna Settings dialog* these are immediately saved for that given antenna. To create a new antenna setting, open the *Edit Antenna list* dialog in the *Tools* menu and press *Add*. The name can freely be given. Then go the *Antenna settings* menu and do the correct settings.



The *Antenna List* dialog box shows a list of antenna settings:

- 100 MHz shielded
- 250 MHz shielded
- 500 MHz shielded
- 800 MHz shielded
- 1000 MHz shielded
- 25 MHz unshielded
- 50 MHz unshielded
- 100 MHz unshielded
- 200 MHz unshielded
- 100 MHz Borehole
- 250 MHz Borehole
- 50 MHz RTA
- HF 1.5 GHz shielded
- HF 1.2 GHz shielded

Buttons: *Add*, *Remove*, *Close*



The *Enter new Antenna Name* dialog box contains the following field:

Antenna Name:	TEST 100MHz
---------------	-------------

Buttons: *OK*, *Cancel*

### 3.2.4 Apply filters during measurement


Filters (see also Appendix 1) 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*).
2. Apply filters
3. Restart the measurement (*F5*).

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 saved on the computer is always kept unaffected.

The filters applied can be turned OFF and ON by pressing  in the toolbar.

### 3.2.5 Change the palette when measuring

The user can define any palette and use it during measurement. The palette can be altered when measuring, by right-click on the radargram and the choosing Change palette.

### 3.2.6 50/60 MHz EM sensor data

When measuring with MALÅ HF antennas with EM option the EM data can be viewed by selecting *50/60 MHz sensor data* in the *View* menu. Both gradients of the EM sensors are viewed in the same EM window.

The EM data can also be turned ON and OFF with the  in the toolbar.

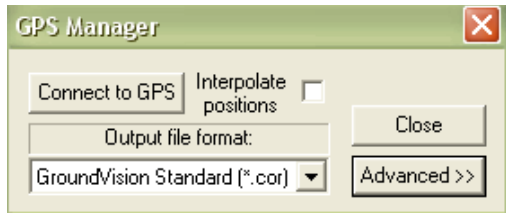
# 4 Detailed instructions - GPS

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## 4.1 GPS Support

GroundVision supports logging of GPS data during measurement. The result of such a measurement is a GPS log file (\*.cor, \*.utm or \*.lcf, 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 Manager* under *View* in the main menu. This menu alternative toggles the GPS Manager On/Off.

When first shown the GPS manager window (found under the view menu) 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.



**Note!** See also Appendix 2 for more information on measurements with GPS.

### 4.1.1 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. When this button is activated the GroundVision software will create a \*.cor-file for each radar file produced

and  is viewed on the main menu, giving the GPS-position.

### *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 stair cased 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 that directly can send transformed coordinates (with an extended NMEA-protocol).

## **4.1.2 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.

Typical settings for the advanced option, for the communication between the GPS and GroundVision, are shown below. The GPS used should of course also be set according to this and connected to the Com-port on the laptop used.



### 4.1.3 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. A GPS data file is created for each slot when measuring with the ProEx control unit.

#### *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
```

#### 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"

# 5 Detailed instructions – Markers, Filtering, Palette

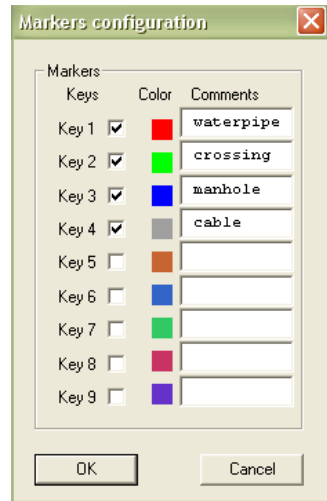
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## 5.1 Markers

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

The Markers configuration dialog is opened from the *Tools* 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 colour can be selected by a double click on the colour 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 lines contain information about the header version. Following in the file there is four columns (should be tab-separated) with trace number, sample number, marker type and marker label.

## 5.2 Filtering

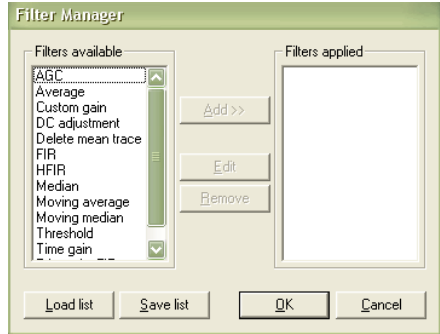
To be able to apply filters at least one file must be open. The filter commands are only valid for the active radargram. Much of the functionality described in the topics below is for mouse usage. However, the keyboard



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.

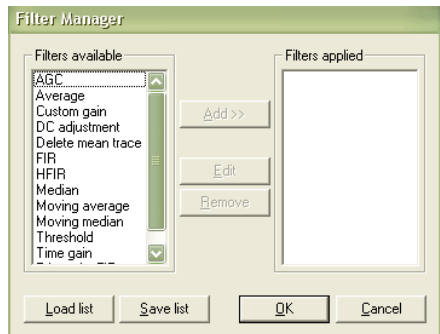
### 5.2.1 Apply and remove filters

Start by choosing *Filter Manager* under *View* 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 *Add* or the *Remove* button and the chosen filter will be either removed or applied. You can also apply a filter by pressing the *space key* and remove a filter by pressing the *Alt+R* or *Del*, 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, press the shortcut *Ctrl+F* or press  in the toolbar.

## 5.2.2 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.

## 5.3 Palette issues

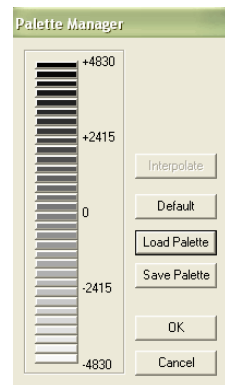
To be able to view, alter, load, and save the palette at least one file must be open. The palette commands are only valid for the active radargram.

### 5.3.1 Change the palette

Start by choosing *Palette Manager* under *View* 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.

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

One single right-click on a "colour box" makes it activated, which means that it will be used when interpolating the palette. Another single right-click on the same "colour 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.



### 5.3.2 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".

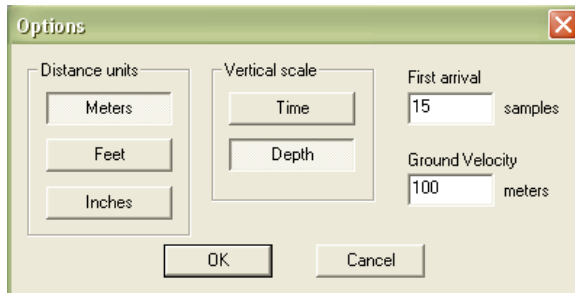
### 5.3.3 Load a palette

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*.

## 5.4 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.

In the *Tools* menu, *Options* is found. Here the vertical scale can be set to Time or Depth together with the first arrival and the velocity to use.



### 5.4.1 Adjust for first arrival travel time

Due to antenna separation, the wave travelling 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.

## 5.5 Printing

### 5.5.1 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.

### 5.5.2 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 5.5.1). If one wants to print several radargrams on a printer other than the default, that printer can be chosen as default (see 5.5.3).

### 5.5.3 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.

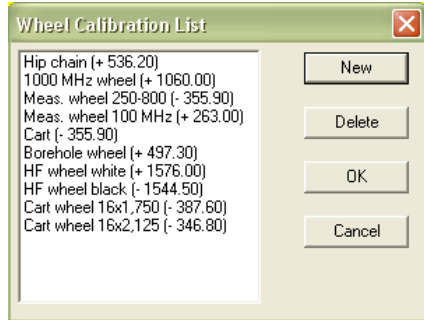
### 5.5.4 Use the print preview

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 5.5.3). When done viewing the radargram in print preview mode, click on the *Close* button.

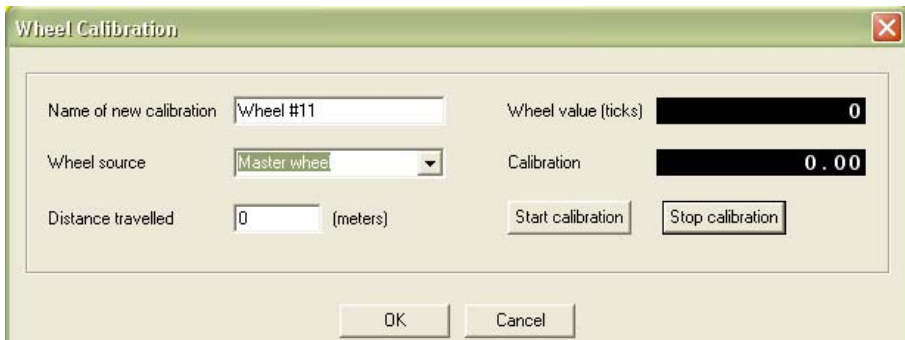
# 6 System settings

## 6.1 Perform a wheel calibration

Start with connecting the control unit and the wheel to calibrate, switch the control unit on. Choose *Edit Wheel List* under *Tools* menu and the *Wheel Calibration List* dialog will appear. Press new.



Observe that in this dialog, the option of deleting wheel calibrations is also found. Mark the wheel name and press *Delete*.

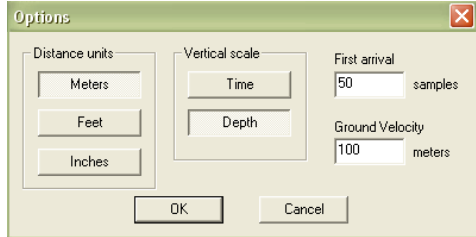


Type the desired name of the calibration in the *Name* edit box and choose the correct wheel source to use, Master, Slot A, B, C or D. Give the correct distance for the calibration, and press *START*. When the distance is travelled press *STOP* and the option *OK* saves the new wheel calibration in the control unit memory.

**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.

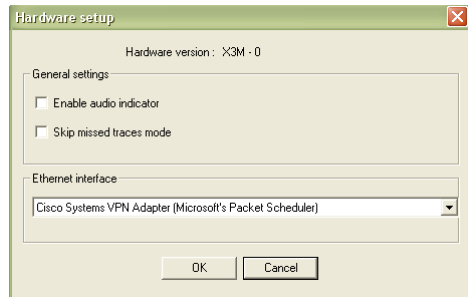
## 6.2 Choose Measurement Units

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



## 6.3 Change Hardware Setup

The *Hardware 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 "No control unit detected".



The second area is for general settings with three checkboxes. The first is for enable or disable the audio device on the ProEx. If it is enabled, the control unit will give an audio signal at each measured trace. The second enables the *Skip missed traces mode*. In this mode the ProEX will skip traces when over-speeding the system. This means that the position of each trace is correct but that there may be empty traces in the data set.

The third 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 Hardware Setup is the communication settings on how communication is performed between the PC and the control unit. In the Ethernet interface drop-down-menu the available Ethernet-interfaces are seen. The communication between the PC and the ProEx or the X3M control unit will work only with Ethernet on wire.

# 7 Trouble shooting

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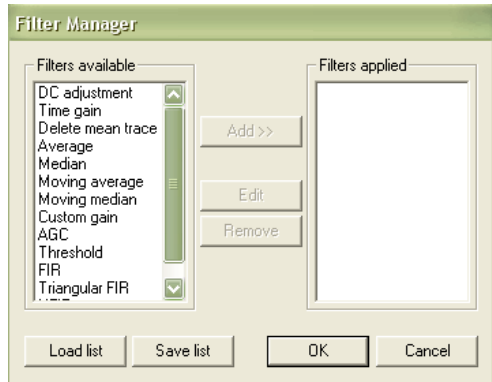
## 7.1 Wheel calibration

- **"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.

# Appendix 1 Filters

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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.



Which filter to use is depending on the application and the quality of the radar image. A filter very useful for some applications can be useless in others. 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 Gain. Below the available filters are listed and also if they are always, often, seldom or very seldom used in common GPR applications.

Always used: DC-shift

Often used: Delete Mean Trace, FIR, Time Gain

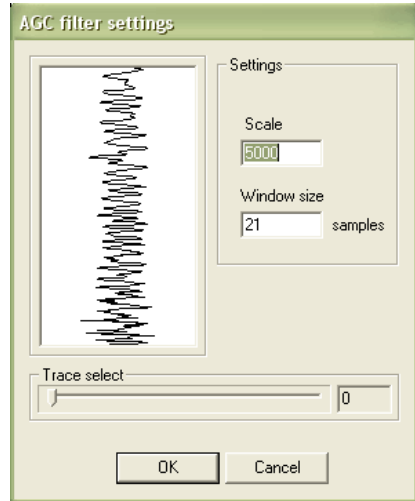
Seldom used: Custom Gain, Moving Average, Moving Median, Threshold

Very seldom used: Average, Median, AGC, Triangular FIR, HFIR



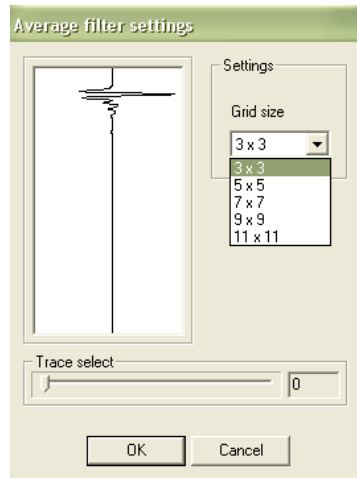
### Automatic gain control AGC

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 be 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.



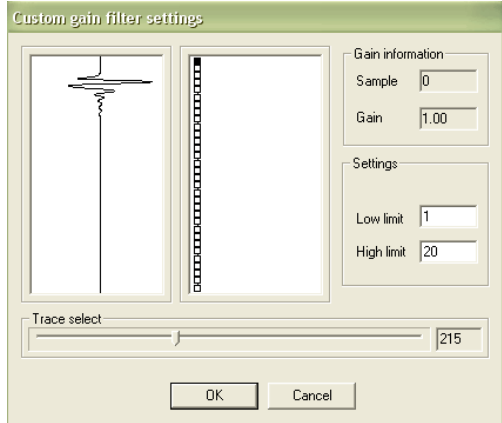
### Average

The Average filter calculates a mean over a given number of samples and traces. The sample in the middle of the grid is replaced by the average value. . This filter acts as a simple 2D-lowpass filter and gives a softer picture.



### Custom Gain

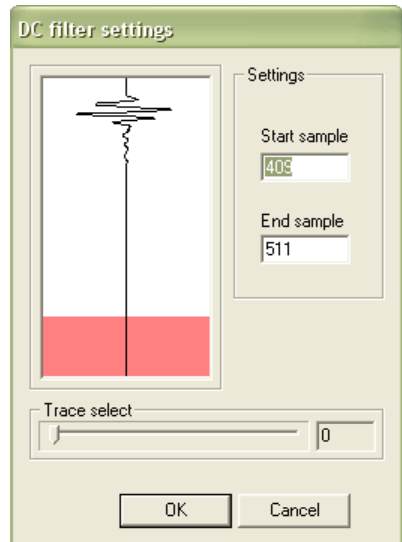
An amplifying filter where the gain factor is given manually for 32 different sections of the trace.



### DC-Filter

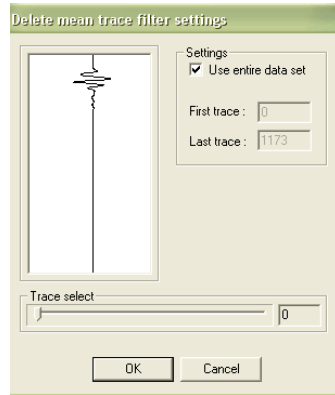
There is often a constant offset in the amplitude of the registered trace, this is known as the DC level or the DC offset. This filter removes the DC component from the data. The DC component is individually calculated and removed for each trace.

In the dialog the sample interval on which the DC component is calculated is specified. Values for the start and end samples can be entered in the edit boxes or by click-dragging in the trace view. The sample interval is shown as a red area in the trace view.



### Delete mean trace

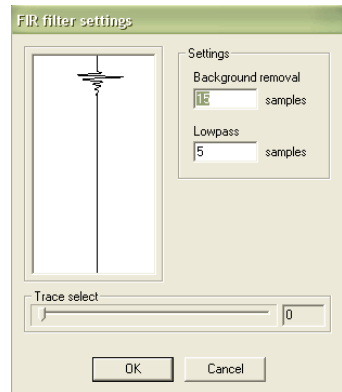
This filter is used to remove horizontal and nearly horizontal features in the radargram by subtracting a calculated mean trace from all traces, sample by sample. The mean trace can be calculated for the whole profile or for a specified section of the profile.



### FIR

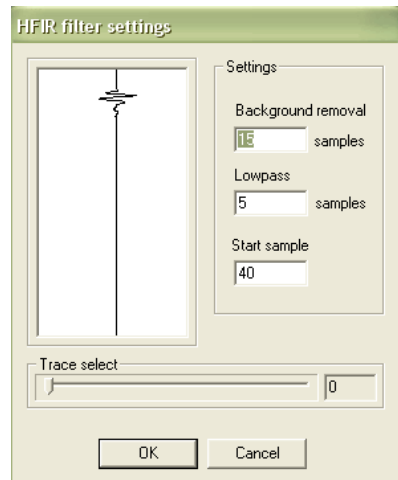
A quick band-pass filter, working with a combination of two boxcar (averaging) filters. The filter is run in two stages. First the lower frequencies are attenuated by subtracting the average in the longer boxcar from the raw data at the centre of the boxcar. Then the higher frequencies are attenuated by replacing each sample with the average calculated in the shorter boxcar.

Both boxes calculate along the whole trace.



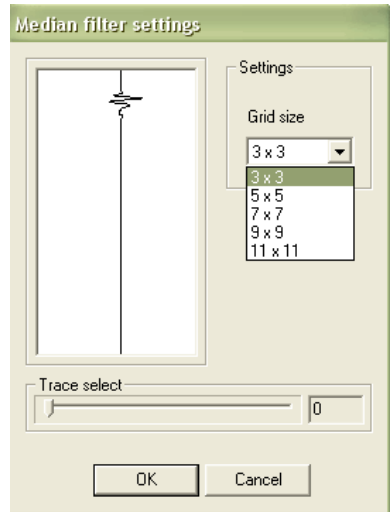
### HFIR

The HFIR filter functions as the FIR filter, but the filter runs along the profile - not along the trace. The filter is a spatial band-pass filter and its effect is similar to that of the background removal filter



## Median

The Median filter functions as the Average filter, but instead of the mean value a median value is used. It removes spikes in the data efficiently while not blurring the image quite as much as the average filter does.

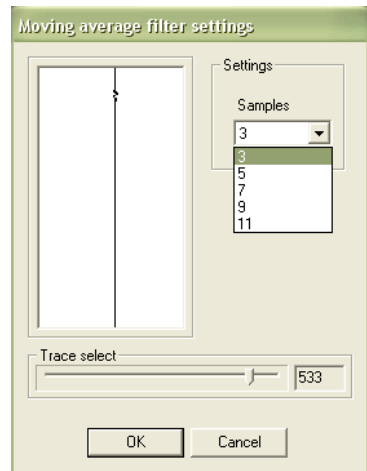


## Moving average

This filter takes the average as calculated by the average filter described above and subtracts it from the sample at the centre of the filter. Its effect is that of a simple 2D high-pass filter.

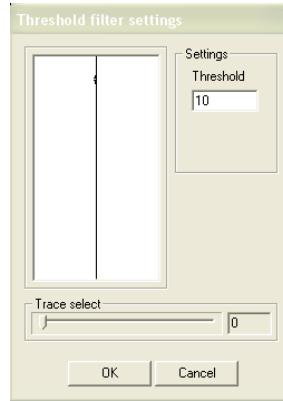
## Moving median

As the Moving average filter, but with the median value instead of the average.



## Threshold

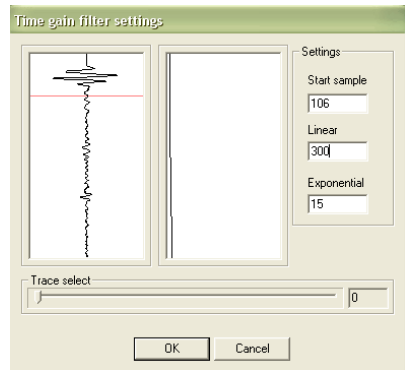
All samples with a value below the threshold are set to zero.



## Time-Gain Filter

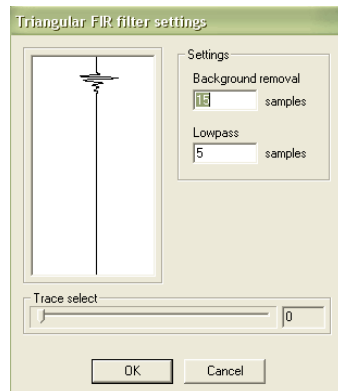
The Time-Gain filter applies a time-varying gain to compensate for amplitude loss due to spreading and attenuation. The trace is multiplied by a gain function combining linear and an exponential gain, with coefficients set by the user. In the Time-Gain dialog, there is one trace window and one gain window. The trace window shows a filtered trace and the gain window shows the gain function applied.

The red line in the trace window indicates the start of the filter (before this point the gain of the filter is unity).



## Triangular FIR

The Triangular FIR filter functions as the FIR filter, but instead of using boxcar averages it uses averages in symmetrical triangular windows.



# Appendix 2 GPS measurements

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This appendix covers some important issues when using a GPS to position the GPR measurements.

The Malå Geoscience Monitor or GroundVision software can be used together with GPS equipment which communicates via a 9-pin series connector. The GPS must communicate with NMEA 0183 protocol with GGA sentence. For the Monitor there is also one type of USB GPS available, see the Operating Manual Monitor.

The GPS equipment available today can be divided into three different types:

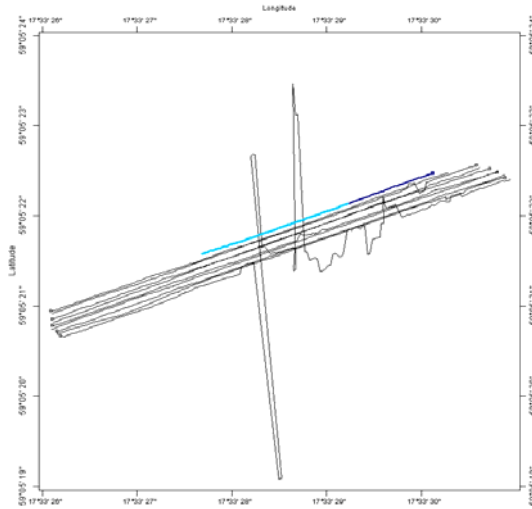
**GPS:** Relatively inexpensive, the GPS is using only satellites for positioning, accuracy around  $\pm 4$  m. Suitable for large scaled layer mapping etc.

**DGPS:** Differential GPS, uses satellites and a correction from a reference station, accuracy around  $\pm 0.5$  m. Similar systems are EGNOS (Europe), WAAS (USA) and MSAS (Japan).

**RTK GPS:** Real Time Kinematic GPS, expensive, uses two GPS receivers (one stationary base and one rover) and correction signal from the base antenna, accuracy around  $\pm 1$  cm. Network RTK also available in many locations, where the correction is received via GSM. RTK GPS accuracy is recommended for utility mapping.

For all the three different GPS systems the following is very important to remember:

1) Regardless the system used; GPS, DGPS or RTK, the positioning data gathered will be of bad quality if the measurements are made under bridges, in dense forest, close to high buildings etc. In the example below the lowermost line is measured 1 m from a building, resulting in incorrect positioning of that measurement line.



2) When using a GPS in motion, the GPS system is updated more or less seldom. Inexpensive systems may update 1 time/second while RTK systems can update 10 or more times/second which of course can effect the end result.

3) The GPS antenna should be placed on the middle of the GPR antenna (on the measurement point) to give the most correct position of the GPR traces. This will be a problem when measuring with the MALÅ Geoscience RT antennas, and should be corrected afterwards, or if the GPS is located elsewhere.



4) It should be observed that during the day the connection to satellites can change, giving better or worse positioning possibilities.



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