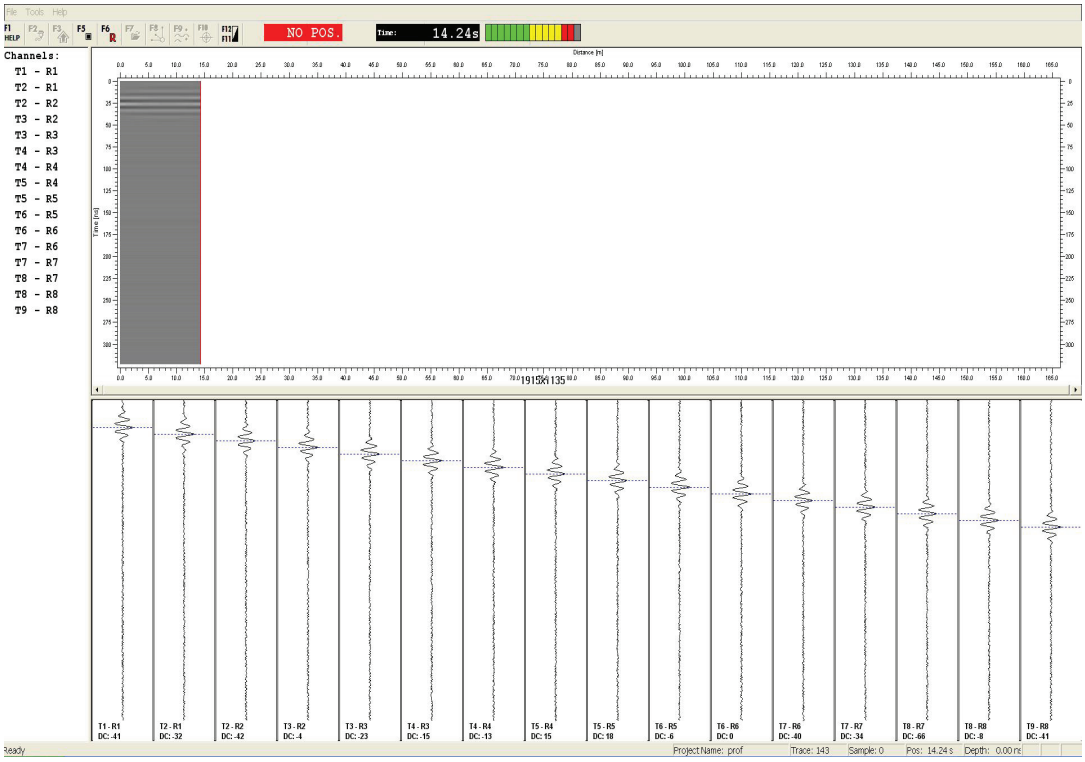
MALÅ

MIRASoft




# Operating Manual v. 3.57.01

19-001035

# Table of Contents

# 1 Introduction

MALÅ MIRASoft is the data acquisition software dedicated to the MALÅ MIRA (MALÅ Imaging Radar Array) system from MALÅ Geoscience. MIRASoft acquires data from the MALÅ ProEx control unit together with the array option. As a Windows™ based software MIRASoft 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. The MIRASoft software supports Total Station, GPS logging and multiple markers during measurement. All radargrams can be printed as such, or post processed by other software (rSlicer, Radexplorer).


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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# 2 Installation

The MIRASoft 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.

**Note!** The WINPCAP library (by running “WinPcap_4_0_1.exe”) has to be installed first of all and then the program (which is done by running “Setup.exe”).

When you double click on the setup files (WinPcap_4_0_1.exe or Setup.exe) 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 MIRASoft it is recommended to uninstall the previous version of MIRASoft first. This is easiest from the Windows Control Panel -> Add/Remove programs.

## 2.1 Computer requirements

The software runs on Windows XP, VISTA or Windows 7 (32 or 64 bits) and requires minimum 1GB of RAM. It’s recommended to have a sufficient efficient computer (CPU 1GHz or higher) since the displaying and storage of the data can be a rather heavy task. Horizontal resolution of the screen is limited to 3000 pixels. The MIRA system collects approximately 130kb data/$m^2$, if using a 400 MHz antenna and the following settings: 400 samples, 16 channels, 8 cm between the channels, and a trace distance of 8 cm.

It’s also recommended to switch off all unnecessary communications links such as blue-tooth, wireless, infrared or any other present line. Some Ethernet cards will cause conflict when the wireless link is enabled. Ethernet packets lost is not acceptable in this system, therefore wireless communication cannot be used, ethernet cable and Ethernet card must be of good quality.

# 3 Using the MIRASoft

## 3.1 Overview

Software for the MIRA system comes in two packages; the acquisition software, MIRASoft and the processing and interpretation package, rSlicer. Both are designed to work with the MIRA$^{TM}$ system (MALÅ Imaging Radar Array).

This manual deals with the acquisition package, the MIRASoft, which enables the operator to freely set up the radar antenna array system and collect data and save it to suitable rSlicer format. During data collection it's also possible to view one radargram and traces from all channels. More information regarding rSlicer is found in the Operating manual rSlicer.

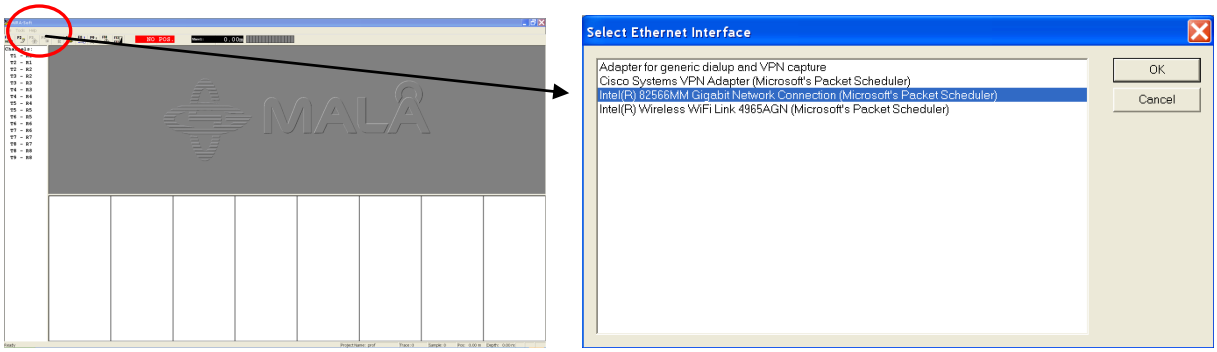
The user interface of MIRASoft is developed to be easy to handle during field work so the most important options are governed by the function buttons, F1 to F12.

The following definitions are used:

**Trace**= The recorded radar signal from one channel at one point. An envelope built up by a certain number of samples.
**Point distance** = Distance between each trace collected for all individual channels.
**Sample**= Instant, digital value of recorded radar signal at one specific time.
**Stacks**= Number of averages for each trace
**Swath**= One complete profile line including all channels in the array. The coverage for every swath depends on the individual channel spacing times the number of channels.

## 3.2. First start

When the programme is started for the first time, the contact between the ProEx control unit and the MIRASoft may not be established directly. In this case select the option Tools -> Link Options and choose the correct Ethernet card to connect to the control unit. Then press F2 to connect to the control unit.




**Note!** Switch off all other communications links such as blue-tooth, wireless, infrared or any other present line. Some Ethernet cards will cause conflict when the wireless link is enabled.

After this it is convenient to check and define the **Channel Configurations** (in which sequence the antennas are going to measure) and the **Channels Order** (the position of the different antenna elements in the antenna array). For more information see Chapter 4. These two must be defined

according to the used antenna array in the MIRA system to give correct end results. Once these two has been defined, they can be used in other projects, measured with the same antenna array and in the same mode.

MIRASoft uses two system files for defining the array configuration: “ch_order.cfb” for the Channels order and “channels.cfa” for the Channel Configurations. These files are created in separate dialogs and are stored in the user’s Application Data directory.

When the Channel Configuration and Channels order are appropriate, the following steps are made prior measurement start:

- **Create New Project** (File -> Create New Project). To define a working project directory and name see Chapter 7. The project name is displayed below the main screen of MIRASoft. Project Header File with extension “.mira” is also created.

  **Note!** It is good practice to create a separate directory for every project so that all positioning settings, tie-in-points etc. are saved in the same place.

- **GPS or Total Station settings** (Tools -> Positioning Parameters). To define correct communication setting between the MIRASoft and the positioning system and to set a centre-point of the investigation area. See Chapter 5.
- **Tie in points** (Tools -> Tie in points). Points surveyed (positioned) as reference for each total station position See Chapter 6.
- **Line and Point Features** (Tools -> Insert points and lines). To position features, such as roads, trees, houses in the investigation area. These features can then be displayed, as a base map, together with the radar data in the processing software rSlicer. See Chapter 6.
- **Measurement settings** (Tools -> Measurement Parameters). To define measurement point interval, sampling frequency etc. See Chapter 7.
- **Time zero** (Tools -> Measurement Parameters). To set a correct time zero for the all array channels used. See Chapter 7.
- **Start measurement** (F3). See Chapter 7.

## 3.3 Main menus

Below, in Fig. 3.1, the main view of the software is shown. The fast keys in the upper left corner give easy access to the main functions 

;

- **F1** Help
- **F2** Connect to Control unit
- **F3** Start measurement with previous parameters
- **F5** Stop/Pause measurement
- **F6** Restart measurements
- **F7** Open existing swath
- **F8** Tie in points
- **F9** Features
- **F10** Positioning parameters
- **F11 and F12** Decrease and Increase contrast. The effect of changing the contrast with the contrast control is, somewhat similar to a change in the gain function, but much easier and faster to do.

Normally communication with the ProEx control unit is established when the software is started. This is indicated by a red coloured arrow for **F3**.

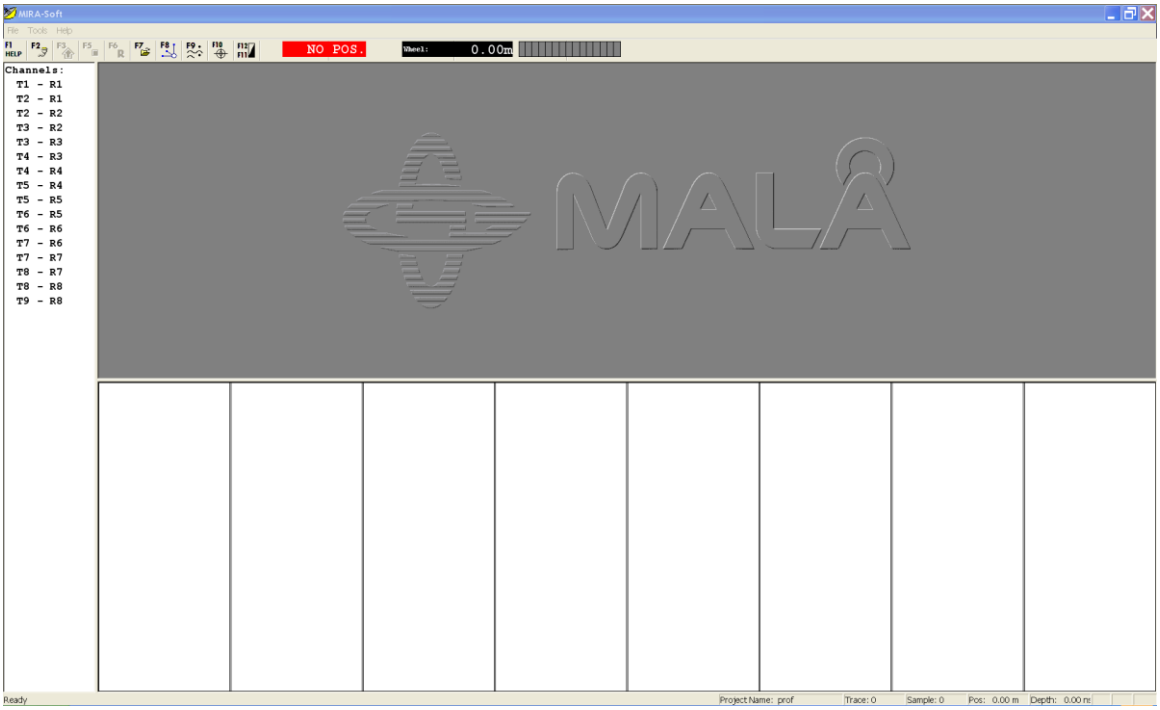
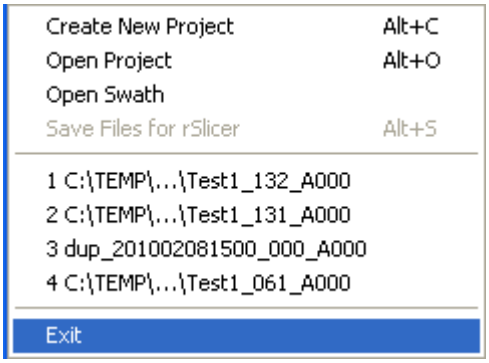


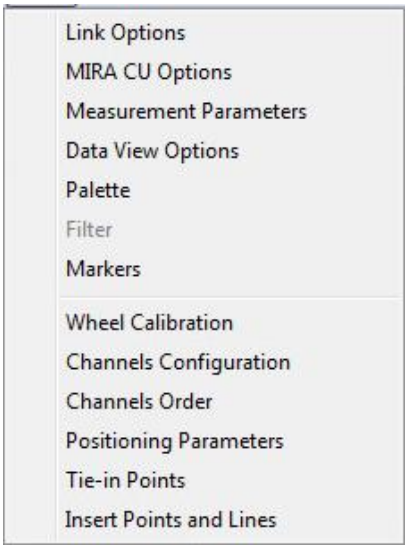

**Figure 3.1** The main screen and menus at start-up.

### 3.3.1 File menu

The **File menu** gives access to the usual file handling, create new project, open a project to continue measurement, open existing swath, save files for rSlicer (processing software). There's also quick selection for recent opened files.



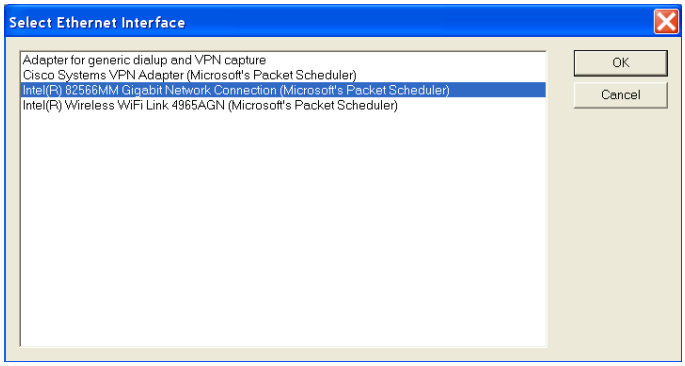

### 3.3.2 Tools menu




The **Tools menu** gives access to menus for Link Options, MIRA CU Options, Measurement Parameters, Data View Options, Palette, Filter, Markers, Wheel calibration, Channel Configuration and Order, Positioning parameters, Tie in Points and Points-Line menu.

Information on Channel Configuration and Order, Positioning Parameters and Tie in points and Points/Lines and Measurement Parameters is found in Chapter 4, 5 , 6 and 7 respectively. Otherwise see below.

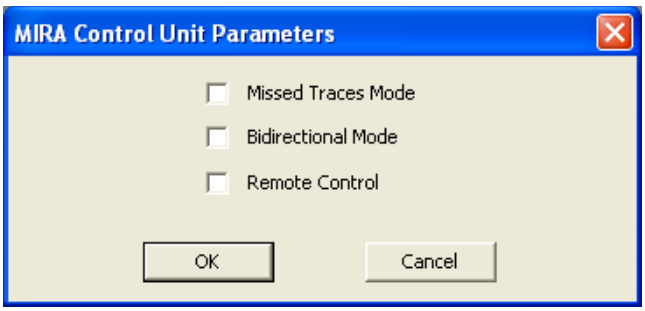
In the **Link Options** the correct Ethernet Interface is chosen.




In the **MIRA CU options** there are 3 selections to select, by default none are seleted.

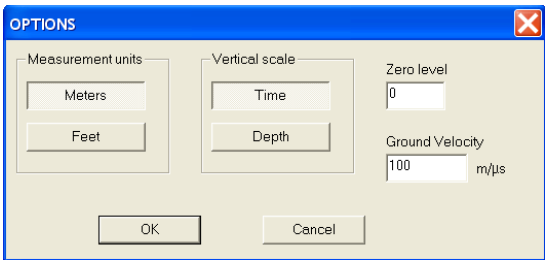
By selecting Missed Traces Mode, the system will write zero traces to the data file, whenever the survey speed is too high for the system. This is done without any data passed from the control unit to the PC.

If Bi-directional Mode is selected, the system collects data in both directions and the distance shown is the total travelled, backward and forward.




In the **Data View option** pop-up menu the vertical scale can be set to Time or Depth together with the first arrival and the ground velocity to use.

The distance units available are meters and feet.

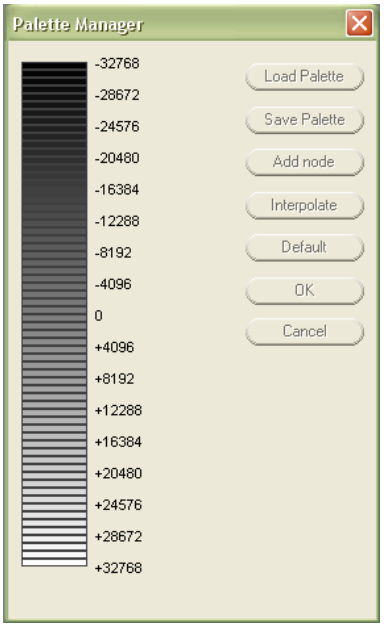



In the **Palette manager** the palette of the active radargram can be viewed, altered, loaded, or saved.

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

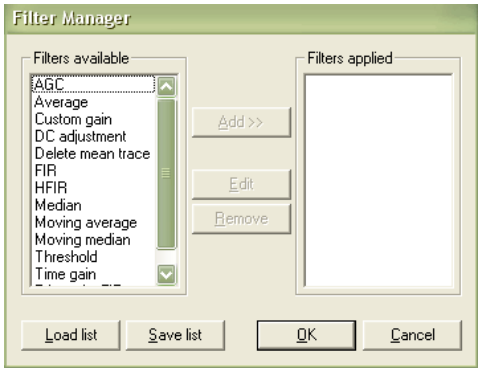
One single right-click on a "colour box" makes it activated, which means that it will be used when interpolating the palette. Another single right-click on the same "colour box" deactivates it. When interpolating the palette is recalculated depending on the colours in the activated "colour boxes". OK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

The palette can be saved with a freely given name and in a freely specified directory with the file extension ".pal". To open a saved palette click the Open Palette button and load the selected palette.



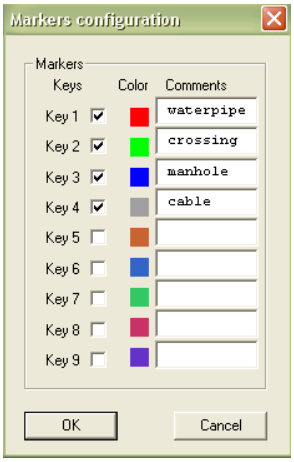
The functionality of the **Filter Manager** is quite straightforward. Choose a filter and click either the Add or the Remove button and the chosen filter will be either removed or applied. It is also possible to double click the filter to be added. By “drag and drop” the order of the filters in the Applied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

To the left, there is a list of available filters and to the right the list of the applied filters is shown. See also Appendix 1 for a short explanation of the different filters.



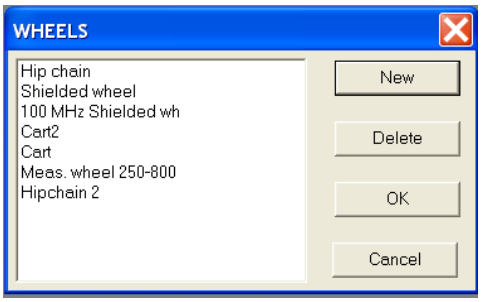

MIRASoft supports a multiple **Marker** function during measurement. Up to 9 markers of different type and colour can be configured in the marker dialog. The nine numerical keys 1-9 on the keyboard are predefined as marker keys. Each key needs to be enabled by checking the white box to the right of each 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.

If markers keys are pressed during the measurement, information will be saved in a text file with the extension *.mrk. The first line contains information about the header version. Following in the file is three columns (space-separated) with trace number, sample number, marker type (1-9).




**Note!** Markers can also be set with the Remote Control by pressing the marker button. Markers set in this way will always be of type 1.

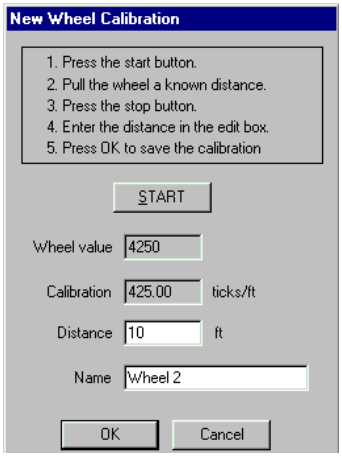
To perform a **Wheel calibration**, start with connecting the control unit and the wheel to calibrate/use, switch the control unit on. Choose Wheel Calibration to open the Wheels dialog.




**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.

If a new calibration is needed, press New and follow the instructions in the New Wheel 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. If the number of ticks/ft for the wheel is known this can be entered manually. OK saves the new wheel calibration in the control unit memory.

Wheel calibrations can also be deleted in the Wheel dialog by marking the calibration and the pressing Delete.



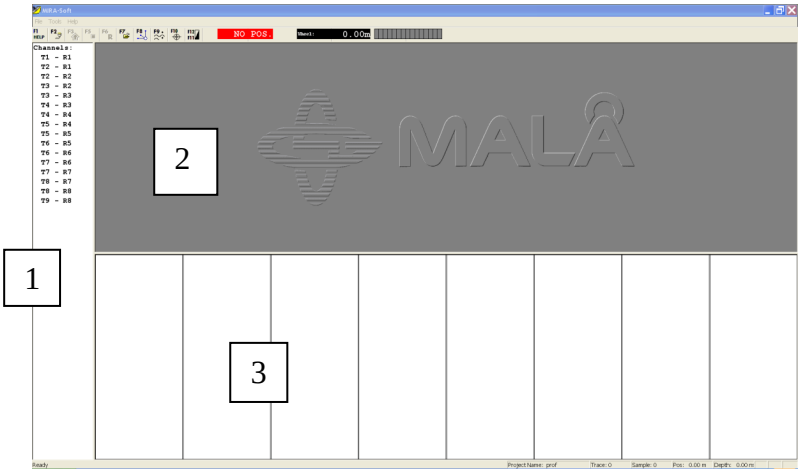

### 3.3.3 Other options in the Main View window

The workload indicator  in the toolbar shows how much the system (GPR and PC) is loaded. The indicator goes from green on the left side, to yellow and finally red on the right side and should not more than occasionally turn red.

indicates how well the positioning is carried out, more can be read in Chapter 5. The other three fields in the Main view shows:

1) The different data channels. By clicking or using the arrow buttons the data view toggles between the channels.
2) The data window.
3) Trace view.

These three fields can not be changed, but are optimized to give the best view during data collection.



# 4 Channel configuration and orders menu

## 4.1 Channel configuration

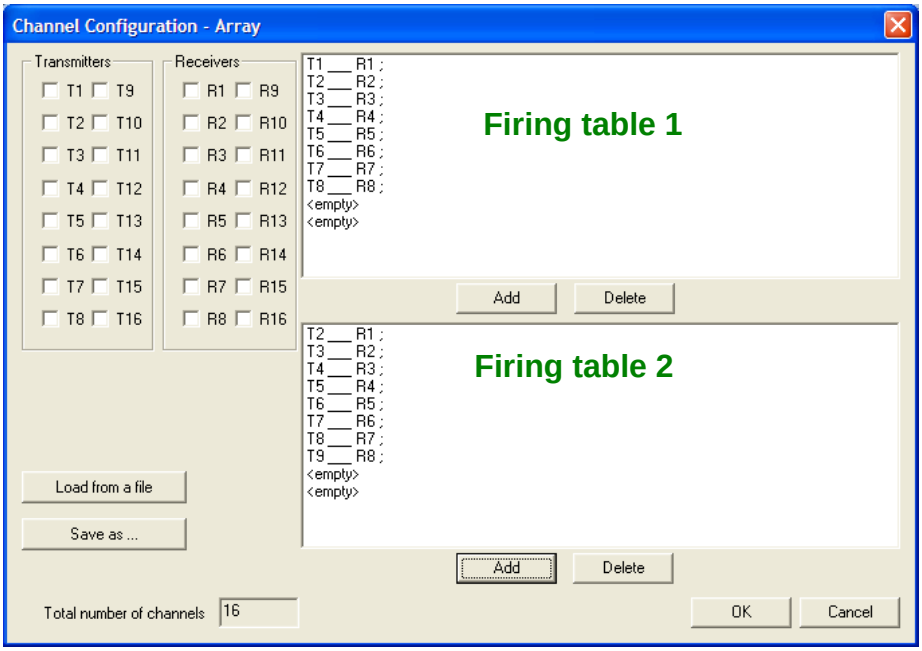
In the channel configuration menu the operator selects how the radar array should be set up to collect data. The user defines a sequence of firing the antennas and this sequence is repeated for every time the trig condition set becomes true, normally every time a new acquisition point is reached along the swath.

A standard channel configuration for a 16-channel antenna array is shown in the picture below. This is also provided within the software at purchase.

The maximum number of sequences, which can be defined, is 16 in one firing table..

**Note!** It's not possible to switch a receiver between two transmitters in the sequence in one firing table (in other words a receiver can not be repeated in one firing table). Doing so will result in an error massages. Array-operation requires, however, each receiver switched between at least two transmitters and therefore two sets of firing tables are to be defined for one sequence. This cross-talk generates the dense profile distance characteristic in the MIRA system.

In the figure below the Channel configuration menu is shown. The number of available channels is dependent on how the system was defined at time of purchase. In the example a standard 16 channel system is activated, 9 transmitters and 8 receivers. Note that the system can only be set up to handle one receiver per transmitter antenna in each "firing" table.




Start the procedure by selecting the transmitter 1 and receiver 1. Once this is done the button "Add" is pressed for the first firing table. The user repeats this until the whole sequence for the array is defined.

**Note!** Channel configurations can be saved and loaded again in so called *.cfa-files. Chose the option Save As and then Load from file to use the saved configurations.

It is important to keep in mind that each transmitter can be activated every 10 microsecond (5 microseconds for 2MHz MIRA). The software will automatically add empty sequences if the operator does not meet these conditions.

After finishing the channel configuration, the operator presses the OK button and the configuration is saved in the internal memory as well as in the configuration file, “channels.cfa”. The configuration file can be viewed with a text editor.

The configuration is transferred to the control unit when the measurement is started or when the traces are viewed in the measurement setup menu.

**Note!**

1) Receivers can not be repeated inside one table.
2) Transmitters can be repeated but it has to be 9 sequences in-between, if there are less than 9 sequences empty sequences will automatically be added;
3) If it is less than 10 sequences in a table empty sequences will be added automatically to maintain a 100 KHz repetition rate;
4) If you want maximise speed, use only the first table and left the second table empty;
5) In the list the string “<empty>” can be seen. This is an empty sequence that granted safe rest time for transmitters (10 microseconds for 100 KHz antennas). One can not delete them (even if one tries). The user can optimize transmitter’s position to minimize number of the empty sequences and by that faster measurement will be possible.

## 4.2 Channel order

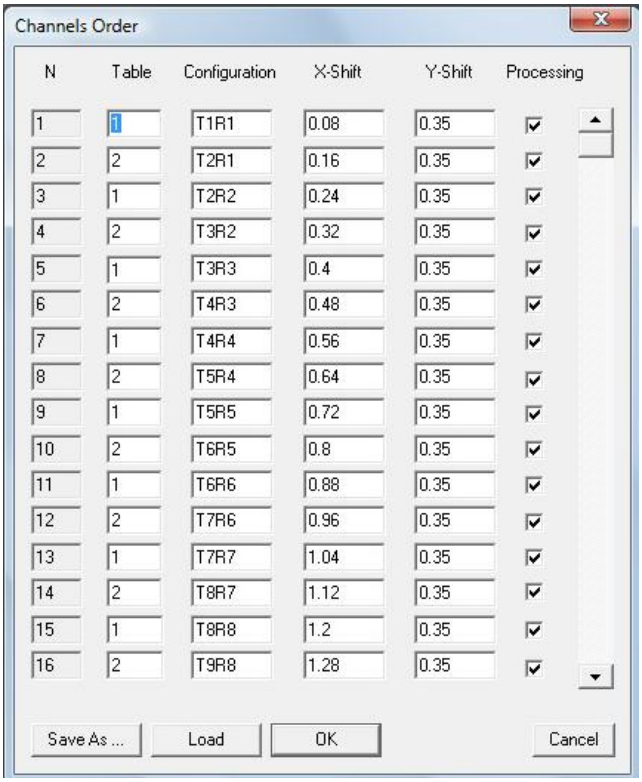
The Channel order option defines the location of each channel and which channels to be included in the rSlicer processing. The Cannel order is used by both MIRASoft and rSlicer to keep track of the antenna array position.

A standard channel configuration for a 16-channel 400 MHz antenna array is shown in the picture below. This is also provided with the software at purchase.

To set the Channels Order table the following steps are done:

- Select “Tools -> Channels Order” (see below);
- One has to enter as many channels as it exists in the Channel Configurations table (see above). If fewer is entered, the OK option does not work, only the CANCEL option. If more channels than necessary are entered they will be zeroed.
- Table field must set to 1 or 2 according to the firing table. Configuration field must be set to TN1RN2 where N1 and N2 are numbers, for example T1R1 or T11R13. X-Shift and Y-Shift are antennas coordinates in meters in the special MIRA coordinate system, where the Total Station prism or GPS receiver is located in the 0/0-point, the X-axis is parallel with Array and the Y-axis is in the measurement direction.
- Mark the channels to be included for the rSlicer processing, in the Processing column.

In the configuration below the Total station prism or GPS receiver is located on the first measurement profile, between T1 and R1. This gives an X-shift value of 0 m. See corresponding antenna array (400 MHz) to this Channels order in Fig. 4.1.



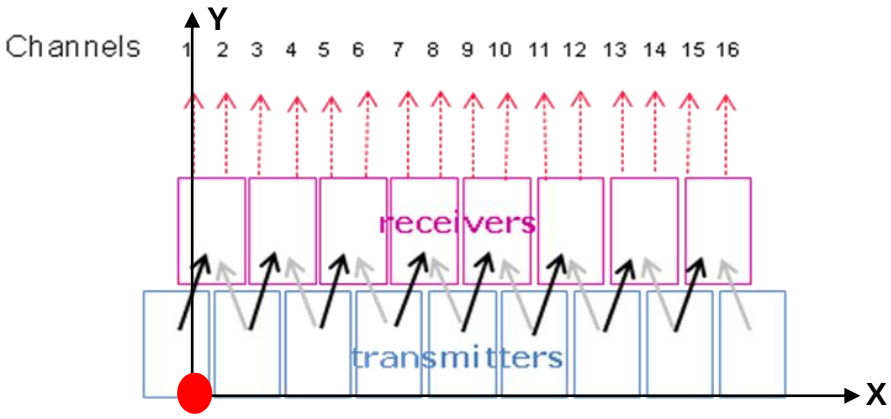




**Fig. 4.1.** The antenna array with 9 transmitter antennas and 8 receiver antennas, gives for a 400 MHz system a distance of 8 cm between the different channels (measured profiles) and a measurement point (Y-shift) 35 cm from the 0/0-point, which is indicated with a red dot. The TS Prism or GPS rover antenna is placed on this red dot.

**Note!** Channel orders can be saved and loaded again in so called *.cfb-files. Chose the option Save As and then Load from file to use the saved order.

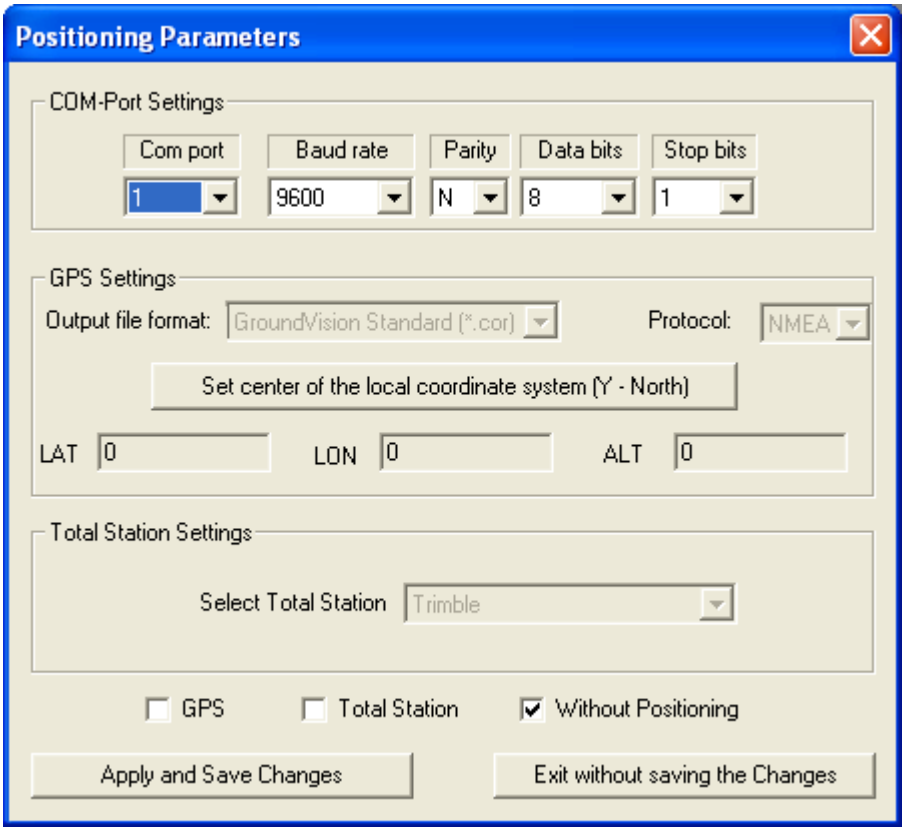
After finishing the channel order, the operator presses the OK button and the configuration is saved in the internal memory as well as in the channel order configuration file, “ch_order.cfb”. The configuration file can be viewed with a text editor.

# 5 Settings of Positioning Parameters

A GPS or a Total Station is essential to position the antenna array box during measurements. The system used needs to have a centimetre accuracy of the position data (RTK-GPS only) otherwise the end-result will not be satisfying. The initialization of the GPS or Total Station is done according to the operating manuals of the system used. In this chapter the settings for the MIRA system is explained.

Both the Total station and the GPS equipment are connected to the computer used for data collection via the serial port. See the MIRA System manual for more information.

The settings for both GPS and Total station parameters are found in Tools -> Positioning parameters




**Note!** For both the Total Station and GPS solution it is essential that the measurement swaths start and stop with a correct and reliable collected positioning data.

## 5.1 GPS settings

MIRASoft can read GPS data from any GPS receiver that supports output of data with the NMEA (0183 GGA) or TSIP communication protocols. The GPS logging is saved in a GPS log file, the file name can be: <first profile name>.cor, <first profile name>.fri or <first profile name>.utm, in which GPS data are written together with the corresponding trace number. Format of these files is described on the next page.

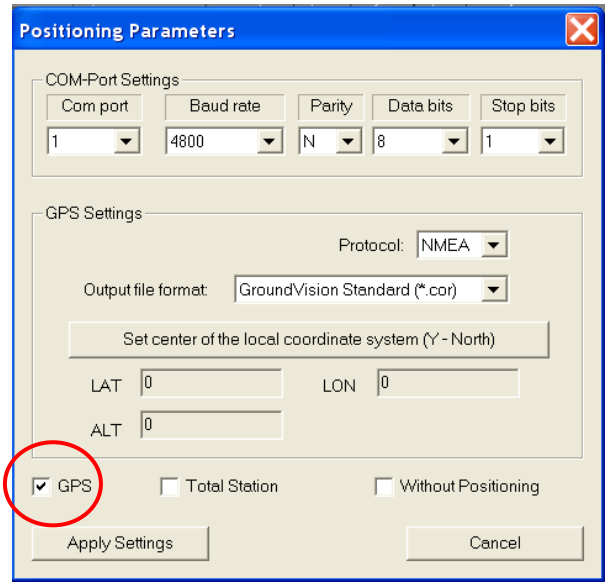
To change the GPS communication settings, choose Tools -> Positioning Parameters. Make sure that the GPS choice in marked in the Positioning parameters pop-up window.

Here the output file format can be changed together with communication settings.

Important in the GPS Parameters window is the option **Set the centre of the local coordinate system.** This is necessary to get the correct local coordinates in the *.POS file for rSlicer.

This command, positions one point in the investigation area and uses this information for a correct coordinate transformation to the *.POS files.

**Note!** This can only be done once in each project and the measurements can not be started unless this is done.




**Output file format**
Use this selection box to choose between the three different position output formats: GroundVision Standard (*.cor), WSKTRANS (*.fri) and UTM coordinates (*.utm)

*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 free format*
The WSKTrans free format is a special format compatible with WSKTrans, a coordinate transformation software from the Norwegian land survey. The format is (space separated):
*EU89-Geodetisk,P,G,HE*
“Trace #” latitude longitude “height above ellipsoid”

*The UTM*
The UTM coordinates format contains coordinates in the UTM grid calculated from the latitude and longitude data from the GPS receiver. The transformation is made using Redfearn’s formulas. GV uses a public domain implementation of these contained in the class KCoordinateTransformer. **Note!** MALÅ Geoscience takes no responsibility in the accuracy of this transformation. The format is (tab separated):

“Trace #” → northing → easting → “height above MSL” → “UTM zone”

**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, default 4800, 0, 8 and 1 respectively.

*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, GGA sentence) 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.

When all settings are done, and the communication functions two extra field is seen in the Tool Bar:

Toolbar with GPS info before measurement

The first field will show the distance of the measurements, and it counts from the GPS coordinates in the local coordinate system. The second field is a quality field, it is ok if it shows values >0 and <8. **Note!** However, to have sufficient accuracy for the MIRA system, this value should stay as **4** and nothing else during the whole investigation, indicating RTK GPS quality.

The second field values are in detail:

```
0 = invalid
1 = GPS fix (SPS)
2 = DGPS fix
3 = PPS fix
4 = Real Time Kinematic
5 = Float RTK
6 = Estimated (dead reckoning)
7 = Manual input mode
8 = Simulation mode

66 = no contact with the GPS
```

.

The toolbar with GPS information under measurements looks like this:


If the second field, the quality field, is not equal to 4 (RTK mode) then both fields become red.

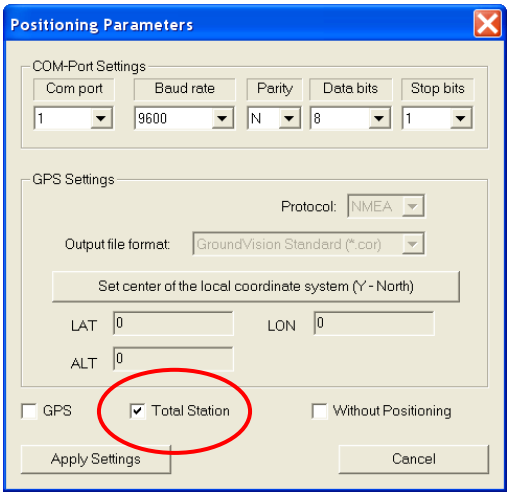
The idea of these fields is that one does not need to control the GPS position under measurement, but one has to control the quality of the GPS data and distance from GPS (this distance must be approximately equal to the distance given by the encoder wheel, if not - one has to check wheel calibration, contacts etc.)

## 5.2 Total Station settings

To change the Total Station communication settings, choose Tools -> Positioning Parameters. Make sure that the Total Station choice in marked in the Positioning parameters pop-up window.

The COM-port settings are explained in Chapter 5.1 above.

**Note!** The Set centre of the local coordinate system is not used when working with a Total station.




As this is done, and the communication functions an extra field is seen in the Tool Bar:


This field shows the measurement distance calculated by the Total station during measurement and this figure is to be compared with the distance given by the encoder wheel. The TS field will start to blink red 

if there is no or a bad contact with the Total Station during the measurements. Decrease the measurement speed or stop for a while and check if there is a free sight between the Total station and the prism on the antenna array.

# 6 Tie in points and Features

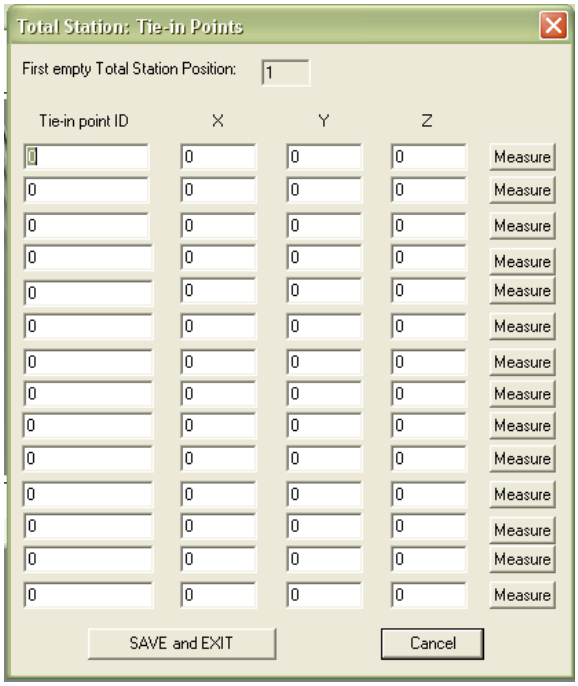
## 6.1 Tie in points

Tie in points are only used when positioning of the antenna array is done with a Total Station. Points around the investigation area are positioned, to create a reference if the Total Station needs to be moved during the investigation.

At least three points have to be established for the first Total Station position. When the Total Station is moved, the same three points are positioned again, to tie in the new Total Station position and by that measurement swaths in the investigation area. All measurement files will then end with "G02".

The rSlicer software uses the coordinate system associated with the first TS position as reference.

Open the Tie in point's pop-up window (Tools -> Tie in Points) and as the prism is placed in the right position at the tie in point, press measure to read the correct coordinates. The point can be named freely, by typing in the Tie-in point ID field.



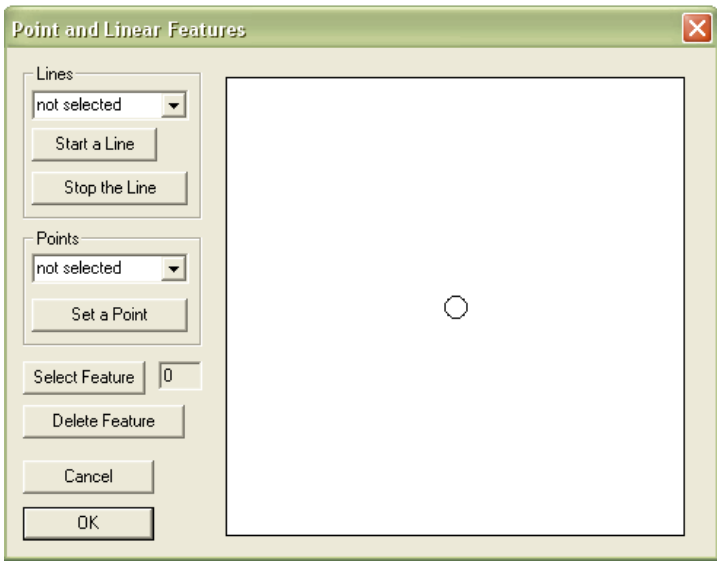

When all tie in points are positioned, press SAVE and EXIT.

## 6.2 Line and point Features

With the option Lines and points (Tools -> Insert points and Lines) straight lines and points can be created to mark roads, trees, houses etc in and around the investigation area.

The prism (for the Total station) or the rover antenna (for the GPS) is located on the lines or objects to mark, while the operator of the software presses Start a Line, Stop a Line or Set a Point.

**Note!** If a Total station is used, two persons are needed, one to move the prism and the other to press "Start a Line", "Stop the Line" and "Set a Point" at the computer. If a GPS is used, one person is enough. The investigation vehicle (with PC, antenna array, GPS antenna) can be moved to the wanted points or lines or only the PC with MIRASoft and a connected GPS.



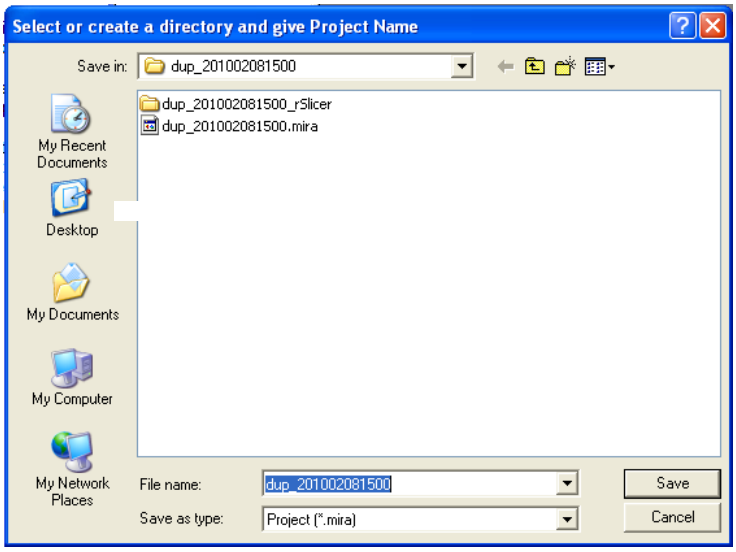

Press OK to save the mapped features.

**Note!** In the file FCODE.txt (located in the MIRA Soft directory) Points and Lines can be defined. This FCODES.txt file is also used by the processing software rSlicer.

# 7 Data Acquisition

In short a measurement is carried out in the following steps. More information on each point is found in this Chapter:

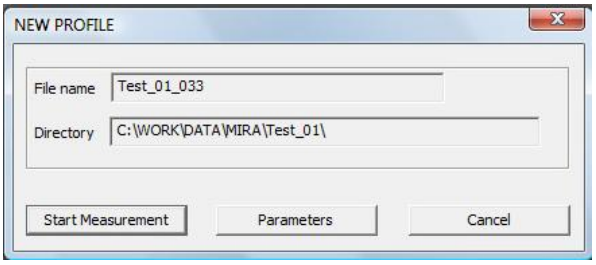
- Ensure that the Control Unit is ON and it is properly connected to the computer.
- Ensure that the Control Unit connected properly to the antennas.
- The program connects to the Control Unit automatically if you start it after the Control Unit is ON. If you switch on the Control Unit after the program, then you need to press F2 to connect to the Control Unit manually. If the connection is established the F3 button will become red. If the connection isn't established even after pressing F2, this may be due to low battery level or disconnected cables.
- **Create New Project**, by choosing File -> Create New Project. Choose the location where you want your project files to be saved, and give a name (better to create a separate directory for the project and the default position for your data files will be inside this directory). Press Save.



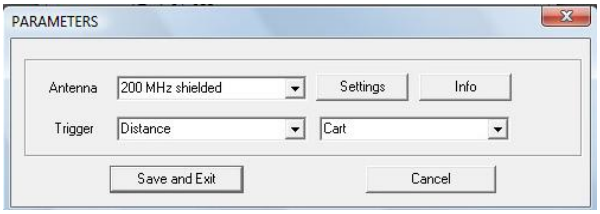

- Press the Start file button (F3) or NEW on the Remote Control. The New Profile dialog opens (see below).
- In the New Profile dialog enter the file name to use. Press Parameter to select the antenna and trigger source to use. Press the Settings button to open the Measurement Settings dialog;
- In the Measurement Settings Dialog the Time Zero (first arrival) is found for the different channels;
- Close the dialogs by pressing OK when all settings are made;
- Select **Start** from the New Profile dialog.
- Select **Stop** by pressing F5 to stop the measurement or STOP on the Remote Control.

**NOTE!** When using the Remote Control the measurements starts directly and no new measurement settings can be made. For the first measurement line it is always best to check all measurement settings, so that they are correct and then use the Remote Control for the rest of the measurement lines in the same project.

Data collection is initiated by pressing the “Start file” button (F3).



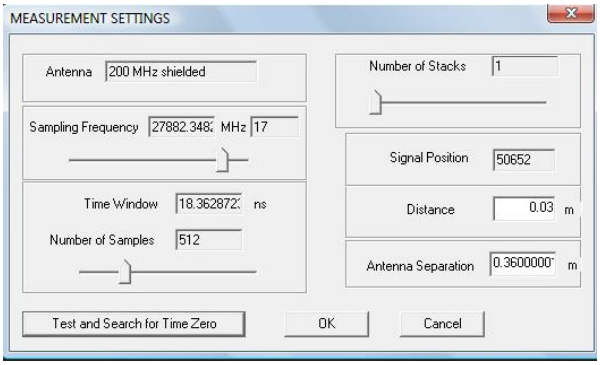

Press Parameters to reach the Parameters pop-up window. In this menu the trig source (time, manual or wheel) and a pre-selection of antenna parameters can be chosen.




In order to view the radar signal and to set the acquisition parameters more in detail, press the “Settings” button. This leads to Measurement settings menu.

In the Measurement settings menu the operator sets radar parameters such as sampling frequency, stacks, number of samples etc.

Detailed description of these parameters as well as information on time zero setting is found below.




## 7.1 Time zero setting

The most important difference compared to normal, single channel operations, is the time zero setting. Since there’s no way to guarantee that all channels have the same lead time in electronics and cables, the time zero have to be set so that it safely register the first arrival of all the used channels. In order to help the operator doing this, a channel number choice is found close to the “Search Time Zero” button. This channel number defines the channel for which the time zero is searched for and set. The “earliest” channel, in other words the channel where the time zero appears first, should be used during the search.

When pressing the “Test and Search for Time Zero” button a window showing traces from all the channels are showed, see fig.5.1 below.

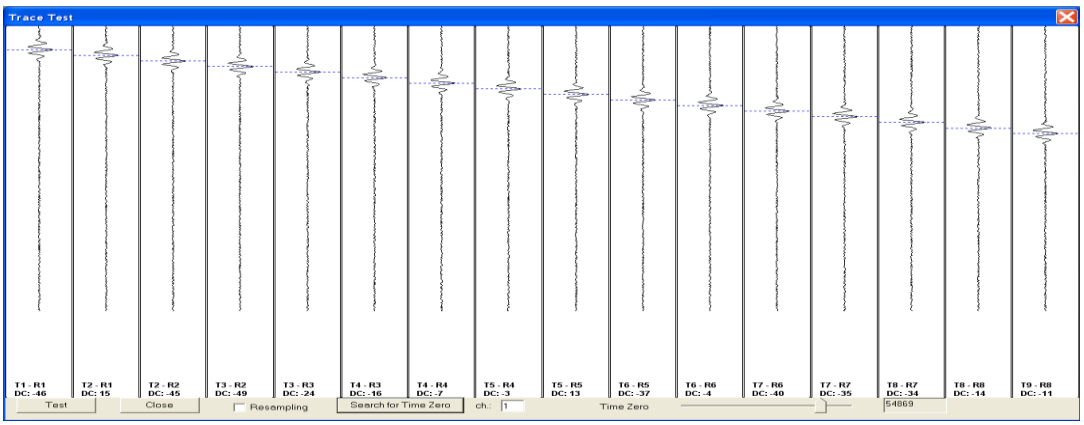


**Figure 5.1** Test for time zero settings.

To fix an inappropriate time zero setting, close the window and go back to the previous menu and either change the signal manually or select another channel and repeat the search. In fig 5.2 below a correct set time zero is shown. Now the first arrival of all channels is clearly distinguished and approximately at the same level for each channel.

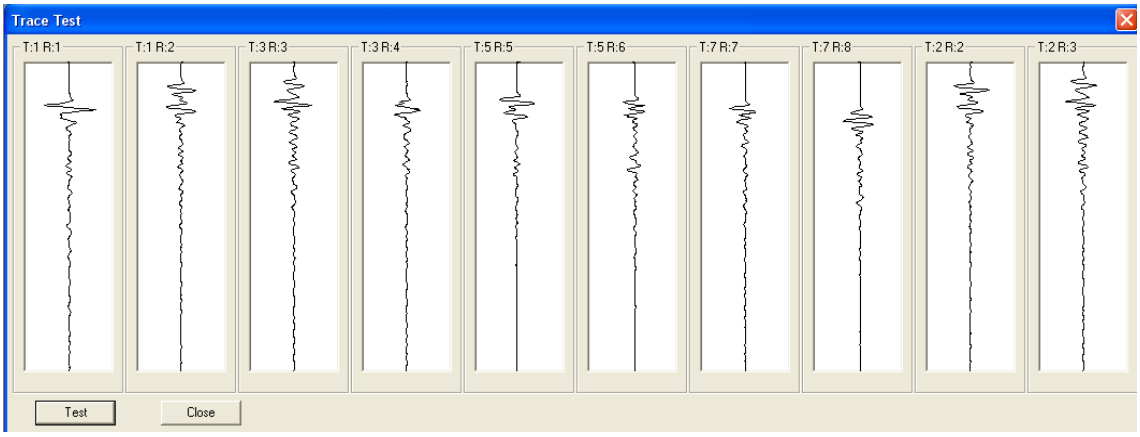



**Figure 5.2** Test for time zero settings.

## 7.2 Measurements settings

In the Measurement settings dialog the following parameters are found:

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** (the 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 number of **Stacks** is equal to the number of times that each sample is measured and averaged over.

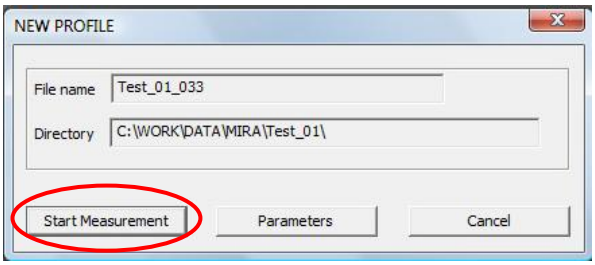
**Note!** Whenever possible, it's always recommended to use stacking. In spite of the high performance of the MIRA systems, this averaging and the selected point distance puts some limits on the maximum survey speed. Assuming 200 kHz repetition rate and 8 cm point distance and 350 samples, the maximal survey speeds are listed below, at different number of averaging (number of stacks).

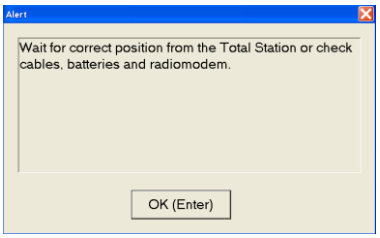
| Number of averages (stacks) | Resulting maximum survey speed, km/h |
|---|---|
| 1 | 75 |
| 2 | 37 |
| 4 | 19 |
| 8 | 9 |

## 7.3 Measurement started and change of measurement line

The measurement is started by pressing Start measurement. If no positioning data is found an alert will show up.

The measurement can not be started if no positioning data for the first point is available, as the data can then not be used for any further processing.




Once the data collection is started, the operator can select one of the channels to be displayed as a radargram in the main view. This is made from the Channel window at the left side of the Main view. A channel can be selected for the Profile View by a mouse click or with the arrow buttons.

All traces from different channels are displayed simultaneously, for the current mouse position. See Fig. 5.3. This window shows the last trace under measurement.

**Note!** No interpretation is possible during data collection. This means that data quality control is very important and most often the trace windows will provide the best solution to check this out during data acquisition.

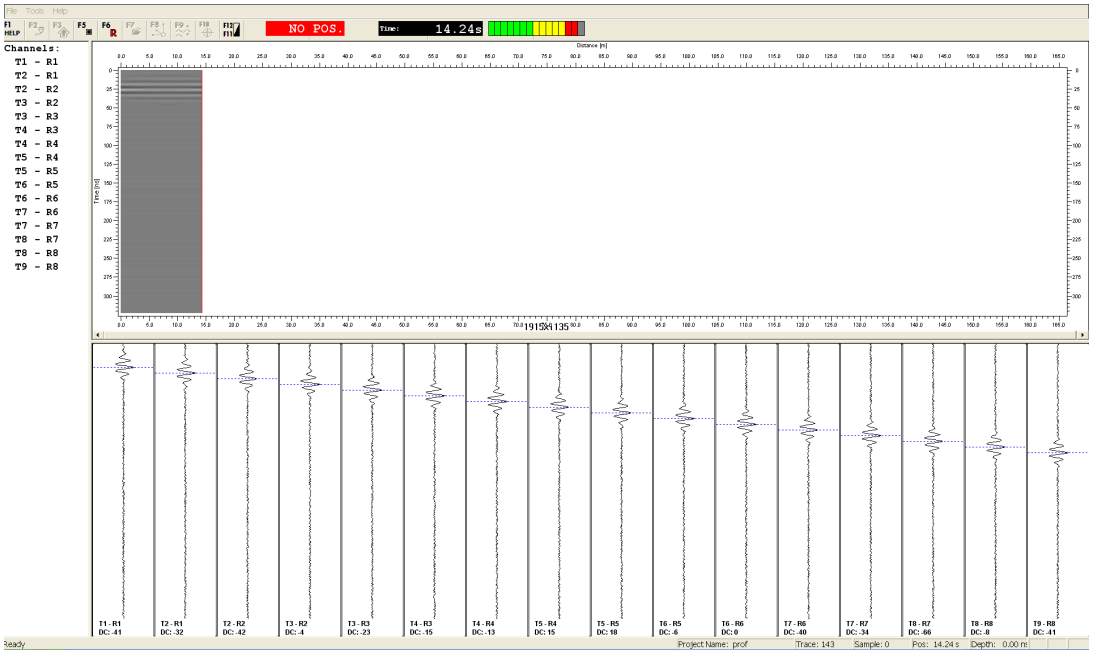
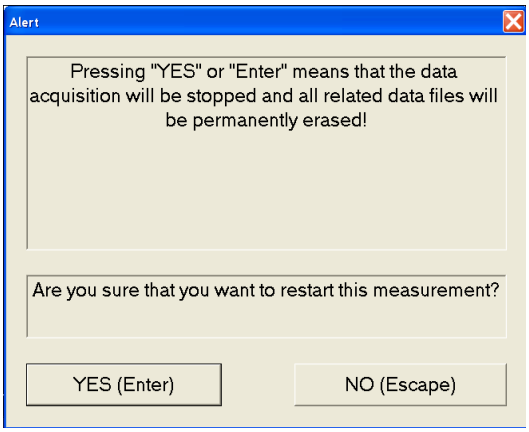



**Figure 5.3** The MIRASoft Main view during data acquisition.

When the measurement is started the workload bar is also seen on the main screen. This should be kept on green or green yellow, but not turn red more than occasionally:

**Note!** The Position Bar (GPS or TS in Fig. 5.3) will start to blink in red if there is something wrong with the connection to the Total Station or to the GPS receiver. Decrease measurement speed or stop and wait until the position data is ok again. For the different GPS error codes, see Chapter 5.

If something goes wrong during measurement (wrong direction, wrong position etc.), the swath can be restarted by pressing F6 (Restart). The following dialog is shown:




When the end of the swath is reached, stop the measurement by pressing F5 (Stop) or STOP on the Remote Control..

**Note!** This should not be done unless the positioning bar is black, indicating a good position for the last trace in the file. Otherwise an alert will show up, with different options to either wait for a correct position or force a stop.

Return to the start position of the swaths, press F3 (New profile) and then enter to start a new measurement or NEW on the Remote Control, and again check that the positioning data is in order.

When all data swaths are collected, use File -> Save files for rSlicer to save the data and positioning files in a correct manner for the processing software rSlicer.

## 7.4 Measurements in any direction

Measurements with the MIRA system can be carried out in any direction as long as the TS prism is located so it is visible (constantly in line of sight) from the TS base station, for example on top of the carrier.

**Note!** Measurements made with more or less straight lines will create a better end result than very curved lines.

When the prism location is decided, a Channels order is created to fit that set up. **Note!** One must be careful when changes are made in the Channels Order so it is made correct, otherwise the positioning of the measured swaths will be incorrect as well as the end results. See Chapter 4.2.

The advantage of the high prism position is that measurements can be carried out by one man (no need to adjust the self-tracking TS), and at the survey lines can be laid out freely (time-saving). However it should be noted that the distance from the TS prism to the antenna array should be less than approximately 2 m. If it is longer the off-set in the Channels order will be large, especially in curves, and by that the positioning in the end result. The disadvantage with high prism position is that position accuracy decreases if the ground is uneven.

## 7.5 Measurements without Total Station or RTK GPS

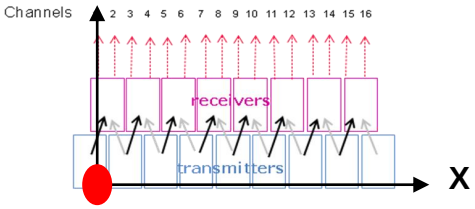
If measurements are going to be carried out without any positioning system (this is however not advisable) and the data are to be processed with rSlicer, the following instructions are to be followed. First of all mark the option “Without positioning” in the Positioning Parameters dialog (Tools -> Positioning parameters), the MIRASoft will automatically create a *.pos file for rSlicer when pressing F5 (stop of profile), based on the measuring wheel.

**Measurements in straight lines**

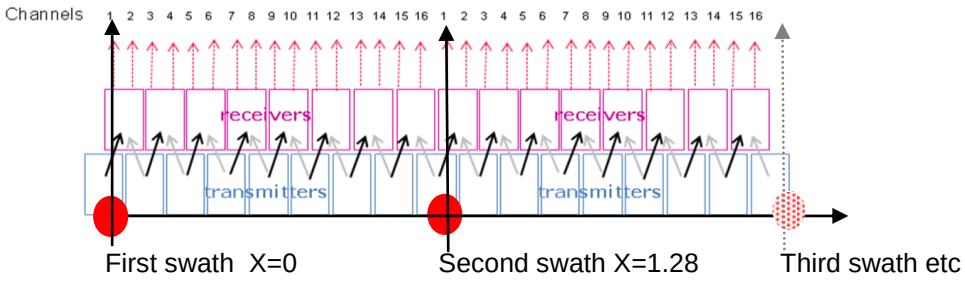
**Note!** The given distances below are applicable for a 16 channel 400 MHz array with 8 cm channel spacing.

1. Measurements have to be made in straight lines. Mark the lines properly on the ground before start of the survey.

2. The start position of the first swath is X=0 and Y=0. The Y coordinate will grow according to the encoder wheel, along the measured line.



3. The 2nd swath starts at X= - or +1.28 m (16 channel spacings times 8 cm channel separations), depending on if the next swath is done left (-) or right (+) of the first one. To ease field work it is convenient to mark the position of channel 1 and 16 on the antenna box. And for the 2nd swath the channel 1 should be 8 cm apart (right) from the marked line for channel 16 in the 1st swath (if 2nd measurement swath is done right of 1st ). The X figures are noted and then used to edit the created *.POS files, see point 6 below.




4. The third measurement accordingly X= 2.56 and so on.

5. When pressing F5 (stop) for each swath, a *.POS file is created. This *POS file has only 2 positions; Start and Stop. The Start position has coordinates: (Tracenumber, 0, 0, 0) and the Stop; (Tracenumber, 0, Ystop, 0), where Ystop is the profile length in meters (based on measurement wheel and number of traces). This *.POS file will be treated as a straight line in rSlicer.

6. When a set of swats is made, as explained in point 3 and 4 above, the created *POS files has to be edited for each made swath. The X coordinate is found as the second figure in the string; Trace, X, Y, Z. **Note!** If the second and following swaths were made to the left of the 1st use a minus sign. See example below.

The first column in the *POS file gives the trace number and the second column the X-values (position of swath). The third column is the Y-value (coming from the length **recording**) and the last and forth the Z-value (the elevation, so this is set to 0).

Below three *.POS files are shown, measured at position X=0, X=1.28 and X=2.56, for 13.2 m long swaths.

| | | |
|---|---|---|
| UNITS:m<br>1 0.000000 0.000000 0.000000<br>164 00.00000 13.12000 0.000000 | UNITS:m<br>1 1.280000 0.000000 0.000000<br>165 1.28000 13.20000 0.000000 | UNITS:m<br>1 2.560000 0.000000 0.000000<br>165 2.56000 13.20000 0.000000 |

Below three *.POS files are shown, measured at position X=0, X=-1.28 and X=-2.56 (the following swaths are made left of the 1st), for 13.2 m long swaths.

| | | |
|---|---|---|
| UNITS:m<br>1 0.000000 0.000000 0.000000<br>164 00.00000 13.12000 0.000000 | UNITS:m<br>1 -1.280000 0.000000 0.000000<br>165 -1.28000 13.20000 0.000000 | UNITS:m<br>1 -2.560000 0.000000 0.000000<br>165 -2.56000 13.20000 0.000000 |

**Measurements in bent lines**

If measurements are to be carried out in a bent swath, then the measurement is started as usually, but in every bent point press for a marker (1 to 9). When the measurement is stopped (F5) a *.POS file is created with 5 positions (if one marker is set for one bend during measurement):

1. Start position, coordinates (Tracenumber, 0, 0, 0);
2. Position before the bent point (Trace, 0, Ybp - 0.5, 0);
3. Position of the bent point (marker): (Trace, 0, Ybp, 0) (where Ybp is the position in meters)
4. Position after the bent point: (Trace, 0, Ybp + 0.5);
5. Stop position, coordinates (Trace, 0, Ystop, 0)

The swath can be opened in rSlicer and bends by moving the points 4 and 5 in the geometry edit option.

**Measurements with a simpler Total Station**

If the used Total Station can not communicate directly with the data collection computer, the measurements should be done without positioning (Tools -> Positioning parameters). The Start and Stop coordinates and the coordinates between them is read from the Total Station and noted and then placed in the *.POS file.

**Continue a Project**

When one wants to continue a closed project the project has to be opened (File -> Open Project). File Open Dialog is opened and the user can find and open Project Header File. When Project Header File is opened channel configuration and channel order from the last swath in this project are opened as well and the user can press F3 and continue create swaths for this project.

**Recreate a Project with the same name**

If the user wants to start a project with the same name from the beginning he can choose File -> Create New Project and give same name in the same directory as the existing project. The message will come: ”<project name>.mira already exists. Do you want to replace it?”. If the user selects ”yes” then a new empty project header file with the same name will be created and the previous file will be saved as ”<project name>.mira_backup_NN” where NN is number from 00 to 99.

# 8 Files

## Data files names

The radar data file names (*.rd3 and *.rad) have following structure:

<Project Name>_<Measurement number>_<Channel number>.<Extension>

For example: Field_033_A003.rd3

## Data files extensions

The following files are created in MIRASoft in conjunction with a measurement:

***.mira** Project Header File

***.rad** Header file containing the measurement parameter for the channel, one for each channel

***.rd3** Binary file containing raw data, one for each channel

***.cfa** Channel configuration file, containing the selected firing sequence for the measurement.

***.cfd** Channel order file, containing the position of the different channels in the array.

***.cor** GPS coordinates

***.pdt** Exact wheel and time positions for every trace.

Format: <wheel position> <time position>

***.tsn** Exact time position from Total Station (only Leica).

Format: <trace number><TAB><time from total station>

For the files, besides the radar data files, the following naming convention is used (files saved in the project catalog):

<project name>_GNN.pos.raw - raw position files for every tie-in-point;

FCODES.TXT.raw - raw codes for rSlicer file;

<swath name>.cfa - channels configuration for this swath;

<swath name>.cfb - chanels order for this swath;

<swath name>.mrk - marker file;

<first profile name>.cor - raw GPS file;

## Files for rSlicer

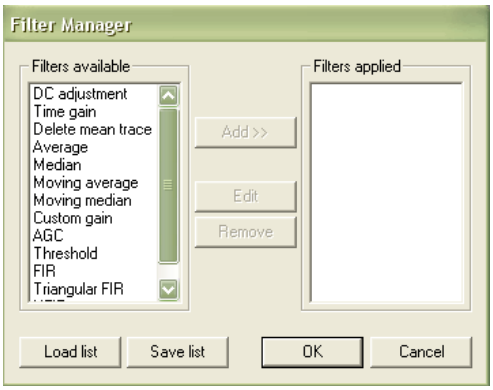
For rSlicer the following data structure is applied and automatically created:

All files are situated in the directory with name = <Project Name_rSlicer>

| | |
|---|---|
| <Project Name>_<Measurement number>.rad | Special header; |
| <Project Name>_<Measurement number>.rd3 | Data (all channels in one file); |
| <Project Name>_<Measurement number>_G01.pos | Positions from GPS or Total Station |
| Lines_G01.pos | Line features |
| Points_G01.pos | Point features |
| Tie_G01.pos | ..Tie in points |

# Appendix 1

This appendix covers the available filters in the MIRASoft 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.

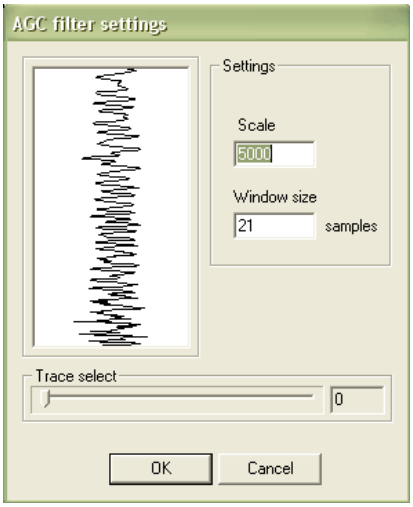
Always used: DC-shift

Often used: Delete Mean Trace, FIR, Time Gain

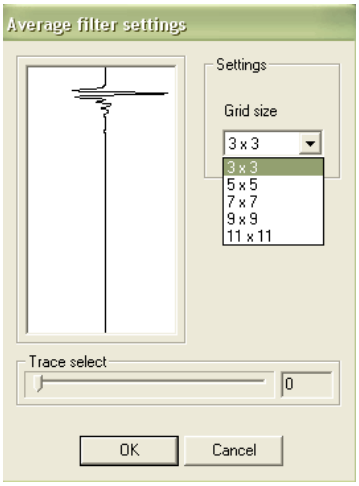
Seldom used: Custom Gain, Moving Average, Moving Median, Threshold

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

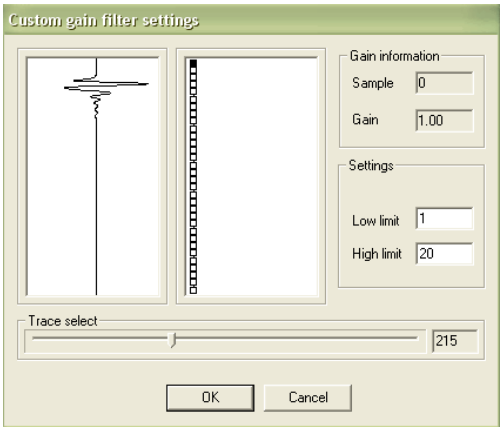
**Automatic gain control AGC**
This filter attempts to adjust the gain of each trace by equalizing the mean amplitudes observed in a sliding time window. A short window gives a more pronounced effect, the extreme of which would a one-sample window, which would cause all amplitudes to be equal. The other 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.

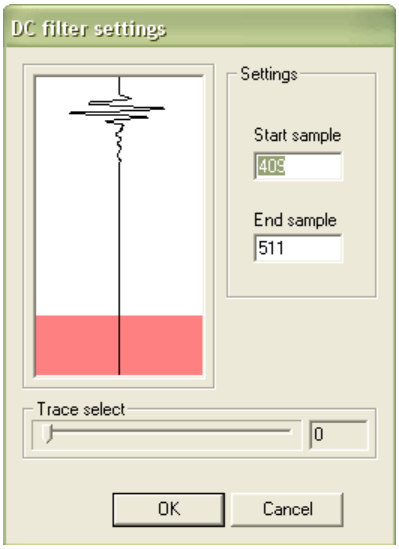



**Custom Gain**
An amplifying filter where the gain factor is given manually for 32 different sections of the trace.

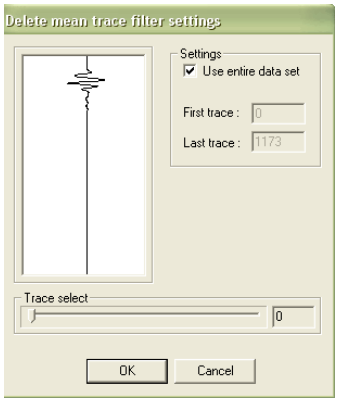



**DC-Filter**
There is often a constant offset in the amplitude of the registered trace, this is known as the DC level or the DC offset. This filter removes the DC component from the data. The DC component is individually calculated and removed for each trace.

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.

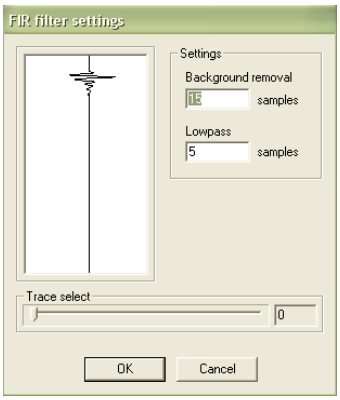


**Delete mean trace**
This filter is used to remove horizontal and nearly horizontal features in the radargram by subtracting a calculated mean trace from all traces, sample by sample. The mean trace can be calculated for the whole profile or for a specified section of the profile.

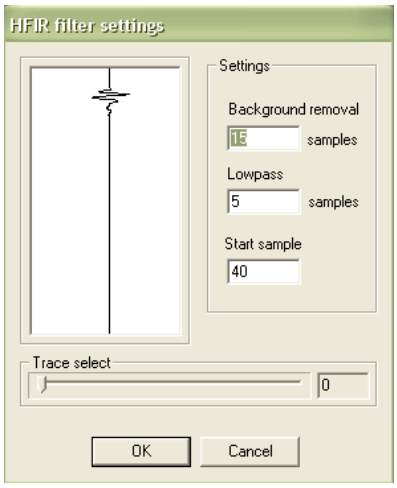



**FIR**
A quick band-pass filter, working with a combination of two boxcar (averaging) filters. The filter is run in two stages. First the lower frequencies are attenuated by subtracting the average in the longer boxcar from the raw data at the centre of the boxcar. Then the higher frequencies are attenuated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

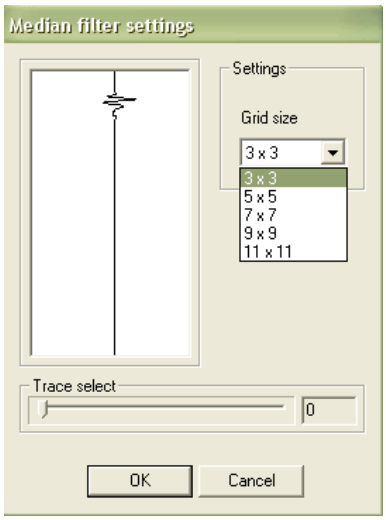
Both boxes calculate along the whole trace.



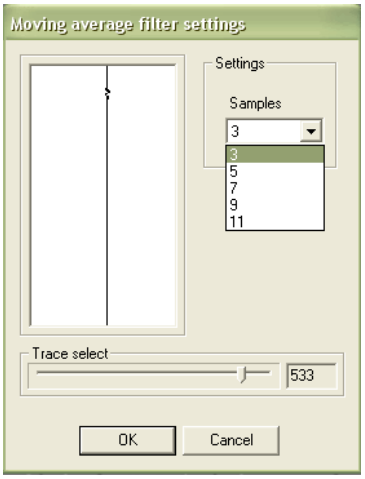

**HFIR**
The HFIR filter functions as the FIR filter, but the filter runs along the profile - not along the trace. The filter is a spatial band-pass filter and its effect is similar to that of the background removal filter




**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.

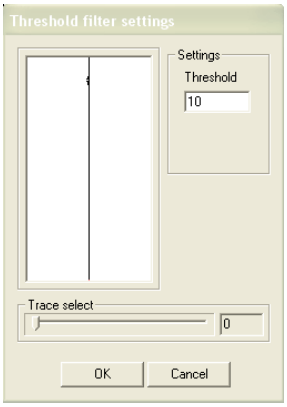


**Moving average**
This filter takes the average as calculated by the average filter described above and subtracts it from the sample at the centre of the filter. Its effect is that of a simple 2D high-pass filter.

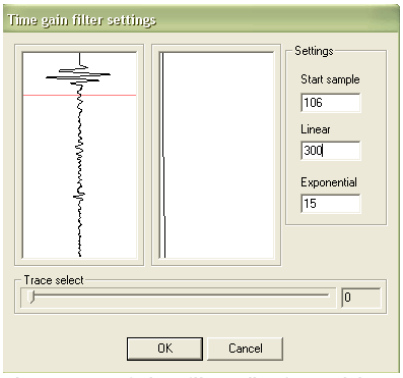



**Moving median**
As the Moving average filter, but with the median value instead of the average.

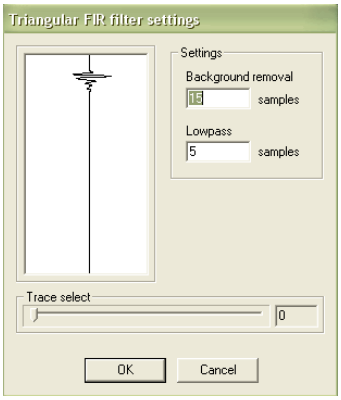
**Threshold**
All samples with a value below the threshold are set to zero.




**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.



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