MALÅ MIRA System

Operating Manual v. 1.1

19-001034

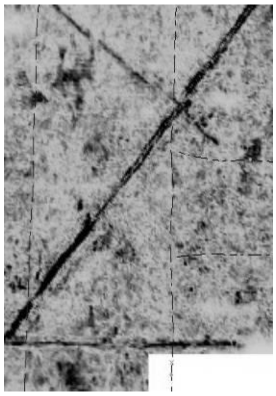
Table of Contents

1 Introduction

Thank you for purchasing the MALÅ Imaging Radar Array, the MIRA System. The MIRA system enables any combination between the individual receiver and transmitter antennas used in the array. The separate transmitter and receiver antennas can be combined into one single antenna array unit tracked and positioned by a total station or RTK GPS for precise positioning. Operated in default mode, this will give parallel swaths of dense and exactly positioned GPR data, which may be seamlessly loaded into the processing software. The results, produced by the rSlicer software, are seamless 3D pictures of the subsurface, with a high-resolution of subsurface features both in horizontal and vertical direction.

The MIRA systems are designed with new technology and protected by new patent applications, meaning that the compatibility with old array systems have been taken away, both for hardware and 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 instructions carefully and address any questions or suggestions to the following:

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Technical support issues can be sent to: support@malags.se

Information about the products from MALÅ Geoscience is also available on Internet:
http://www.malags.com

1.1 Unpacking and Inspection

Great care should be taken when unpacking the equipment. Be sure to verify the contents shown on the packing list and inspect the equipment for any loose parts or other damage. All packing material should be preserved in the event that any damage occurred during shipping. Any claims for shipping damage should be filed to the carrier. Any claims for missing equipment or parts should be filed with MALÅ Geoscience.

1.2 Repacking and Shipping

If original packing materials are unavailable, the equipment should be packed with at least 80 mm of absorbing material. Do not use shredded fibres, paper wood, or wool, as these materials tend to get compacted during shipment and permit the instruments to move around inside the package.

1.3 MALÅ Geoscience Indemnity Clause

Operators of MALÅ MIRA system or other GPR systems shall hold harmless, defend, and indemnify MALÅ Geoscience from and against any and all losses, liabilities, damages, injuries, claims, demands, costs and expenses or claims including claims by third parties arising out of the use or possession of the MALÅ MIRA GPR system.

1.4 Important information regarding the use of this GPR unit

According to the regulations stated in ETSI EN 302 066-1 (European Telecommunication Standards Institute):

- The control unit should not be left ON when leaving the system unintended. It should always be turned OFF when not in use.
- The antennas should point towards the ground, walls etc. during measurement and not towards the air.
- The antennas should be kept in close proximity to the media under investigation.

2 System components

In short the MIRA system comprises the following parts (see Figure 2.1):

- Antennas, separate transmitters and receivers antennas with the centre frequencies of 200MHz, 400MHz or 1.3GHz.
- The antennas are preferably placed in a special antenna box for deployment of the system.
- The MIRA option. The standard configuration is equipped with 16 channels but can be customized for any number of channels up to 31.
- A modified ProEx control unit.
- A positioning system, Total station (ATS type) or RTK GPS.
- A Windows based computer to collect, save and process data, with data acquisition (MIRASoft) and processing (rSlicer) software
- Suitable vehicle or arrangement (with antenna array on wheels for moving).
- Power supply for the ProEx control unit and the antenna array, 12V.

These different parts are explained in more detail below.

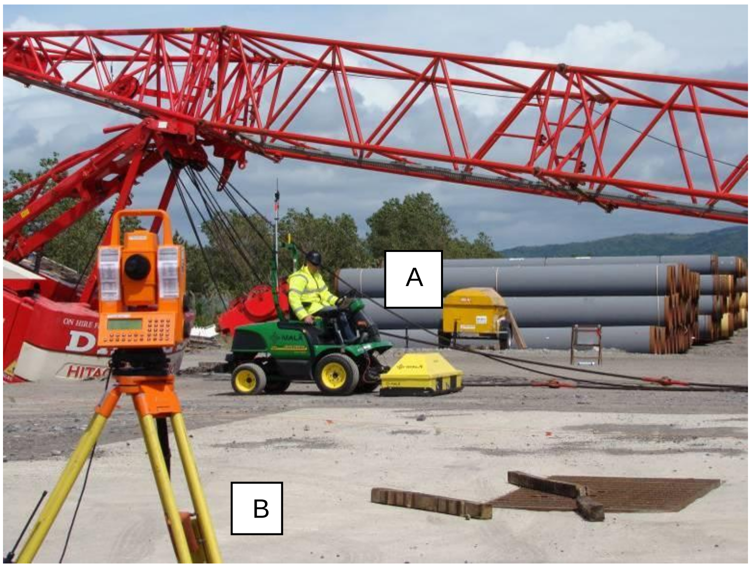


Fig. 2.1 *The MIRA system, with the antenna array on a vehicle (A) and the positioning system (self-tracking Total station) (B).*

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.

2.1 The ProEx control unit

The ProEx™ control unit (Fig. 2.2) is a general tool for controlling data acquisition with various GPR systems. In its basic configuration it operates all kinds of antennas, shielded, unshielded, borehole etc. More on this can be read in the ProEx operating manual.

The ProEx main unit communicates via a fast Ethernet link with a PC. In the MIRA system the ProEx control unit will operate more or less as a slave. Its main task is to keep track of the position along the profile and collect data at equidistant points.

Fig. 2.2 *The ProEx control unit.*

The leading thought behind the design of this unit is modularity and data throughput, the latter being very important in conjunction with the array option. In order to handle the data stream, each data channel has its own processor taking care of the reading, stacking, buffering and transfer of data. This will ensure undisturbed data throughput, regardless of the number of channels used. Internally this is implemented via a distributed design with multiple controllers, each taking care of its own data stream and communicating with the master controller via dual port memories.

In this design, the master controller is mainly managing the flow of data to/from the distributed controllers. The design also lends itself to expansion to any number of data channels, a fact used in the array option design.

ProEx standard units are not configured for the array option, if not asked for at time of purchase. In order to be able to control an array option/module the base unit must be equipped with connectors on the back side, see Figure 2.3 below.

Fig. 2.3 *The back-side of a ProEx unit configured for array-use.*

2.2 The MIRA option

The design supports arrays of up to 31 receivers and transmitters, making it the most versatile array option on the market.

The array option connects to the main ProEx unit by means of two 25-DSUB connectors, see Figure 2.4 below. It is powered from the main unit and has no external power connector.

Fig. 2.4 *Connectors for attaching the MIRA option to the main ProEx unit.*

One side of the array option has coaxial connectors for the receiver and transmitter trig lines. The number of lines is dependent on how the system was ordered. The MIRA option in Fig. 2.5 is for maximum 10 receivers and transmitters. The standard array option is equipped to handle 16 channels.

Fig. 2.5. *On one side of the array option, the receive and transmit trig signals cables are connected (left) and on the other side connectors for the digital data lines from the receiver antennas are found (right).*

The array option is fastened to the main unit with help of screws and small metal plates. See Fig.2.6.

Fig. 2.6. *The MIRA option connected to the ProEx control unit. The metal plate and place for securing screws are marked.*

2.3 Antennas

The MIRA system is designed to handle shielded separable antennas only, no other antennas can be used with the MIRA system. The MALÅ separable antennas are designed to show as similar response (signature) as possible and each data channel in the array is tested individually with regard to this parameter.

The MALÅ shielded separable antennas are available with the centre frequencies of 200MHz, 400MHz or 1.3GHz. These frequencies will cover investigations ranges from 0 to approximately 6 m depth in non-conductive ground.

These antennas have one power connector and one trig connector. The receiver antennas are also equipped with a connector for the digital data.

For each trig line there's a LED on the antenna. This LED, when blinking, tells that the trig signals are received by the electronics inside the receiver and transmitter antennas. Similarly there is a LED telling that digital data is leaving the receiver antenna, when blinking.

The antennas contain all electronics for generating the impulse, sampling the incoming signals and digitise it to 16-bit. The raw 16-bit data is transferred to the array-option where it's buffered for later transport to the PC for final storage and display. In Fig. 2.7 below available MIRA antennas is shown.

Fig 2.7. *200 MHz, 400MHz and 1.3 GHz antennas. Lengths are 455, 230 and 90 mm respectively.*

Several separate transmitter and receiver antennas are combined into one single antenna array unit mounted in a box suitable for field surveys. 200 and 400MHz boxes are designed to include also the control unit.

2.4 Positioning systems

The antenna array must be positioned with a high level of accuracy through out the survey. A precise control of the geometry is an absolute prerequisite to make the resulting 3D radar picture correct and reliable. Centimetre accuracy is needed over the whole investigation site. The MIRA system can be positioned by using a RTK GPS system or a self-tracking laser theodolite, a so called total station. A prism or a GPS rover antenna is attached to the array box, and a radio link transfers the positioning data from the GPS base station or Total station back to the acquisition laptop. See Fig. 2.8.

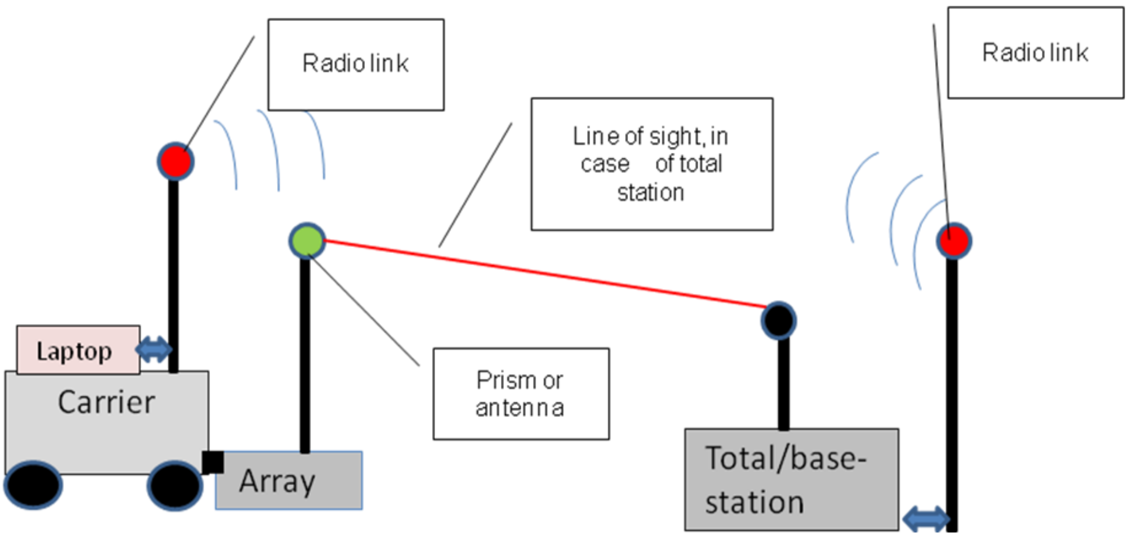


Fig 2.8 *Principal layout of the positioning system.*

With the layout in Figure 2.8 the operator of the carrier vehicle will be able to control/monitor both the operation of the radar system as well as the positioning system while steering the carrier vehicle.

The positioning system used needs to communicate the positioning data in XYZ- format for Total Station and in NMEA 0183 GGA for GPS, so that the data acquisition software MIRASoft can read it and connect it correctly to the measured GPR swaths.

Total station: A self-tracking total station is locked on and follows a prism mounted on the antenna array when the MIRA system moves in the investigation area and a radio link communicates the data from the Total station to the MIRASoft. See Fig. 2.9. The Total station should be of ATS type.

Fig. 2.9. *A self-tracking Total station is used to position the MIRA array.*

RTK GPS: A base station is established in the investigation area, while the rover antenna is mounted on the antenna array. A radio link communicates the positioning data to MIRASoft. An example base station is shown in Figure 2.10.

Fig 2.10. *The RTK GPS base station.*

Depending on the conditions on the investigation site the best method is used. Some points to consider:

- If working in an environment with a number of trees, high buildings or others that might disturb the communication with GPS satellites a Total station is preferred. In these types of environments it can also be hard to define lines and point features with the GPS.
- However, on open ground with lower vegetation or obstacles, the RTK GPS solution most often is a faster and easier way of positioning.
- The Total Station needs line of sight, and by that one extra operator for the Total station if the tracking fails.
- If the investigation area is large, the Total Station needs to be moved and new Total Station positions need to be defined, which can be more time consuming. However every type of investigation area can be covered by a Total Station, which is not the case with a GPS.

It should also finally be mentioned, that temporary loss of tracking will not cause the data to be useless, as long as start and end points of each swath are well defined.

Note! A GPS is very effective when it works! In order to be 100% sure that you can perform the investigation a Total station is needed, though.

2.5 Accessories

The target applications for the MIRA systems are radar surveys over large areas and, practically, it's not feasible to move the array manually over thousands of square meters. Some kind of motorized carrying system is usually necessary. It's possible to ship the radar parts and accessories and attach the system to any carrier, but this requires a case by case handling and cannot be described precisely.

For example lawn-mower types of vehicles are very suitable for carrying the MIRA arrays and in Figure 2.11 below a carrier, including the antenna array box, are shown. This type of arrangement is highly recommended by MALÅ Geoscience on surfaces like grass and high vegetation. For small size scanning on concrete and asphalt the antenna box can be attached to a special design of our standard RTC cart, see example in Figure 2.12.

Fig. 2.11*. A suitable mounting of the array system on a lawn-mower type of vehicle. The antenna box contains a 400 MHz 16 channel array.*

Fig. 2.12*. A 12 channel MIRA 400 MHz antenna array mounted on a small cart.*

Whatever vehicle chosen to carrying the MIRA, some adoption for the radar system has to be done, these include:

- Fastening arrangement for the array box.
- Power supply, typically the generator has to be exchanged to one with higher current specifications. Cables, fuses, and switches have to be installed.
- Attatchment of marking system and laptop mounting.

If the carrier is part of the purchase, these details will be taken care of by MALÅ Geoscience. However, the client may find it more suitable to supply the vehicle locally, in which case he has to arrange the mounting details by himself. It is most highly recommended to use the power from the

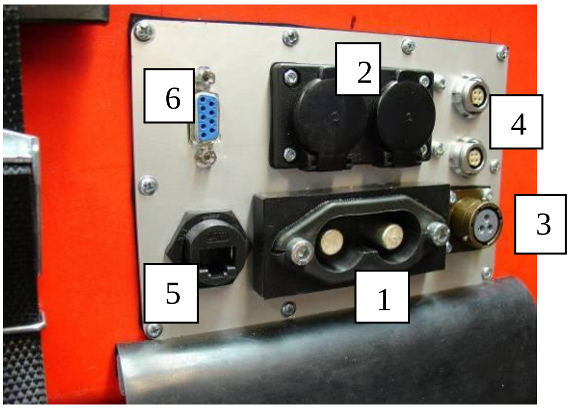
carrier as the antenna array box has quite high power consumption. The vehicle must be able to support 12V@22Amps.
In order to perform effective surveys the following tools and accessories are needed:

- Marking system for plotting the array paths on ground. This is necessary in order for the operator to ensure proper coverage of the area. It's simply a spray-bottle with remote control, attached to the array and aligned with the centre line of the outmost channel.
- Measuring wheel for control of the data acquisition. Usually this is mounted on one of the wheels of the carrying vehicle, but other designs are possible.
- Power supply. Preferably a connection to the generator of the carrying vehicle is used, if this is not an option, arrangements with portable power sources may be considered. Operation from batteries is possible but will require exchanges during a working day.

Other accessories may be necessary in the specific case/application, which can be discussed with the MALÅ Geoscience Head Office. The contact information is found in Chapter 1 Introduction.

3 System set up

In this chapter all connections to make prior operation of the MIRA system is explained. The MIRA system is developed to be rough and stand heavy weather conditions. However, it is advisable to make all connections within the antenna box in dry conditions, to prevent water in the electrical outlets. An overview on the main connectors on the MALÅ standard antenna boxes is shown in Fig. 3.1.



1. Power supply from the battery box. 12V DC
2. Connector for the Spray paint system.
3. Connector for the remote control for the Spray paint system.
4. Connectors for power (12V DC) of extra equipment as radio link and prism for positioning system.
5. Connector for data communication, Ethernet cable. **Note!** This should be crossed to the control unit and straight from the antenna box to the computer.
6. Connector for encoder wheel cable.

***Fig. 3.1**. The main connectors on the MALÅ standard antenna box.*

3.1 Antenna array

The separate receiver and transmitter antennas are placed in the antenna box, according to the configuration chosen. See Fig. 3.2. To each antenna the antenna cables are connected, three to the receiver (power, trig and data) and two to the transmitter (power and trig) antennas. The standard configuration of a 16-channel set up is shown in Fig. 3.3.

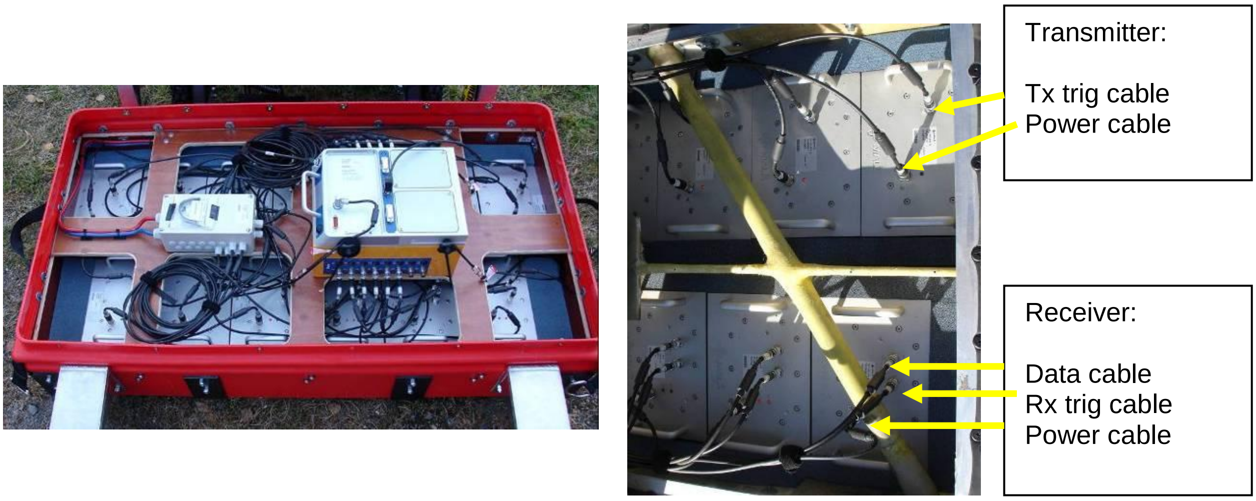


***Fig. 3.2.** Examples of antennas in the antenna box and the connection to the coaxial cables and power supply. The receiver antennas are seen at the bottom and transmitter antennas, at top. In this example 400 MHz antennas are seen.*

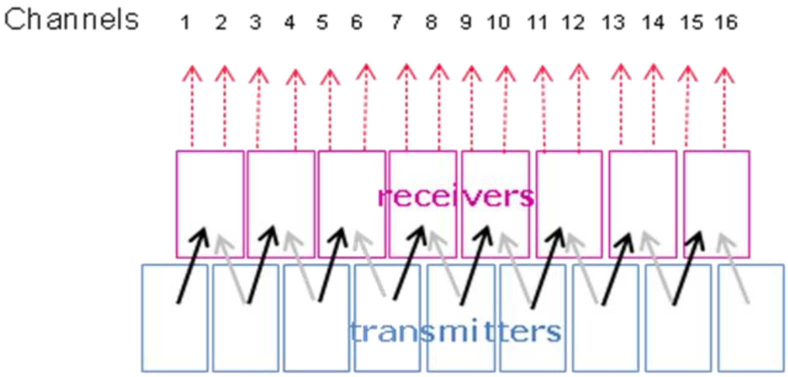


Fig. 3.3. *The standard bi-static fixed offset 16 channel array, with 9 transmitter and 8 receiver antennas. Each receiver is synchronized against two transmitters in order to make the physical channel spacing as small as possible.*

3.2 ProEx control unit and MIRA option

The ProEx control unit is mounted to the MIRA option, with the two 25-DSUB connectors, and secured by two screws on each side. See Fig. 3.4.

Fig. 3.4. *Connection of the ProEx unit to the MIRA option.*

IMPORTANT NOTE! The interface between the main ProEx unit and the array option is not protected against over voltage. Therefore the units must be powered off before connection/de-connection.

Connect the Ethernet cable from the ProEx unit and further on to the main connector (Fig.3.1) and the power cable from the power box to the ProEx unit. Note! The power box is equipped with fuses for each source.

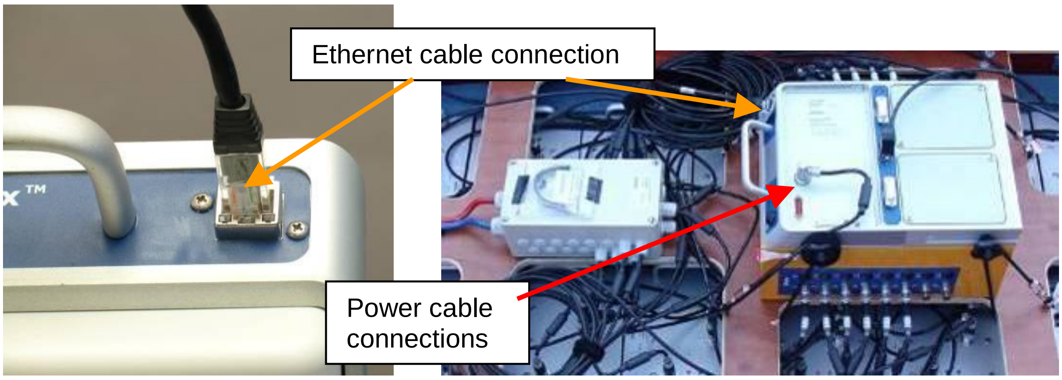


Fig. 3.5. *Ethernet cable and power connection to the ProEx unit.*

3.3 Antennas

The MIRA option is connected to the antennas by means of coaxial lines, carrying control signals and digitized data. Deployed for data acquisition, numerous cables will be connected to the option and, therefore, it is recommended to be mounted as a fixed installation, whatever the carrying system may be. Care should also be taken for minimizing the environmental stress on the option, such as rain, temperature variations etc. However, when a standardized package is purchased, these kinds of practical issues will be taken care of by MALÅ Geoscience.

The cables between the antennas and the MIRA option are connected according to Fig. 3.6 below.

Note! In order for the MIRASoft data acquisition software to work, the numbering of the connectors must follow the antennas.

Fig 3.6 *The cables from the antennas are connected to the MIRA option. Observe that the connectors are marked both on the antennas and on the MIRA option, with T (Transmitter), R (Receiver) and D (Data). The T and R are found on one side and D on the other.*

3.4 Power

Depending on your system the power supply is customized. One example on how to power the antennas and the control unit is shown in Fig. 3.7.

Fig. 3.7. *The red/blue power cable supplies the power box directly from the carrier battery or en external battery (connected via the main connector shown in Fig. 3.1) and the black cables are connected to each antenna element and to the ProEx control unit. In this power supply box, fuses for each connector are also found.*

The ProEx control unit, together with the attached MIRA option and the antenna array are powered externally.

The main power for the whole set up is turned ON or OFF by switching the key on the external battery box, shown in Figure 3.9. This will turn off the power to the antennas, the ProEx control Unit, the Spray paint marker, the radio link and prisms.

IMPORTANT NOTE! It is important to turn off the power when the antenna array is not in use, otherwise it will drain the power supply.

The MIRA system operates at 10-14V and to supply the system from a car battery is most convenient. MALÅ Geoscience provides suitable cables and boxes for this. See Fig. 3.8. However it is recommended to power the system directly from the carrier used, as an ordinary car battery will last for approximately 4-5h. MALÅ Geoscience provides suitable solutions for this.

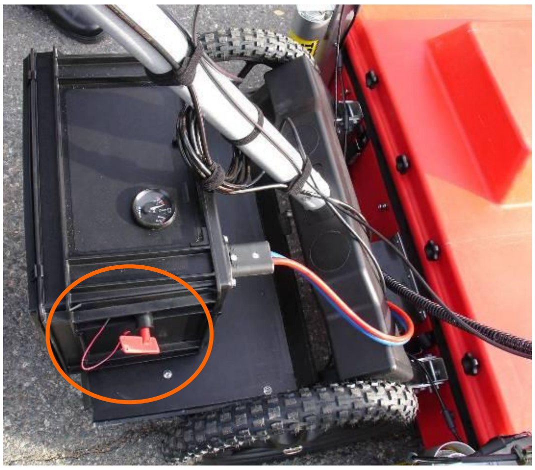


Fig. 3.8*. The main power switch on the external battery box.*

3.5 Computer

The computer used for measurements are placed as convenient as possible for the operator carrying out the measurements. The Ethernet cable is used to transfer the measured data from the control unit to the computer for storage, display and processing. Fig. 3.9

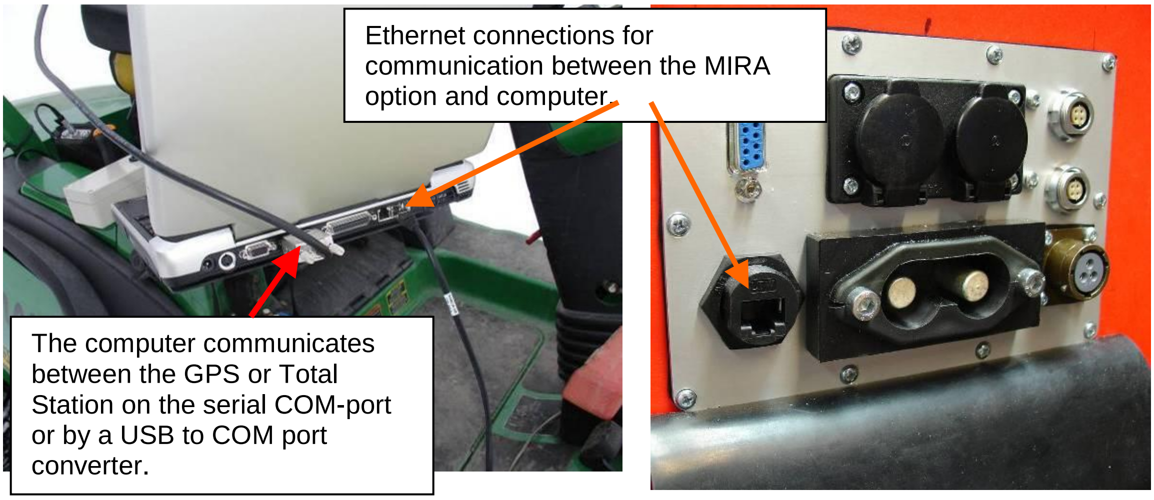


***Fig. 3.9**. Connection of the Ethernet cable between the antenna box (left) and the computer (right).*

3.6 Positioning system

The used positioning system is initialised according to the equipments operating manual. Make sure that the communication settings match the settings made in MIRASoft (see operating manual MIRASoft).

Total Station
The total station needs to send out data in XYZ-format.

- Place the Total Station so a good coverage of the investigation is reached.
- Properly mark tie-in-points outside the investigation area (use the prism) (see operating manual MIRASoft) and position these. **Note!** If the Total Station needs to be moved the same tie-in-points needs to be seen from the new location.
- Place the prism on the antenna array, in one of the spray mark holder (with the 5-8 UNC thread, see Fig. 3.15). Preferably in line with the encoder wheel.
- Connect the external radio link to the Total station and on the antenna array carrier. The radio-link antenna is connected to the computer to gather the positioning data from the Total station.

Note! In some areas the radio link needs to be elevated for best possible transferring. Although the radio modems provided by MALÅ Geoscience is of high quality, with checksum handling and quite high power ratings, they may be disturbed by ongoing radio traffic. In such case a different frequency should be chosen, manuals for the modems are provided separately.

Examples of Total station and radio link arrangements are seen in Fig. 3.10.

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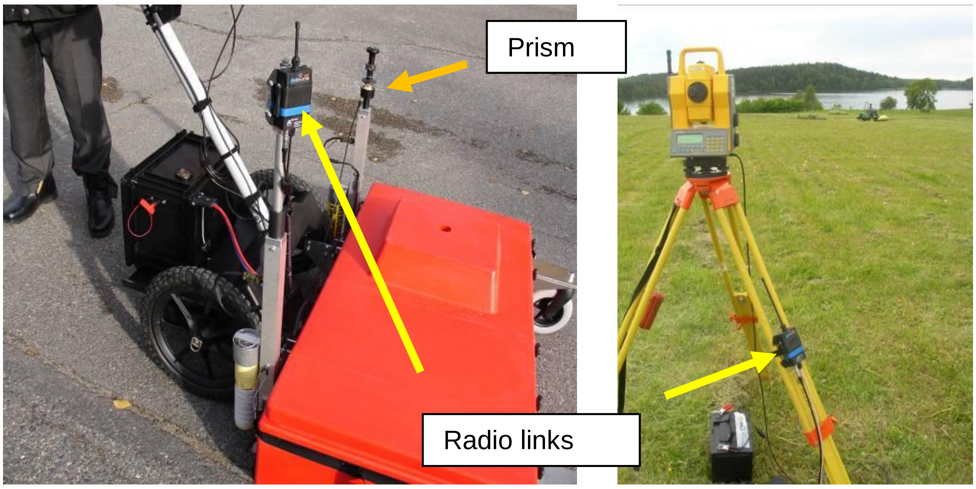

Fig. 3.10. *Left: Radio link on carrier and a prism on antenna array box. Right: Robotic total station and radio link.*

GPS
The GPS needs to send out data in NMEA 0183 GGA format. However this is saved in a local coordinate system, related to the centre of the local coordinate system set in MIRA Soft.

- Place the GPS base antenna outside the investigation area. **Note!** Sometimes the distance between the base and the rover needs to be several hundred meters during initialization.
- Make all connections between the base antenna and the GPS base receiver.
- Place the GPS rover antenna on the antenna box, in one of the spray mark holders (with 5-8 UNC thread, see Fig. 3.15), preferably left side in-line with the first channel and make all connection between the rover antenna and the receiver antenna and the computer.

Examples of GPS arrangements are seen in Fig. 3.11.

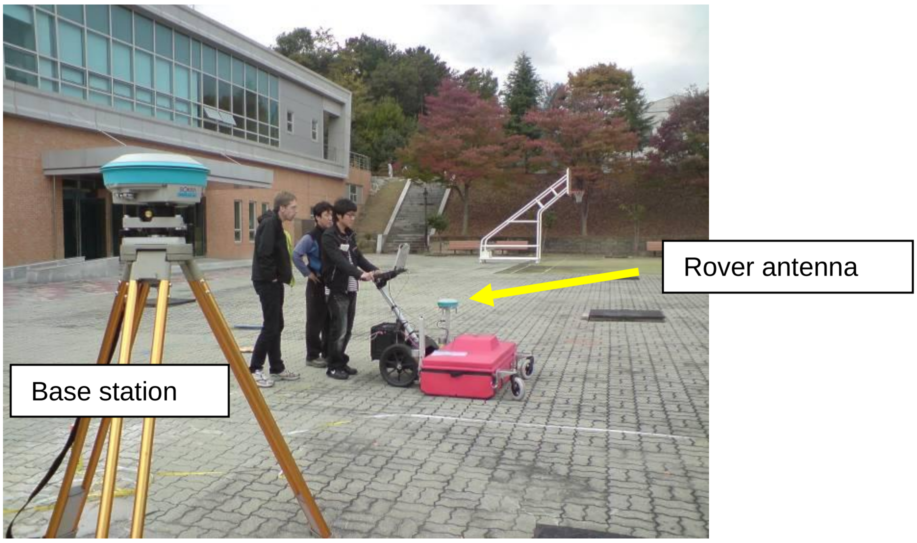

Fig. 3.11. *RTK GPS set up.*

3.7 Remote Control

The MIRA system can also be used together with a remote control for an even easier operation of the measurement system, see Figure 3.12. Instructions in eight simple steps are found below.

Fig. 3.11. *The MIRA remote control, with three function buttons (Stop, New and Marker) and 4 LED indicators. The two LED´s (1 and 2) indicates ongoing survey (measurement) with steady green light and when blinking ready or stopped. The LED´s (3 and 4) indicates no connection or error with steady or blinking red light..*

Note! The remote control should be connected prior the power of the MIRA antenna box is turned ON.

Note! Whenever a button is pressed on the remote control, a beeping sound is heard.

1. **Connect the remote control** to the 15-pin DSUB connector on the outside of the MIRA antenna box, see Figure 3.12.

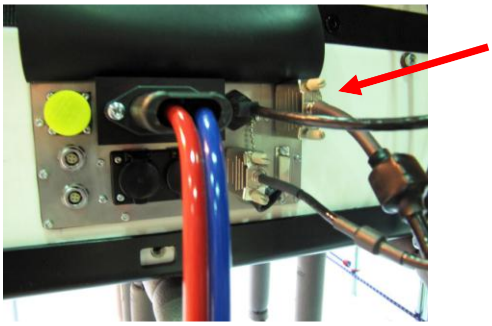

Fig. 3.12. *Connection of the MIRA remote control to the MIRA antenna box.*

2. **Connect the remote control cable** between the ProEx AUX1 connector and the internal 15-pin DSUB connector of the MIRA box. See Figure 3.13.

Fig. 3.12. *Connection of the MIRA remote control cable inside the MIRA antenna box. Left: Connection on the ProEx (AUX1). Right: Connection on the inside of the antenna box (15-pin DSUB)..*

3. **Turn the power ON** to the MIRA antenna box and make sure that MIRASoft is running.

4. **At start**, the LED´s 3 and 4 are showing a red steady light to indicate that the ProEx do not have any connection with the MIRASoft. When the communication is established, these LED´s turn down and LED 2 starts to blink. This shows that the system is ready for measurements.

5. **Make all necessary measurement settings in MIRASoft**. See Operating Manual for MiraSoft for more information.

6. **To start a measurement:** Press the button NEW. Both LED 1 and 2 is showing a steady light, indicating ongoing measurement.

7. **To stop a measurement:** Press the button STOP. The LED 2 is turned down and LED 1 is starting to blink. LED 1 will blink until all data is correctly saved by MIRASoft, then it turns off, and LED 2 is starting to blink, indicating that the system is ready for measurement again. ´

8. It is possible to set **markers** whenever wanted during measurement, just press the Marker button. There can be a delay of up to 100 ms before the marker is set by MIRASoft. Information about the marker is stored in the *.mrk file, as type 1. The file is saved in the project folder.

9. If an error occurs, the LED 3 and 4 starts to blink in red, together with a beeping sound. Check the type of error in MIRASoft and fix it before continuation. Error messages can be reset by pressing STOP and a new measurement started when READY (LED 2) starts to blink again.

Note! See Operating manual for MIRASoft for more information.

3.8 Others

For positioning along the measurement swaths, and to control the data collection, the MIRA system is compatible with all MALÅ measuring wheels. On individual basis it might, however, be better to combine the used antenna array carrier wheel with a standard MALÅ encoder unit mounted on one of the wheels. See Fig. 3.12.

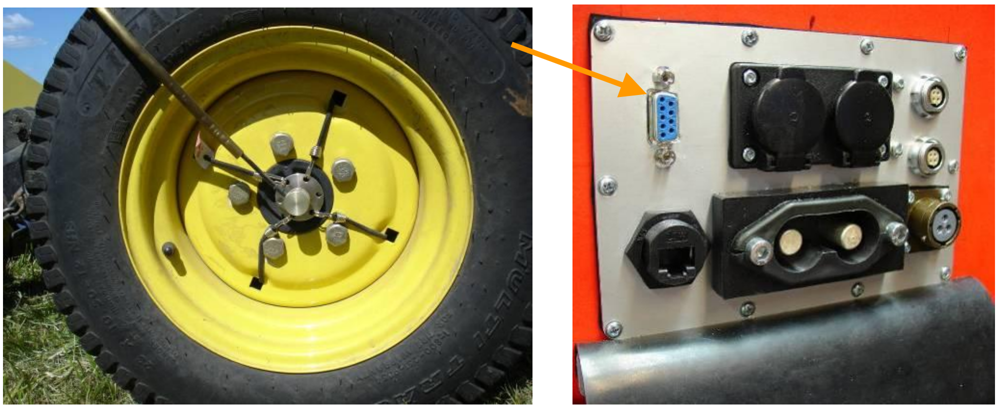

***Fig. 3.12**. The encoder wheel on the carrier wheel (left) and connection of the encoder cable to the antenna box.*

Inside the box the encoder cable is connected to the ProEx unit. See Figure 3.13.

***Fig. 3.13** The wheel encoder connector on the ProEx unit.*

If no antenna box is used the encoder cable is connected directly to the ProEx unit.

The spray marker device (to help the operator to keep track of the measured swaths) can be used on both sides of the standard antenna box (see Figure 3.14). It is connected to a remote control and powered by a standard MALÅ battery pack or by the main power supply. The remote control and automatic spray marker is customized to suit your system.

Note! Use a colour of the marker spray that is suitable for the investigation area. A high contrast between the ground and marker is best, for instance red colour for grass. It is also advisable to use a marker colour that will disappear quickly.

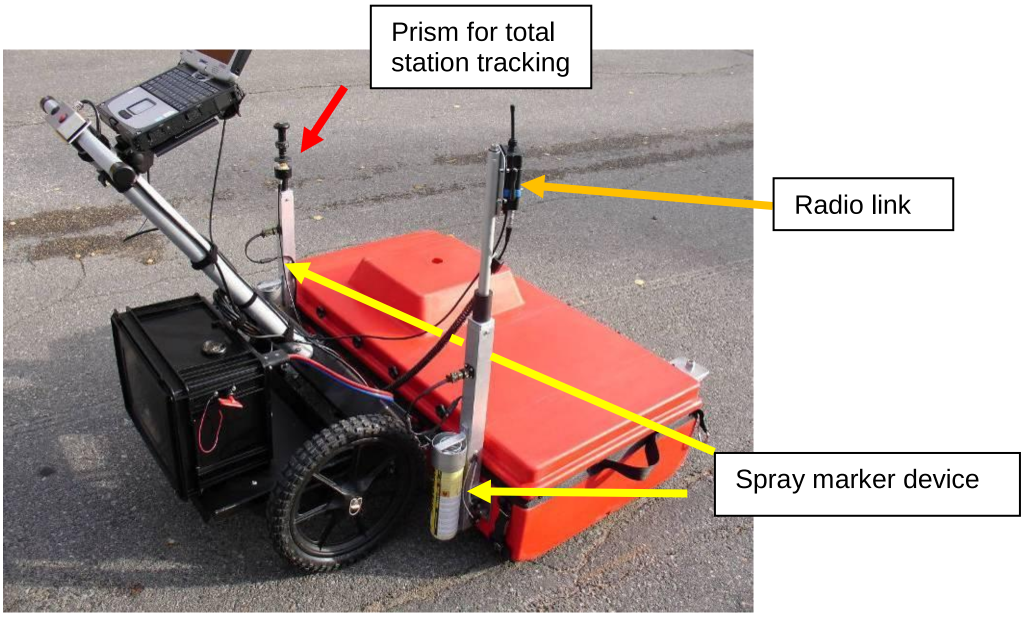

Fig. 3.14. *Marker system and carrier.*

In Figure 3.15 the top part of the spray marker holder is shown in detail. As seen, the holder is also equipped with a 5/8 UNC thread suitable for Total Station prism, radio link holder and GPS rover antennas.

Note! It is advisable to have the prism of the Total station or the GPS rover antenna as close to the antenna box as possible during measurements, especially on uneven ground.

Fig. 3.15. *Standard UNC thread on top of the spray marker holder.*

The spray can marker box is seen in Figure 3.16 below and is powers supplied from the MIRA antenna box.

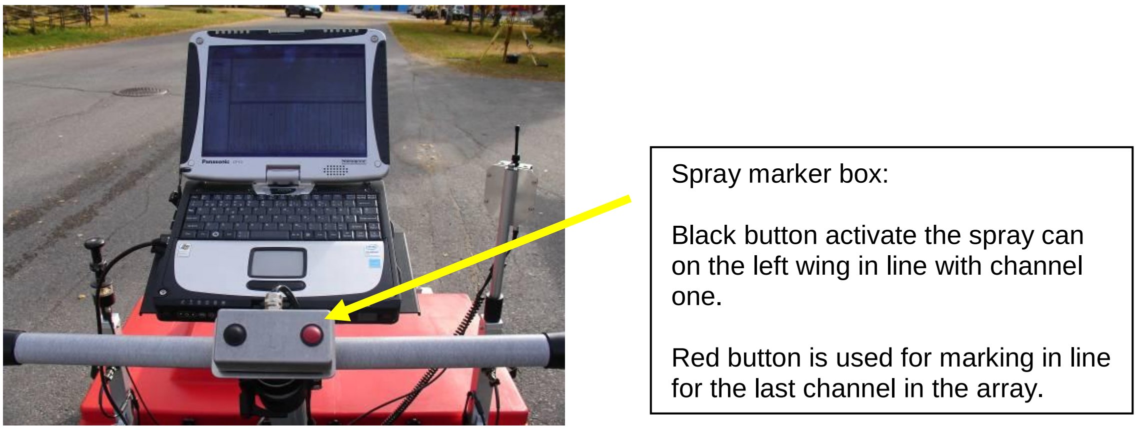

***Fig. 3.16**. Spray marker box.*

4 Data acquisition

4.1 Planning the survey

Prior to radar data acquisition, thoroughly planning of the survey should be done. It's advisable to conduct the data acquisition in straight lines, so called swaths, whenever possible. The MIRA system does not require straight swaths but the positioning errors will be less and the coverage of the area will be easier managed if the geometry is kept simple, see an example in Figure 4.1.

Utilises are best detected if the measurement swaths are made in the same direction as the utilises are located. If the direction is unknown it is best to measure in two directions and look at the two different projects separately in rSlicer.

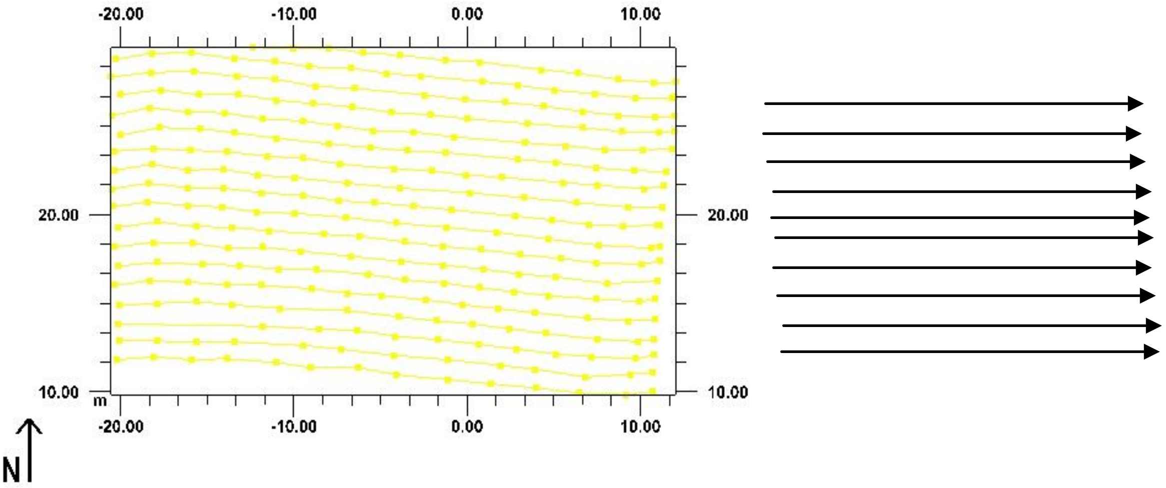

Fig. 4.1. *Example of measurement swaths for a smaller investigation area where all swaths are made in the same direction, from west to east.*

It's essential to ensure proper positioning over the whole area and this includes line of sight from the Total station to the radar array, if a total station is used. However, most modern Total station can handle the fact that the signal is interrupted (due to smaller trees etc) for a short while.

Most often it is also good to have the radio-link at some height above ground.

Planning for how many different Total station positions as well as mapping of reference points (buildings, man-holes, roads etc.) is preferably done prior to radar data acquisitions. In Fig. 4.2 an example is shown with marked roads (red lines) and trees (A).

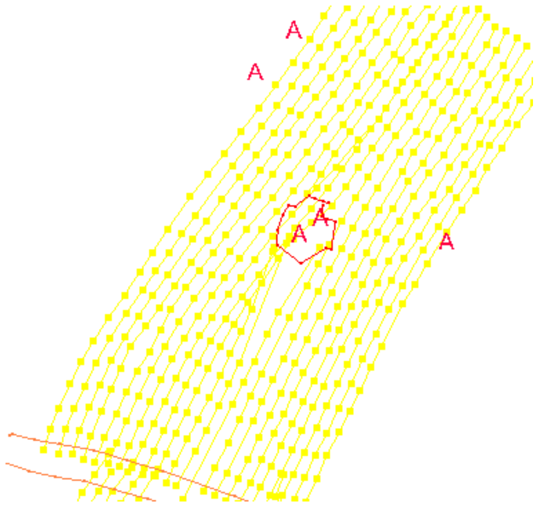

Fig. 4.2*. Example of measurement swaths and mapped objects in the surrounding for reference.*

So called Tie-in points are used if the Total Station position needs to be moved. More can be read in the operation manual for MIRASoft.

To control the actual data acquisition, an odometer (encoder) wheel is used to achieve a precise trace interval (point distance). The encoder is mounted on the carrying vehicle and directly connected to standard antenna box and the ProEx control unit. The wheel controls the data acquisition along the survey line while the positioning system logs the position at predefined times/events. When selecting the point distance, one should use a distance no longer than the channel spacing within the array. To get good data for the radar and the positioning a suitable speed for a survey is roughly 20 km/hour.

Note! The encoder on the carrier wheel should be placed in line with the Total Station Prism or the GPR rover antenna to ensure a good quality length measurement.

As previously shown, a spray can, attached to the antenna array box, is advisable to use to mark the edge of the swath measured, and by that see where the next swath should be measured to get sufficient. Minor, uncovered, areas do not result in significantly deteriorated data, though. See an example in Figure 4.3.

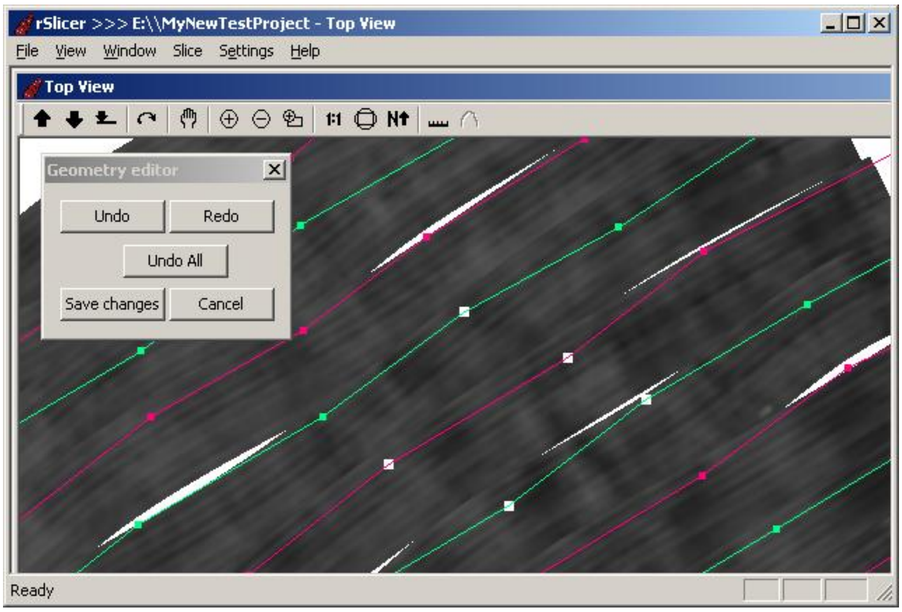

Fig. 4.3*. Example of radar data were the radar swaths are not completely overlapped, leaving unmeasured white spots in the data.*

4.2 Data collection

When the MIRA system is connected as explained in Chapter 3, the system can be powered on and data acquisition can start.

Note! The power cannot be turned ON before the MIRA option is securely connected to the ProEx unit.

The data collection is configured in the MIRASoft software. More can be read in the MIRASoft operating manual. As the configuration is ready, the measurement can start.

Note! Whenever possible, it's always recommended to average data, so called 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

It should also be noted that if the higher speeds are used, the demands on the positioning system (total station or GPS) become higher as well. It must be able to reliably track the position of the antenna array box, regardless of the survey speed.

Practically, the site conditions usually constitute the limit in survey speed. Surface roughness, obstacles preventing straight lines, crossing traffic and other details usually limit the speed to below 20km/h.

Note! No measurements are carried out before the antenna array moves forward, and the encoder wheel send a signal to the ProEx unit to measure.

The array gathers data at every point interval specified in the MIRA Acquisition software and the operator should keep an eye on the incoming data and positioning during the survey.

During data collection the following is good to consider:

- The warm up time for the system before measurement is at least 10 minutes for a 1.3 GHz array and shorter for 200 MHz and 400 MHz.
- The antenna array box should be kept on the ground, or as close to the ground as possible.
- Be aware of all system warning messages from the MIRASoft, as for instance quality of positioning data, exceeded measurement speed etc. For more information see MIRASoft operating manual
- For every swath, each channel will be precisely positioned and it is up to the operator to overlay the previous swath somewhat in order to completely cover the area. Excess overlap will be taken care of automatically by the processing software during the binning process but uncovered areas will produce artefacts in the resulting images. The processing software has been designed to minimize these effects but nevertheless, a careful data collection procedure is essential for the resulting image quality.
- It is ok to stop the movement of the antenna array and make a break. **Note!** However if the break is long make sure to turn of the antenna array, as it will otherwise continue to use power. Traces will only be collected when the encoder wheel is moving.
- If a measurement swath is wrongly made, stop it and re do it. In the rSlicer you decide which files will be concluded in a certain project.

- Swaths can also be remade later and included in earlier projects. However, then it is important that the swaths are marked, and can be re-found, and if working with the Total station, the same tie-in-points are used and positioned for the new swaths.

As one swath is finished, the measurement is stopped according to the MIRASoft manual, the antenna array is moved back to the start position and a new swath is started. This is continued until the whole investigation area is covered.

And as the measurement is finished, data processing and interpretation can be started, with the rSlicer software. More information is found in the rSlicer operating manual.

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