GUIDELINEGEO | MALÅ

MALÅ ProEx Control Unit

User Manual

Our Thanks...

Thank you for choosing Guideline Geo and MALÅ. The very core of our philosophy is to provide our users with great products, support, and services. Our team is committed to providing you with the most efficient and easy-to-use solutions with the capability to meet your needs for efficiency and productivity.

Whether this is your first MALÅ product, or addition to the MALÅ collection, we believe that small investment of your time to familiarize yourself with the product by reading this manual will be rewarded with a significant increase in productivity and satisfaction.

Please let us know about your use and experience of our products as well as the contents and usefulness of this manual. We're excited to be part of your journey!

MALÅ

Guideline Geo AB

www.guidelinegeo.com

Table of Contents

Preface

About this Manual

This manual is written for the end user of the product and explains how to set up and configure the product, as well as providing detailed instruction on its use.

Additional Resources

Training:	www.guidelinegeo.com/training-gpr-resistivity-seismics-tem/
Downloads:	www.guidelinegeo.com/support-service-advice-training/resource-center/
Applications:	www.guidelinegeo.com/application-areas/

Feedback

Feedback regarding the contents of this manual or the product may be sent using any of the contact details found at www.guidelinegeo.com

Safety and Compliance User Notices

This GPR-device is certified according to FCC, subpart 15, IC RSS-220 and ETSI EN 302 066-1&2.

You are cautioned that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: —Reorient or relocate the receiving antenna. —Increase the separation between the equipment and receiver. —Connect the equipment into an outlet on a circuit different from that to which the receiver is connected. —Consult the dealer or an experienced radio/TV technician for help.

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 unattended. 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.

Canadian and US regulations state that whenever GPR antennas are in use the following notes apply:

This Ground Penetrating Radar device shall be operated only when in contact with or within 1m of the ground.

Only law enforcement agencies, scientific research institutes, commercial mining companies, construction companies and emergency rescue or firefighting organizations shall use this Ground Penetrating Radar Device.

This device complies with Industry Canada license-exempt RSS standards. Operation is subject to the following two conditions: (1) This device may not cause interference and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

French translations:

Cet instrument de Géoradar se devra d'être opéré seulement en contact à même le sol ou en deça d'un mètre du sol.

Cet instrument de Géoradar se devra d'être utilisé seulement par les agences chargées de l'application de la loi, les instituts de recherches scientifiques, les compagnies minières à buts lucratifs, les compagnies de construction et les organisations responsables pour le sauvetage et la lutte contre les incendies.

Cet instrument répond aux exigences de la licence avec Industrie Canada- exempt des standards RSS. L 'opération est sujette aux deux conditions suivantes : (1) Cet instrument ne peut pas causer une interférence et (2) cet instrument se doit d'accepter quelque interférence que ce soit, incluant une interférence qui pourrait causer une opération non-souhaitable de l'instrument.

Radiation Exposure Statement

To comply with ISED RF exposure compliance requirements, a separation distance of at least 20cm should be maintained between the EUT and all persons during normal operation.

Pour se conformer aux exigences de conformité d'exposition ISDE RF, une distance de séparation d'au moins 20 cm doit être maintenue entre l'EST et toutes les personnes pendant le fonctionnement normal.

About ProEx Control Unit

The MALÅ Professional Explorer (ProEx) Control unit is designed for the demanding user, supporting all the Guideline Geo MALÅ antennas available and prepared for customization. The ProEx gives you a modular design with interchangeable antenna modules, enabling measurements in any mode, single or multi-channel. With the MALÅ ProEx solution, collecting data is done using either GroundVision 2 (PC) or the MALÅ XV Monitor.

Unpack. Inspect. Register

Great care should be taken when unpacking the equipment. Be sure to verify the contents shown in the packing list and inspect the equipment and accessories for any loose parts or other damage.

Note: The packing list that is included with the shipment should be read careful and any discrepancy should be reported to our sales department at www.guidelinegeo.com.

Note: All packing material should be kept in the event that any damage occurred during shipping.

File any claim for shipping damage with the carrier immediately after discovery of the damage and before the equipment is put into use. Any claims for missing equipment or parts should be filed with Guideline Geo within fourteen (14) business days from the receipt of the equipment.

Repacking and Shipping

The Guideline Geo packing kit is specially designed for shipping MALÅ ProEx Control unit. The packing kit should be used whenever shipping is necessary. If original packing materials are

unavailable, pack the instrument in a box that is large enough to allow at least 80 mm of shock absorbing material to be placed all around the instrument. This includes top, bottom and all sides.

Warning: Never use shredded fibres, paper or wood wool, as these materials tend to pack down and permit the instrument to move inside its packing box.

Please read our shipping instructions before returning instruments to Guideline Geo. These instructions can be found on our website www.guidelinegeo.com.

Registering MALÅ ProEx Control unit

By registering your equipment, you ensure that you will receive important information, such as manual updates, software upgrades and other product information, which all helps to optimize the utilization of the equipment and realize the maximum return on your investment.

To register your equipment, simply visit www.guidelinegeo.com.

Note: The serial number is found on the control unit, on the battery compartment.

The ProEx control unit

The radar control unit ProEx is the main part of a MALÅ GPR system. The ProEx control unit is compatible with all current MALÅ antennas, both unshielded, shielded, borehole and high frequency antennas.

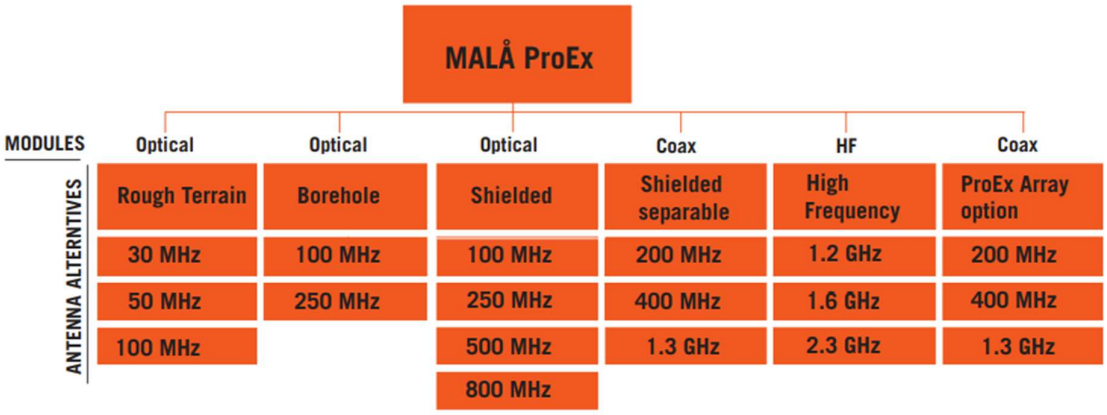


Figure 2.1 An overview of all antennas that can be used together with the ProEx. For latest update, visit Guideline Geo`s homepage, www.guidelinegeo.com

The MALÅ ProEx is the administrator for the radar data collection. It consists of a power supply, an analogue section that generates the crucial control signals and internal computers. Three parallel 32-bit processor controls transmitter and receiver timing, sampling and trace intervals, stores raw radar data in a temporary buffer and data transfer to a PC interface (with MALÅ Ground Vision 2) or to the MALÅ XV Monitor. The three controllers communicate internally by means of fast, double port memories and externally by means of a high-speed Ethernet link hence taking away bottlenecks common with older control units.

For safe and easy operation, the needed calibrations parameters are stored in the internal memory of the ProEx. The antenna configurations are stored in separate files in the XV Monitor or PC.

The main unit has (see Fig. 2.2 below):

- a 100MBit Ethernet link for XV Monitor or PC communication.
- connector for Master wheel (distance-measuring devices) (see section *Trigger Devices*).
- input power (see section *Power Supply*).
- connectors for the different antenna modules and auxiliary ports (see sections *Antenna Modules* and *Auxiliary ports*).
- connectors for expansion unit (see section *Expansion Units*).
- Two slots for antenna modules, see sections *Opto module*, *Coxial module* and *HF module*. Currently 3 different antenna modules are available.

The ProEx requires only short warm up time and is ready for data acquisition in just a few minutes.

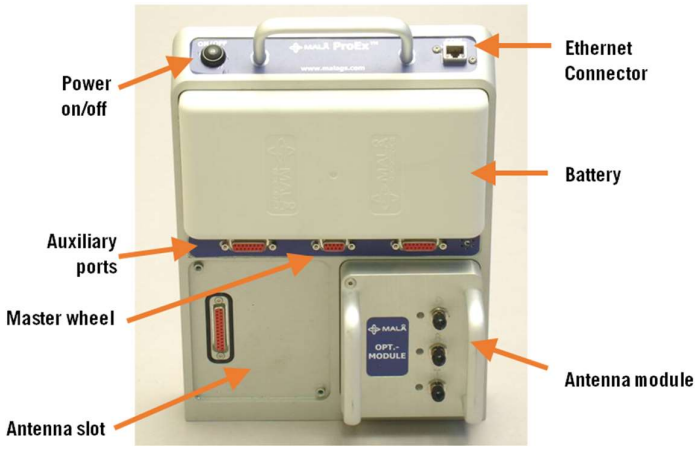


Figure 2.2 The MALÅ ProEx Control unit.

The ProEx is designed for outdoor use. The unit is made in worked aluminum and is completely waterproof. The mechanics is designed to protect connectors and switches from physical damage.

During operation the ProEx is mounted on a backpack holder or used together with the MALÅ backpack. The ProEx can also be attached to the MALÅ RTC (Rough Terrain Cart), see Fig. 2.3.

Figure 2.3 The MALÅ ProEx Control unit mounted in the backpack and on the RTC.

Note: The backpack is not suitable if the HF-option is used.

More information on assembling the ProEx to the different MALÅ antennas, see sections *RTA antennas, Shielded antennas, Separate antennas* and *HF antennas*.

For fixed, mounted operations, as on a vehicle, there's a power connector under the main battery as well as on each expansion unit. When the ProEx unit is used with one or more expansion units, it has to be connected to an external 12V power source; battery operation is not possible in these configurations.

The ProEx measurement modes

The ProEx, in its origin form, has two module slots, A and B, where three different types of antenna modules can be connected (optical, coaxial and HF). See Fig. 3.1 and section *Antenna Modules*. To this base unit two more extension modules can be connected (*see section Expansion Units*) which increases the number of slots up to a maximum of eight.

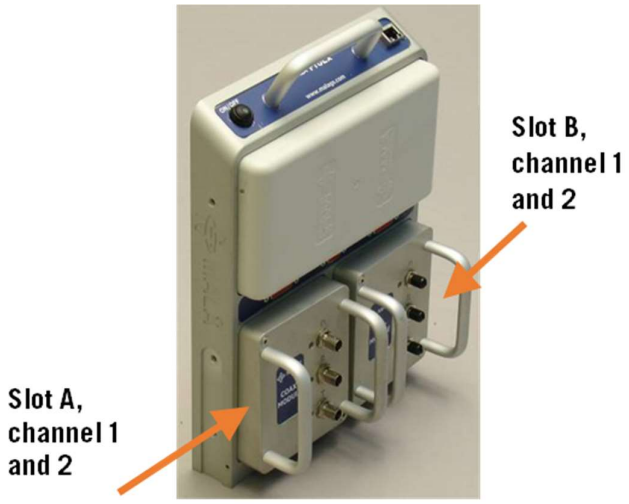


Figure 3.1 The ProEx and the name of the two different slots on the main unit.

Each of these slots with its antenna module can collect data on two different channels, 1 and 2 or also called Internal Tx and External Tx. Internal Tx means that the antenna measures as an ordinary antenna, with its transmitter and receiver part. External Tx means that the antenna connected will only function as a receiver. The transmitter is used on the antenna connected to the second slot in that slot pair.

A common, practical 2-channel configuration would be a HF-module in slot A and an optical unit in slot B. This configuration would be ideal for road measurements with a high frequency antenna (1.2, 1.6 or 2.3 GHz) connected to the HF module, measuring asphalt thickness and a 500/800 MHz connected to the optical module, measuring the layers within the roadbed.

Adding a second optical module gives a system suitable for more advanced analysis such as continuous velocity sounding, multi-path analysis of structures etc. See section *Expansion Units*.

Antenna modules

The ProEx Control Unit is made in a modular design with changeable antenna modules (Fig. 4.1 and 4.2) to be able to support different antenna types. There are three different types of modules to make the ProEx compatible with all antennas: Optical, Coaxial and High Frequency modules.

These modules can be combined in any way to enable different types of antennas to be run simultaneously, each antenna with their individual settings. Note that an individual processor controls each module and timing board, no switching takes place, giving each channel the best possible performance.

Figure 4.1 The ProEx and the three different antenna modules.

Figure 4.2. Mounting the antenna module on the ProEx main unit.

Optical module

The optical unit (Fig. 4.3) connects to all antennas with optical interface, including borehole, shielded and RTA antennas. The main benefits of using optical interfaces are that no dependence on cable lengths is present and that the optical fibers do not interfere with the radar waves.

The connections on the module are marked with T (Transmitter), R (Receiver) and D (Data). Corresponding connections are found on the borehole, shielded and RTA antenna electronics.

Supported antennas:

- Shielded 100, 250, 500 and 800 MHz
- RTA 30, 50 and 100 MHz
- Borehole 250 and 100 MHz

Figure 4.3 The optical module. In the picture the three different fibre optical connectors are seen, for T (transmitter), R (receiver) and D (Data).

For troubleshooting purposes, the module has a LED connected to each optical connector. The ones on the R and T connectors indicate that trig signals are leaving the module, when flashing. The one on the D-connector indicates that the module, when flashing receives data.

Optical fibres

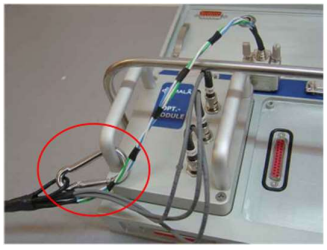
When using the optical module, the ProEx communicates with the transmitter and receiver antenna electronics through fibre optical cables. The data transfer rate through the fibres is 4 Mbytes/sec and they operate:

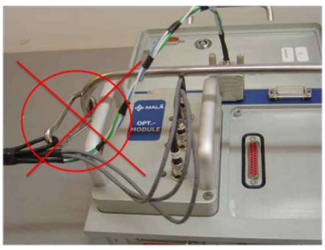
- Trig signals to the transmitter element from the ProEx
- Trig signals to the receiver element from the ProEx
- Data from the receiver element to the ProEx.

The antennas can be operated through the standard set of optical fibres for MALÅ GPR systems. These optical fibres come in a standard length of 3 m. They are also available in lengths up to 100 meters or more for applications such as CMP measurements or cross scanning where the two antennas are be separated from each other.

For the shielded antennas Guideline Geo have designed a special set of fibres housed in a plastic hose for convenience. This is to protect the fibres from damage when operating the antenna in e.g. rough environments. The attachment of the optical fibres to the antenna includes a metal cover over

the optical connectors. This is to protect the connectors and the fibres at their attachment on the antenna.





Note: The safety hook should be fastened in the bow of the module and not the protective bow.

Note: The bending of a trig fibre should be avoided because it can play an important role for the time displacement of the pulse in the time window.

For using the shielded antennas at longer distances from the ProEx than 3 m there is also a plastic hose of 20 m length available. Alternatively, the standard optical fibres with lengths up to 100 m can be used.

All the fibre optic cables provided with the MALÅ GPR are reinforced with Kevlar™ and feature stainless steel and ceramic tip connectors. However, care should always be exercised when handling this type of cable. The light carrying fibre core is only 50 micrometer in diameter, which is less than the thickness of hair.

Note:

- Avoid excessive bending
- Keep cables protected against physical damage
- Keep connectors clean

Coaxial module

This unit is used for MALÅ Separable Shielded Antennas (separable Tx and Rx) and for customized solutions, including third-party products. The separate shielded antennas combine some of the possibilities you have with the unshielded design with the less environmentally sensitive shielded designs. This includes possibilities to vary the polarization and R-T distance as well as to design any antenna configurations.

The connections on the module are marked with T (Transmitter), R (Receiver) and D (Data). Corresponding connections are found on the used antenna electronics.

Supported antennas:

- 200, 400 and 1.3 GHz receiver and transmitter
- All borehole antennas operated with winch.

Figure 4.4 The coaxial module. In the picture the three different coaxial connectors are seen, for T (Transmitter), R (Receiver) and D (Data).

For troubleshooting purposes, the module have LED connected to the each coaxial connector. The ones on the R and T connectors indicate that trig signals are leaving the module, when flashing. The one on the D-connector indicates that the module receives data.

HF module

The High Frequency module is used together with the high-resolution (HF) antennas, including the HF antennas with EM-option.

Supported antennas:

- 1.2 GHz, 1.2 GHz+EM, 1.6 GHz, 1.6 GHz+EM and 2.3 GHz

Figure 4.5 The HF module. In the picture the connector for the HF antenna cable is seen.

As for the other modules, this one also have LED's connected to the internal signals. Since the recorded data is digitized within the unit, no LED' is indicating incoming data. Flashing R and T LED's indicate that trig signals are leaving the module.

Rough Terrain Antennas (RTA)

The MALÅ Rough Terrain Antenna (RTA) is a one-piece unshielded radar antenna (Figure 6.1) where the antenna elements are mounted in an in-line configuration. The antennas are commonly used for deep geological investigation (groundwater/soil layers/bedrock surface) and glaciology. The antennas are suitable for very rough terrain. The RTA is available with 100, 50 and 30 MHz frequency.

These antennas are connected the ProEx control unit with the optical module.

Figure 6.1 The RT antenna in field (left). The three different antenna frequencies; 100, 50 and 30MHz (right).

The RTA antennas communicates with the control unit through fibre optic cables. The fibre optic cables within the RTA are reinforced with Kevlar™ and feature stainless steel and ceramic tip connectors. The connecters should always be handled with care, keep them clean for best possible data flow and protect them against physical damage.

Start up

When initializing RTA measurements, the following easy steps are made to connect and start up the whole GPR system:

- Make sure that the batteries are fully charged, both for the RT antenna (see section *Power supply*) and for the ProEx.
- Connect the ProEx to the Ethernet port on an external PC or on the XV monitor.

- Connect the fibre optic cables between the control unit and the RTA antenna. See Figure 6.2. The T corresponds to transmitter, R to receiver and D to data. One extra fibre is also provided as a spare.

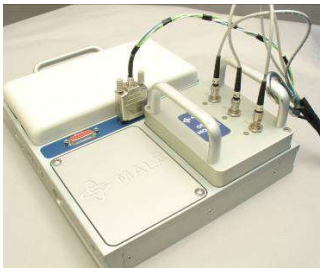


Figure 6.2 Connection to the ProEx.

Note: It is essential to attach the strain relief (the snap-hook) to the ProEx or the towing belt in order to protect the optical fibres and connectors. Failure to do so, will likely result in damaged cables.

- Attach an appropriate length-measuring device and connect it to **Wheel** (on the ProEx) (See section *Trigger devices* for more information).
- Make sure that the batteries are correctly mounted on the antenna electronics. They are attached with a snap-lock on the end part of the electronic unit. Push the on/off bottom on the back of the units to turn the power on. A firm light indicates power, and a flashing light a correct connection with the control unit. See Figure 6.3.

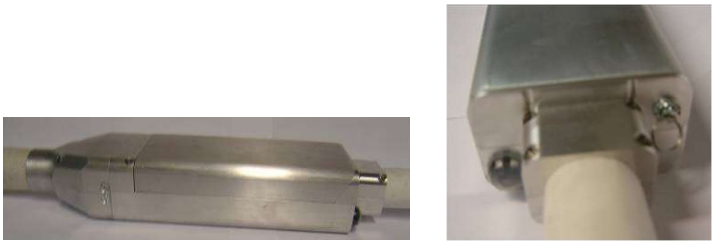


Figure 6.3 Left: Electronic unit with battery. Right: The on/off button is seen at the left side and the snap-lock for the battery on the right side.

- Mount the skid plates around the antenna electronics. Use cable strips or tape to secure the skid plate. See Figure 6.4.

Figure 6.4 Skid plate mounted around the electronic unit.

- Turn on the power on the control unit. Turn on the PC or the MALÅ XV Monitor. Your RTA is now ready for operation.

Using the RTA

The RTA concept is a very light and compact GPR system. The weight, for an RTA 50 MHz system is for example less than 14 kilos (including XV Monitor and ProEx) and will thus enable measurements in also the roughest terrain.

Depending on the character of the investigations site (dense vegetation or accessible tracks) the RTA can be mounted on a towing belt or the ProEx backpack to be manually operated or on a vehicle. In each case, make sure that the snap-hook (strain relief on the RTA) is properly connected.

The RTA is used together with the standard MALÅ Geoscience distance measuring hip-chain, which is most suitable to mount close to the ProEx. A measuring wheel can also be used, hand-held or if the RTA is mounted on a vehicle (See section *Trigger devices* for more information).

Of course, the RTA concept is also compatible with a GPS system directly connected to the XV Monitor or measurements can be done by time or manually trigged.

Note: An appropriate time interval when measuring with RT antennas and time is 0.15-0.5 seconds giving 2-4 traces (measuring points)/second.

Note: The measurements point on the RT antenna is located in-between the two antenna electronic parts. If a GPS is used and attached to the backpack, remember this offset when interpreting the results.

The MALÅ RTA is developed to stand the demands of IP65. This means that the antenna is completely safe to use during rain and on wet ground conditions, and can occasionally be lowered under water, but it should not be used for longer underwater investigations.

Shielded antennas

The Guideline Geo MALÅ GPR shielded antennas are available in a variety of frequencies, as seen in the Table 7.1 and 7.2. Different shielded High Frequency antennas (above 1 GHz) are also available; see section *High Frequency Antennas*.

The shielded antennas are connected the ProEx control unit with the optical module.

The construction of the MALÅ shielded antennas makes them most suitable for urban investigations or at sites with a lot of background noise.

Table 7.1. Shielded antennas and suitable areas of use.

100 MHz	The shielded 100 MHz antenna is the lowest shielded antenna frequency commercially available. It is use for medium to low resolution. Suitable for geological and geotechnical applications.
250 MHz	The shielded 250 MHz antenna is a general-purpose antenna. It is used for medium penetration depth and medium resolution. It is commonly used for utility detection, Underground Storage Tanks and void detection.
500 MHz	The shielded 500 MHz antenna is probably the most popular general purpose GPR antenna ever built. It delivers medium to shallow penetration and good resolution. Most commonly used for utility detection, road surveys and archaeological investi-gations.
800 MHz	The shielded 800 MHz antenna delivers very good resolution for shallow investigations. The interchangeable electronics makes the 800 MHz antenna an economically good alternative to the high resolution 1 GHz antenna. Commonly used for road mapping and concrete investigations.

Note: The 800 MHz antenna needs some warm-up time prior measurements are started, around 10 minutes.

Table 7.2. Approximate depth ranges for different antenna frequencies.

Antenna frequency (MHz)	Approximate Radial Resolution @,c=100 [m/µs] , $\lambda_c/4$ [cm]	Approximate max penetration depth (m)
100	25	25
250	10	8
500	5	6
800	3	2.5

* In typical soil conditions where high conductivity layers are absent.

A shielded type of antenna means that most of the energy is only transmitted in one direction. It is also insensitive to radiation from all directions except from the bottom part of the antenna where the receiving antenna element is located. The shielded antenna element comprises both transmitter and receiver antenna elements in one single housing. These consist of a modified bow-tie antenna construction with the receiver element at the front end and the transmitter element at the back of the housing.

Note: Even though the antenna is shielded, air reflections can occur in the data.

The front of the antenna is equipped with a hook for attaching a tow handle or strap. A fastening device at the back of the housing accommodates the distance-measuring wheel. This wheel operates as a triggering device instructing the MALÅ GPR system to collect traces at operator pre-set distance intervals (see *GroundVision 2* or *XV Monitor* user manuals). See Figure 7.1.

Note: That the detachable wear plates (also called skid plates) should always be used to insure a long antenna life.

Figure 7.1 Shielded antennas. Top: 100 MHz (left) and 250 MHz (right). Bottom: 500 MHz (left) and 800 MHz (right).

Antenna electronics

When shielded antennas are used with the ProEx control unit they are used with shielded electronics units (see Figure 7.3 and 7.4). The Shielded Electronics Unit contains both the transmitter and the receiver electronics. Power to the electronics is provided by a standard MALÅ GPR battery or externally from the MALÅ standard 12 V battery pack. Communication with the control unit is managed via three optical fibres and a cable for a distance-measuring wheel (see also section *Trigger Devices*). These cables provided are in a protective housing.

Figure 7.3 Shielded antenna electronic unit without the optical fibre cable. The connector for the external battery is seen at the front, right-hand side.

Figure 7.4 The cable hose to the shielded electronic unit (left), and the electronic unit with battery and mounted cable (right).

As in the unshielded electronics the LED-indicators show the status of communications between the shielded electronics unit and the ProEx control unit. When flashing, the T and R trigger pulses are being received from the control unit. No light indicates that no power is being received by the electronics. A steady light indicates that no trig pulses are received from the control unit.

When flashing, the LED labelled D indicates that data are sent to the control unit. No light indicates no power is being received by the electronics. A steady light indicates that no data are being transmitted to the control unit.

As seen, a steady light on a LED indicates an interruption in the optical communication. This means either that a fibre optic cable has failed or, the fibre optic connectors need to be cleaned (easily managed with compressed air). When none of the LED's is blinking a power failure to the electronics unit has occurred. Replace or recharge the battery. If the electronics still do not function with a fresh battery, then there is an internal failure in the shielded electronics unit.

To mount the shielded electronic on a shielded antenna, carry out the following steps:

- Place the shielded electronics unit on the antenna with facing the cable hose towards the antenna front.

Note: Do not try to mount the electronics in the reverse direction. This will damage the electronic unit.

- See to that the unit is firmly attached to the antenna before you fasten the two black mounting screws.
- Mount a battery pack to the electronic unit.
- When appropriate mount the survey wheel at the antenna rear and connect the signal cable to the electronics unit.
- Attach the cable hose to the backpack as a strain relief.
- Connect the optical fibres labelled T, D and R to the control unit.
- Connect the signal cable from the survey wheel to the control unit.

Note: Two rubber O-rings are fitted on the connecting metal plate in the D-sub connectors on the antenna for water resistance and should be inspected periodically.

Shielded antenna accessories

The 250, 500 and 800 MHz shielded antennas can be used together with the MALÅ RTC, as seen in Fig. 7.5.

Figure 7.5 The RTC for shielded 250, 500 and 800 MHz antennas.

The RTC is assembled by first attaching the pulse encoder on one of the back wheels, as seen in Fig. 7.6.

Note: Before the wheel with the encoder is attached the O-ring must be threaded over the axle, as seen in Fig. 7.7.

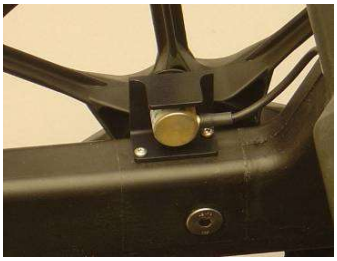


Figure 7.6 The pulse encoder on the back wheel. The screw below is for the wheel axles.

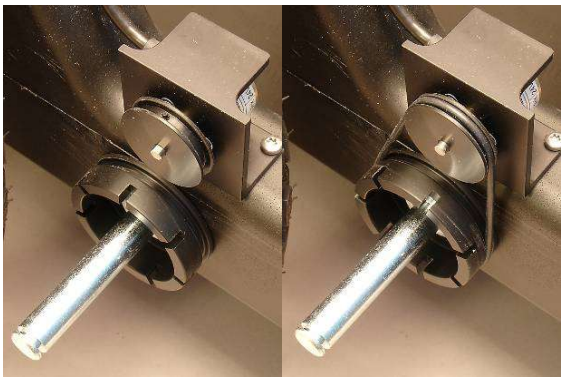


Figure 7.7 The O-ring attached to the wheel axes.

When this is done the wheels can be attached, see Fig. 7.8. And the finally the handle inserted and secured (Fig. 7.5)

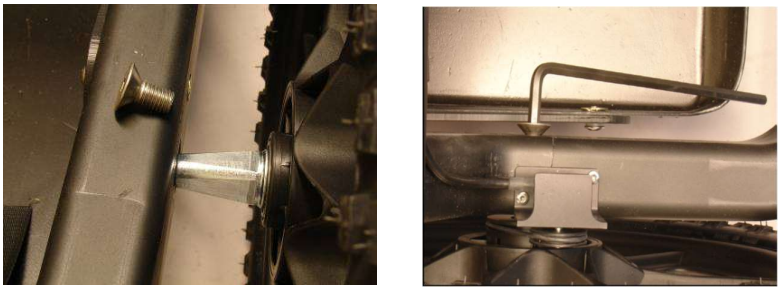


Figure 7.8 Attachment of wheel.

Separate T and R shielded antennas

Guideline Geo MALÅ shielded antennas are also available as separate shielded transmitter (T) and receiver (R) antennas. The MALÅ separate shielded antennas are available with frequencies of 200, 400 MHz and 1.3 GHz.

These antennas are connected the ProEx control unit with the coaxial module.

Separate transmitter and receiver antenna units enable different types of tomographic measurements and velocity analysis as CMP (Common Mid-Point) etc.

Note: The 1.3 GHz antennas need some warm-up time prior measurements, around 10 minutes.

The transmitter antenna unit have one power connector and one trig connector, while the receiver antenna unit also have a connector for the digital data communication. See Fig. 8.1.

For each trig connector on the antenna unit there's a LED, when blinking, tells that the trig signals is received by the electronics inside the antennas. Similarly, there's a LED saying that digital data is leaving the antenna, when blinking.

The separate shielded antennas are connected to the coaxial module used with the ProEx control unit with coaxial cables, which are available in variable lengths.

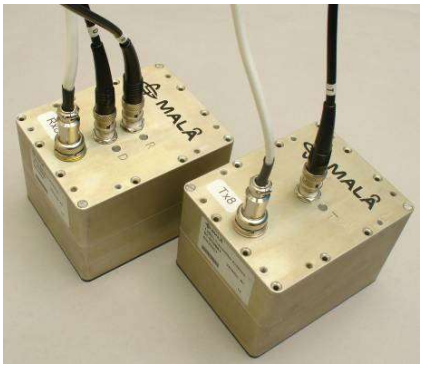


Figure 8.1 Separate T (right) and R (left) shielded antennas with the frequency of 1.3 GHz.

High Frequency antennas

Guideline Geo MALÅ High Frequency (HF) antennas are available with frequencies of 1.2, 1.6 and 2.3 GHz. The 1.2 and 1.6 GHz antennas also have an EM (Electromagnetic) option, giving a GPR antenna with a 50/60 Hz EM-locator.

These antennas are connected the ProEx control unit with the coaxial module.

Note: The High Frequency antennas need some warm-up time prior measurements, around 10 minutes.

The HF antennas are most suitable for investigations where high resolution is important, as for construction/concrete investigation, asphalt mapping, ice thickness etc. See also Table 9.1.

Table 9.1. Approximate depth ranges for different antenna frequencies.

Antenna frequency (GHz)	Approximate Radial Resolution @,c=100 [m/µs] , $\lambda_c/4$ [cm]	Approximate max penetration depth (cm)
1.2	2.1	100
1.6	1.6	50
2.3	1.3	40

* In typical soil/construction conditions where high conductivity layers are absent.

The HF antennas are one-piece radar antenna where the antenna elements are contained in a small handheld, shielded box, which in turn can be mounted in a wheel carriage, the HF cart. See Fig 9.1 to 9.3.

Figure 9.1 The HF antenna without the wheel carriage (1.2 GHz with the EM option).

Figure 9.2 *The HF antenna (1.6 or 2.3 GHz) in a wheel carriage, the HF cart.*

Figure 9.3 *Mounting the HF antenna in the HF cart. The antenna is attached on two sides, see black arrows.*

The HF antennas are attached to the ProEx control unit through a 4 m long cable, allowing a flexible and mobile data collection. A 10 m extension cable is also available.

If the antenna is used without the HF Cart, the skid plate (attached with screws underneath the antenna box) should be changed when worn, to insure a long lifetime of the antenna.

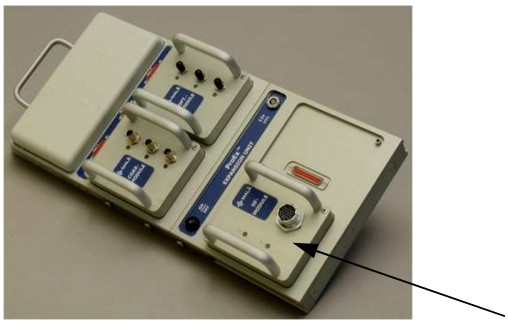
The antennas can also be used with a single wheel encoder, see Fig. 9.4 below, instead of the small wheel carriage (also see section *Trigger Devices*). This is quite convenient if the investigation surface is rough and uneven or if the HF antenna is to be used in another measurement direction, for instance to investigate polarization effects.

Figure 9.4 *The single wheel encoder (top) and attached to a HF antenna (below) in two different directions.*

Start up

Before starting up the ProEx radar system the following connections are made:

- Mount the battery for the ProEx. This battery also supplies the HF antenna with power if the HF module is mounted on the ProEx main unit, otherwise the antenna is powered by the external power supply for the extension module.
- Connect the HF module to one of the slots on the ProEx unit and connect the antenna data cable to the HF module.



- Connect the ProEx to the XV Monitor or an external PC with an Ethernet cable.
- When using the wheel carriage or single wheel encoder to the antenna, the encoder cable is connected to the antenna (recommended). If using a separate encoder wheel or hip chain this is connected to the ProEx.
- Turn on the ProEx and the XV Monitor or PC. Your HF system is now ready for operation.

Using the HF antennas

When the HF antennas are used with the XV Monitor to create Grid Projects, the data collection is controlled by the two buttons on the handle of the antenna (Fig. 9.5). The button on the right-hand side of the handle (black, button 1) starts and stops data collection of the current profile and the left-hand button (red, button 2) begins a new profile.

Figure 9.5 The 1.6 GHz antenna with the right (black) and left (red) hand buttons visible.

Figure 9.6 Extension pole. On the handgrip the two buttons are seen, the one on the top (red) starts a new profile.

When using the extension pole, as seen in Fig. 9.6, the two buttons are located on the hand grip, with one button underneath the grip starting and stopping the data collection, and the other one on the handle top starting a new profile.

Note: For North American sold units only. The black button on the antenna (or the extension handle) will act as a 'kill-switch'. I.e., the button must be kept pressed while collecting data. When the button is released, the antenna will stop transmitting within a few seconds.

The extension handle is mounted on the wheel carriage and the extension handle cable is connected to the connector at the back of the High Frequency antenna. See Fig 9.7. If measuring single profiles, the buttons on the antenna or the extension handle are not in use. However, please note the kill-switch function on North American sold units (above).

Figure 9.7 Mounting of the extension handle.

Note: If you need to do different types of tomographic measurements, velocity analysis as CMP (Common Mid-Point) or similar, with separate Tx and Rx, please contactIt support@guidelinegeo.com for assistance.

When the HF antennas are operated together with the XV Monitor, you have access to the fully integrated data collection tool, 2.5D analysis tool and Migration Wizard.

Expansion units

In the basic mode the ProEx control unit supports two individual antennas connected simultaneously, but in order to increase the number of physical channels, expansion units can easily be connected to the ProEx (see Fig. 10.1 to 10.3). Each expansion unit enables two extra antenna module slots, which can be used in any antenna module combination.

The slots are named A to H (see Fig. 10.2) on the ProEx and this prefix is also used for the name convention of files. See User Manual for GroundVision 2 and XV Monitor.

Note: The slots work in pairs, A and B, C and D, E and F and G and H. The slots can communicate within the pair but not with other pairs.

A maximum of three expandable units can be connected to the main ProEx, which results in a total of eight totally independently configurable antenna modules.

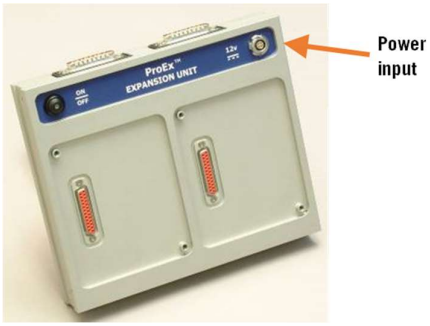


Figure 10.1 The expansion unit, with the possibility to connect two different antenna modules.

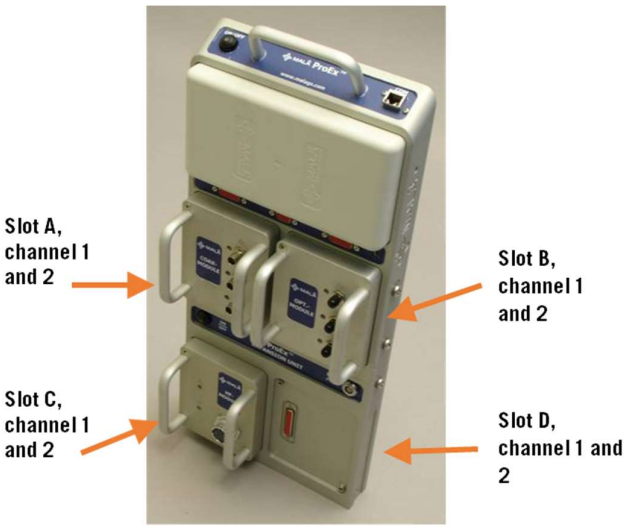


Figure 10.2 The ProEx with one expansion unit and three antenna modules. To this set up two more expansion units can be connected.

Figure 10.3 The expansion unit is connected and secured with 3 screws and a metal plate on each side.

When the ProEx is used with expansion units, the system is considered to be a fixed installation; meaning that we believe it will be used installed in a vehicle or in laboratories. An example of application is seen in Fig. 10.4 where the ProEx and one expansion unit is used for snow thickness and water content investigations, including two separate transmitter antennas and four separate receiver antennas.

The expansion units have to be powered trough the power connector on each unit. See Fig. 10.1. It's not possible to "daisy-chain" units.

Note: Even though the units are protected internally against reversed polarity, we recommend you use MALÅ cables only.

Note: In order for the main unit to identify and properly set the system up, you need to power on the expansion units prior turning on the main unit. The main unit gives a beep for each of the slots detected when booting, regardless of if there's a module attached to the slot or not.

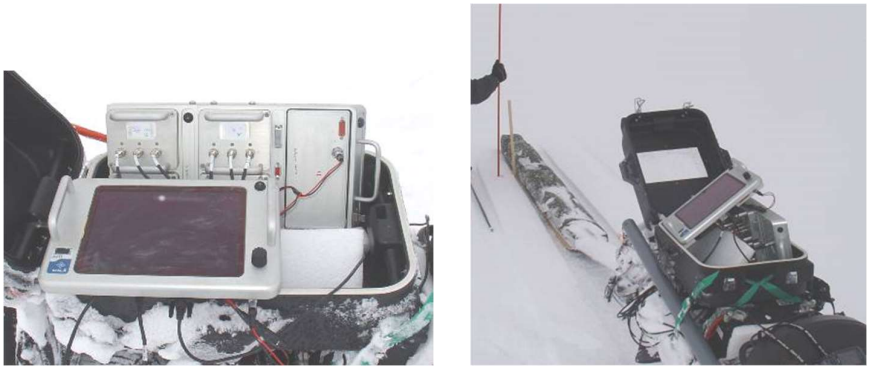


Figure 10.4 The ProEx unit installed on a snowmobile, using one expansion unit and 4 different antennas.

Auxiliary ports

The ProEx control unit is equipped with two versatile auxiliary ports (Fig. 11.1). The functionality of these ports is to be defined by the customer and have to be ordered on a case-by-case basis.

The auxiliary connectors include serial ports for communication with external devices, analogue inputs for sampling of other than radar data, digital input/output etc. These extras are to tailor the unit to any specific needs which may arise.

Note that the firmware of the ProEx is upgradeable from a normal computer, to prevent the need for sending the unit back for upgrades.

Contact Guideline Geo for further information, contact information found on https://www.guidelinegeo.com/contact/.

Figure 11.1 The two auxiliary ports.

Trigger devices

The most efficient method of radar data acquisition is to use a distance-measuring wheel or profile encoder (a so-called hip chain) to control the collection of radar data. Data is acquired at user defined distance intervals so that the position of each trace along a survey line is given by the position of a radar trace in the data file. This simplifies data processing procedures and positioning of identified targets.

The ProEx works with all standard Guideline Geo MALÅ encoders, and the connector is located at the front, easily reached, see Fig. 12.1. The HF-module and HF antennas have its own distance encoder, so no cable to the external wheel connector is necessary when these antennas are used.

If several HF-antennas are used, the operator have to select which wheel are to be used as trigger device, it is possible to use any of the wheels on the antennas or the master, external, wheel.

Figure 12.1 The encoder connector.

Note: The precision of the encoder wheel is depending on several factors, such as the surface conditions, the pressure applied on the wheel, if the wheel is worn. To obtain best possible encoder wheel precision for a specific survey, a re-calibration of the survey wheel, at site, is recommended.

The hip chain can be used when scanning from a sled or when the transmitter and receiver are mounted on carrying handles. The hip chain comes with cotton string at a length of 2800 meters in a roll. The string is made of pure cotton that decomposes in nature. Its greatest advantage is in trackless and undulating terrain where it would be impractical to use a measuring wheel.

The measuring wheel (Fig.12.2) may be more appropriate to use for distance control for surveys on flat terrain or in urban areas (for shielded antennas). The measuring wheel is attached directly on the shielded antennas.

Figure 12.2 Two different types of measuring wheels (Ø150mm, Ø300mm).

All distance-measuring devices for the MALÅ GPR use an optical encoder that transmits electrical pulses to the ProEx. A distance calibration file is used to convert the number of pulses to the correct distances. The operator can create calibration files or use those supplied with the installation-USB.

These calibration files for different length encoders contain information about both the numbers of pulses that are counted per meter and the rotation direction in which it will calculate the optical pulses correctly. The triggering of readings from the GPR will ONLY be done in the positive direction of rotation. Thus, you can move the wheel back-wards without any readings being made. However, if the wheel needs to be rotated constantly in the opposite direction this can be accomplished by changing acquisition direction in the GroundVision 2 software or in the MALÅ XV Monitor.

Note: When using both devices you should keep accurate record of your calibration files for the devices so the right one is selected for the device used at each measurement occasion.

Note: The distance interval when using a measuring wheel should be set to a value greater than 0.003 m. The measuring wheel counts about 427 pulses/m, which is less than one pulse/2mm. A distance <0.003 m will correspond to zero pulses and cause the antenna to start collecting data immediately at full speed.

Power supply

The ProEx is powered by a 12V Li-Ion battery (Fig. 13.1). The ProEx can also be powered externally, with the power connector found on the battery slot. The unit is protected internally for power surges and wrong polarities, but it is recommended for all users to use MALÅ cabling only.

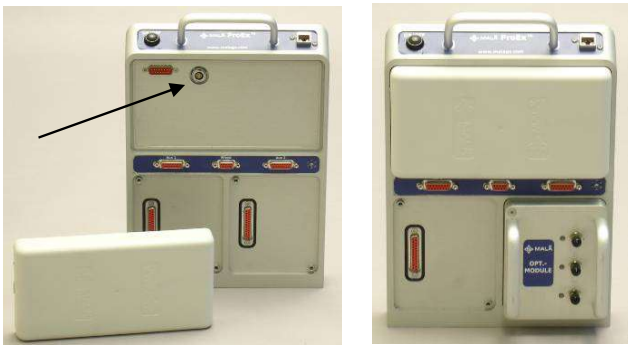


Figure 13.1 The ProEx without and with a mounted battery. The connector for external power is marked.

The batteries are mounted by simply placing the battery compartment with the lid on the rear short side under the corresponding groove in the electronic units. The front end or the battery pack has a locking tab on the plastic housing. See Fig 13.2. Gently press on the front end of the battery until the lid is released from the groove before removal.

Figure 13.2 Mounting the battery

The battery should always be stored fully charged to maximize the lifetime of the battery.

The operating time of the system is dependent on the charge cycle history of the batteries as well as the modules in use. Normally, maximum operating time is not reached until the batteries have been fully charged and discharged 3-5 times. Optimum performance is achieved through fully discharging and recharging the battery packs.

The expansion units are powered externally, with 12V AC/DC or any 12 V battery or with MALÅ standard Li-Ion Batteries, see Fig. 13.3.

Figure 13.3 MALÅ battery pack and battery bag. Internal of the battery bag (left) and the connectors on the outside (right). Note! Before use, open the battery bag and connect the battery to the outside connectors.

For the unshielded system or the shielded system with electronic antenna units each electronic component in the system is powered by the same type of battery as for the ProEx control unit, shown in Fig. 13.1.

The unshielded RTA antenna has specially designed batteries. The batteries must be disconnected from the electronic units before charging. The battery charger is then connected to the round connection beside the serial port (D-sub) on the battery unit. See Fig. 13.4.

Figure 13.4 Battery pack for the RTA antennas.

The MALÅ battery chargers are an automatic quick charger designed for Li-ion batteries. Recharging the first 80% of the full capacity goes very quickly. However, it is recommended to keep the battery charging until it is fully charged. The battery charger then automatically begins to maintain the charge.

The indicator lamp on the charger gives the following information:

- Red: charged < 80%
- Yellow: charged 80-100%
- Green: maintenance charging

Note: The batteries lose efficiency in cold temperatures. Therefore, in severely cold field conditions, it is recommended to insulate the electronics and battery packs to prolong battery life.

Start up of your MALÅ ProEx

In order to operate the system, the following items are required:

- MALÅ ProEx control unit
- XV Monitor or PC with GroundVision 2 installed
- Antenna module (Optical, Coaxial or HF)
- The antennas chosen; shielded, RTA, borehole, HF, or separate T and R units.
- Optical fibres, Coaxial cables or HF antenna cables.
- Power supply for the ProEx and the antennas.
- Ethernet data cable for communication between the ProEx and the XV Monitor or computer.

In addition, the above mentioned there exists different length measuring devices, pulling and carrying handles which are regarded as accessories.

Connecting the system components

- Mount the antenna electronics if shielded antennas are used.
- Connect the ProEx to the XV Monitor or an external PC with an Ethernet communication cable.
- Connect appropriate fibre optic cables between the ProEx and the antenna electronics. See section *Connection of different antennas* below.
- Attach the appropriate Measuring Device and connect to the port labelled **Wheel** on the ProEx.

Note: The precision of the encoder wheel is depending on several factors, such as the surface conditions, the pressure applied on the wheel, if the wheel is worn. To obtain best possible encoder wheel precision for a specific survey, a re-calibration of the survey wheel, at site, is recommended.

- Turn on the power on the antennas, the extension units and on the ProEx. Turn on the XV Monitor or the PC and start the data acquisition program GroundVision 2. Your Guideline Geo MALÅ GPR system is now ready for operation.

Connection of different antennas

For RTA systems: Single fibre optic cable from the fibre optic connector labelled T on the ProEx to the Transmitter Electronics. Dual fibre optic cable from the fibre optic connectors labelled D and R to their respective connectors on the Receiver Electronics

Note: It is essential to attach the strain relief to the ProEx in order to protect the optical fibres and connectors. Failure in doing so will likely result in damaged cables. This applies for both RTA and shielded antennas.

For shielded systems: Fibres labelled T, D and R should be attached to their respective fibre optic connectors on the ProEx optical module.

For separate shielded systems: Cable labelled T should be attached between the transmitter antenna and the coxial module on the ProEx. Cables labelled D and R should be attached between the receiver antenna and the coxial module on the ProEx.

For HF systems: The HF cable should be attached to the HF antenna and to the HF module on the ProEx

Running a survey

Starting a survey routine is a simple task with the MALÅ ProEx system. The ProEx offers you a fast way of parameter choice through the "Pre-set" parameter settings. Factory default and user selected parameters can be saved for later use. First-time GPR users will find the default settings to be helpful in setting up their system parameters.

During data collection the radar data and other information are displayed on the XV Monitor or on the computer screen. Once data collection is in progress modifications to display functions, screen colours, gain settings can be performed without affecting the start parameters or the recorded data. The data collection can be interrupted and resumed at any time. This feature facilitates the entry of field notes and comments. For more information see *XV Monitor* or *GroundVision 2 User Manual*.

The ProEx offers you three different ways of acquiring data:

- By the use of a distance measuring device (distance triggered)
- Through the XV Monitor (by pressing the turn-push button) or an external PC keyboard (by pressing the SPACE button)
- By taking readings at fixed time intervals

We recommend measurements to be performed using some kind of distance measuring control. This way you can relate the results to a fixed geographic location. Using time triggering is as an alternative for lake, river and wetlands surveys where the equipment may be set-up in a boat or raft or, for studies where a GPS may be deployed for positioning control. For More information on GNSS see the *XV Monitor* or *GroundVision 2* user manual.

Troubleshooting

As with all electronic equipment it is important to handle the ProEx GPR system with great care and to avoid harsh handling and bumps against the control units or antennas. During transport of the equipment the ProEx system should be packed properly and firmly in a transport box. When finishing a survey, the equipment should be checked and packed properly before transport.

Care should also be taken for the optical fibres (when used) so they are protected against dust and dirt. When finishing a survey the equipment should be checked and packed properly in the transport case. Batteries should be kept charged if possible and if stored away for longer time they should be charged now and then.

Most of the troubles occurring with optical fibres can be resolved with the help of the LED's on the modules, please refer to the appropriate section in this manual for further reading.

Always check our website www.guidelinegeo.com for latest news and updates and if needed, please contact Guideline Geo support (support@guidelinegeo.com) or your closest Guideline Geo sales representative.

For information on GPR technique in common, see our Help Articles on our website www.guidelinegeo.com

An error messages appear on the computer screen when taking a reading, Communication problem:

Cause	Action
Communication problem between the XV Monitor or the PC and the ProEx.	Check the data cable.
	Check that control unit is on.
	Check battery for control unit.
	Check communication set up in the data acquisition programme.

No traces are collected when survey starts:

Check Trig set-up and calibration with measuring wheel file.

Move the antenna in the correct direction.

Traces disappear during survey and only a straight line appears intermittently:

Check Tx fibre connection at the antenna.

Only a straight line appears on screen when taking a reading:

Cause	Action
The transmitter is not turned on	Turn the transmitter on.
Signal search has not been performed	Perform signal search.
The transmitter is not triggered by the ProEx	Check the LED located on the transmitter unit. If it blinks the electronics receives a correct trig signal from the ProEx. If the LED does not blink, check for dirt in the optical connector in the transmitter.
The ground is too conductive for a GPR survey	Check the system by collecting a trace with the antenna above the ground.