MALÅ Borehole System

User Guide

Our Thanks...

Thank you for choosing Guideline Geo and MALÅ as your Ground Penetrating Radar solution provider. The very core of our corporate philosophy is to provide our users with the very best products, support and services. Our development team is committed to providing you with the most technologically advanced and easy-to-use GPR products with the capability to meet your needs for efficiency and productivity now, and into the future. 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.

At Guideline Geo, we welcome comments concerning the use and experience with our products, as well as the contents and usefulness of this manual.

Guideline Geo team

Guideline Geo AB

www.guidelinegeo.com

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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 instructions 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 1 m 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 translation

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 20 cm should be maintained between the EUT and all persons during normal operation.

French translation

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 MALÅ Borehole System

The MALÅ Borehole system is available in two frequencies, 100 MHz and 250 MHz. Data collection is easily carried out with the Guideline Geo software, MALÅ GroundVision 2 or with the dedicated MALÅ XV Monitor.

Unpack. Inspect. Register.

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.

Repacking and Shipping

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

Description of individual parts

Antennas

The MALÅ Borehole antennas consist of separate transmitter (Tx) and receiver (Rx) antennas. The nominal frequency is either 100 or 250 MHz.

Each antenna consists of outer fiberglass housing. The outer diameter (O.D.) is 40 mm for the 100 MHz antenna and 48 mm for the 250 MHz antenna. The standard set-up of antennas is approved to 15 bars of water pressure. If needed Guideline Geo can provide probes withstanding higher pressure as well.

Note: As the tube material is glass fibre one should handle it with caution in order not to break it or damage the housing.

Note: If you need a borehole system for higher water pressure, please contact Guideline Geo at support@guidelinegeo.com.

The electronic part is mounted inside the housing. The dipole antennas are placed in the upper part of each housing. The battery pack is mounted in the bottom part of the antenna (see Section *Charging batteries* for more information).

The metal bottom part in each probe (Rx and Tx) houses the ON/OFF and battery charging plug where the battery charging cable should be mounted during charging.

In the top part of each antenna, the optical connector(s) for the borehole cable is mounted. The Tx is equipped with one (1) connector, which receives trig signals from the ProEx control unit.

The Rx is equipped with three (3) connectors at the top that receive trig signals from the ProEx control unit and send data back to the ProEx control unit, respectively. One of the connectors is for the trig signals down to the Tx antenna. These signals are transported through the antenna by a short optical fibre down to the bottom optical connector in the Rx antenna.

The optical connectors are mounted in a bayonet type housing for quick connection.

The borehole antennas are delivered in a shipping case together with all accessories. One shipping case for each antenna frequency exists.

Cables

Optical data transmission is used for both antennas. The optical cable used is a 4-fibre cable, where:

- Two fibres are used for sending the trig signals to the receiving and transmitting antennas.
- One of the fibres is used for returning data.
- The last fibre is a spare one.

The cable is reinforced with Kevlar strength membranes. The length of the cable is 150 m. The cable breaking strength is 650 kg. The cable-head is, however, equipped with a weak point that breaks off at a pulling strength of approximately 200 kg.

The cable lengths have been chosen to allow for reflection work down to 150 m borehole depth.

Note: If you need a borehole system with longer cables, please contact Guideline Geo at support@guidelinegeo.com.

In reflection mode, the borehole cable is attached only to the (upper) receiving antenna. The trig signals for the transmitting antenna are led through the receiving antenna, where it is extracted and transferred to the transmitter via one single optical fibre.

The fibre connectors in the system are of two types:

- Pin type as in the MALÅ ProEx system.
- The probe connectors are a bayonet type (Lemo) that is watertight.

As always, when handling optical devices, one should be careful and keep the connectors free from dust and dirt.

The borehole cables are equipped with mechanical strain relief. This should be attached to either the backpack or to the frame attached to the MALÅ ProEx control unit. This construction is shown in Figure 2.1.

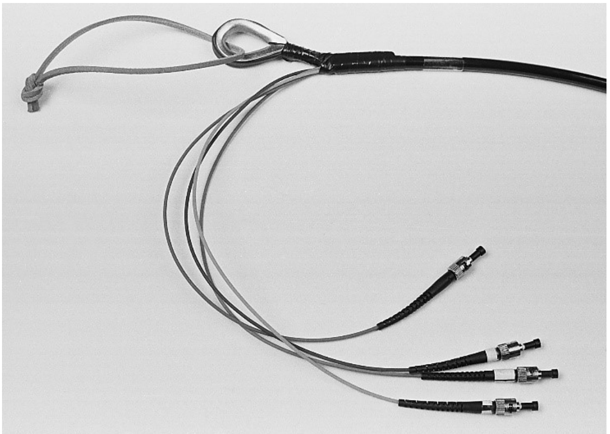

Figure 2.1. Optical cable termination and strain relief.

Tripod

Tripods are used to simplify measurements in boreholes. The cable wheel at the top of the tripod guides the cable safely in and out of the borehole. The wheel includes an optical encoder to trigger the borehole GPR measurements at equidistant and predefined intervals.

The tripods are of the "Surveyor's Tripod" type. The measuring wheel is attached to the top of the tripod using a screw attached to the tripod.

If you are using another type of tripod the attaching screw should be of the following type: Thread type = UNC 5/8 -11.

Two types of tripods exist. The first type has an optical encoder of the same type as the hip-chain and measuring wheels for Guideline Geo MALÅ GPR Systems. This type is equipped with a connector for the enclosed orange data cable that should be connected to the MALÅ ProEx control unit marked "ENC" in the rear. This tripod is seen in Figure 2.2.

Figure 2.2. Tripod with an optical encoder.

The other type of tripod is equipped with a mechanical encoder to be used for one of the antennas when performing cross hole measurements. This tripod is not connected to any device but is read and controlled manually.

Both tripods are equipped with adjustable legs to accommodate for different casing heights at the boreholes.

Note: The tripod should be placed behind a dipping borehole in such a way that the borehole cable is easily fed down the borehole. This is shown in Figure 2.2. If placed on the opposite side, there is a risk of the tripod tumbling over and damaging the cable.

Separators

For separation of the antennas, in single hole reflection mode, a firm fiberglass tube is used. This tube houses the single optical fibre, which carries the trig signals to the transmitting antenna. The purpose of the separator is to avoid oversaturation of the receiving antenna.

With the equipment a separator is delivered. Depending on antenna frequency, this separator is either 0.5 or 1.2 m long. The separators can be used for both antenna frequencies. If e.g., the formation conductivity is high, a shorter distance can be used for the 100 MHz antennas. If on the other hand the formation conductivity is very low a longer separation might avoid oversaturation of the Rx-antenna thereby avoiding clipping of the first part of the time record.

Operating modes of the antenna

Single hole reflection mode

In single hole reflection mode both antennas are operated in the same borehole. They are separated by the fiberglass tube that keeps the antennas at a fixed interval.

Measurements are performed by lowering the antennas into the borehole whereby the optical encoder on the tripod triggers the measurements at the preset depth interval.

The principle is much the same as when performing surface measurements using the hip-chain or measuring wheel as trigging device.

Note the starting point of your measurements as the XV Monitor and GroundVision 2 always set this to 0 m for single hole reflection measurements.

When performing reflection measurements, it should be noted that the measurement point is defined as the midpoint between the antennas. This location depends on the antenna lengths and the separation used.

As a rule, when starting a survey, the reference point for ”0” is important as the antenna center is calculated from this position. We recommend you use the position of the optical plate in the Rx antenna as 0-location. This is located at the top of the Rx where the cable-head starts.

Table 1 below gives you the different distances for the different antennas.

Tomographic mode

The purpose of a tomographic or so-called cross hole measurement is to scan the plane between two boreholes. In order to carry out a tomographic survey, the transmitter is used in one borehole and the receiver in the other.

It is required that the boreholes are in the same plane and that careful notice of the borehole’s direction is taken.

The normal procedure for performing tomographic measurements is to have one antenna fixed at a starting position in the borehole. The other antenna is thereafter moved in the other borehole the whole section length whereby readings are taken at even increments in that section.

When this section if finished the first antenna is moved one position in the first borehole and the procedure with data reading is repeated.

The whole section in both boreholes is scanned this way, which results in a large number of cross paths of data.

Tomographic processing software, as Guideline Geo´s WinTomo, is thereafter used to analyze the data with respect to the attenuation and velocity distribution between the boreholes.

The Guideline Geo dedicated XV Monitor has a Tomography Measurement option for tomographic measurements.

Surface-to-Borehole mode

With the MALÅ ProEx GPR system, surface antennas can be used together with borehole antennas.

E.g. a surface transmitter antenna of 100 MHz can be used with a 100 MHz borehole receiver. Normally the receiver is located in the borehole to minimize noise and other disturbances in the recorded data.

The record received from a VRP (Vertical Radar Profile) will show reflecting layers and objects between the surface and borehole. The analysis of such data is not quite straightforward, however. From the raw data record, it is possible to extract different layers around the borehole.

By performing multiple VRP with varying offset for the surface antenna from the borehole the data can be treated in a similar way as VSP (Vertical Seismic Profiling) data to study layering in the vicinity of the borehole.

Connecting the system

Mounting the cable to the antenna

Figure 4.1shows the construction of the cable-head of the optical cables and probe top.

Figure 4.1. Optical connectors at probe top (Rx) and cable-head.

The cable-head is molded around the optical connector piece. The optical connector piece is secured against water intrusion by sets of O-rings. The loose metal sleeve (located to the left of the molded cable-head in the picture below) tightens against these O-rings when secured with the 4 screws (see figure below).

The optical fibers in the cable-head are terminated using a type of pin connectors. Four fibers are connected in the cable-head: two for the Rx, one for the Tx and one spare fiber. The connector for the Rx probe is also seen in Figure 4.1.

The borehole cable is attached to the Rx antenna by inserting the metal connector into the Rx antenna firmly until a ”click” is heard asserting that the locking function is in place. Figures 4.2 show the different parts. Both the cable-head and the antennas are marked with a red dot that should be aligned against each other.

Figure 4.2. Optical cable-head including hex-tool, screws and plastic probe-top cover. The optical fiber (black) runs through the aluminum sleeve and ends with the molded optical connector. (The borehole probe top is seen to the right).

The cable-head metal sleeve is then attached over the cable-head and fastened with the 4 screws. When mounting the sleeve it should be pushed as long forward towards the antenna until a firm ”click” is heard. This ensures that it has passed the two O-rings to tighten the cable-head construction. This construction secures the cable-head against water intrusion. It also acts as an extra strain relief for the cable, figure 4.3.

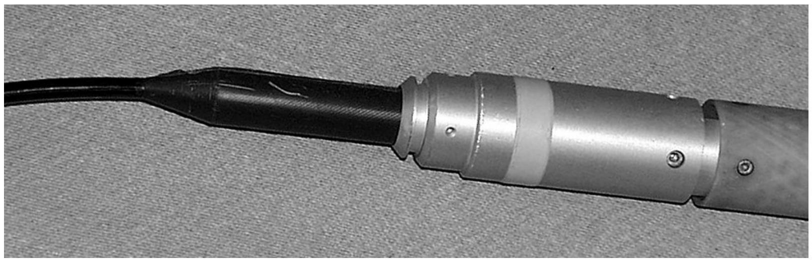

Figure 4.3. Optical cable-head connected to probe.

Note: The cable-head metal sleeve is different between the 100 MHz (O.D. 40 mm) and the 250 MHz (O.D. 48 mm). To use the same borehole cable, replace the 48 mm cable-head by replacing it with the 40 mm cable-head.

The MALÅ borehole cable-heads are watertight and can be operated in water-filled boreholes down to at least standard maximum cable length (150m).

Note: If you need a borehole system with longer cables, please contact Guideline Geo at support@guidelinegeo.com.

It is important to take care of the fiber optic connectors. During shipping and when not in use the protective cap should always be used, figure 4.4.

Figure 4.4. Removing the protective cap.

The protective cap needs to be removed as we are setting up the system for measurements. Remove the protective cap from the optical connector by pulling back the safety slider with one hand and removing the cap with the other (Fig. 4.4). Remember to always replace the protective cap as soon as the optical cable is disconnected from the borehole antenna.

The borehole cables are delivered with an attachable "collector" that can be mounted on the cable and fastened at the cable-head top. This is done with the 4 screws that are delivered with the cable. The purpose of this device is to collect small rock that might be falling from the wall causing the probe to get stuck in the borehole. This is to be used only when performing surveys in slim holes in hard rock.

In soft rock this device is not always needed and need not be mounted on the cable.

If the borehole has been drilled using different casings or in cases where one can suspect that the casing might not have been properly installed it is advisable not to use this collector. Otherwise, problems might occur when the antennas are being lifted into the casing if there exists any form of edge in the borehole.

Remember to attach the plastic covers to the probes when having disconnected the cable-head after a survey.

The borehole cable fibre ends should be attached to the CU at their respectively connector. One spare fiber with connector is available in case any damage appears to any of the other fibers. In order to protect the optical connectors from damage the cable end is equipped with a strain relief that should be attached either to the control unit or to the backpack.

Connecting the single fibre between the Tx and Rx

The single fiber for the trig signals to the Tx antenna is connected between the Rx and Tx antenna. The fiber is seen in Figure 4.5.

Figure 4.5. Single fiber connecting Rx to Tx.

The Tx and Rx antennas are also inter-connected by one glass fibre tube. The purpose of the separator is to avoid over-saturation of the Rx-antenna performed by increasing the distance between the antenna probes.

- The correct procedure for connecting the separator and the single fiber is as follows:
- Insert the single fibre into the glass fibre separator tube.
- Connect the single fibre to the Rx antenna.

- Thread the glass fibre tube on the Rx antenna and fasten the four screws.
- Connect the single fibre to the Tx antenna.
- Thread the glass fibre tube on the Tx antenna and fasten the four screws.

Dismantling of the separator is performed in the opposite manner.

The connection of the fiber to the Rx and Tx antenna is performed by simply inserting each of the Lemo connectors into the antenna connectors. The white string is to protect the fibre when disconnecting the glass fibre tube. Attach the fibre connectors firmly until a “click” sound is heard. This ensures that the connectors are firmly attached. The connection of the fiber to the Rx antenna is shown in Figure 4.6.

Note: That the fibre connectors are NOT identical. The reason for this is that one connector also houses an electric part, which acts as ON-OFF switch for the Rx-antenna electronics.

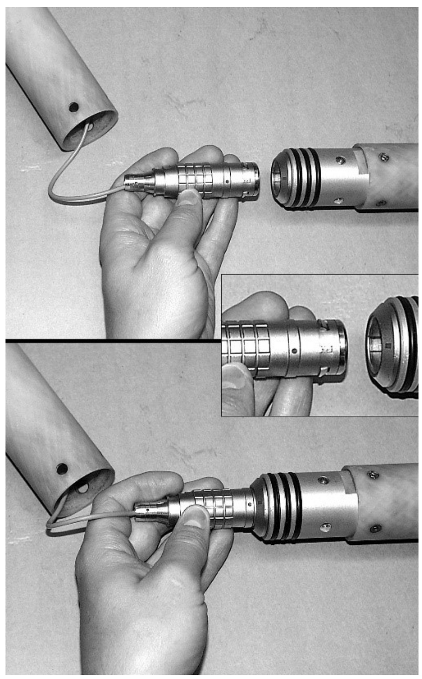

Figure 4.6 Connecting the Rx fibre to Rx probe.

When the optical fibre is connected and the fiberglass tube is mounted, it is VITAL that the tube is fastened using the four locking screws at both Tx and Rx as shown in Figure 4.7.

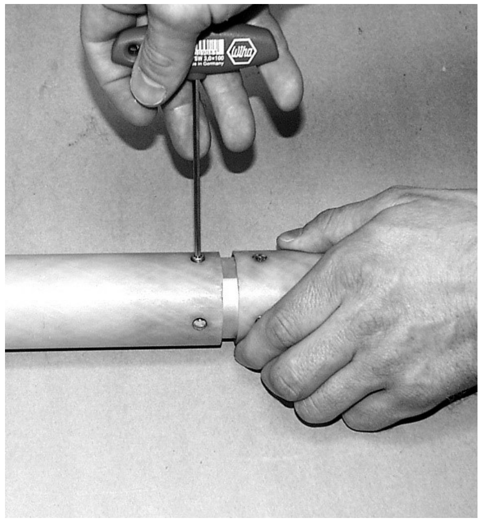

Figure 4.7 Mounting the screws for the glass fibre tube.

Note: Care should be taken when mounting and dismounting the single fibre. When separating the glass fibre tube from the antenna extra care should be taken NOT to pull the antenna apart more than the extra length of the optical fibre inside the tube.

When operating the antennas in Cross hole mode the Tx is operated with the second borehole cable. In Cross hole mode, the Tx is attached to the cable-head in the same manner as the Rx antenna. More information in the section *Performing boreholes surveys* below.

Starting the antennas

The MALÅ BH antennas are equipped with internal batteries. They are mounted inside in the bottom part of each probe to allow for charging and ON-OFF switching.

The ON-OFF switches for the two antennas consist of ”start-plugs” that fit into the holes in the bottom of the antennas. The plugs are of different construction and the following types are used:

- Tx plug that is threaded into the Tx antenna bottom
- Rx plug for reflection work
- Rx plug for tomographic work

For attaching the Tx plug an HEX-key is enclosed in the equipment. The Rx plug is connected directly by inserting the connector firmly into the bottom of the probe.

The Tx antenna should <u>always</u> be equipped with a protection plug on the ON-OFF switch as shown in Figure 4.9 below.

The Rx antenna should in the same manner be equipped with this protection plug then the system is used in tomographic survey mode.

As soon as the plug is attached firmly to the antenna it is ready for operation assuming the optical cable has been mounted correctly.

Running the software (GroundVision 2 or XV Monitor) is identical as for the surface antennas. You should however remember to import the correct calibration file for the length encoder on the tripod if you are using length triggering through length control.

Carrying the set-up

When all parts are connected, carry the probe vertically, if you need to transport the probe for a shorter distance between e.g., two boreholes.

Do not carry the probe horizontally, to avoid overload on the joints between the separator tube and the Rx and TX antennas.

Performing borehole surveys

Borehole surveys discussed here are referred to either single hole reflection or cross hole surveys.

They are described here separately even though many of the procedures are common for both types.

Reflection survey

The procedure of performing a reflection survey includes:

- Combining the antennas
- Inserting the antennas into the borehole
- Collecting data
- Lifting and dismounting the antennas
- Disconnecting the start plug in the Tx antenna

Combining and carrying the antennas

Make sure to follow the instructions in the previous chapter.

Note: Carry the antenna in a correct way (vertically) to avoid damage.

Inserting the antennas into the borehole

Depending on whether the borehole to be surveyed is dipping or is horizontal the procedure for inserting the antennas into the borehole varies.

In a horizontal borehole where the antennas can be arranged to lay still during installation the start procedure is simplified.

In a dipping borehole the mounting of cables to antennas should be carried out on the ground close to the borehole.

When the system is connected it is advisable to perform a system check on the ground to ensure the function. Parameter settings and Trig mode should be selected according to antenna frequency and aim of the survey.

When taking a test trace on ground the pulse shape may be heavily distorted depending on antenna coupling to the ground.

The aim of the test is to assure that a pulse is received by the Rx antenna and that the overall trace shape is normal.

The antennas are thereafter lowered into the borehole and should be locked at the casing top using the antenna key, see Figure 4.8.

Figure 4.8 Borehole locking key mounted at cable-head of Rx antenna.

At this stage the cable should be threaded on the tripod and attached as described in section *Tripods*.

The antennas will now hang free in the borehole as long as the tripod locks the cable.

If the tripod with the digital encoder is used the encoder cable should be connected to the control unit at the port marked ”ENC”.

A good reference point to start the survey is to level the end of the cable-head against e.g., the top of casing (T.O.C.) if such exist. Also Ground Level (G.L.) might be a suitable reference if casing is missing.

Note: As the antenna system consists of separate Tx and Rx antennas the measurement point is referred to as the midpoint between the antennas.

The location of this midpoint depends on the antenna lengths and the separation used. For the available antennas and common separations, the values will be as follows:

Table 1. Antenna distances and midpoints.

Antenna type	Separator	Antenna center separation	Midpoint from antenna top*
100 MHz (O.D. 40 mm)	1.00 m	2.77 m	2.283 m
	0.50 m	2.27 m	2.033 m
250 MHz (O.D. 48 mm)	0.50 m	1.70 m	1.20 m
	1.00 m	2.20 m	1.50 m

(*= refers to the gap where the borehole key fits in cable-head).

Collecting data

The data collection procedure itself is much the same as for the surface antennas.

The main difference between operating surface antennas versus borehole antennas is that the borehole antenna radiates 360 degrees around the borehole. Therefore, reflections will occur from all directions. As the dipole antennas are not directionally sensitive in any way there is no way of orienting the origin of the reflections.

If the operator has any previous information or knowledge about the site he is operating on, orientation can be made. However, one should bear in mind that the 2D-image presented on the screen actually represents information from the 3D around the borehole.

Also, to note about scanning boreholes is that borehole diameter will have influence on the radar results. Generally speaking, the greater the borehole diameter is the worse will the coupling between the antennas to the host rock be. In water filled boreholes this will result in waves starting to propagate along the borehole fluid causing a form of high frequency tube-waves.

This will be seen in the images as a high frequency ringing.

Lifting and dismounting the antennas

Once the survey is completed the antenna should be dismounted in reverse as described in the mounting section.

When the antennas are lifted from a vertical borehole, care should be taken when the antenna array is lifted in the free air. A firm grip should be taken at both antennas to avoid breaking of the array. Also see section *Carrying the set up*.

Note: Carry the antenna in a correct way (vertically) to avoid damage.

If a survey has been performed in a water-filled borehole it is of importance to drain the cable heads from water and to clean them of e.g., borehole mud or clay before packing the equipment.

Cross hole survey

When planning a cross hole survey layout, it is important to recapitulate the basic needs for a successful outcome of a tomographic investigation.

Are the selected boreholes well suited for a tomographic survey? Do they form a plane, which is a requirement?

What is the geometry like? As the inversion is based on rays traveling in different directions through a cell this sets some limitations on the distance between the boreholes and the borehole depth. We recommend that if the boreholes are parallel the distance between them should not be greater than the depth of the survey interval. Otherwise, the rays tend to be too parallel resulting in bad resolution and in worst cases erroneous tomograms.

On the other hand, the distance between the boreholes may not be too short. If the resistivity of the host rock is fairly high this may result in oversaturation of the direct wave at the receiving antenna. Thereby no correct amplitude data can be extracted.

Tomographic surveys are based on the knowledge of the antenna positions during the whole survey. Does the client provide borehole deviation surveys? Are these done with enough accuracy? Have the starting coordinates of the boreholes been measured and then also the heights?

Field work

Planning the actual fieldwork deals with selecting appropriate antenna frequency and measuring parameters.

The antenna frequency should be selected as high as possible to obtain the highest possible resolution. On the other hand, the range decreases with increasing frequency so this leads to a compromise. Remember that the maximum ray distance does not necessarily have to be recorded in a section in case the range does not cover this distance.

Sampling frequency should also be selected as high as possible to obtain maximum resolution and time accuracy. Make calculations of the travel distance difference between the shortest and farthest ray. Use the velocity in the host rock to convert this into a time difference. Make sure that you select the sampling frequency so that the resulting time window covers this time interval with a good margin.

Make some test measurements with different ray distance and use little and long stacking time to determine the noise level. This will determine the stacking time.

Finally, it cannot be repeated too many times:

- Remember to charge the batteries before use.
- Check the optical communication by test measurements.

Borehole operations

In cross hole mode each antenna should be connected to the respective optical borehole cable. In this case the fiberglass tube and single optical fibre from Rx to Tx is NOT used.

Instead a separate ”ON-OFF” switch is connected to the Rx. This connector MUST be covered by a housing as described in Figure 4.9.

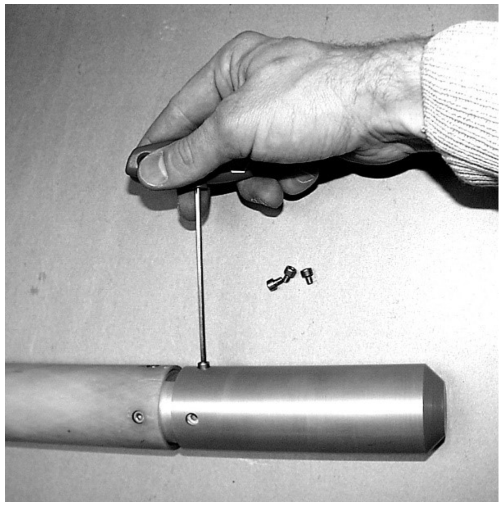

Figure 4.9. Mounting bottom plug on ON-OFF switch.

Both borehole cables are attached to the control unit, one to the R and D connectors and the other to the T connector.

At the boreholes both borehole cables should be attached to the respective tripod and the probes aligned in the borehole to adjust the depth position.

In data collection mode one antenna is kept at a fixed position in the borehole while the second antenna is moved continuously collecting data at the preset depth interval. This implies that the moving antenna cable should be mounted to the tripod equipped with the digital depth encoder. These data are transferred to the control unit while the depth data from the tripod with the stationary antenna need to be manually entered in the XV Monitor

Note: GroundVision 2 cannot be used for tomographic cross hole surveys.

It is very important that the depth data is entered in a correct way, as they will be recorded onto a file that is imported into the tomographic processing software.

Per definition one run in the borehole with one fixed antenna position is referred to as one SCAN. It is advisable that the depth position and depth information is corrected after each double scan that is after each run both downwards and upwards. This can be done by aligning the antennas again relative to the depth reference that was used initially.

It is natural that the depth information will differ slightly after each scan as the cable is stretched differently during runs downwards and upwards.

According to the law of reciprocity the Tx and Rx antennas can be switched between the boreholes without affecting the processed results.

The antenna positions in the borehole need however to be adjusted with respect to the position of the antenna centers relative to the antenna tops.

The following table shows the different distances for the antennas.

Table 2. Antenna distances and midpoints.

Antenna type		Antenna top* to antenna center
100 MHz	Tx	0.695 m
(O.D. 40mm)	Rx	0.722 m
250 MHz	Tx	0.325 m
(O.D. 48mm)	Rx	0.365 m

(* = refers to the gap where the borehole key fits in cable-head).

Charging batteries

The operation length of the battery packs in each antenna is 5-8 hours depending on the mode of operation and how much the data is stacked. In all antennas Li-Ion cells are used.

Two special connecting cables are supplied to connect the chargers to the two antennas. The cables are different for the Tx and Rx antenna and cannot be connected the wrong way.

When charging, we recommend the following procedure:

- Connect the charging cable to each antenna at the bottom plug.
- Connect the charging cables to the battery chargers.
- Connect the chargers to the power outlets.

Note: It is important to follow this procedure. If the charging cables are first connected to a powered charger before the battery, sparks may be caused when the charging cable is inserted into the antennas. The sparks will not necessarily damage the antennas but if repeatedly done the chargers may be damaged.

Note: The chargers supplied are universal voltage and will work from 100V AC to 240V. Use the appropriate cord-set depending on region and wall socket type.

The charging time for these types of chargers is 2-3 hours for a fully drained battery. The charging status is seen on the back side of the charger.

Figure 5.10 shows the charging equipment for the Tx antenna and Figure 5.11 shows the connection of the charging plug to the Rx antenna.

Note: The pictures below refer to chargers used for the 250 MHz antenna.

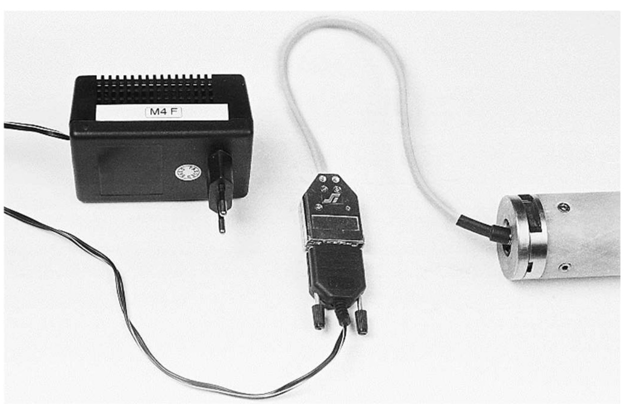

Figure 5.10. Connection of battery charging cable to Tx antenna.

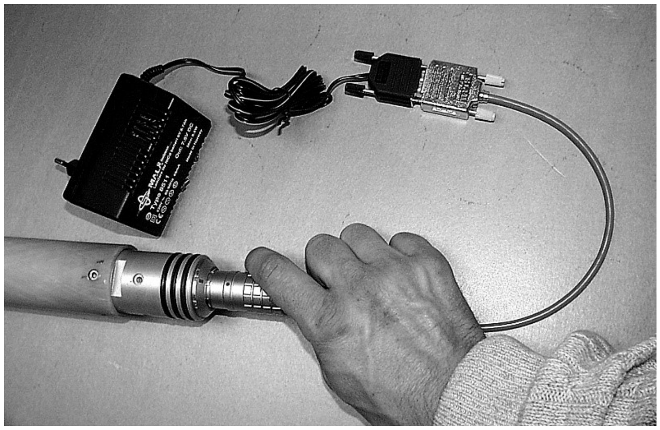

Figure 5.11. Connecting the battery charging to Rx antenna.

Note: The batteries have a lifecycle of approximately 400 charging cycles. It is highly recommended that the antennas are shipped to Guideline Geo for replacement of the batteries when it's clear that they can't keep their voltage.

Check trig signals

Antennas manufactured before 1st January 2024

250 MHz (O.D. 48 mm) and 100 MHz (O.D. 40 mm) Transmitter (Tx) antennas

One single red LED (see Fig. 6.1) which indicates valid transmitter trig signal being received from GPR control unit - in normal operation it is flashing.

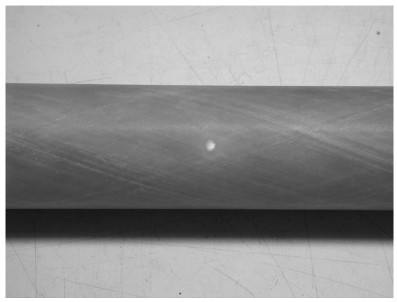

Figure 6.1. Diode on 250 MHz antennas.

250 MHz (O.D. 48 mm) and 100 MHz (O.D. 40 mm) Receiver (Rx) antennas

Two red LEDs (see Fig. 6.2) are seen on the Tx antenna. One LED indicates valid receiver trig signal being **received** from GPR control unit - in normal operation it is flashing. The additional LED indicates expected internal behaviour in the RX probe, that the data signal is being generated and **transmitted** in response to the receiver trig signals from the GPR control unit - in normal operation this LED is also flashing.

To understand if the data signal is being received OK by the GPR control unit in the other end, observe the D LED on the control unit - it should be flashing.

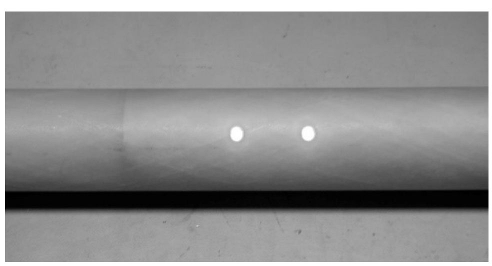

Figure 6.2. Diode on the 100 MHz Rx antenna

Note: There are older antennas manufactured (both 250 MHz and 100 MHz) with only one or no diodes on the Rx and Tx antennas. If you need help with these, contact Guideline Geo Support at www.guidelinegeo.com

Antennas manufactured after 1st January 2024

In normal operation the indicator lights on both the Tx and Rx probes indicates:

- Red LED flashing. A valid signal is being received from the control unit.
- Green LED ON. The optical link is OK.

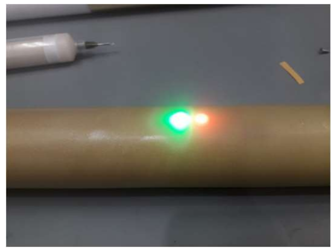

Figure 6.3. Diodes during normal operation.

If the optical cable is partially damaged, or one or more of the connectors are dirty, to the point of about 50% signal loss in the optical link, the indicators will show:

- Red LED flashing. The optical signal is being received from the control unit.
- Green LED OFF. The optical signal strength is poor, but present, given the flashing action of the red LED.

When the green LED goes out and the red LED is flashing, the equipment may or may not operate normally, work already in progress can be finished but the optical components, cables etc – should be examined and cleaned at first possibility.

If the optical fibre is completely torn off or some connector is perhaps not fastened properly, the indicators will show:

- Red LED ON. No signal being received from the control unit.
- Green LED OFF. The optical link is not working, given the static nature of the red LED.