SENSORS & SOFTWARE
from RADIODETECTION

pulseEKKO®

Ground Penetrating Radar

Operation manual

2005-00040-11



SPX
TECHNOLOGIES

Warranty Confirmation

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Component Serial Numbers (refer to packing list or the sticker on the component)

Comp:	Serial #	Comp:	Serial #
Comp:	Serial #	Comp:	Serial #
Comp:	Serial #	Comp:	Serial #
Comp:	Serial #	Comp:	Serial #
Comp:	Serial #	Comp:	Serial #
Vendor Name:		Date Received:	

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Important Safety Information

Use the Digital Video Logger (DVL) only as specified in these operating instructions, or the protection provided by the unit may be impaired.

The battery charger/AC adapter must only be connected to a power outlet which provides a protective earth (ground).

Connect the AC power cord only to designated power sources as marked on the battery charger/AC adapter.

The battery charger/AC adapter is rated for indoors use only.

Do not replace detachable MAINS supply cords for the battery charger/AC adapter by inadequately RATED cords.

Do not position the DVL such that it is difficult to disconnect the 37-pin GPR connector.

The exterior of this product should be cleaned using a damp cloth.

Safety Symbols



Consult this documentation in all cases where this safety symbol appears. This symbol is used to inform you of any potential HAZARD or actions that require your attention.

Do not attempt to open or dismantle any part of this equipment unless directed specifically by this manual. Doing so may render the equipment faulty and may void the manufacturer's warranty.

Use authorized accessories only. Incompatible accessories may damage the equipment or give inaccurate readings.

Follow your company and national safety procedures and or requirements when operating this equipment in any environment or workplace. If you are unsure what policies or procedures apply, contact your company or site's occupational health and safety officer or your local government for more information.

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1. Introduction

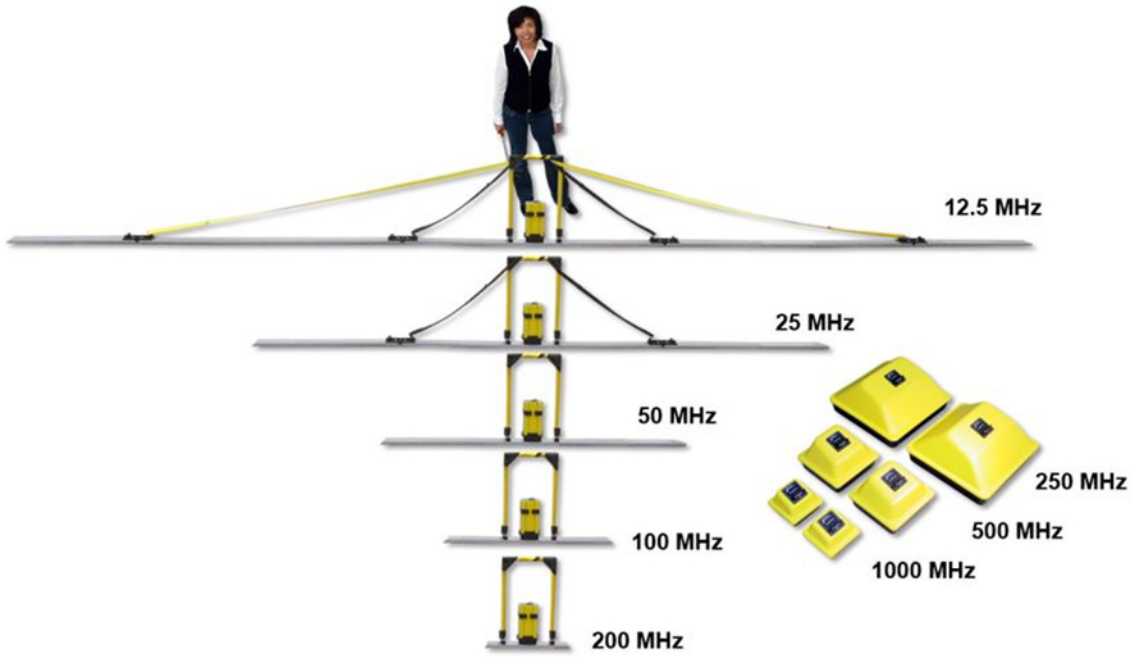
Congratulations on your purchase of a pulseEKKO Ground Penetrating Radar (GPR) system. pulseEKKO is designed to meet the needs of GPR professionals by addressing a wide range of GPR applications. The variety of components available allow for a truly customizable unit. Features include:

- Multiple frequencies provide a variety of exploration depths and spatial resolutions required by different applications.
- Lower frequency (LF) antennas with center frequencies and bandwidths of 12.5, 25, 50, 100 and 200 MHz connected to transmitter and receiver electronic modules.
- Shielded, higher frequency (HF) transducers provide center frequencies and bandwidths of 250, 500 and 1000 MHz.
- Several antennas and/or transducers can be deployed simultaneously when using SPIDAR hardware.
- Multiple configurations and deployment methods provide practical field operation.
- The fully bistatic configuration enables variable antenna offsets and orientations for advanced survey types such as multi-offset, trans-illumination and multi-polarization.
- Data is collected and displayed on the DVL-500. The DVL-500 is a ruggedized display, with a high-visibility touchscreen, Wi-Fi compatibility and easy USB data export.
- Acquired data is in Sensors & Software's industry standard format. Post-processing and analysis can be accomplished by importing the data into the EKKO_Project software.

The first half of this manual describes the physical assembly of the various configurations. The remainder describes menu operation, data collection, troubleshooting and techniques for proper surveying.

2. Assembly

The image below displays all the antennas and transducers that are available for the pulseEKKO. All antennas and transducers come in pairs: one for transmitting and one for receiving. The one exception is the TR1000, which combines the 1000 MHz transmitter and receiver into a single, integrated sensor head.



The DVL (short for Digital Video Logger) is a ruggedized field computer that displays, and stores collected data. All the cable connections, including power, plug into receptacles on the back of the DVL.





2.1 Low Frequency Antennas

You can configure the pulseEKKO with 12.5, 25, 50, 100, or 200 MHz low frequency, unshielded, bistatic antennas. The shortest antennas (200 MHz) are 0.5 meters long, while the longest antennas (12.5 MHz) are 8 meters long.

2.1.1 Attaching Antenna Sockets to the Transmitter & Receiver

Insert and tighten the two female brass antenna sockets into the bottom of the transmitter and receiver electronic boxes. Finger-tighten the sockets; do not over-tighten. These should be checked every time the transmitter and receiver are connected to the antennas, as they may get loose during regular field operations.



2.1.2 Latching the Transmitter & Receiver to the Antenna Mounting Blocks

Place the transmitter and receiver electronic boxes onto the black mounting blocks in the middle of the antennas, ensuring the brass sockets connect to the brass pins in the antenna.



Connect the electronics boxes to the mounting block using the two plastic draw latch connectors.







2.1.3 Inserting batteries into the Transmitter & Receiver

Unlatch and then open the two battery covers on the sides of the transmitter and receiver.



Place one 12-volt battery on each side of each of the electronics boxes. Make sure the positive (+) terminal faces inward toward the electronics.

> **NOTE:** The battery is “keyed” with a notch in one side so it only fits properly in this orientation.

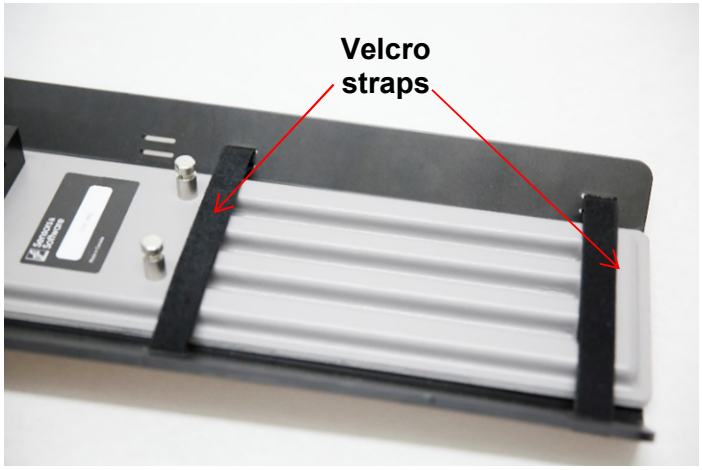


Close and latch the battery covers.



2.1.4 Attaching Skid Plates to Antennas

When using the SmartCart (3.2) or SmartTow (3.3), it is recommended to use antenna skid plates which protect the antennas from damage caused by contact with the ground when moving.

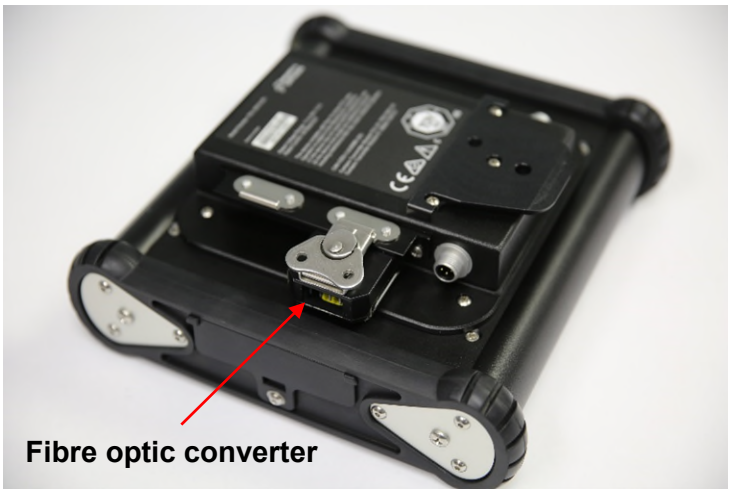


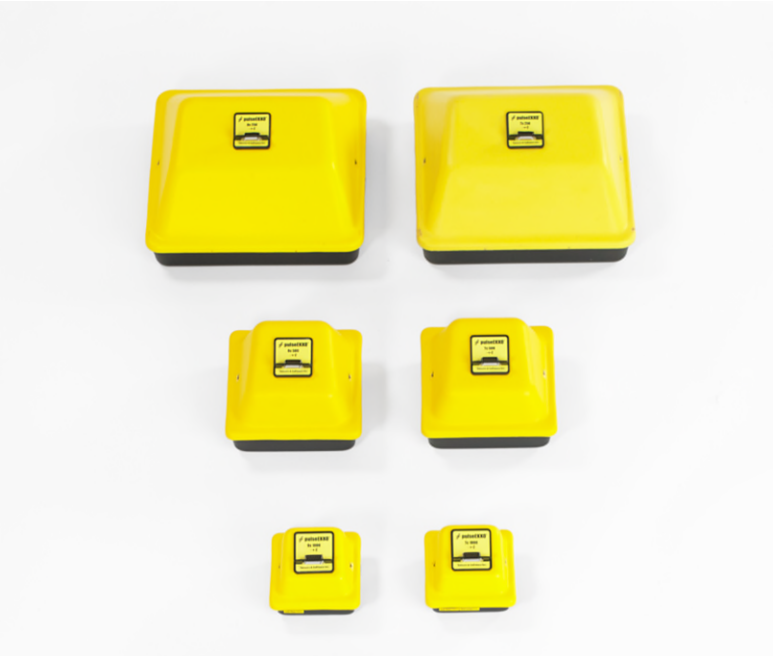
The antennas are secured with Velcro straps to the skid plates. The picture below shows an assembled SmartCart with antenna skid plates.



2.1.5 Attaching Fibre Optic Converters to the DVL

Fibre optic cables connect low frequency (12.5 to 200 MHz) transmitter and receiver electronics to the back of the DVL. First, attach the fibre optic converters to the back of the DVL and secure them using the latches shown in the following image.





To connect fibre optic cables, see section on Connecting Fibre Optic Cables (3.6.2).

2.2 High Frequency Transducers

2.2.1 Bistatic Transducer Assembly

pulseEKKO can use three high frequency, shielded, bistatic antennas: 250, 500, and 1000 MHz.



Each component is a transducer because it consists of both an antenna and either the transmitter or receiver electronics. The transmitting transducer is indicated by Tx, e.g. Tx500, while the receiving transducer is indicated by Rx, e.g. Rx500.

2.2.2 Mounting Transducers to the Skid Plate

Skid plates fit a pair of transducers positioned side by side.

a) On a flat surface, position the skid plate assembly bottom and two side flanges as shown in the following image.



1. Place the transducers onto the bottom skid plate with the labels facing the same direction.



2. Place the two transducer flanges onto the skid plate over the mounting posts.

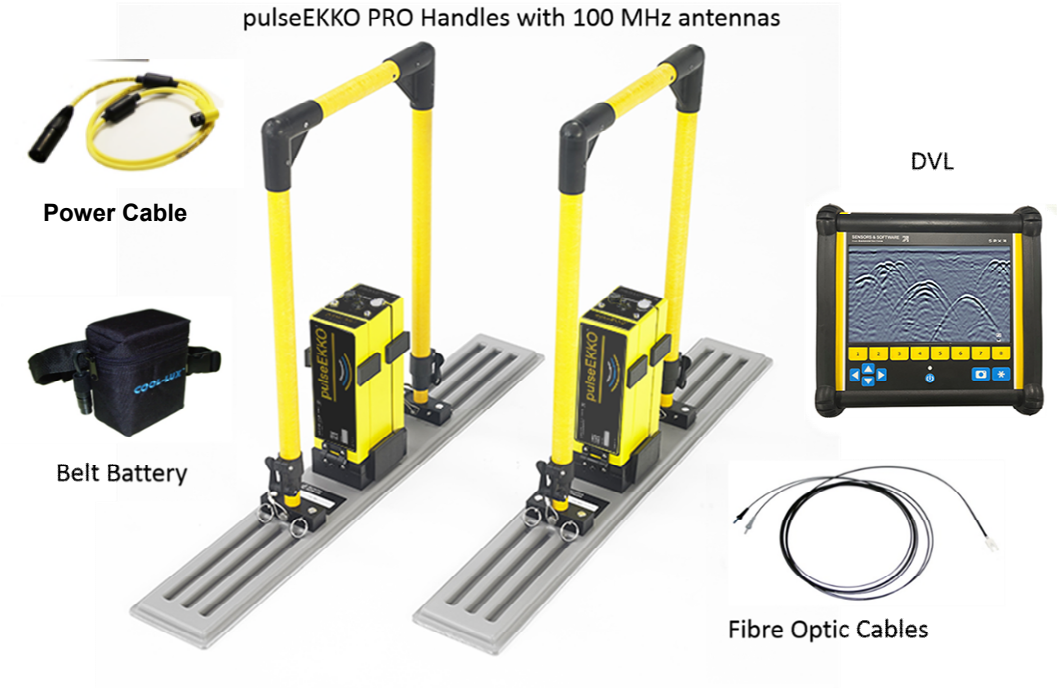


Attach the completed transducer - skid plate assembly to the SmartTow (3.3) or the SmartCart (3.2). See section on Connecting Transducer Cables (3.6.3).

3. Assembling Full Configurations

3.1 Bistatic System

Before assembling the full Bistatic system, make sure the transmitter and receiver are connected to the antennas. The following image displays the complete low frequency pulseEKKO handheld assembly.



3.1.1 Attaching Adjustable Handles

1. To attach the adjustable handle to the antenna, place the handle blocks over the 4 posts on the antenna and insert the pins to secure.



2. Adjust the handle height by loosening the two levers by hand.

3. Move the handle to the desired height and then retighten the levers.
4. Once the handles are adjusted, lock them by tightening the levers until they click into place.







3.2 SmartCart

The SmartCart is configured for operation with 50, 100 and 200 MHz antennas and 250, 500 and 1000 MHz transducers to rapidly acquire data in flat and smooth environments.

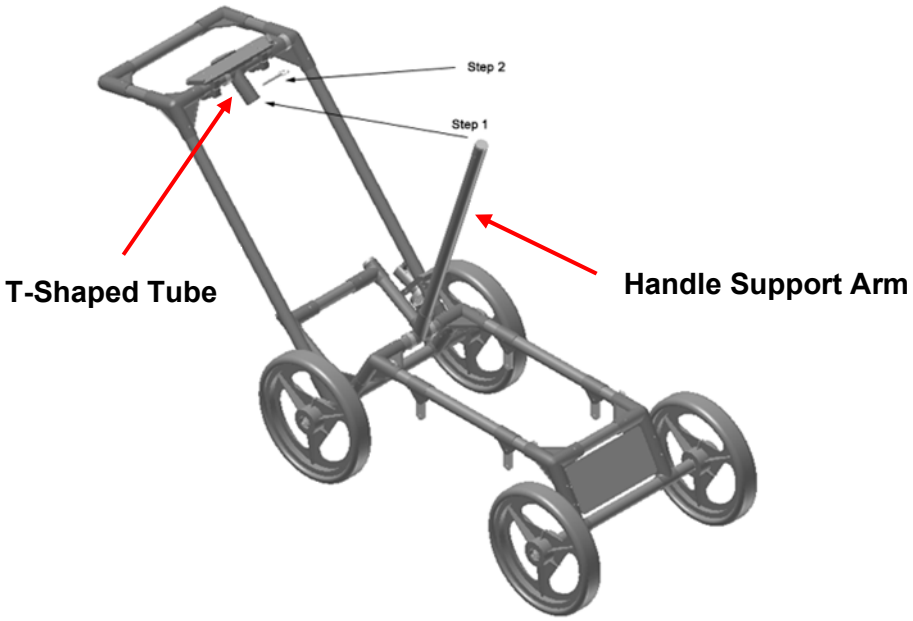
The following image shows a completely assembled SmartCart with a frequency of 100 MHz.



100 MHz

3.2.1 Unfolding the Handle

The Sensors & Software SmartCart is shipped in a folded position for easier transportation and storage. Refer to the following image while unfolding your SmartCart.



a) Remove the pin from the handle support arm.

b) Raise the handle support arm.

c) Raise the handle up, past the support arm and towards the back of the cart until the handle support arm can be placed in the T-shaped tube.

d) Place open end of the T-shaped tube on the handle onto the end of the support arm (**Step 1**)

e) To lock the handle into position, align the hole in the support arm with the hole in the T-shaped tube. Insert the handle pin (**Step 2**)

> **Note**: When folding the SmartCart back up, fold the handle down before folding the handle support arm.

3.2.2 Attaching Wheels

SmartCarts are shipped with the wheels attached. If your wheels ~~arrive un-attached or~~ have been removed for maintenance or cleaning, complete the following procedure to attach them to your SmartCart:

- Press the button on the end of the wheel axle to unlock the axle catches.
- Insert the axle through the wheel and into the SmartCart frame until it locks into position.

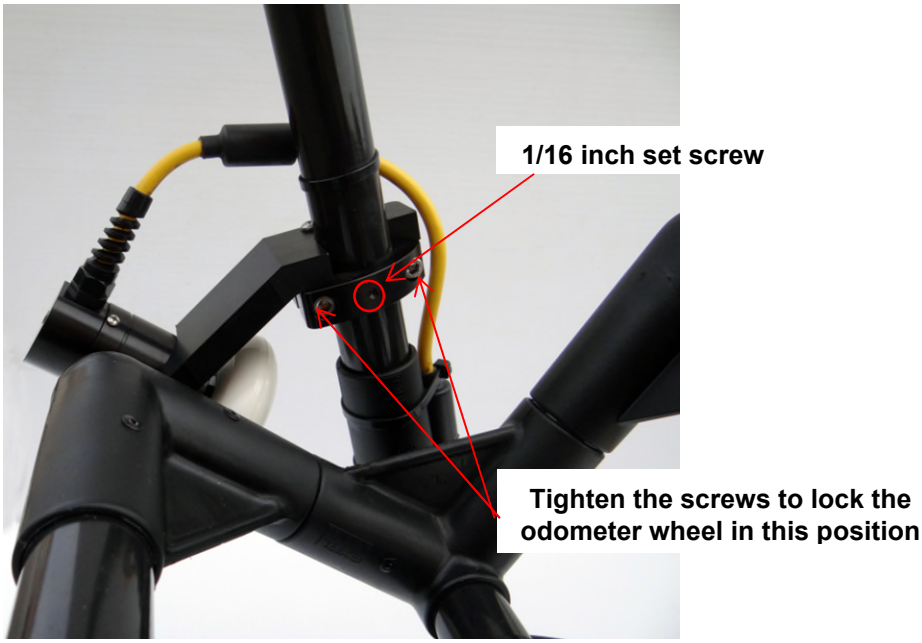


- Make sure the odometer wheel makes good contact with the side of the wheel (see figure below). The odometer wheel is the one which has a “scuffed” inside rim, to reduce wheel slippage in wet conditions.



If the odometer contact with the wheel is too loose, the odometer wheel may slip resulting in incorrect position measurements. If the odometer wheel seems loose:

1. Use a ¼ inch Allen (hexagonal) wrench to loosen the screws on the side of the odometer.
2. Pivot the entire odometer assembly until the small odometer wheel makes good contact with the side of the cart wheel.
3. Tighten the screws to lock the odometer wheel in this position.



4. Tighten the 1/16 inch set screw into the fibreglass tubing to prevent the odometer from rotating from this position.

It is always a good idea to recalibrate the odometer (5.2.6) whenever this adjustment is made.

3.2.3 Attaching Antenna Separation Bars to the SmartCart

The following image displays an assembled SmartCart with separation bars for low frequency antennas.



Each system has a unique set of separation bars to attach the transducers or low frequency antennas to the SmartCart and suspend them over the surface.

> Before you begin, detach the DVL from the SmartCart and battery as the back half of the cart may fall to the ground and be damaged.

Attach the 200 MHz antennas to the SmartCart using the 0.5 meter separation bars (left); the 50 MHz antennas have 1 meter separation bars (right) while the 100 MHz antennas can be used with either 0.5 or 1.0 meter separation bars.

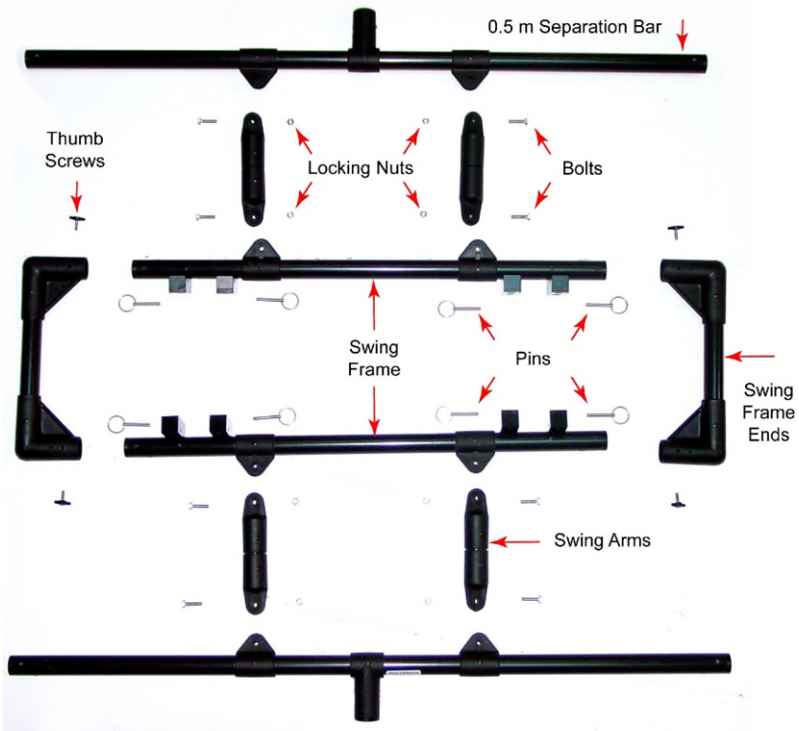


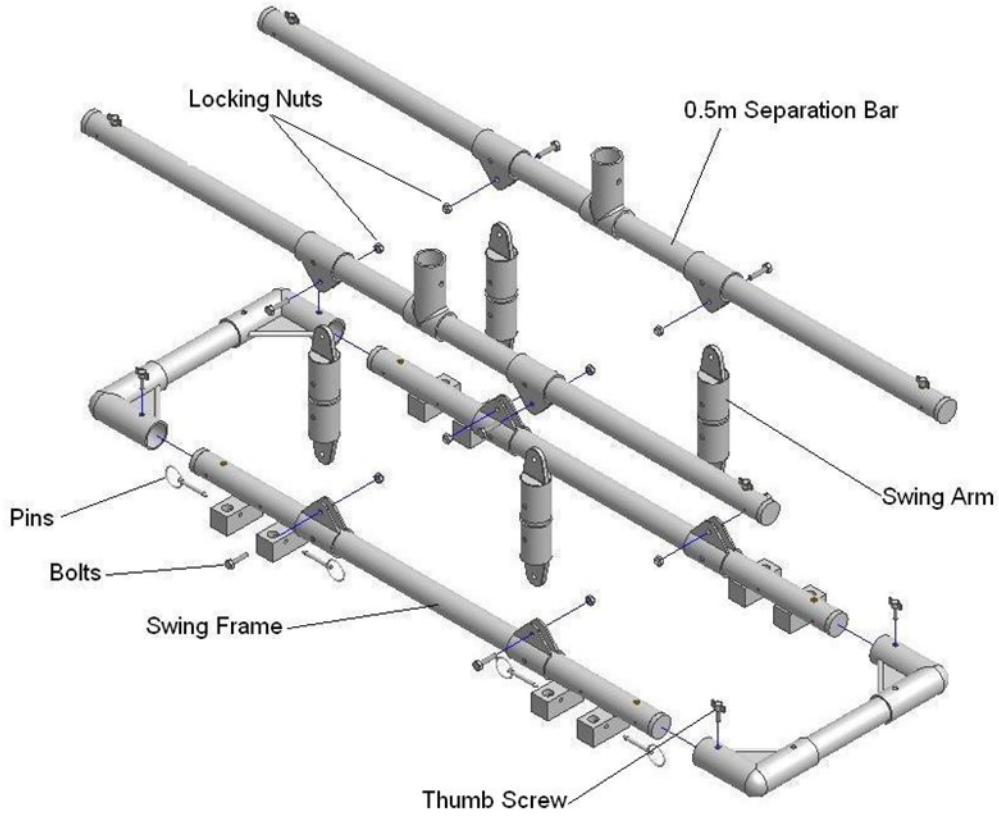
0.5 meter



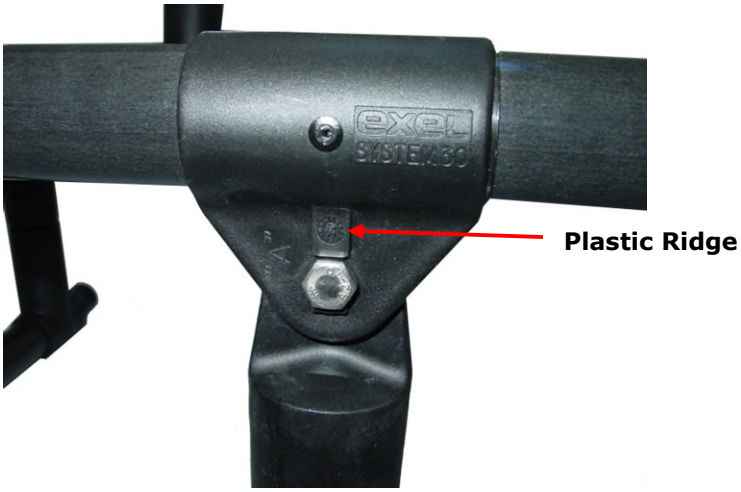
1.0 meter

Refer to the following image to assemble the 0.5m separation bars. (The 1m separation bars can be assembled in a similar manner). You need two user-supplied 10mm wrenches for tightening lock nuts onto the bolts.





1. Make sure the Swing Arm bold head is caught by the plastic ridge, so it cannot rotate. Do not over-tighten, the Swing Arm needs to move freely.



2. To attach the separation bars to the SmartCart tube frame, carefully align the screws so they go in straight.

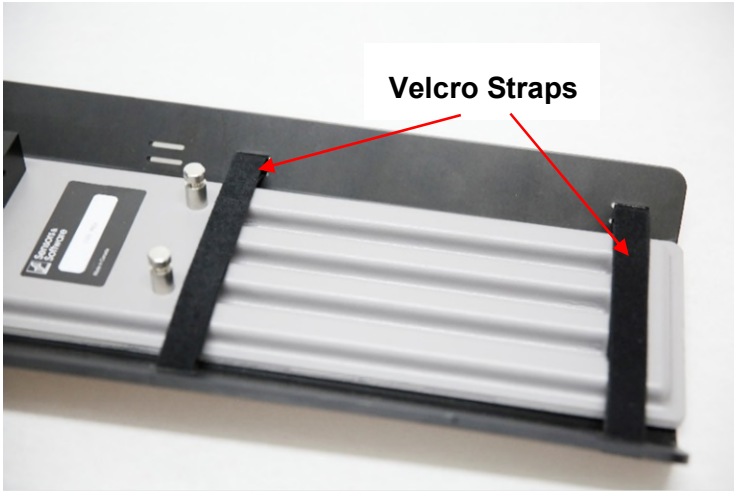
> **Note:** Forcing the screws can strip the threads. If the holes are not aligned, the thumb screw will bind after half a turn and damage the hole by cross-threading it. Forcing the thumb screw to turn also causes damage. If you have damaged the insertion point, run a 10-32 tap through the insert to re-tap the hole.

3. Use the Thumb Screws to attach the separation bars to the front and rear axle SmartCart assemblies. Do not over-tighten.



3.2.4 Attaching the Antennas

If the antenna skid plates are not attached, now is the time to attach them. Use Velcro straps to hold the antennas on the skid plate, as shown below. The skid plates are recommended for 50, 100 and 200 MHz antennas.



Then attach the antennas to the bottom of the separation bars using the metal posts on the antenna and pins.



Attach the antennas to the SmartCart before attaching the transmitter and receiver (with batteries inside) to the antennas. To complete all cable connections, see section on Connecting Fibre Optic Cables (3.6.2). Once completed, the assembled SmartCart is shown below with 50 MHz antennas, using 1m skid plates. Note that the 50 MHz antennas stick 0.5m out each side and are vulnerable to damage (see figure below).



50 MHz

3.2.5 Attaching Transducer Separation Bars to the SmartCart

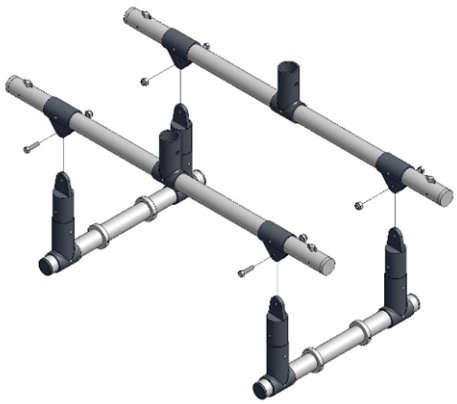
Before assembling the SmartCart, make sure the transducers are assembled on the skid plate assembly (2.2.2).

The following image displays a SmartCart with the Transducer Separation Bars attached:



Each transducer pair has a unique set of separation bars to attach them to the SmartCart and suspend it over the surface.





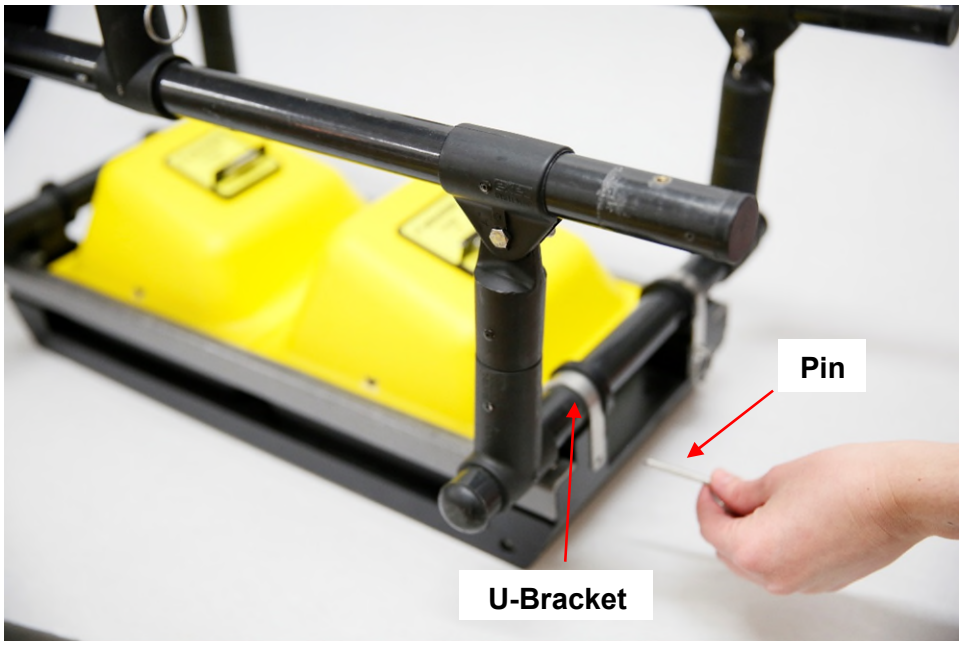
To attach the separation bars to the SmartCart tube frame, carefully align the screws so they go in straight.

Note: Forcing the screws can strip the threads. If the holes are not aligned, the thumb screw will bind after half a turn and damage the hole by cross-threading it. Forcing the thumb screw to turn also causes damage. If you have damaged the insertion point, run a 10-32 tap through the insert to re-tap the hole.

Use the Thumb Screws to attach the separation bars to the front and rear axle SmartCart assemblies. Do not over-tighten.



Use the silver U-brackets and pins to secure the skid plate assembly to the separation bars as shown below



3.2.6 Attaching the Battery

The following image displays the SmartCart 12V (9 Amp-hr) battery. Follow the steps for placing the battery in the SmartCart:



1. Set the battery onto the lower inclined shelf on the back of the SmartCart.

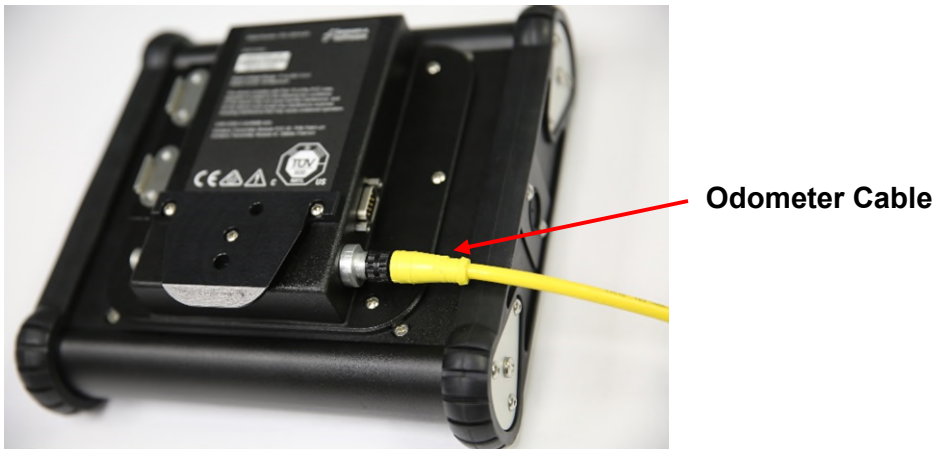


2. Ensure the battery unit handle is facing the back of the cart and the cable receptacle is on the right. The battery should rest in this area without moving.
3. Secure the battery onto the cart by placing the straps provided over the battery.
4. Fasten the plastic buckle to lock the straps.
5. Tighten the straps.

Once complete, see section on Connecting Transducer Cables (3.6.3).

3.2.7 Connecting the Odometer Cable to the DVL

Connect the odometer cable to the receptacle on the back of the DVL. Secure the odometer cable to the cart using Velcro straps.



3.2.8 Attaching the DVL

1. Align the back plate on the DVL with the Mount on the DVL tray.
2. Slide the DVL down onto the mount so that the sides of the mount catch on the DVL back plate.
3. The spring-loaded release pin will snap into place when secure. Do not let go of the DVL until you are sure that it is secure.



4. Rotate the DVL to adjust the view angle. If it is difficult to rotate, slightly loosen the thumbscrews on the bottom of the support shelf. Tighten to fix the viewing angle.
5. To remove the DVL from the SmartCart, pull the cylindrical release pin outward and lift the DVL off the shelf.

3.2.9 Installing the GNSS Mount (optional)

The optional SmartCart GNSS mount is designed to mount a GNSS receiver, which can log GNSS information during data collection. It uses a 5/8-11 UNC-1A thread at the top of the pole.

Attach the GNSS to the mount using the gold-colored adapter supplied with the GNSS.



1. Fasten the U-shaped **Vertical Support Section** onto the **tubes** on the separation bars and secure it by inserting the 2 quick release pins.
2. Insert the **GNSS mounting post** into the top of the **Vertical Support Section** and secure it with a quick release pin.

To install and connect the GNSS to the DVL, see Section 3.7.3.

3.3 SmartTow

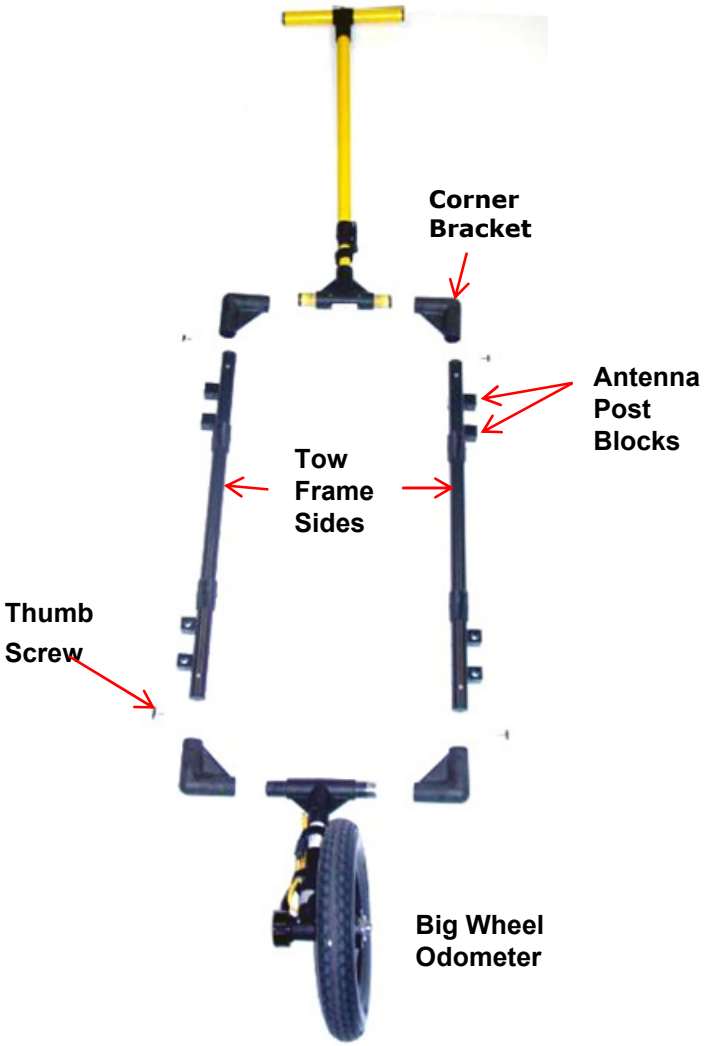
The SmartTow configuration enables you to drag 50, 100, 200 MHz antennas and 250, 500 and 1000 MHz transducers across the surface to acquire data. The following image displays a low frequency SmartTow system.



100 MHz SmartTow system

3.3.1 Low Frequency Antenna SmartTow

Ensure that the antennas and electronics are assembled and connected. The following image displays the parts of the SmartTow frame:



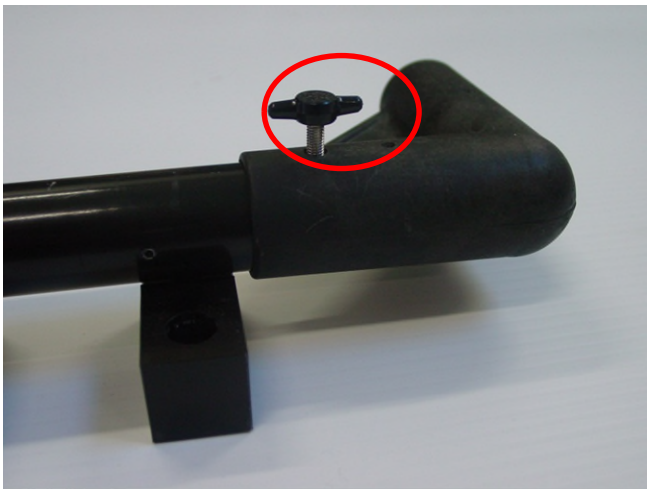
pulseEKKO SmartTow frame parts



Assembled pulseEKKO SmartTow frame

The instructions below describe how to assemble the Tow Frame:

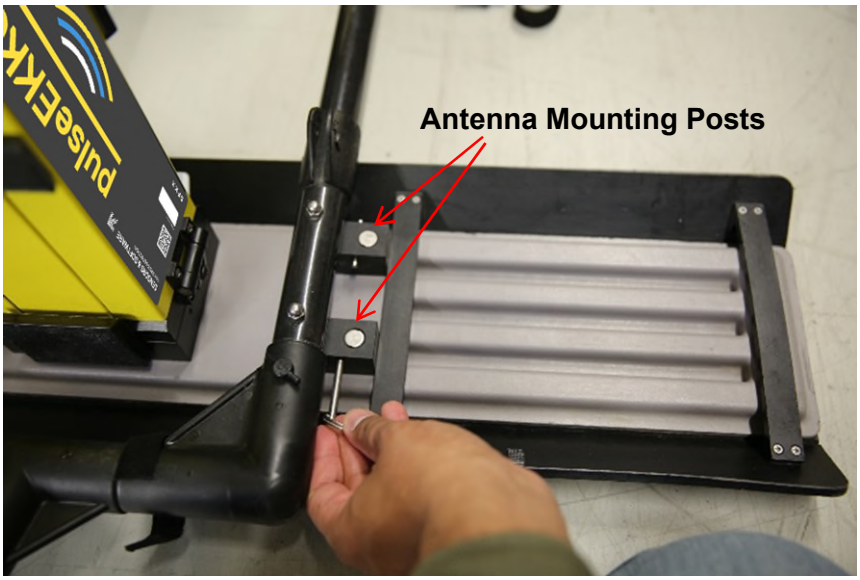
1. Place the Tow Frame Sides so the antenna post blocks are facing outward.
2. Connect each piece using the four thumbscrews. Be careful to not strip the threads. The handle and big wheel odometer are not connected to the frame with thumb screws but held in place once the low frequency antennas are attached.



> **Note**: The assembly kit comes with extra end pieces so both SmartCart and SmartTow configurations can be assembled; as a result, there will be extra pieces after assembly.

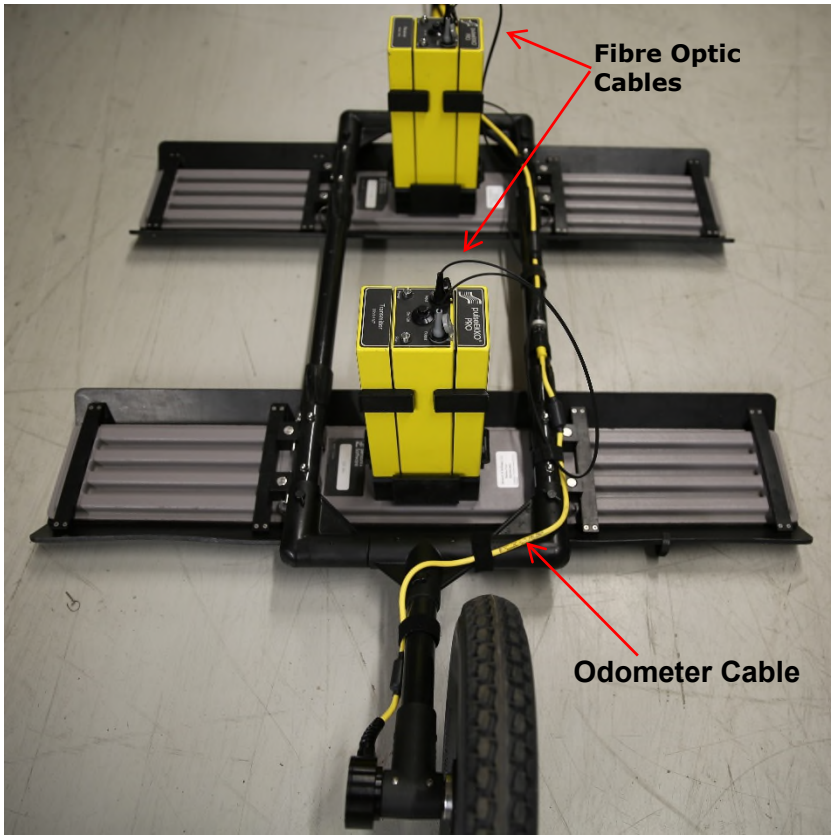
To connect the antennas to the Tow frame:

3. Place the SmartTow frame over the antennas.
4. Align and then insert the eight antenna post blocks on the frame into the antenna mounting posts on the antennas.
5. Secure the SmartTow frame to the antennas by inserting the pins into the eight post blocks.



6. **One Person Operation**: Route the odometer cable along the frame and up the handle. Keep the cable away from the electronics and antennas. Secure the cable to the frame

and handle with Velcro straps. The cable should have some slack to reduce any stress during data collection, as the handle assembly moves up and down.



When the metal odometer cable is routed overtop of the low frequency antennas, it can cause banding in the GPR data. Banding can often be removed in post-processing, however, if possible, we recommend two-person operation so the odometer cable does not cross the low frequency antennas.

7. **Two Person Operation**: Route the odometer cable behind the wheel odometer to the second person carrying the DVL.



Refer to section on Connecting Fibre Optic Cables (3.6.2), to complete those connections.

Once the SmartTow is assembled, connect the round four-pin battery cable to the belt battery receptacle.

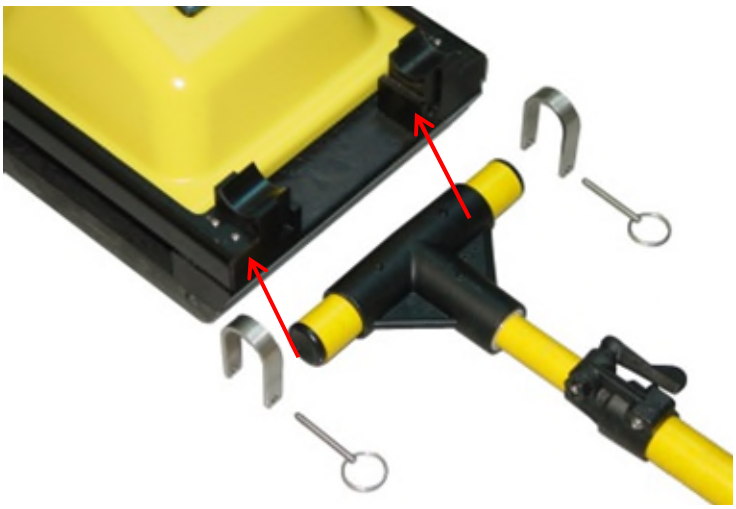
3.3.2 High Frequency Transducer SmartTow

The following image displays a pulseEKKO 500 SmartTow:



500 MHz SmartTow

Ensure the transducers are assembled in the skid plate assembly (2.2.2). Then attach the adjustable tow handle to the skid plate assembly by placing the smaller T-end of the handle into the trough on the end of skid plate assembly. The label on the transducers should be facing away from the handle, as shown in the picture above.



Attach the T-end of the handle to the skid plate assembly by placing the U-bracket over top and into the vertical slots.



Secure the handle to the skid plate assembly by inserting the metal pins into the holes at the bottom of the U bracket.



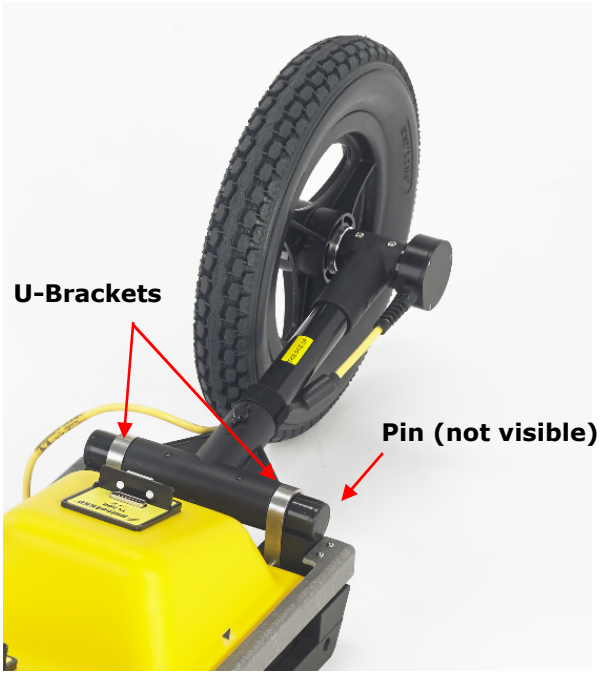
3.3.3 Attaching a Wheel Odometer

pulseEKKO SmartTow allows you to use two different odometers for collecting data; generally, operators use the Big Wheel Odometer in rough conditions and the Small Wheel Odometer in flat, smooth areas.

Big Wheel Odometer

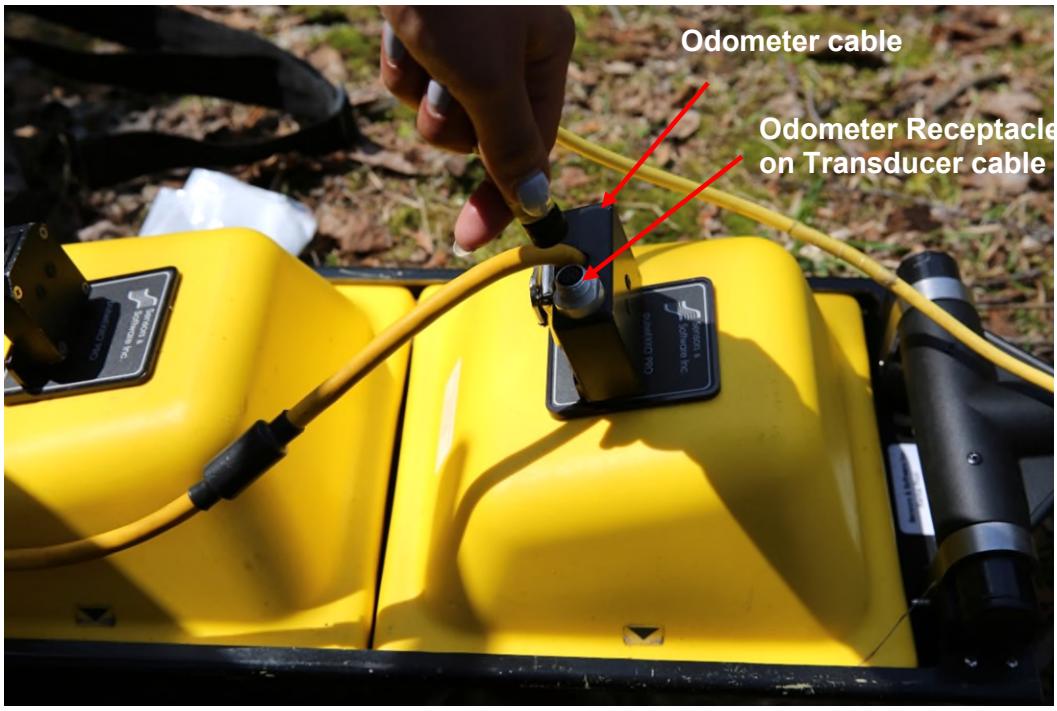
Attach the large odometer wheel to the end of the skid plate assembly. Look at the “This Side Up” label on the tube to ensure that it is installed in the correct orientation.

To attach the T-end of the odometer to the skid plate, place the U-bracket over top and into the vertical slots. To secure the odometer, insert the metal pins into the holes at the bottom of the U bracket. This is the same way the handle was secured (see above).



Face the labels on the transmitting transducer toward the odometer wheel. Secure the cable to the T-bar with Velcro straps.

Connect the yellow odometer cable to the receptacle on the transducer cable. You can also connect the odometer cable to the back of the DVL, but you will need an odometer extension cable; this is not recommended as the cables now need to run a longer distance, near the antennas.



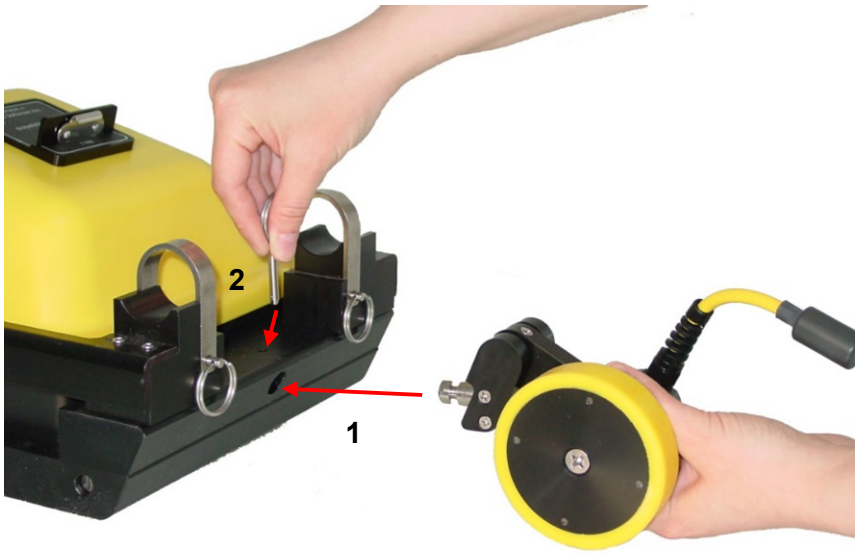
Loop the odometer cable so it does not interfere with the rotation of the odometer wheel.

Calibrate the odometer (5.2.6) to ensure accurate data images.

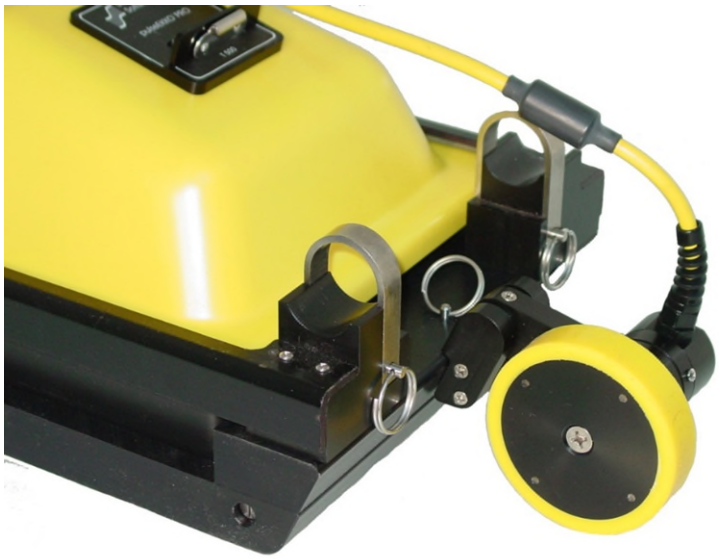
Small Wheel Odometer



Attach the small wheel odometer to the skid plate assembly by inserting the metal post into the hole on the end of the skid plate (1).



Secure the odometer by inserting the metal pin into the vertical hole on the edge of the skid plate (2).



Loop the odometer cable so it does not interfere with the rotation of the odometer wheel. Connect the odometer cable to the receptacle on the transducer cable. You can also connect the odometer cable to the back of the DVL, but you will need an odometer extension cable; this is not recommended as the cables now need to run a longer distance, near the antennas.



Secure the cables to the cart using Velcro strips or electrical tape. Complete all transducer cable connections as described in the section Connecting Transducer Cables (3.6.3).

Calibrate the odometer (5.2.6) calibration to ensure accurate data images.

3.4 SmartChariot

The SmartChariot is used to deploy GPR transducers at medium speeds (maximum 25 km/hr or 15 mph) from a tow vehicle. The SmartChariot can only be used with the pulseEKKO 500 or 1000 MHz transducers.

The following image shows a fully assembled SmartChariot system with 500 MHz and GNSS.



500 MHz SmartChariot

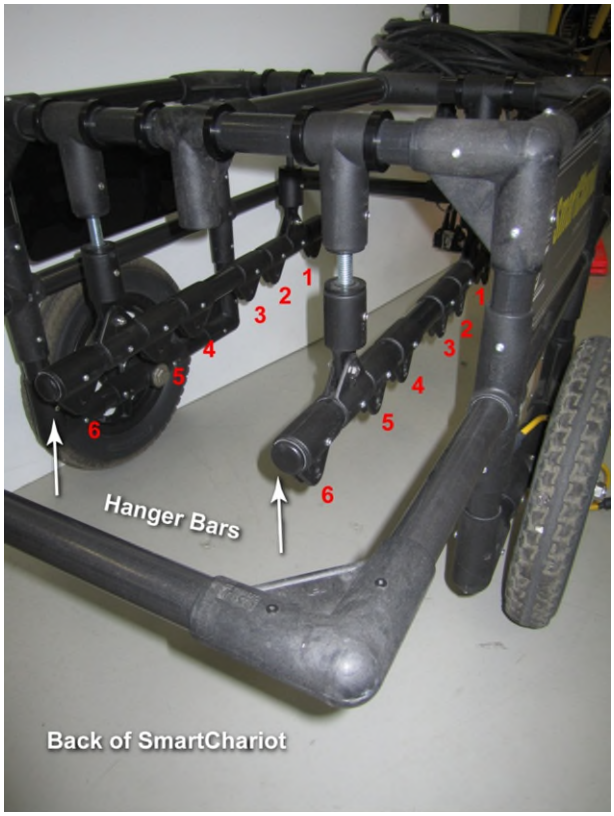
3.4.1 Hanger Kits

The transducers are attached to the SmartChariot using the appropriate hanger kit. The hanger kit is attached to the skid plate assembly. Ensure that the transducers are secure in the skid plate assembly (2.2.2) before proceeding.

Each hanger bar has six parallel mounting locations to attach the hanger kits to. The hanger kit for each GPR transducer must be mounted in the correct position on the Hanger Bars for proper operation of the system:

1. the pulseEKKO 500 hanger kit connects to Hanger Bar Mounts 2 and 5.
2. the pulseEKKO 1000 hanger kit connects to Hanger Bar Mounts 3 and 4.

When the transducers and skid plates are mounted to the SmartChariot, ensure that the transducer cable connections face the back of the SmartChariot.



Attach the hangers to the hanger bar using the nuts and bolts provided. Use two 10 mm wrenches to assemble the hangers (wrenches not provided).

The resulting pictures show the assembled SmartChariot with 500 MHz and 1000 MHz transducers.



500 MHz



1000 MHz

3.4.2 Attaching the SmartChariot Handle

Depending on the height of the ball hitch used on the tow vehicle, the SmartChariot Handle Assembly can be installed in two different positions. Attach the handle assembly to the SmartChariot so the GPR sensor is as level as possible.

Low Handle Position



High Handle Position



Attach the handle to the back of the SmartChariot using the two locking pins:



3.4.3 Attaching the Ball Hitch Receiver

The Ball Hitch Receiver is shipped detached from the handle assembly.

1. Determine whether to use the handle in high or low position.
2. Find the appropriate side of the handle arm to attach the Ball Hitch Receiver to.
3. Align the two white blocks with the handle arm bolt holes.



4. Place the Ball Hitch Receiver on top, lining up the holes.
5. Insert the bolts, with washers.





6. Tighten the bolts with a 7/16-inch wrench.

3.4.4 Adjusting the Transducer Height

Once the SmartChariot is attached to the tow vehicle, check that the skid plate assembly is above the surface and doesn't touch the ground. Typically, it should be 0.5cm (1/4 inch) above the ground.

If necessary, adjust the four SmartChariot Height Adjusters to attain the optimal height above the ground:

- To change the height, remove the bolts and lock nuts from the bottom of the front or rear height adjusters



- Turn the bottom of the height adjusters clockwise to raise the transducer and counter clockwise to lower the sensor height.
- When rotating the height adjusters, remember the number of turns so you can apply the same number of turns to the other side of the SmartChariot.
- Reattach all the locknuts. Do not over-tighten the locknuts; the skid plate assembly should be free to swing forward and backward.

During data collection with the SmartChariot on a flat road, the skid plate assembly should not come in contact with the ground. It is normal to periodically hear the skid plate briefly scraping on the ground; typically, when going over curb edges or rough patches of road. However, if excessive scraping is heard or suspected, inspect the skid plate bottom and, if excessive wear is seen, adjust the height if necessary. Generally, the height of the SmartChariot only needs to be adjusted once per tow vehicle.

3.4.5 Adding GNSS

If an optional Global Positioning System (GNSS) unit was shipped with your SmartChariot GPR system, attach it to the GNSS mounting threads using the gold-colored adapter supplied with the GNSS.



3.4.6 Routing Cables

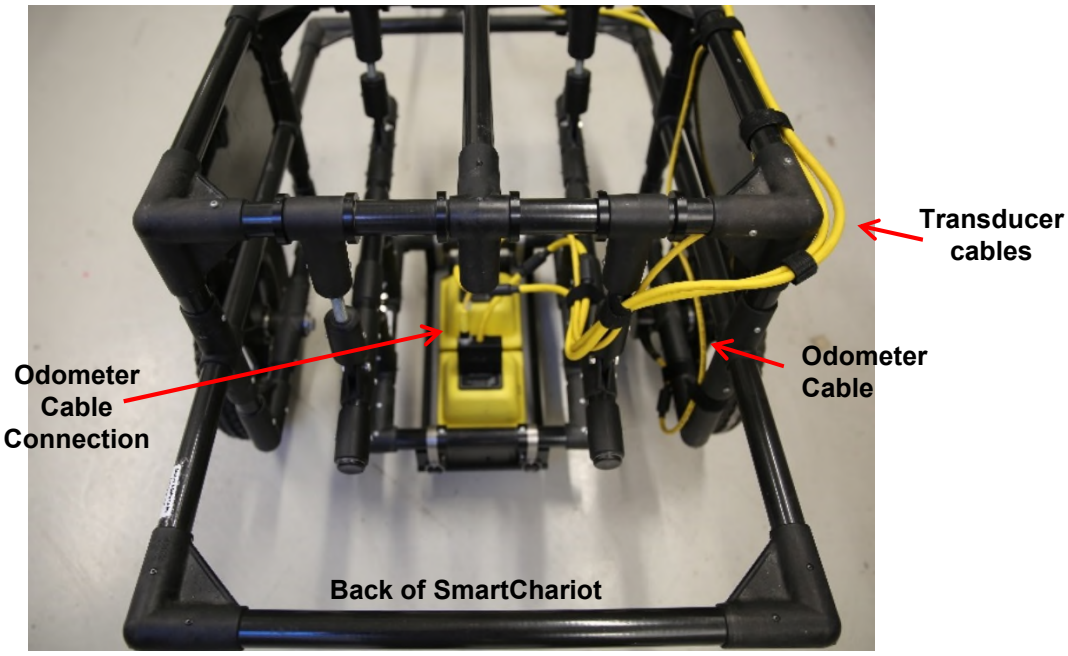
It is important to route your cables properly to eliminate interference with the GPR signals, as well as keeping the setup neat and secure.

Transducer Cables

1. Route the cables up the hanger brackets and along the SmartChariot frame on the same side as the odometer cable. Use Velcro straps provided to secure the cables to the hanger bracket.
2. Route the cables to the top of the SmartChariot frame and secure with the Velcro straps provided.
3. Run the cable along the SmartChariot handle and into the towing vehicle.
4. Attach the cables to the back of the DVL in the tow vehicle.

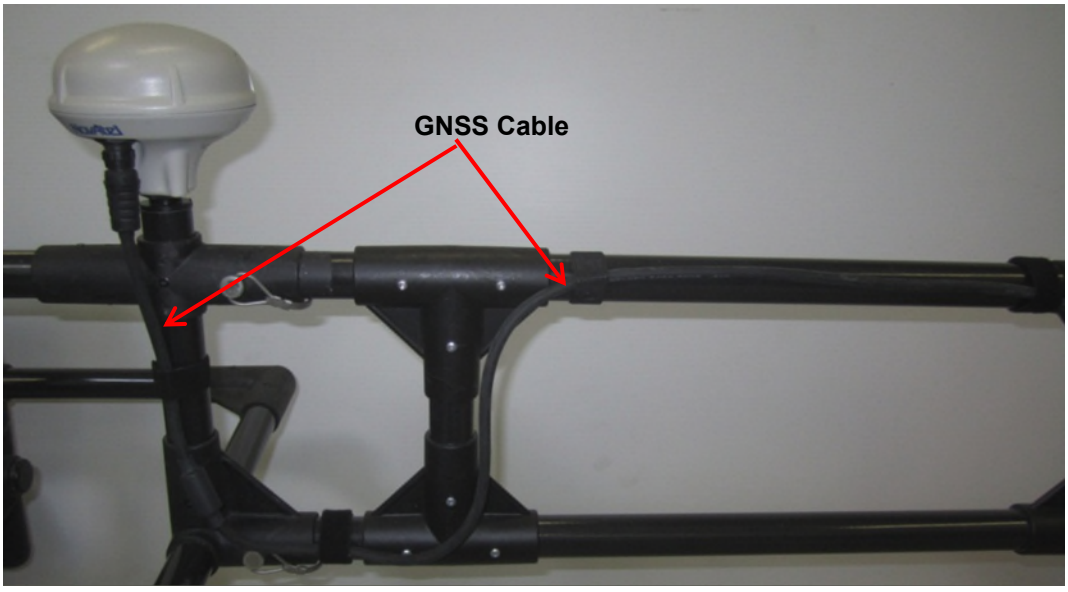
Odometer Cable

1. Route the yellow odometer cable, along with the transducer cables, up the hanger bracket to the top of the SmartChariot frame. Secure to hanger bracket along with the transducer cables.
2. Route the cable down the Hanger, where it connects to the odometer receptacle on the transducer cable.



GNSS Cable

1. Route the GNSS cable up to the top of the SmartChariot Handle Assembly.
2. Route the cable along the top of the SmartChariot handle and into the tow vehicle.



To connect the GNSS cable, see Section 3.7.3

Connect all transducer cables as described in the section Connecting Transducer Cables (3.6.3).

3.4.7 GPR System Parameters

The following table lists suggested GPR parameters based on the maximum SmartChariot speed of 25 kph (15 mph). These can be set in the System Configuration (6).

Parameter	GPR Sensor (MHz)	
	500	**1000**
Depth (m)	1.5	0.75
Transducer	500	1000
Stacks	1	1
Trigger Method	*Odometer*	
Step Size (cm)	5 cm	5 cm

3.4.8 Tips for Using the SmartChariot

Step Size

Many pavement structures contain asphalt over concrete which can be difficult to distinguish in the GPR cross-section. Most concrete is reinforced with metal rebar which can be seen in the GPR cross-section when the step size is set to a resolution that is small enough to identify individual pieces of rebar. Set step size to a maximum of 5cm to identify this type of pavement structure.

SmartChariot Odometer Calibration

Although typical SmartCart/SmartTow odometer calibrations are completed on short lines, SmartChariot odometer calibrations should be completed on 20m long lines.

Zoom (Position)

The SmartChariot can collect GPR data very fast and the data on the DVL screen may scroll too quickly to view the image in real time. You can change the zoom to increase the total distance shown on one screen (7.1.5). This causes the screen to scroll more slowly, making the data image more visible.

Skipped Traces

The system will occasionally skip traces. Typically, only a few traces will be skipped but thousands will be collected so it's not usually an issue. For an explanation of skipped traces, see Show Skips under GPR Line Options (5.1.11).

3.5 SmartSled

3.5.1 SmartSled Assembly

SmartSled comes with the following components:

- Durable Pelican Trek 60 tow sled with replaceable runners. Specs are as follows:
  - Length: 59.75 in (152 cm)
  - Width: 24 in (61 cm)
  - Height: 12.5 in (32 cm)
  - Weight: 12.5 lb (5.7 kg)
- Metal tow hitch
- Sled cover – made of water-repellent polyester
- External GPS Mounting plate
- Anti-skid mat
- Ratchet straps for securing GPR Sensor
- Fibreglass hold-down bars (only required for pulseEKKO GPR sensors)
- Wheel odometer (optional)
- 1 m Odometer extension cable (optional)
- GNSS receiver (optional)

The assembly procedure below assumes that you already have a pulseEKKO GPR sensor and associated cables to use with SmartSled. A fully assembled SmartSled is shown in *Figure 3-1*.



Figure 3-1: Fully assembled SmartSled

To begin assembly, place the anti-skid mat in the center of the sled, as shown in Figure 3-2. When the GPR sensor is placed on it, and secured with the ratchet straps, it will prevent the sensor from moving around during operation.



Figure 3-2: Anti-skid mat

3.5.2 pulseEKKO 250 MHz

Before placing the skid plate assembly in the SmartSled, attach the two fibreglass bars to the skid plate. To do this, remove the stainless steel “U” brackets, insert the fibreglass bars on both ends of the skid plate, and reinstall the “U” brackets. Now place the assembly, containing the pulseEKKO transducers, on the anti-skid mat in the SmartSled (*Figure 3-3*), centered in both directions. The cable connector plates should be tilted towards the front of the sled. Route the ratchet straps over the fibreglass tubes and along the sides of the transducers. Tighten the straps using the ratchet straps (use of ratchet straps are described in Section 3.5.8).

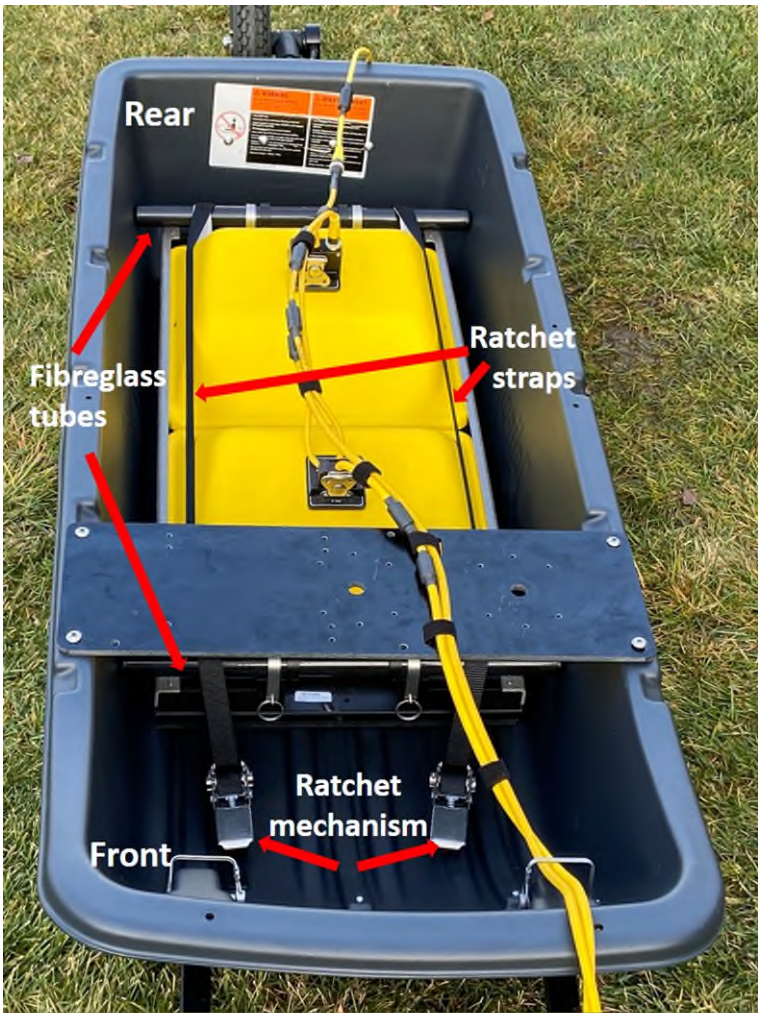


Figure 3-3: pulseEKKO 250 MHz GPR Sensor secured with ratchet straps

Secure the mounting plate as shown in *Figure 3-4*. It is important to connect this plate, even if you are not using the external GPS, as it serves as an anchor point for the cables, so they are not moving around during operation. For a full description of the mounting plate, see Section 3.5.5.

Insert the pulseEKKO transducer cables into the cable connectors on the Tx and Rx respectively, as shown in *Figure 3-4*. As illustrated, fasten the cables to each other, then to the mounting plate using the Velcro straps provided. The mounting plate has oval shaped cut-outs for the Velcro straps. Route the cables under the locking pin, as it makes it way towards the front of the sled. Cable management is described in detail in Appendix A.

If you are using the wheel odometer, connect the yellow odometer extension cable to the input on the rear-most transducer cable. Loop and secure any excess cable with the Velcro straps. The wheel odometer is described in Section 3.5.6.

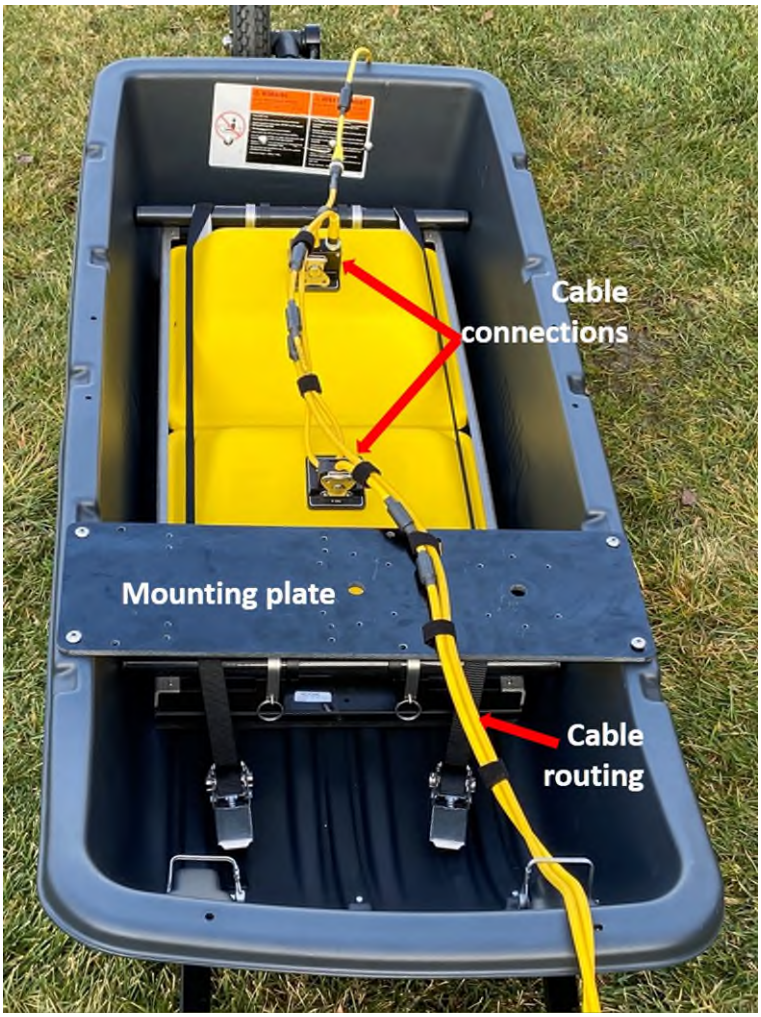


Figure 3-4: Inserting pulseEKKO cables and routing towards the front of the sled

Proceed to Section 3.5.5 to continue with the remainder of the assembly.

3.5.3 pulseEKKO 500 MHz

Before placing the skid plate assembly in the SmartSled, attach the two fibreglass bars to the skid plate. To do this, remove the stainless steel "U" brackets, insert the fibreglass bars on both ends of the skid plate, and reinstall the "U" brackets. Now place the assembly, containing the pulseEKKO transducers, on the anti-skid mat in the SmartSled (*Figure 3-5*), centered in both directions. The cable connector plates should be tilted towards the front of the sled. Route the ratchet straps over the fibreglass tubes and along the sides of the transducers. Tighten the straps using the ratchet straps (use of ratchet straps are described in Section 3.5.8).

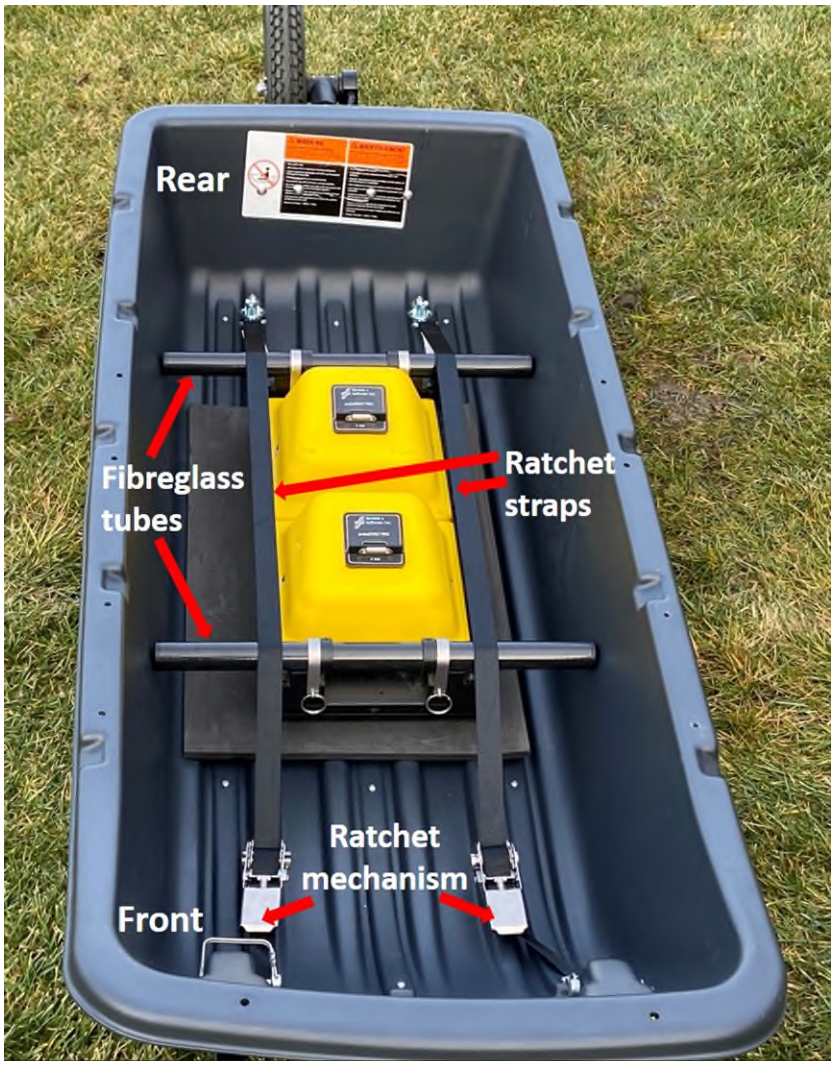


Figure 3-5: pulseEKKO 500 MHz sensor secured with ratchet straps

Secure the mounting plate as shown in *Figure 3-6*. It is important to connect this plate, even if you are not using the external GPS, as it serves as an anchor point for the cables, so they are not moving around during operation. For a full description of the mounting plate, see Section 3.5.5.

Insert the pulseEKKO transducer cables into the cable connectors on the Tx and Rx respectively, as shown in *Figure 3-6*. As illustrated, fasten the cables to each other, then to the mounting plate using the Velcro straps provided. The mounting plate has oval shaped cut-outs for the Velcro straps. Route the cables under the locking pin, as it makes it way towards the front of the sled. Cable management is described in detail in Appendix A.

If you are using the wheel odometer, connect the yellow odometer extension cable to the input on the rear-most transducer cable. Loop and secure any excess cable with the Velcro straps. The wheel odometer is described in Section 3.5.6.

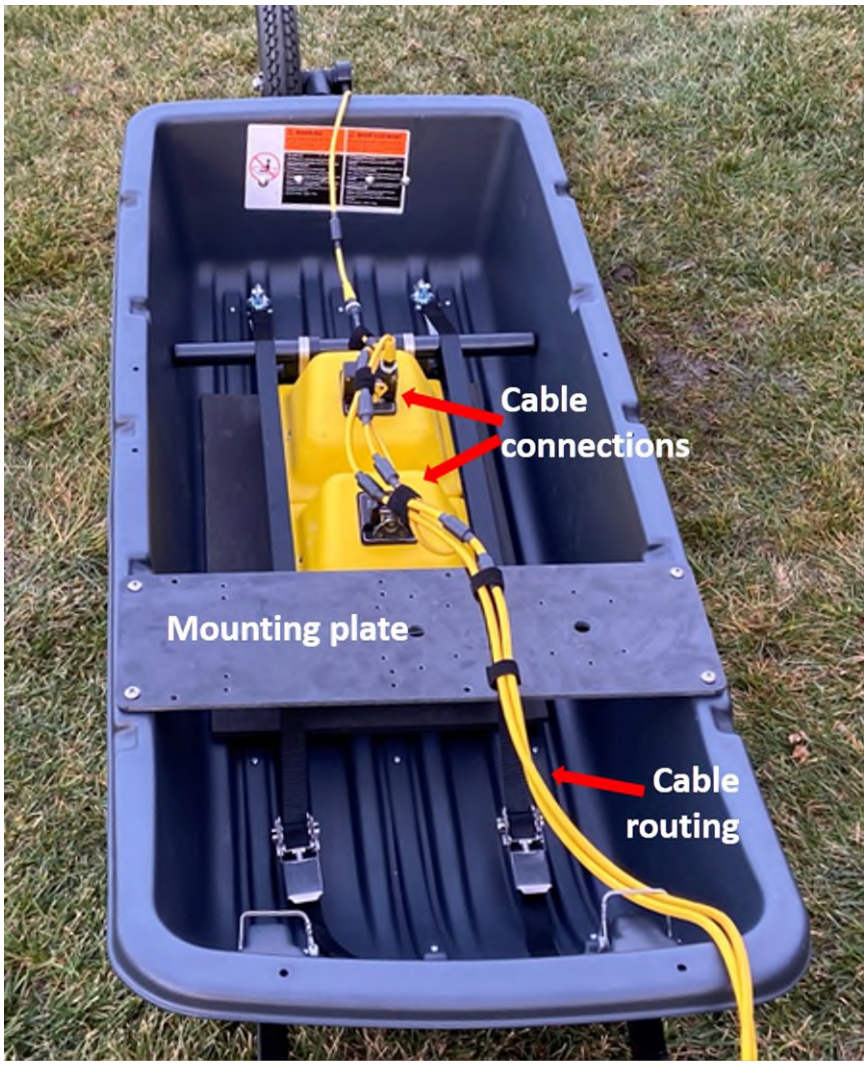


Figure 3-6: Inserting pulseEKKO cables and routing towards the front of the sled

Proceed to Section 3.5.5 to continue with the remainder of the assembly.

3.5.4 pulseEKKO 1000 MHz

Before placing the skid plate assembly in the SmartSled, attach the two fibreglass bars to the skid plate. To do this, remove the stainless steel "U" brackets, insert the fibreglass bars on both ends of the skid plate, and reinstall the "U" brackets. Now place the assembly, containing the pulseEKKO transducers, on the anti-skid mat in the SmartSled (*Figure 3-7*), centered in both directions. The cable connector plates should be tilted towards the front of the sled. Route the ratchet straps over the fibreglass tubes and along the sides of the transducers. Tighten the straps using the ratchet straps (use of ratchet straps are described in Section 3.5.8).

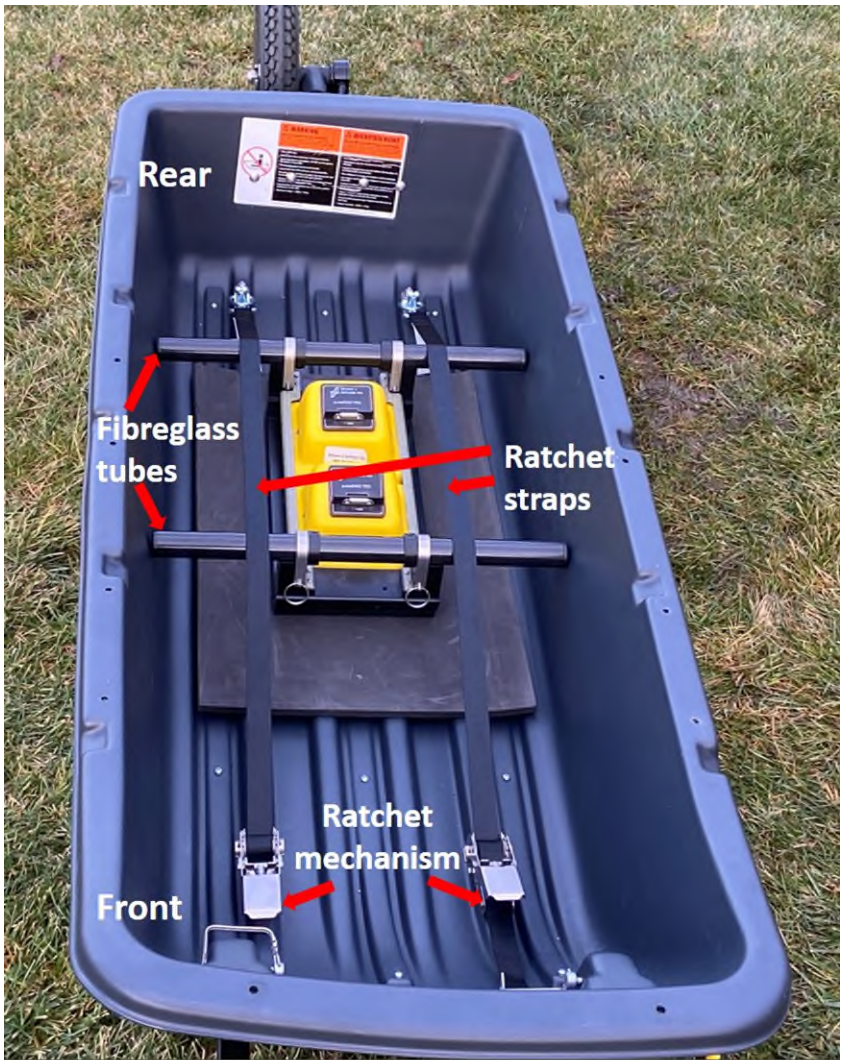


Figure 3-7: pulseEKKO 1000 MHz sensor secured with ratchet straps

Secure the mounting plate as shown in *Figure 3-8*. It is important to connect this plate, even if you are not using the external GPS, as it serves as an anchor point for the cables, so they are not moving around during operation. For a full description of the mounting plate, see Section 3.5.5.

Insert the pulseEKKO transducer cables into the cable connectors on the Tx and Rx respectively, as shown in *Figure 3-8*. As illustrated, fasten the cables to each other, then to the mounting plate using the Velcro straps provided. The mounting plate has oval shaped cut-outs for the Velcro straps. Route the cables under the locking pin, as it makes it way towards the front of the sled. Cable management is described in detail in Appendix A.
If you are using the wheel odometer, connect the yellow odometer extension cable to the input on the rear-most transducer cable. Loop and secure any excess cable with the Velcro straps. The wheel odometer is described in Section 3.5.6.

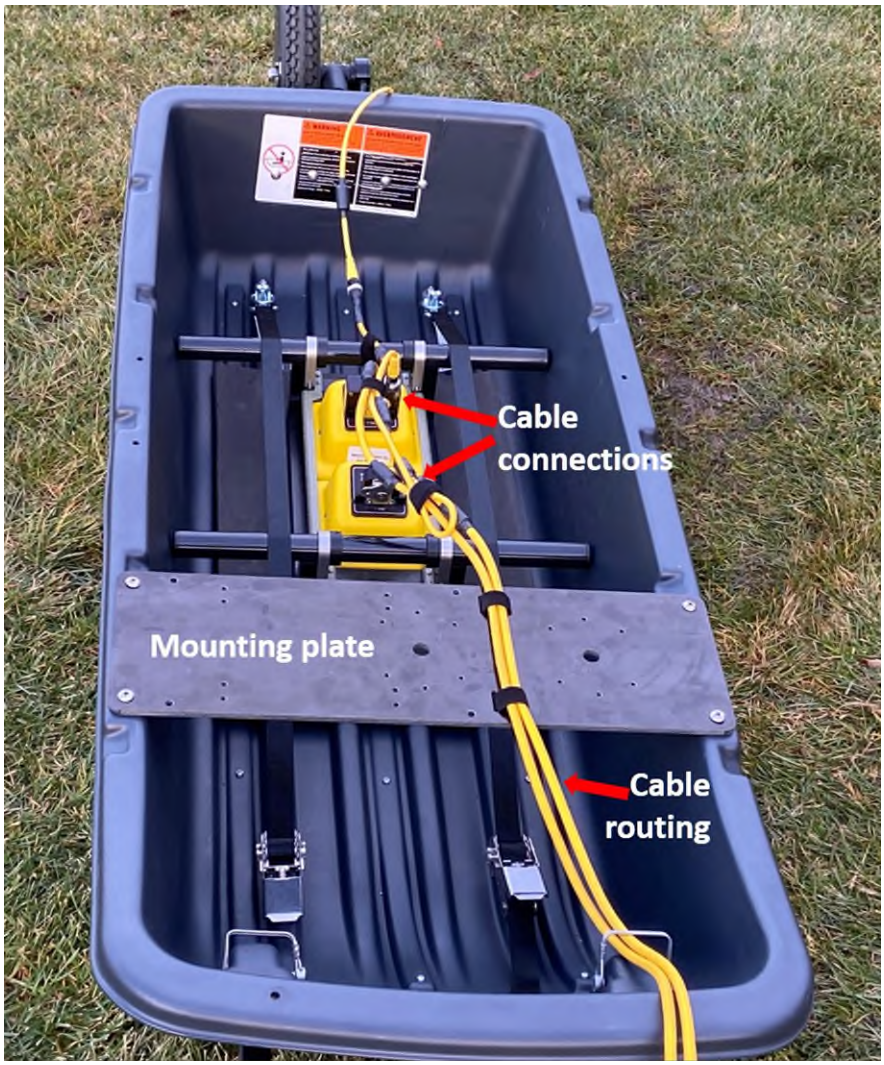


Figure 3-8: Inserting pulseEKKO cables and routing towards the front of the sled

Proceed to Section 3.5.5 to continue with the remainder of the assembly.

3.5.5 Mounting Plate for Optional GNSS & NIC-500

The mounting plate (Figure 3-9) is used to hold a GPS and if required, a NIC-500.



Figure 3-9: Mounting plate

There are several holes along both sides of the sled, that allow the mounting plate to be set in two different locations. Keep in mind the location of cables and the use of the GPS when you choose the position. If the GPS is not mounted directly over the GPR sensor, and you require very accurate GPS readings, measure the X, Y and Z offsets; the GPS offset can be corrected in the EKKO_Project software. For practical purposes, this may not matter since the GPS offsets will likely be very small compared with the overall size of the survey.

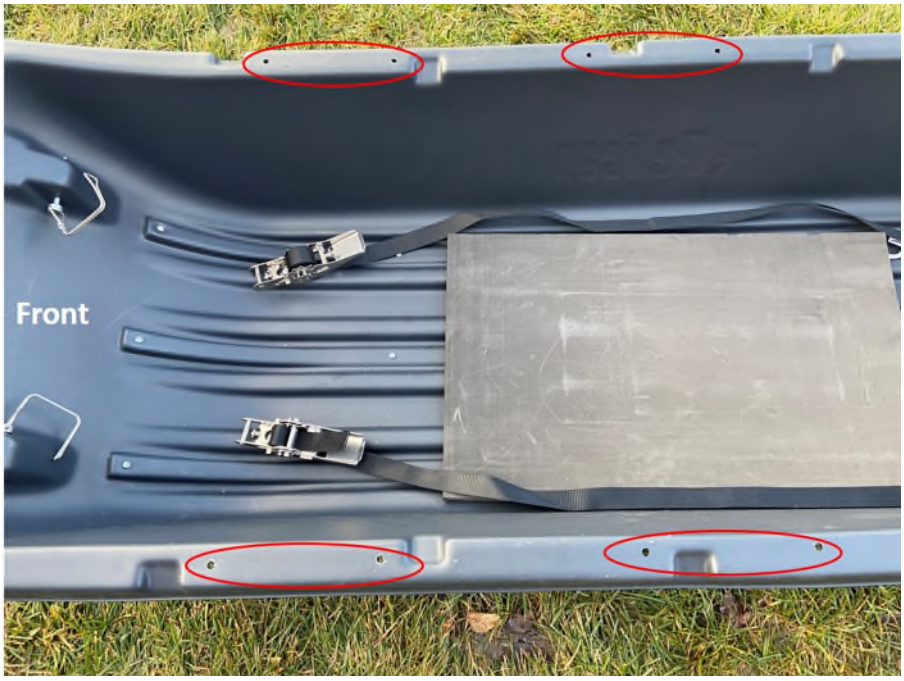


Figure 3-10: Two possible locations to attach the mounting plate

To attach the optional Topcon GPS supplied by Sensors & Software, line up the holes on the underside of the GPS (Figure 3-11) with the small pre-drilled holes in the mounting plate. Locate the bag marked “Topcon screws” and attach the GPS receiver to the mounting plate using the 3 supplied screws and washers. The completed setup in shown in *Figure 3-12*.

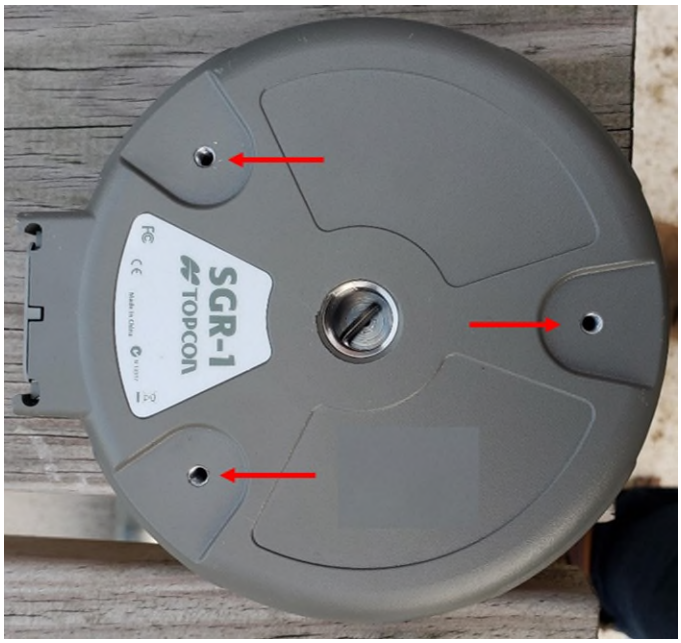


Figure 3-11: Underside of GPS showing the 3 holes for mounting

If you are using a different 3rd party GPS receiver which has a standard 5/8-11 UNC-1A thread (common to many GPS units), you can insert a mounting bolt up through one of the larger holes on the mounting plate. This mounting bolt can be supplied by the GPS manufacturer.



Figure 3-12: GPS receiver attached to the mounting plate

Secure the mounting plate with GPS to the sled using the supplied nuts and bolts. While the GPS connector can face the front or rear of the sled, it is preferred to have it face the front for ease of cable routing. Route the GPS cable along with the other cable(s) through the locking pin using Velcro as shown in *Figure 3-13*.

There are two positions where the GPS can be mounted. Keep in mind the position of the GPR cable and the routing of the other cables. SmartSled cable management is described in detail in Section 3.5.8.



Figure 3-13: GPS attached to mounting plate and cables routed properly. Two different GPS mounting positions are shown.

If connecting a SPIDAR NIC, secure it to the mounting plate by lining up the holes on the plate with those on the backing plate of the NIC. An example of a SmartSled showing a SPIDAR NIC and GPS is shown in Figure 3-14. For SPIDAR systems, contact Sensors & Software to discuss specific details about mounting and cable connections.



Figure 3-14: SPIDAR NIC and GPS connected to the mounting plate.

3.5.6 Wheel Odometer (optional)

The SmartSled can use a big wheel odometer mounted at the rear of the sled. The odometer triggers data collection at user-defined intervals as well as keeping track of distance travelled and current position, providing it has been calibrated.

The wheel odometer assembly is shown in *Figure 3-15*, along with the 1 m long odometer extension cable.



Figure 3-15: Wheel odometer assembly

To attach the wheel odometer, go to the rear of the SmartSled and insert the T-bar of the wheel odometer assembly into the mounting blocks at the rear of the sled. Ensure the side of the T-bar with the sticker “This side down” faces down. Secure with the U-bracket and pin as shown in *Figure 3-16*. Insert pins from the top down, to minimize the chance of them becoming loose, due to vibration when surveying.



Figure 3-16: Attaching the wheel odometer assembly

The completed assembly is shown in Figure 3-17.



Figure 3-17: Secured wheel odometer assembly

The cable from the odometer wheel assembly alone isn't long enough to reach the connector, so ensure the odometer extension cable is connected.

Then connect the odometer cable to the input of the pulseEKKO cable connector (*Figure 3-18*). If there is excess cable, it should be secured with Velcro, to prevent unnecessary movement. Cable management is described in detail in Appendix A.



Figure 3-18: Yellow odometer extension cable is connected to the pulseEKKO transducer cable

3.5.7 Tow Bar

SmartSled comes with a tow bar with a standard clam style hitch to connect to a tow vehicle. To connect the tow bar to the sled, remove the locking pins from the inside of the sled (*Figure 3-19*).



Figure 3-19: Removing locking pins

On the front of the sled, slide the tow bar into the slots as shown in *Figure 3-20*, then insert and close the locking pins that were previously removed in *Figure 3-19*.



Figure 3-20: Connecting tow bar to the SmartSled

The other end of the tow bar is a clam-style vehicle hitch, which can be attached to different types of vehicle hitch mounts.



Figure 3-21: Clam-style vehicle hitch

3.5.8 SmartSled Cable Management

In any GPR survey, it is important to minimize noise in the data. A major source of noise can be improperly routed cables. GPR sensors contain dipole antennas that transmit and receive GPR energy. Cables that are close to the antennas, and not routed properly, can introduce ringing noise in the data, making it much harder to interpret and notice subtle features in the data. When cables must pass close to the antennas (as in the SmartSled configuration), there are two things to keep in mind:

1. Route cables down the middle of the GPR sensor

2. Tie up any excess cable length, so they do not bounce around during operation. Velcro straps are supplied for this purpose.

In Figure 3-22, the transducer cables for the pulseEKKO 250 MHz sensors are routed down the middle of the sensors, along with the odometer cable. The excess odometer cable is secured to the transducer cables with Velcro to minimize movement.



Figure 3-22: Routing and securing cables for the pulseEKKO 250 MHz sensors

In Figure 3-23, the pulseEKKO 1000 MHz sensors are shown. Once again, the transducer cables are secured to each other and to the odometer cable. They are then secured to the mounting plate. Finally, the cables are run underneath the locking pin and secured to the tow bar itself (Figure 3-24). Leave a little slack to allow for the tow bar to move around freely during the survey.



Figure 3-23: Routing and securing cables for the pulseEKKO 1000 MHz sensors



Figure 3-24: Securing cables to the tow bar

In rare situations, you may do a survey with the antennas rotated 90°. In these cases, the cables cannot be run down the middle as shown above. Contact Sensors & Software to discuss the best way to route cables for these special scenarios.

3.5.9 Using the Ratchet Straps

Ratchet straps are a fastening method to secure various types of cargo (*Figure 3-25*). In SmartSled, ratchet straps are used to secure the GPR sensor so it does not shift while surveying.

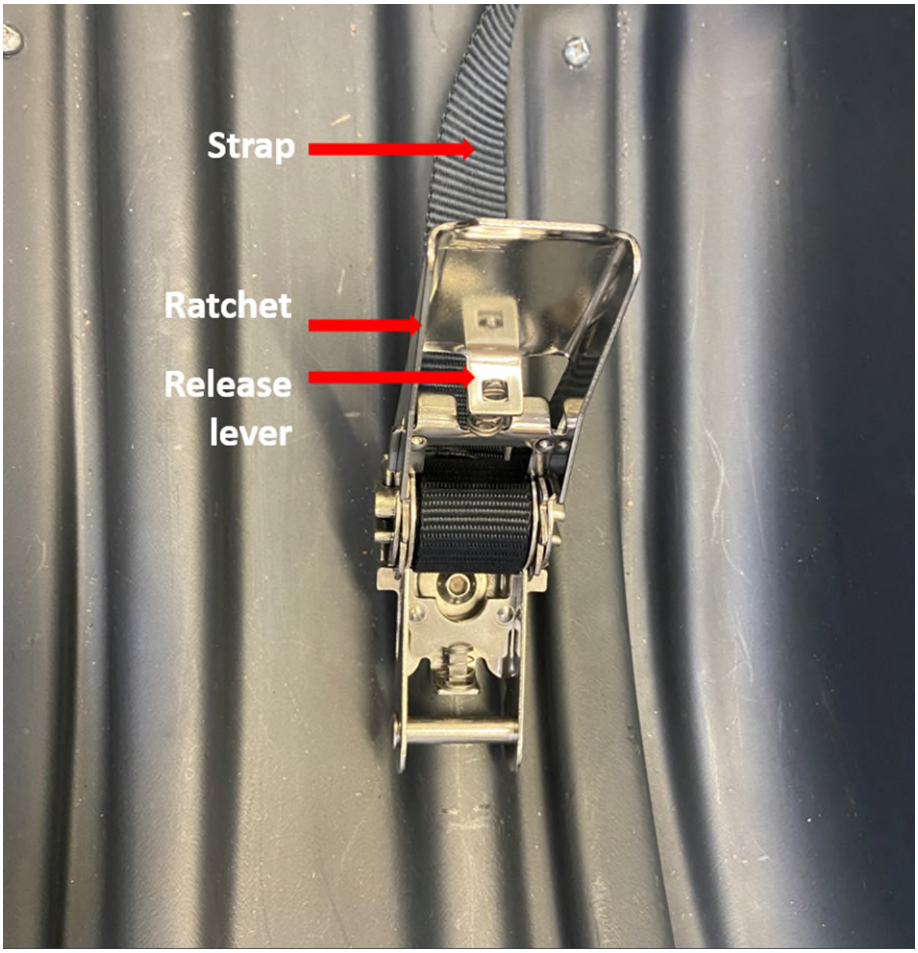


Figure 3-25: Parts of the ratchet mechanism

Once the straps are placed over the sensor, the ratchet needs to be tightened. First, make sure the strap is threaded through the ratchet mechanism. Then straighten the ratchet base and make sure it's in line with the strap. Now, pull the ratchet handle back and forth; you will feel the strap tighten. Be careful not to over-tighten as too much pressure could damage the ratchet mechanism, the GPR or the fiberglass tubes (pulseEKKO systems). Once the GPR feels secure, stop ratcheting and close the ratchet (Figure 3-26) to ensure it doesn't loosen.



Figure 3-26: Ratchet closed

To loosen the straps, pull up on the release lever and open the ratchet 180º so that it is completely open; you will hear click when this happens. This will release the ratchet “lock” and you can pull the straps to give it some slack (*Figure 3-27*).

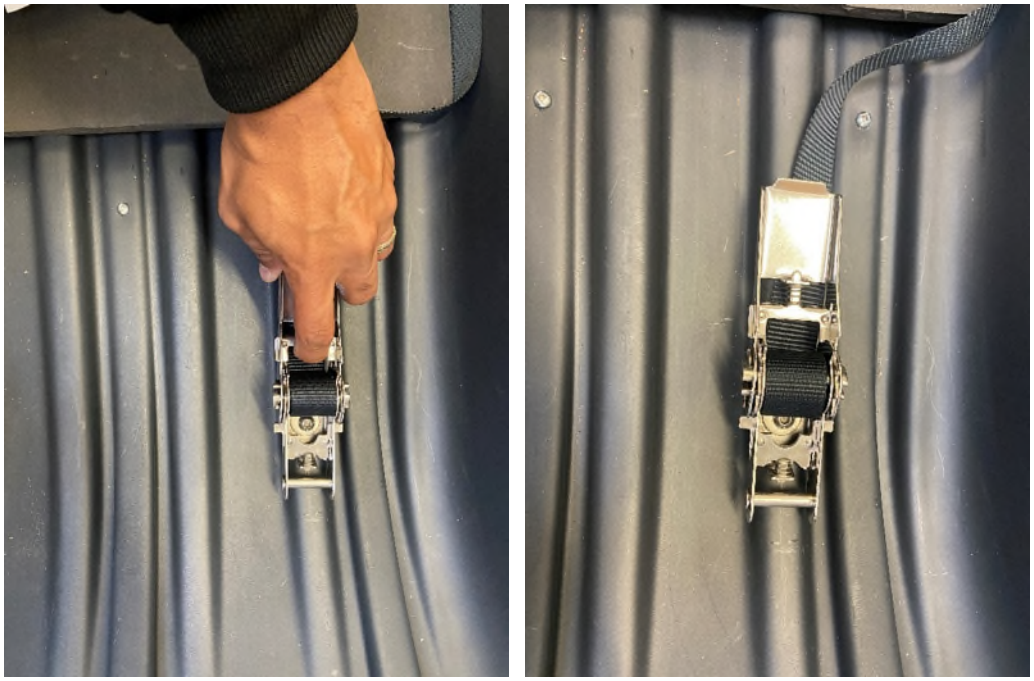


Figure 3-27: Pulling on the release lever (Left) and completely opening the ratchet (Right)

3.5.10 DVL Collection Parameters for SmartSled

If you are using the wheel odometer, on the DVL set the Trigger method to **Odometer**.

If you are not using the wheel odometer, set the Trigger method to **Free Run**.

When setting the data collection parameters on the DVL, you need to consider step size, the depth setting and the number of stacks (or DynaQ if using the wheel odometer). If you plan on travelling fast, you may need to increase the step size or decrease the depth setting, to avoid skipping data.

3.5.11 SmartSled Operation & Tips

Below are some things to keep in mind when using the SmartSled:

- The speed of operation will depend on the evenness of the terrain, step size interval, depth of penetration and observation of data quality.
- Since SmartSled is expected to be used in rough terrain (not suitable for SmartCart operation), it is normal for the wheel to bounce around a little bit. However, if the wheel is bouncing around too much, and the data looks choppy, consider slowing down.
- The SmartSled cover should be used to protect the equipment from the elements, especially when operating in rain or snow.
- Do not place any other items in the sled, especially items that are metallic. This can interfere with the GPR signal and cause unwanted effects.
- Make sure to secure the cables near the connection point between the sled and the tow vehicle. Leave a little slack to allow for full range of movement, but make sure they are secure, so they don't come loose and start dragging on the ground.

3.6 Connecting Cables

It is recommended to only connect cables after the entire system is assembled and powered off.

3.6.1 Cables

There are several types of cables available to pulseEKKO users: fibre optic, transducer, power, GNSS and odometer cables. These cables are available in different lengths, depending on the type of survey you are doing.









3.6.2 Connecting Fibre Optic Cables

pulseEKKO systems use two dual fibre optic cables with the low frequency transmitter and receiver.

Fibre optic cables typically come in the following lengths:

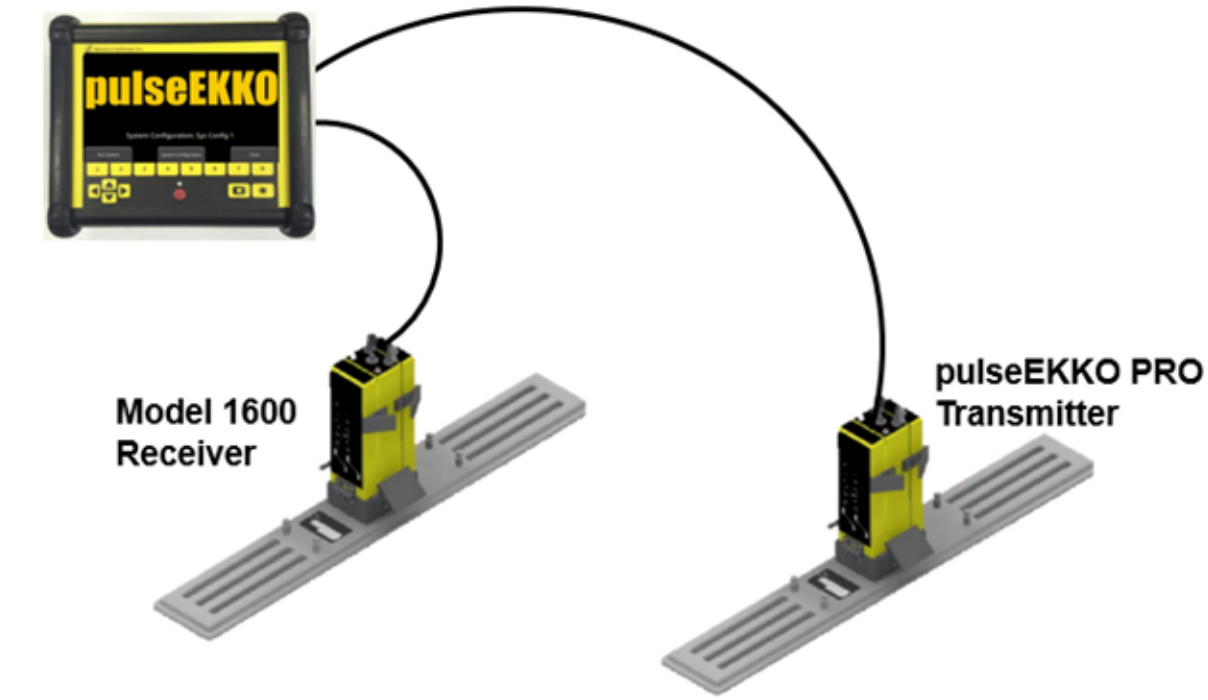
- 5 meter cables are standard for the Bistatic (3.1) system.
- 2.5 meter cables are used with the SmartCart Assembly (3.2).
- 20 meter cables are used with the 12.5, 25 and 50 MHz antennas or for all antenna frequencies when collecting low frequency Common Mid-Point (CMP) (6.2.1), Wide Area Reflection and Refraction (WARR) (6.2.1) or Transillumination survey data (6.2.1).

The Care and Maintenance section describes how to care for Fibre Optics Cables (13.2), and repair them if necessary (see Fibre Optics Cable Repair, 13.2.2).

The connections will be slightly different depending on which receiver is being used: the PRO receiver (Model 1600) or the Ultra receiver (Model 3200).

Receiver – Model 1600

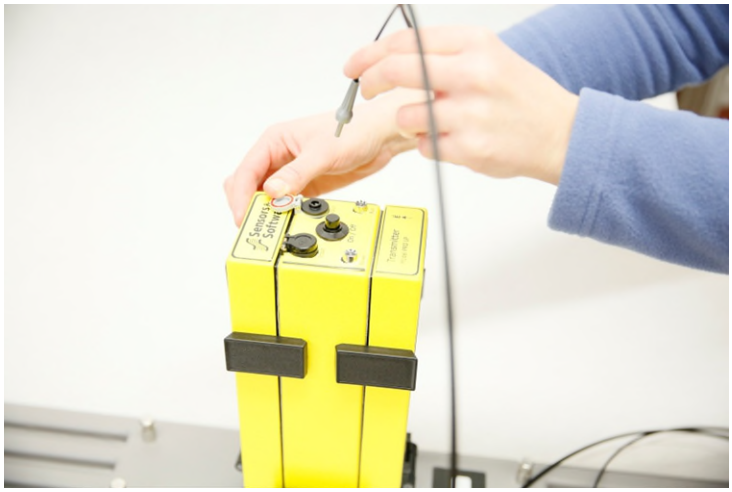
The black and gray strain reliefs on the end of the cable plug into the same colored fibre optic receptacles on the top of the transmitter and receiver. The other end of the cable connects to either receptacle on the back of the DVL.





To connect the pulseEKKO cables:

1. Plug the dual fibre optics cable into the transmitter. Make sure the color on the strain relief jacket matches the color of the receptacle door: black to black and grey to grey.



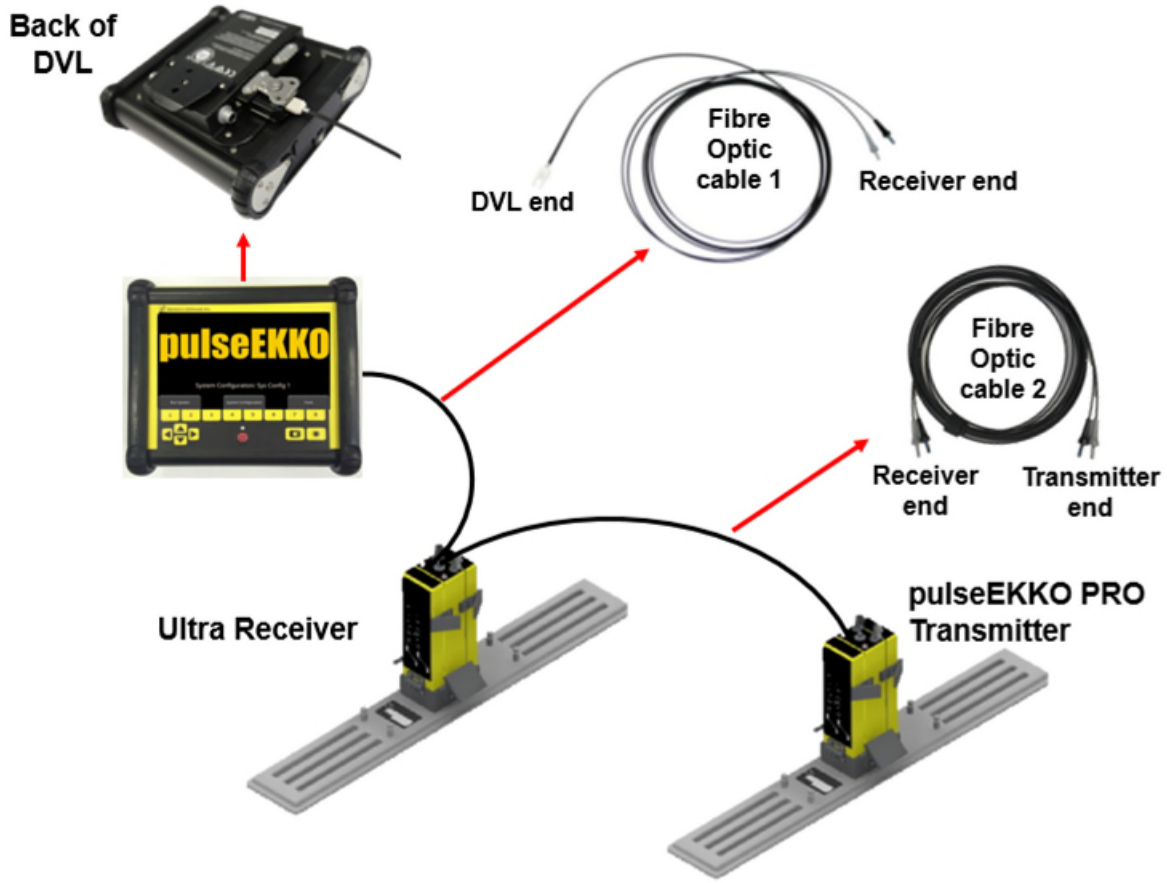
2. Install the fibre optic connection by pushing gently until the connection clicks into place.

Attach the other end of the fibre optic cable to the fibre optic converter on the back of the DVL. The fibre optic connection is keyed and will only attach properly in one orientation. Make the same connections for the other cable.



Ultra Receiver (Model 3200)

The fibre optic cable connections for the Ultra (Model 3200) Receiver are different. The Ultra Receiver employs a serial connection running from the DVL to the Ultra Receiver and then from the Ultra Receiver to the transmitter.



As a result, there are two different cables used.



1. Using the cable 1 shown above, connect the receiver end to the ports labelled DVL on the receiver, by pushing gently until the connection clicks into place. Make sure the color

on the strain relief jacket matches the color of the receptacle door: black to black and grey to grey.



2. Attach the other end of the fibre optic cable to the fibre optic converter on the back of the DVL. The fibre optic connection is keyed and will only attach properly in one orientation.



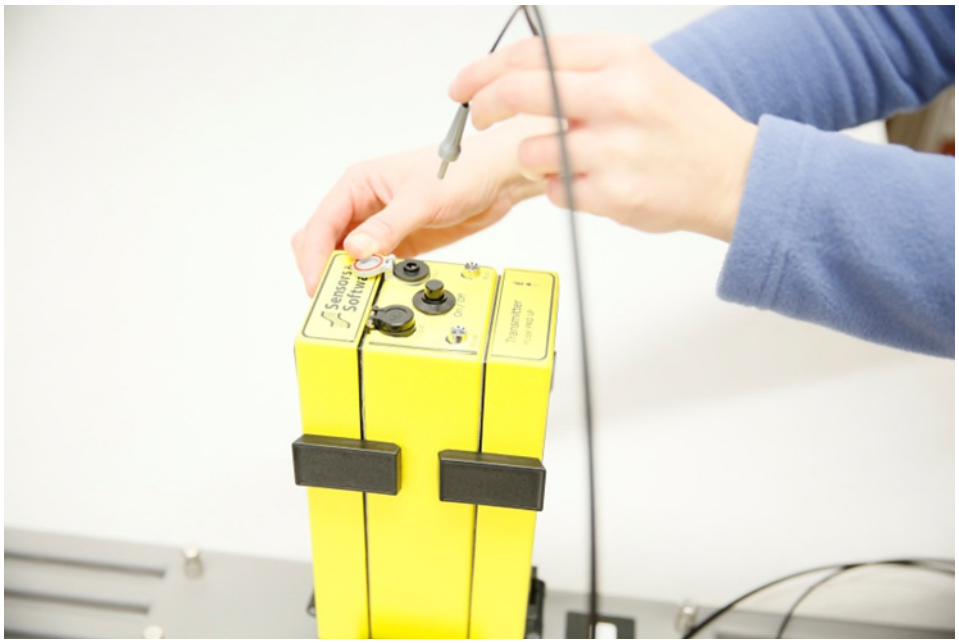
3. The next connection uses a special dual fibre optic cable 2, where both ends are identical.



4. Connect one end of the cable to the ports labelled **Tx** on the Receiver.



5. Gently push the Fibre Optic cable end until the connection clicks into place. Make sure the color on the strain relief jacket matches the color of the receptacle door: black to black and grey to grey



6. Connect the other end to the transmitter, again matching black to black and grey to grey.

You can use an older pulseEKKO 100 transmitter with the pulseEKKO PRO and Ultra Receivers (see Transmitters, 6.1.6).

> **Note**: If you are using a pulseEKKO 100 transmitter, do not connect the fibre optic **Output** connection on the transmitter.

3.6.3 Connecting Transducer Cables

Transducer cables connect the transducers to the DVL and are available in 2-, 3-, 10-, and 30-meter lengths.



Connect the female end of each transducer cable to the transducers. Secure the connection with the latch.



Connect the male end of the transducer cables from the transmitting and receiving transducers to the back of the DVL. The electronics recognize which device is connected to which receptacle. Secure the cable attachments with latches.



3.6.4 Connecting Cables with an Odometer Receptacle

Some configurations, such as SmartTow and SmartChariot are supplied with transducer cables that support odometer input. Attach an odometer cable to the receptacle at the transducer end of the odometer transducer cable.



3.7 Accessories

The following accessories can be connected to the pulseEKKO system:

- Triggers
- Harness
- GNSS

These are explained in detail below:

3.7.1 Wireless Trigger

A trigger is used to fire the GPR transmitter to collect a trace of data. There are several ways to trigger the GPR system to collect a data trace; these include Odometer, Manual/Button and Free Run. These options are set in Trigger Method (6.2.3)

If the system has an odometer wheel, such as the SmartCart, SmartTow, SmartChariot or TR1000 configurations, that is usually the preferred triggering device. However, for bistatic operation or other special cases, there is an option to use the optional wireless trigger button, shown below. Details on configuring and pairing this device is explained in Section 5.1.7.



Once the trigger is paired with the DVL-500 and working, simply press the button on the device to trigger data collection.

3.7.2 Harness

The Harness is a convenient option for mounting the DVL when acquiring data using the SmartTow and SmartHandle configurations:



The DVL will connect to a mounting platform, which will then connect to the harness. The viewing angle of the DVL can be adjusted to suit the user.

3.7.3 GNSS Supplied by GPR Manufacturer

If you have purchased the Juniper Geode GNSS receiver from Sensors & Software, it comes pre-programmed for use with the pulseEKKO DVL.

Warning: NEVER press the Juniper Geode power button for more than 5 seconds. This reset its programming, resulting in no communication with the DVL. If this occurs, the Geode will need to be reprogrammed. Contact Sensors & Software for assistance.

Ensure that the DVL-500 is powered down when connecting or disconnecting the GNSS cable.

Use the custom 9-pin (serial) cable labeled "GPR-Juniper Geode GNSS Cable"; it has internal wiring is different than a standard serial. Using a different cable result in unexpected behaviour.

Connect the 9-pin male end of the cable to the GNSS receiver, and the female end to the 9-pin serial port on the back of the DVL-500. This single cable is used to both power the GNSS and receive positional data from it.





Setting Up GNSS in DVL-500 Menu

The GNSS must be enabled in the DVL-500's menu. Go to **Tools > System Test > GPS > GPS Setup** and set:

GPS Mode = External

Format = Lat/Lon

Serial Port Power = On (say Yes on the warning screen that appears).

Then press Exit/Back from each menu to return to the main menu.

For more details, see Section 5.2.5.

Should some of the settings change, download the Geode Connect app to a cell phone, connect to the Geode and use the following settings:

- Baud Rate = 19200
- Saved Strings = GGA only

GNSS Internal Battery and Cable

The Geode GNSS has an internal battery that can be charged using the supplied USB-C cable and wall charger block, however this is not necessary when using the GNSS cable and settings listed above.

A standard 9-pin straight-through, Male/Female serial cable (not supplied) can be used to connect the Geode GNSS to the Display Unit, but if so:

1) The serial port power on the Display Unit **MUST** be turned OFF (see Section 5.2.5).
2) The Geode GNSS will be powered using its internal battery, so it will be necessary to charge it separately using the wall charger block and USB-C cable, supplied with the Geode.

3.7.4 3rd Party GNSS

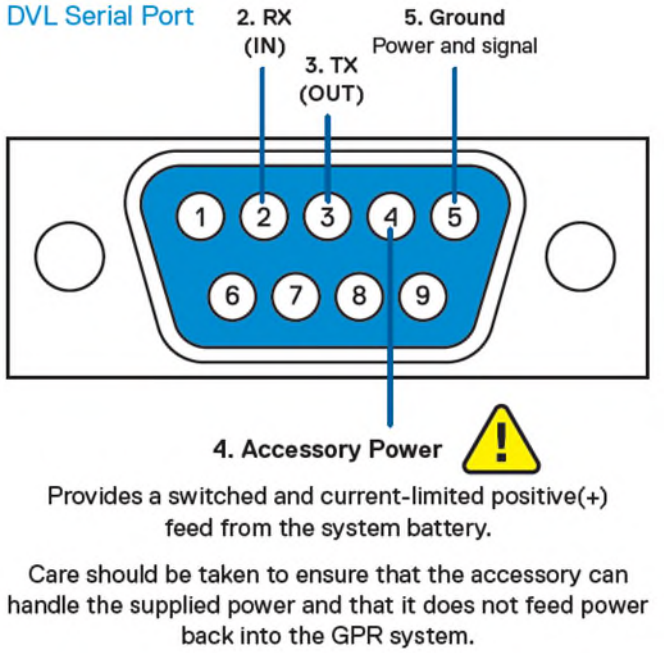
To connect and utilize a 3rd party GNSS with the pulseEKKO DVL, it must meet the following criteria:

- Be able to communicate over RS232 with a standard 9-pin serial output cable
- Output a NMEA GGA string in ASCII format, at a rate no faster than 20 Hz
- Set the following parameters:
    - Baud rate = 19200 bps
    - Parity = None
    - Stop Bits = 1
    - Data Bits = 8
- If it cannot safely accept power via the serial port (as shown below), it must have its own battery or way of receiving power.
- GNSS must not expect any handshaking from the DVL

NOTE: Since the serial port of the DVL-500 outputs power (current=1A, voltage=12V), it is the responsibility of the user to confirm with the GNSS manufacturer that the serial cable does not provide power to the GNSS or that the GNSS will accept 12V power from the serial cable on the pins shown above.

Sensors & Software is not responsible for damage caused to a GNSS from using the serial port.

You can enable or disable power to the serial port, see Serial Port Power in 5.2.5.



4. Getting Started

4.1 Powering up the Low Frequency Transmitter & Receiver

Once all connections are made between the DVL and the antennas/transducers, odometer and accessories, turn the transmitter and receiver on by pressing the **On/Off** button on the top of the units (Figure 4-1).



Figure 4-1: Turning on the Transmitter

- The red Power LED on the top of the unit will flash five times and then stay on to indicate the unit is ready for operation.
- If the unit doesn't turn on, check that the transmitter and receiver batteries are fully charged and installed correctly. See Section 2.1.3 for details.

> **Note**: If you are not collecting data for more than 15 minutes, turn the transmitter and receiver off to increase the life of the batteries.

4.2 Powering up the DVL

> **Note**: **If you are using Low Frequency antennas, it is recommended to power on the Transmitter and Receiver prior to turning on the DVL.**

Make sure the power cable is plugged into the back of the DVL (Figure 4-2).

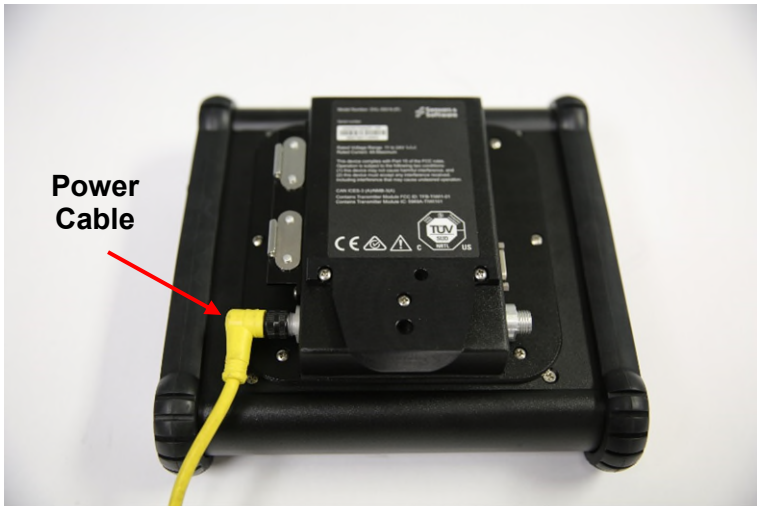


Figure 4-2: Connecting power cable into back of DVL

Connect the other end of the cable to a 12-volt power source; typically, this is either the large battery or the belt battery, pictured in Figure 4-3.

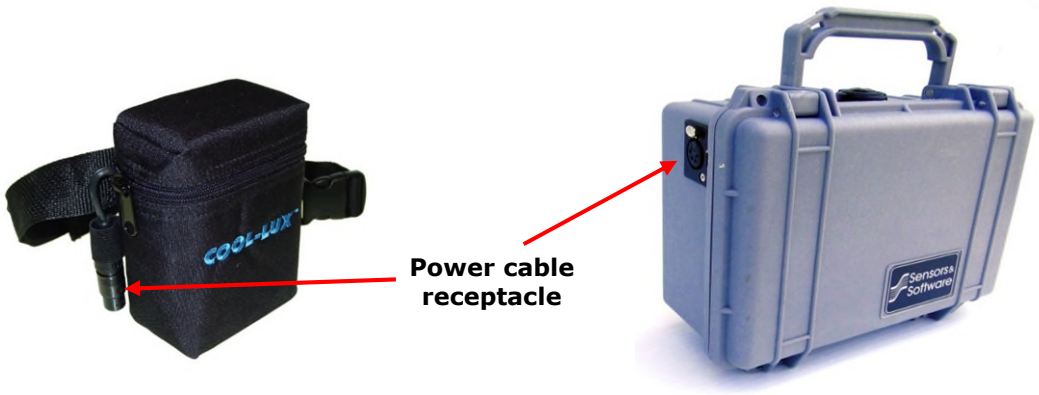


Figure 4-3: Belt battery (left) and Large battery (right).

Connect the round four-pin power cable to the receptacle on the side of the battery (Figure 4-4). When the battery is first plugged in, the LED light turns green for 5 seconds then turns off.



Figure 4-4: Connecting to belt battery

To start the system, press the **red power button** on the DVL (Figure 4-5). The LED on the front panel will light up red.



Figure 4-5: Buttons pressed when turning on DVL

Once boot up is complete, the color of the LED will indicate the amount of battery power remaining:

- 20% to 100% = green
- 10% to 20% = orange
- 0% to 10% = red

The first time you turn on the DVL, you will see a Start-Up Wizard. A series of screen prompts will allow you to setup the language, units, date & time, and additional options. You will need to enter these settings again anytime you update the embedded software (Section 13.6). Every subsequent time the system boots up, you will see the main screen (Figure 4-6).

If the system boots up, but no antennas or transducer is connected, you will see the warning message in Figure 4-7.



Figure 4-6: Main screen after bootup

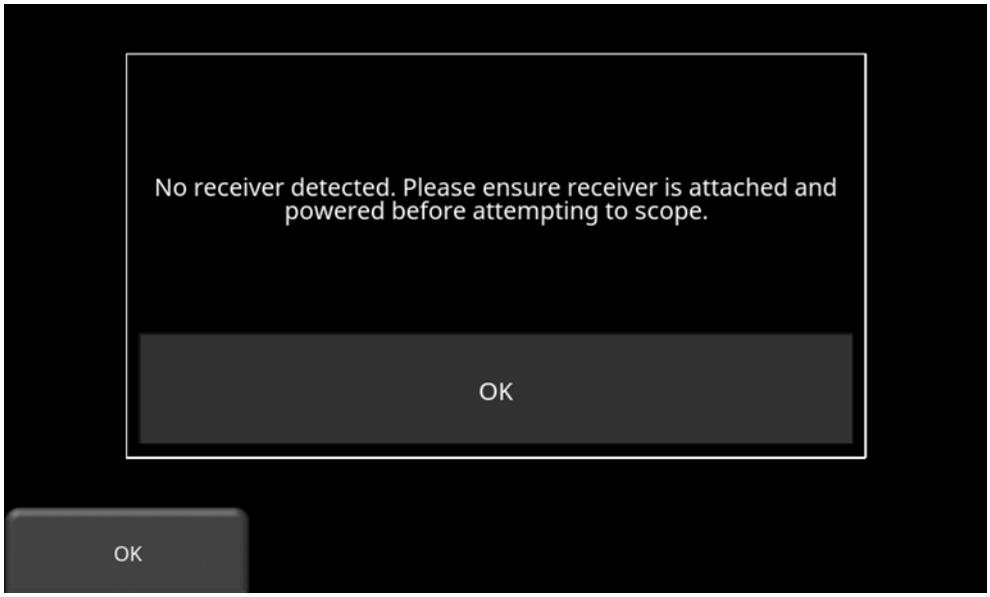


Figure 4-7: Warning message that no antenna or transducer is connected

4.3 Interacting with the DVL

Data collection is controlled by the DVL Display. The DVL can set survey parameters and collect, display and store data. It offers touch screen operation, as well as a keypad with a number of buttons that can be pressed to perform various tasks. Most operations can be done using either the touch screen or the keypad.

Use the following table as a guide to working with the keypad:

Item	Description
Menu Buttons 	The yellow buttons labelled 1 to 8 correspond to menu choices that appear on the screen.
4-way directional keypad 	Controls Up/Down/Left/Right operations in certain menus.
Camera 	Saves an image of what is displayed on the screen.
Asterisk / Special Function 	Used for adding Flags during data acquisition.

4.4 Swipe Down menu

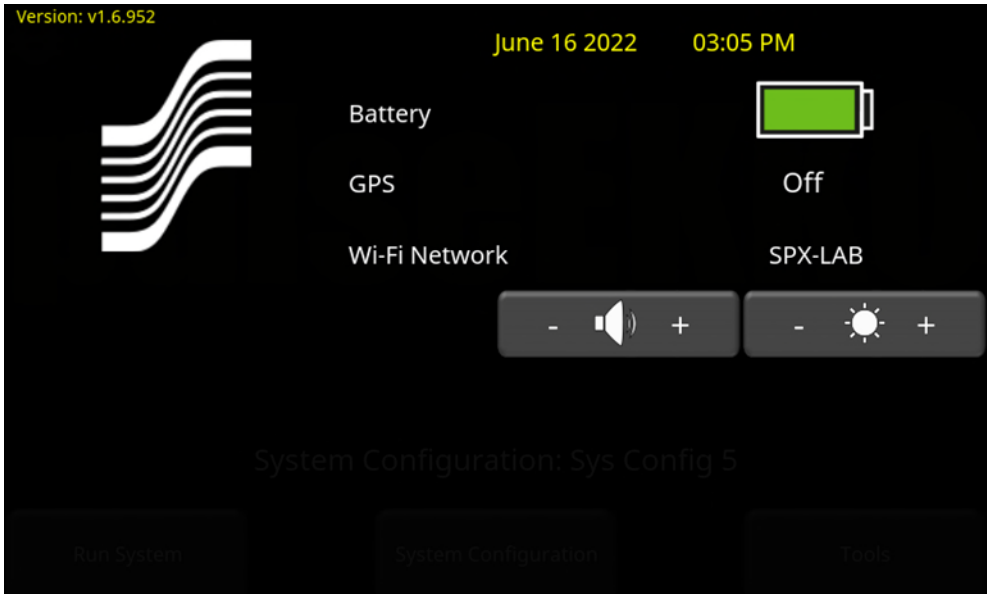


Figure 4-8: Swipe down menu

When the DVL is powered on, you can “swipe” your finger from the top of the screen towards the bottom, to display a Swipe-Down menu (Figure 4-8) with the following items:

Date and Time: The current date and time (12-hour clock). (See Section 5.1.6 for more details).

Battery: The battery icon displays the amount of power remaining in the main battery. Note the low frequency Transmitter and Receiver battery levels are not shown.

GPS: Shows which GNSS is being used (Internal or External) and the signal strength. Refer to Section 5.2.5 for more details.

Wi-Fi Network: Indicates if the system is connected to a wireless network and, if so, the name of the network. See Section 5.1.8 for details on connecting the system to a wireless network.

Volume: The Volume + and - buttons are used to increase and decrease speaker volume.

Brightness: The Brightness + and - buttons are used to increase and decrease the screen brightness. For example, increasing the Brightness setting may improve the visibility of the screen in bright sunlight. However, increasing the screen brightness also increases power consumption, thus reducing battery life.

To close the Swipe-Down menu, touch anywhere on the screen below the swipe-down menu.

To power down the DVL, press the **red power button** on the DVL once. A confirmation message will appear, after which you can press **Yes** to proceed. If necessary, a hard shutdown can be done by pressing and holding the red power button until the DVL shuts down.

4.5 Quick Start for Collecting Data

While it is recommended that you go through the Tools and System Configuration to ensure that everything is properly configured, sometimes the user just needs to quickly get the system setup and collecting data. This section gives a quick overview of what you need to do prior to surveying.

1. Set Units (5.1.2) to Metric or Us Standard.
2. Go to System Configuration (6) and input the Survey Type, Antenna Frequency, Time Window/Depth and Step Size.
3. Go into Scope Mode (0) to set the First Break properly.
4. From the main menu, select Run System (7) and then select a Project number.
5. Enter Line Scan (7.1) to collect individual lines or Grid Scan (7.2) to collect a grid of data and create depth slices
6. When the survey is finished, insert a USB memory stick into the DVL and export all data (5.3.4) or go to File Management (5.3) to export and view only certain projects.

5. Tools and Preferences

Once the system boots up, you will see the main screen below in Figure 5-1



Figure 5-1: pulseEKKO main screen

The Tools option allows you to set global Preferences (such as language, date/time and Wi-Fi, etc.), conduct System Tests to verify proper component operation and Manage/export data files.

Press **Tools** to enter this sub-menu. You will see the screen shown in Figure 5-2.

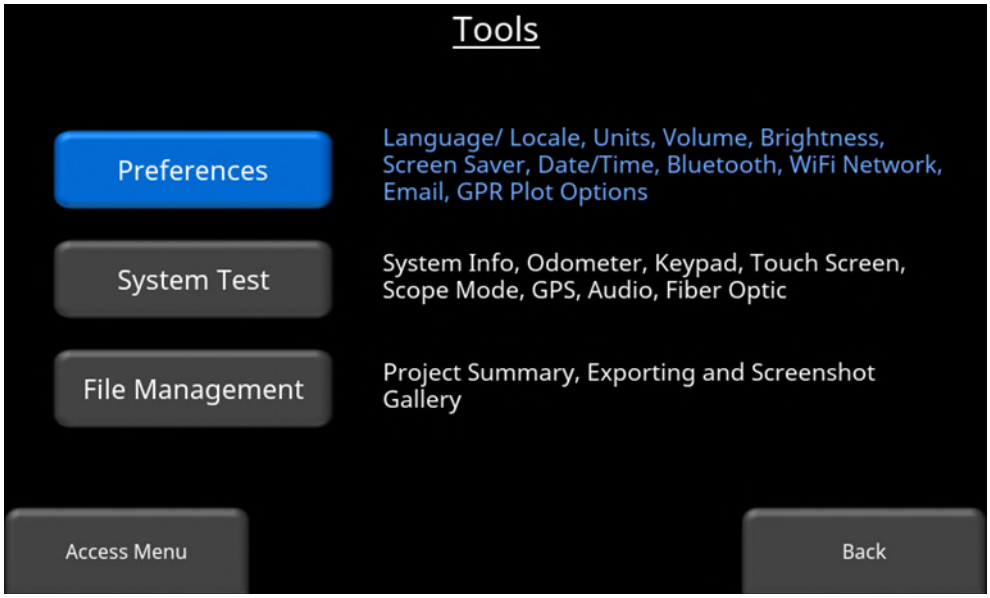


Figure 5-2: Tools menu

Press the desired button directly on the touchscreen to select a menu or use the 4-way keypad to highlight the desired option, then press **Access Menu** in the lower left side.

5.1 Preferences

Selecting the preferences option will take you to the sub-menu shown in Figure 5-3.

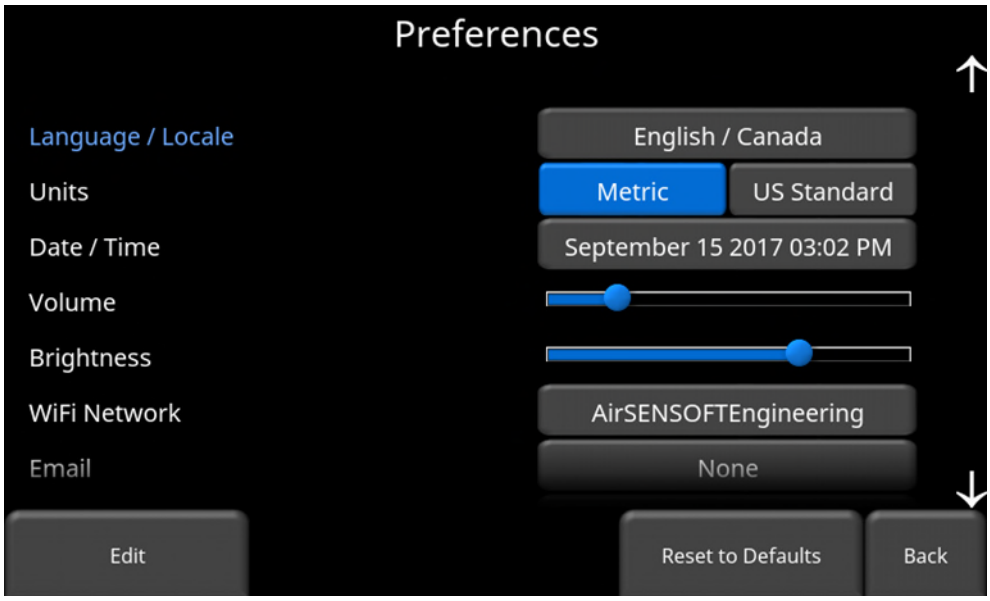


Figure 5-3: Preferences Menu

To change parameters, you can either:

- directly touch the buttons on the right side of the screen
- use the 4-way keypad to select the desired parameter then press the **Edit** button in the lower left side

To access parameters not currently shown, touch anywhere on the screen and swipe up or down.

For some parameters, it will take you to a sub-menu where you can configure the options, whereas others will toggle on the screen. The parameters are explained below:

5.1.1 Language/Locale

Pressing this button takes you to a sub-menu where you can set the language and country/region (Figure 5-4).

The current language is displayed. Pressing the **+** and **–** buttons on either side of the current language will cycle between available languages.

Below that, the Country/Region is displayed. Pressing the **+** and **–** buttons on either side of the Country/Region will allow you to alphabetically move to the next or previous country.

Alternatively, you can also change the Language and Country/Region at the bottom of the screen. Press **Back** to accept changes and return.

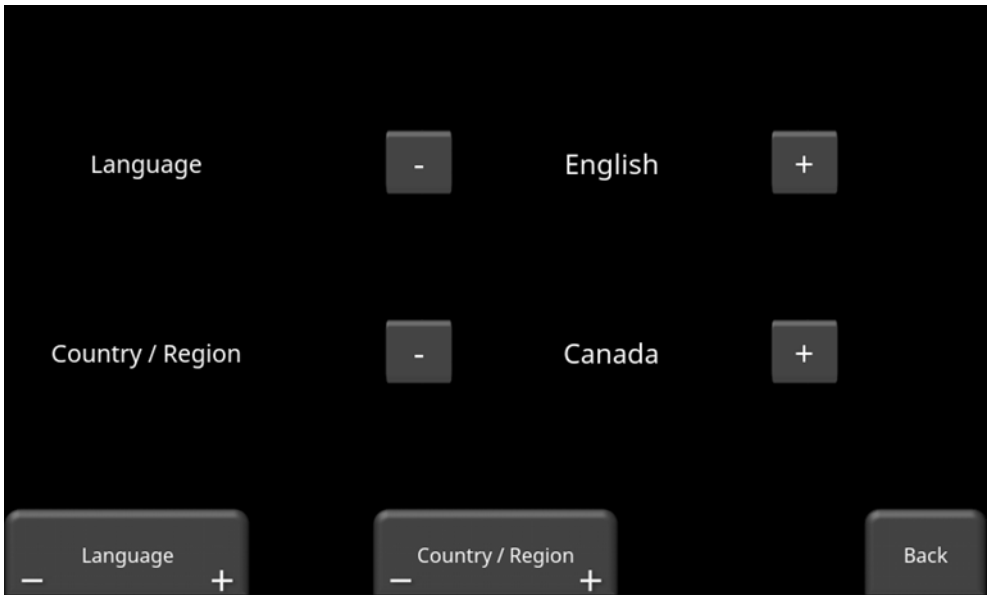


Figure 5-4: Setting the Locale

5.1.2 Units

Toggles between US Standard and Metric Units.

5.1.3 Volume

Adjusts the volume of the speaker. This can also be changed by using the Swipe Down menu (4.4) anytime the system is not collecting data.

5.1.4 Brightness

Adjusts the brightness of the screen. Note that increasing the brightness consumes more battery power. This can also be changed by using the Swipe Down menu (4.4) anytime the system is not collecting data.

5.1.5 Screen Saver

A screen saver can be setup to turn off the DVL screen after a period of inactivity to save power. The Screen Saver can be set to turn the screen off after 1 minute, 5 minutes or never (OFF setting). Pressing this button cycles between those three options. When the screensaver is activated and the screen shuts off, touch anywhere on the screen to turn it back on again.

5.1.6 Date / Time

Pressing this button takes you to a sub-menu where you can set the Date and Time, see Figure 5-5. The time is manually set and will not automatically correct for daylight savings time.

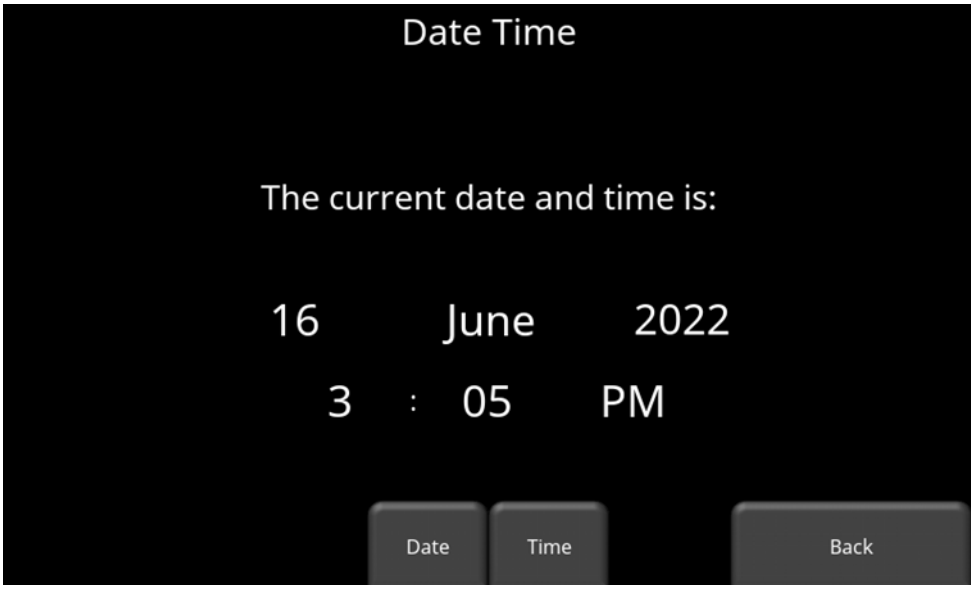


Figure 5-5: Setting the date and time

5.1.7 Wireless Trigger

One of the options for the GPR Trigger option is to press a wireless remote to collect each GPR data trace (GPR Trigger)

To pair the pulseEKKO DVL to a wireless remote, press the **Bluetooth** button to display the set-up screen (Figure 5-6). The system will detect and display the name of all the Bluetooth devices in the area. To make it easier to identify the correct device, if possible, turn off other wireless devices nearby.

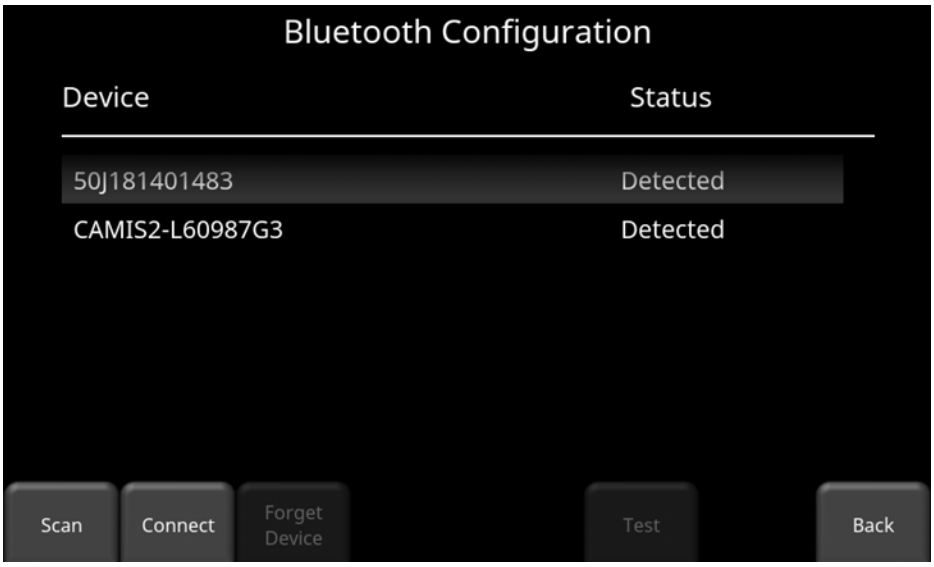


Figure 5-6: Configuration screen

To use a wireless remote, begin by putting the remote into “pairing mode”.

If the remote name is not displayed on the DVL screen, put it in pairing mode and then press **Scan** (this may take a few scan attempts to find the remote).

Once paired, the remote name will be displayed in orange on the screen, as show in Figure 5-7.

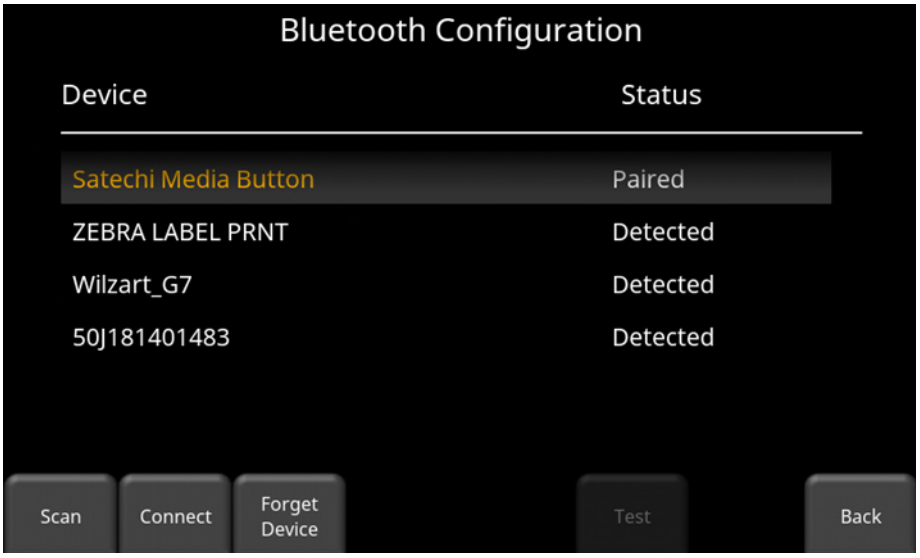


Figure 5-7: Device is paired

To connect to a paired remote, press **Connect**. To confirm the device functionality, the system prompts to press a button on the remote (Figure 5-8). If necessary, press the **Test** button to start the test.

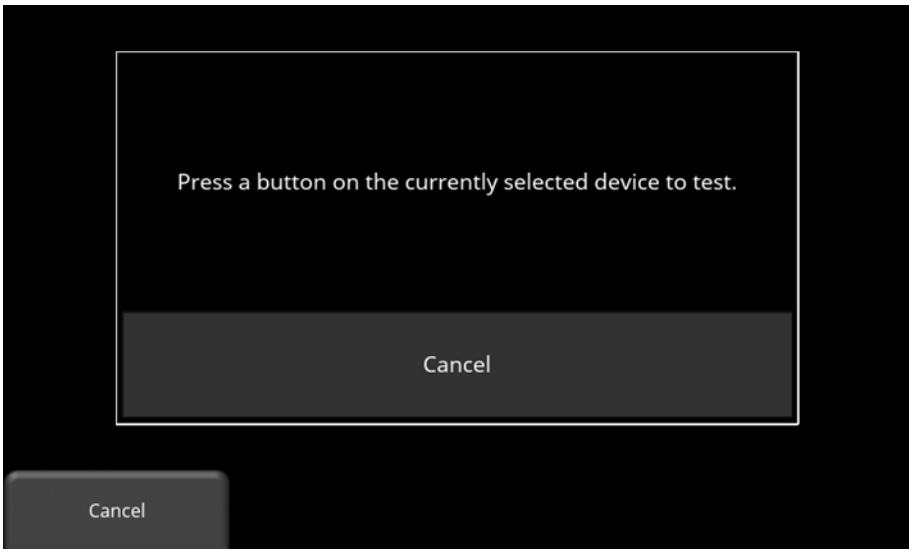


Figure 5-8: Testing wireless trigger

After a successful test, the remote name is displayed in green and the Status is indicated as “Connected”.

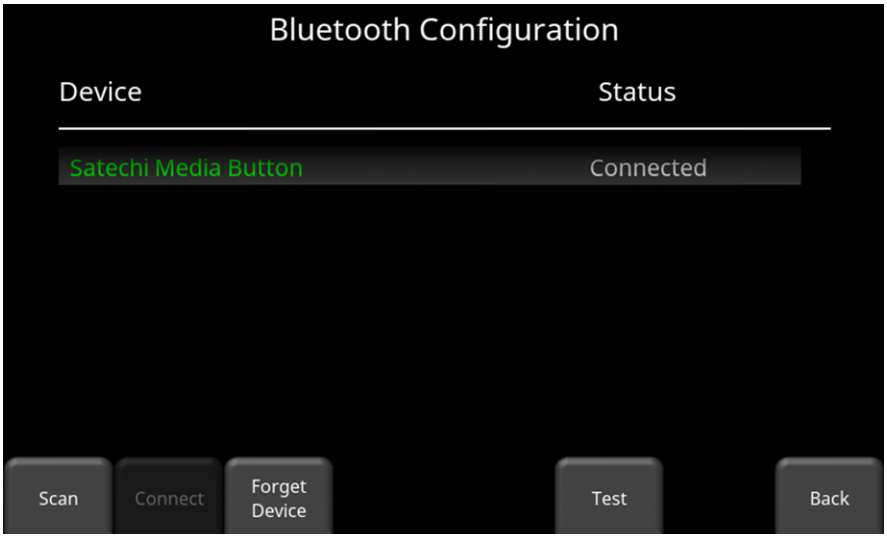


Figure 5-9: Device is connected

Press **Disconnect** to disconnect from a connected device, and press **Forget Device** to unpair from a paired device.

Be aware that remotes requiring special apps will not work with the pulseEKKO DVL. As well, you cannot pair your Smart Phone to the pulseEKKO DVL.

5.1.8 Wi-Fi Network

Connecting to a wireless network allows you to send a mini-report from the DVL to someone by email. This connection is made through a standard Wi-Fi network or through a hotspot on your mobile device while in the field.

> **Note that the DVL cannot connect to Public Hotspots (typically restaurants, hotels and airports) that require a web-based login and acceptance of their Terms & Conditions. It also cannot connect to unsecured networks (networks that do not require a password).**

If you are already connected to a Wi-Fi network, the name of the network is listed beside the Wi-Fi Network field in the **Preferences** menu (Figure 5-3). Pressing the **Wi-Fi Network** button takes you to the Wi-Fi sub-menu (Figure 5-10) to connect and configure Wi-Fi settings.

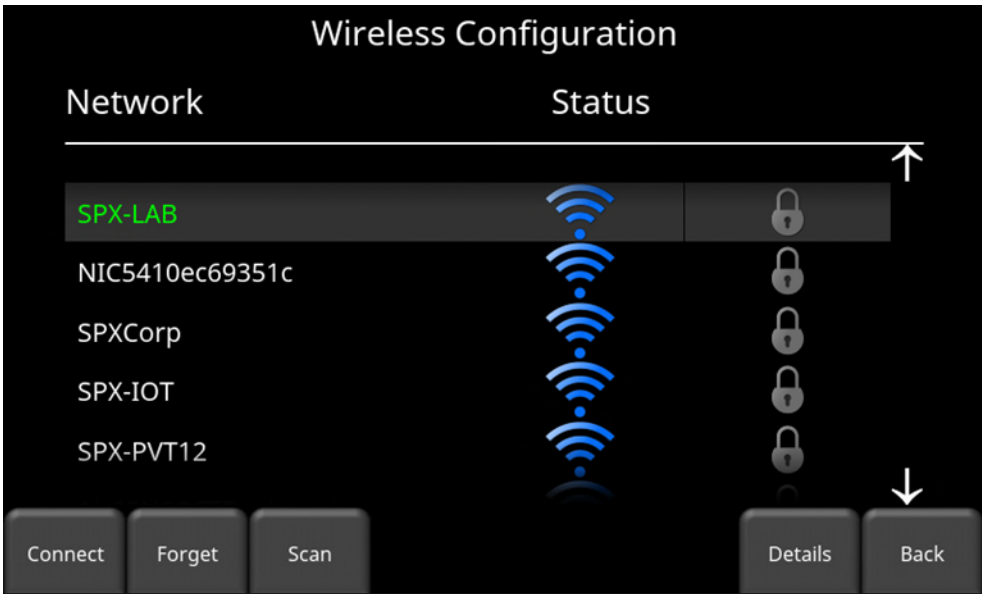


Figure 5-10: Options in the Wi-Fi Settings menu

The DVL automatically scans for available networks when you enter this menu. Use the 4-way directional arrows or touch screen to select the desired network. Swipe up to scroll to the next page to see additional networks, if available. The color of the Network Name indicates the status:

- Green = Connected
- Yellow = not currently connected but remembered from before when you previously connected and entered a password.
- White = Not connected

The options for this screen are explained below:

- **Connect** – Select the desired network and press Connect. If the connection is successful (this can take a minute or so) a screen appears asking for the password for that network. If the network name is yellow (from a previous connection to this network), it will not ask for a password because it is a remembered network. Once the DVL connects to the desired network, the Network Name will turn green.
- **Forget –** Use the Forget button to remove connected or remembered networks (text in green or yellow). Once the 'forget' button is pressed on a selected network it will remove the password and the Network Name will turn white. You will also be disconnected if you are currently connected to that network.
- **Scan –** Scans for any available networks in the area and displays them in order of strength of signal. You may need to press this button a second time if you don't see the network you are looking for.
- **Details –** Press this button to display the security settings and device addresses related to the selected network.
- **Back –** Press this button to return to the System Settings screen.

5.1.9 Email

Press **Email Setup** to enter the sub-menu where you can setup and configure a sending email address. This is the sending account where messages will originate from. All mini-reports received by the recipient will appear to come from this account. Ensure that this email address already exists. You can only save email settings if you are connected to a Wi-Fi network or hotspot on a mobile device.

Using GMAIL

The system is already pre-configured to use GMAIL as the email provider for the sending account (Figure 5-11):

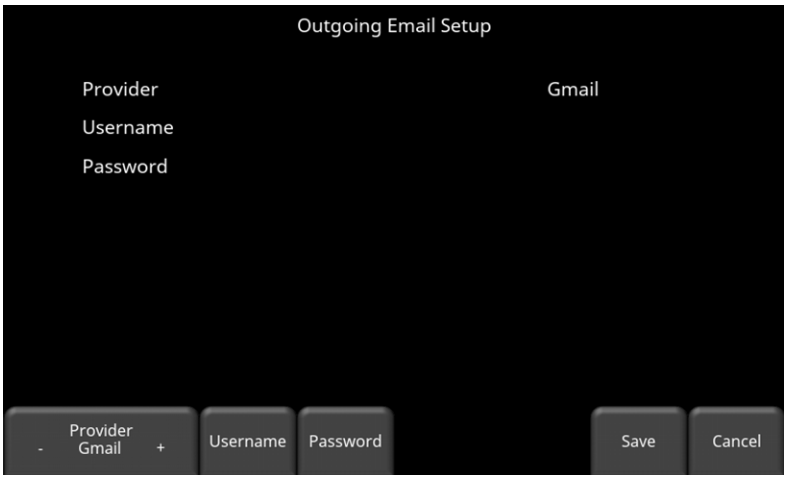


Figure 5-11: Using Gmail as provider.

- Press **Username** to display a keyboard where you can enter your GMAIL username only; you do **not** need to enter @gmail.com. Then press OK when done (left image in Figure 5-12).
- Press **Password** to display a keyboard where you can enter your GMAIL password. Then press OK when done (right image in Figure 5-12).
- Press **Save** when both the GMAIL Username and Password have been entered.

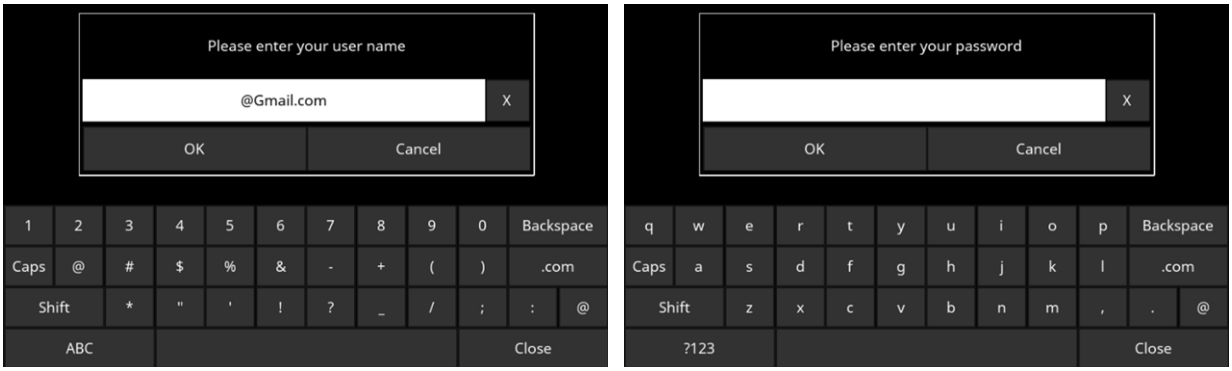


Figure 5-12: Entering a GMAIL email address (L) and password (R)

If everything works, you will see a confirmation message that the email address is setup properly, and you are now ready to email mini-reports from the field. If this does not work, see the Failed Setup section below.

Using Another Email Provider

To use another email provider, press the **+** and **–** buttons under **Provider** to access **Custom.** This will display the screen shown in Figure 5-13 allowing you to setup and configure a different email provider:

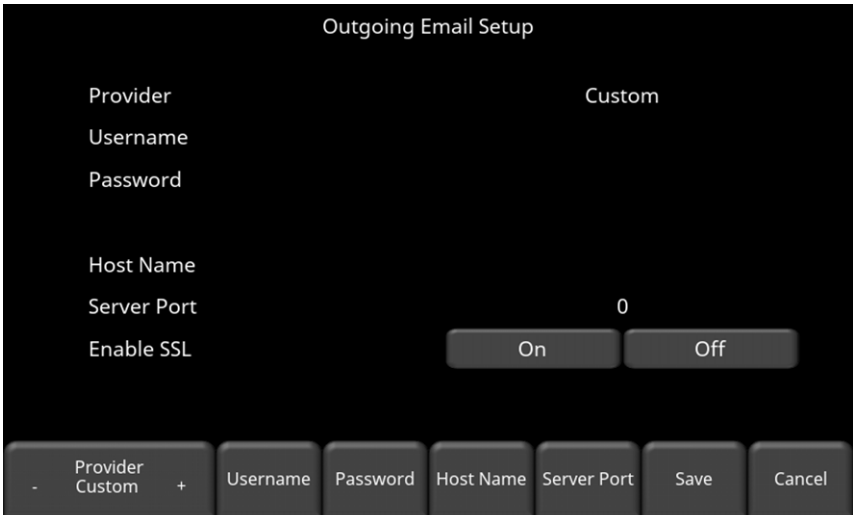


Figure 5-13: Setting up a custom email provider

- Press **Username** to display a keyboard where you can enter the complete email address, then press OK when done.
- Press **Password** to display a keyboard where you can enter the password, then press OK when done.
- Press **Host Name** to display a keyboard where you can enter the name of the server handling the outgoing mail. See chart below for some common email providers. If your provider is not listed, it can usually be found by searching online for "SMTP host name <provider>", where provider is the host name e.g., Yahoo or AOL. Press OK when done.
- Press **Server Port** to display a keyboard where you can enter the port number used by the email server. Searching online for host name will usually provide the port number for that email provider. In most cases, it's usually 465 (if SSL is enabled, see next bullet point), or 587. See chart below for some examples. Press OK when done.
- Enable SSL – you can select **On** or **Off** on the display. SSL provides encryption security. Some email providers require this set to ON. This will usually be indicated on the same online search page that was used above. See the chart below for examples.
- Press **Save** when all the information is entered and correct.

Below is the chart for some common email providers:

Provider	Host name	Server Port	Enable SSL
Hotmail/Outlook	smtp.live.com	587	Off
Yandex	smtp.yandex.com	465	On

If there are no warning messages, the email address is setup properly and you are ready to email mini-reports from the field.

Failed Setup

If setup failed, possible reasons include:

1. No Wi-Fi connectivity
2. Email address or password was entered incorrectly – try re-entering these fields.
3. Hostname, port or SSL setting are incorrect
4. Your email security settings **may need** to be adjusted to a more permissive setting, which may require you to login to your email account from a PC or mobile device. For Gmail, see the section below.

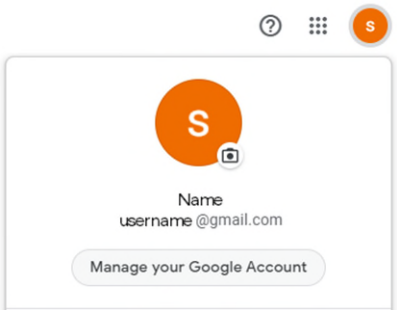
5.1.10 Generating a DVL Password for Gmail

Using a Gmail address on the DVL-500 requires “app specific password”. An app specific password is a 16 character randomly generated passcode that allows access to a portion of the overall Google account. These passwords can be deleted at any time if the user feels it has been compromised. Note that 2 factor authentication is required for the use of app specific passwords.

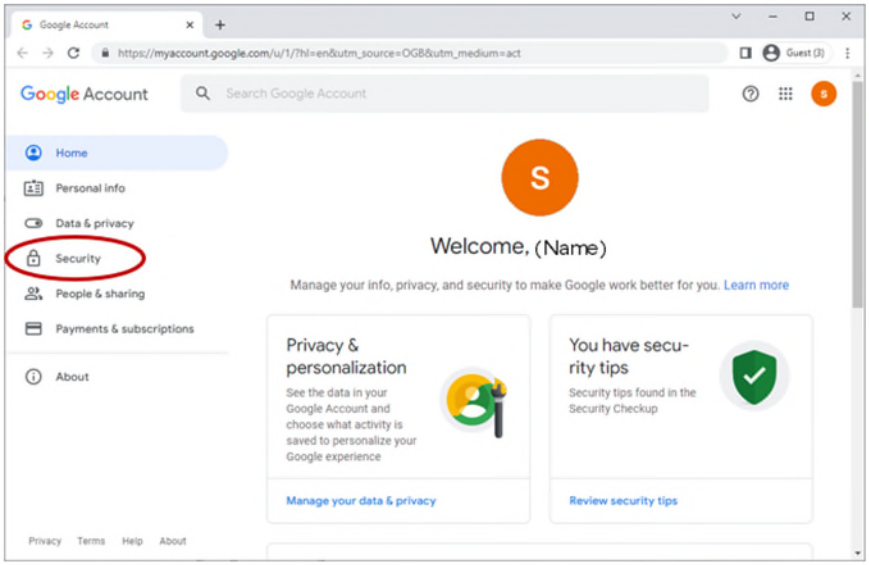
The following procedure details the steps required to enable and generate an app specific password:

1) Log into Google account on a desktop computer.

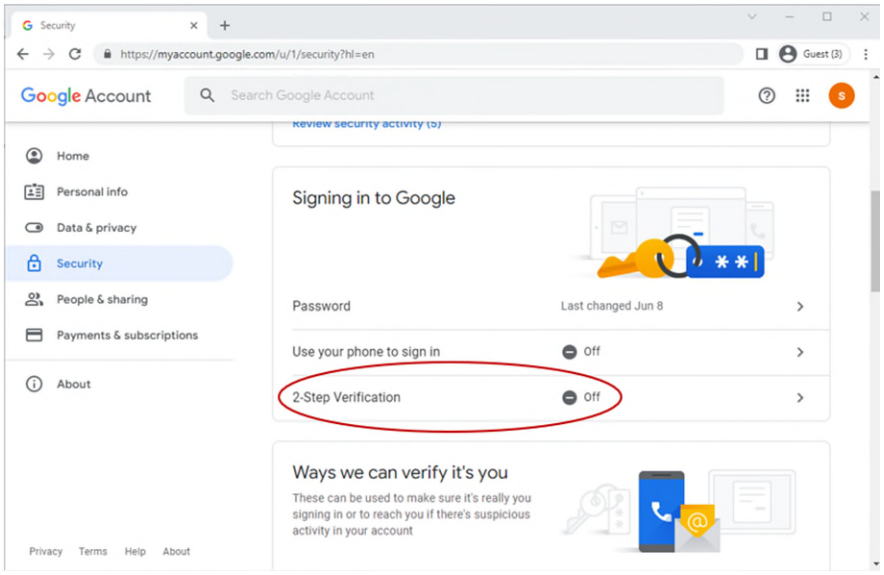
2) Click on the top right account icon and select **Manage your Google Account**



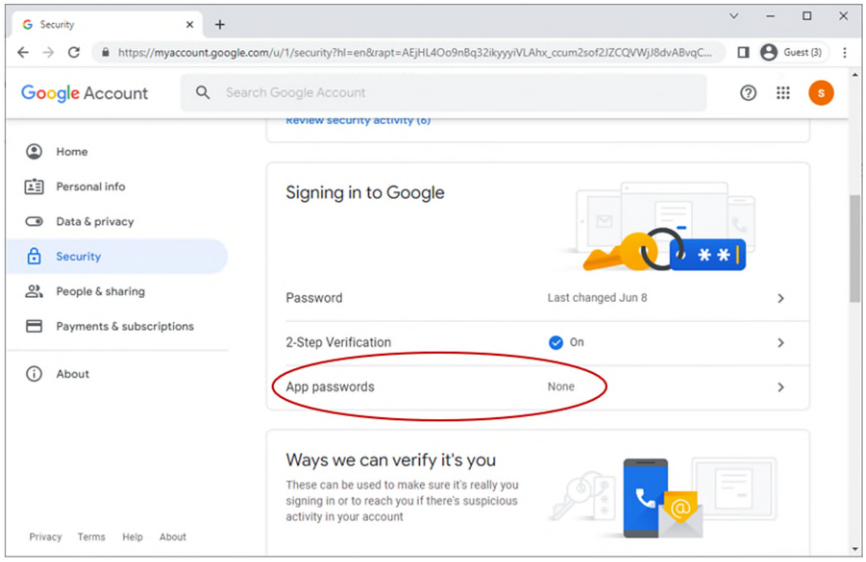
3) Select **Security** from the left menu



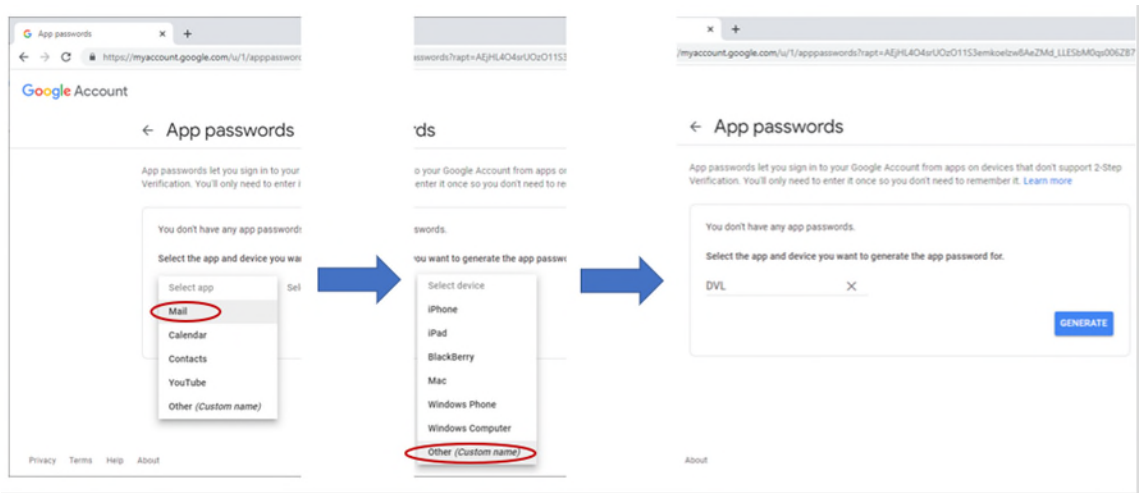
4) Scroll down to the **Signing into Google** section and turn on **2-Step Verification** (if it is not already enabled). Follow the onscreen instructions to add/verify your phone number



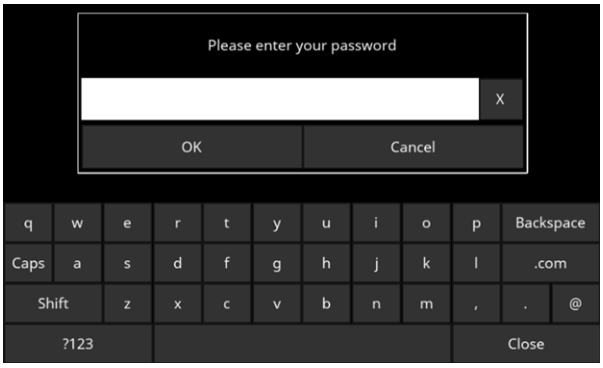
5) Return to the Security menu and you should now find the **App passwords** option under **Signing into Google**. Click on **App passwords.**



6) Under “Select app” choose **Mail**, and under “Select device” choose **Other** and enter an appropriate name (i.e., DVL). Click **Generate**.



7) Use the generated 16-character password when configuring your Gmail account on the DVL:



5.1.11 GPR Plot Options

Pressing **GPR Plot Options** takes you to a new screen that allows you to set a few options that control how lines are collected and displayed (Figure 5-14).



Figure 5-14: Line Plot Options menu

- **Auto-Hide Buttons -** If this is set to **ON**, then in Line Scan mode, the buttons at the bottom of the screen disappear shortly after data collection begins, effectively enlarging the area for data display. The buttons will re-appear 2 seconds after the sensor stops moving forward. The buttons will also re-appear when the system is backing up or when any button is pressed on the keypad. If this is set to **OFF**, buttons do not disappear from the bottom of the screen.

- **GPS Status –** During Line Scan, the status bars indicating the GNSS signal can be displayed on the screen (Figure 7-5). Setting this to **OFF** will no longer display the status bars.

- **Grid Line Stop** – When collecting lines as part of a Grid, the lines can automatically end when the grid dimension distance is reached (e.g. 5m in a 5x5m grid). Pressing **Auto** will set the grid lines to stop automatically. Pressing **Manual** will allow the user to decide when they want to end their line, up to a maximum of 50% beyond the normal line length. For example, if the grid is 20m x 20m, and Grid Line Stop is set to Manual, the user can collect any line up to 30m long. Sometimes you might want to collect a little more data if there is an interesting feature at the end of your line.

- **Show Skips** – This refers to skipped traces. A trace refers to the data that is collected each time the GPR pulses, which is based on the step size distance. Each trace takes a certain amount of time to collect (which increases as you increase the time window or stacks). If you try to collect another trace (that is, by moving fast) before the first is completed, the first trace will be skipped (Figure 7-6). During Line Scan mode, you can choose to display whether or not the skipped traces are shown on the screen by setting this to **ON** or **OFF**.

- **Scale Lines –** Lines can be drawn over the data corresponding to the position scale and/or depth scale intervals. Selecting **OFF** will not draw any lines. Selecting **Position** will draw vertical lines at regular position intervals. Selecting **Depth** will draw horizontal lines at the depth intervals shown on the left axis. Selecting **Both** will draw both Position and Depth lines.

- **Gain Type –** An exponentially compensated gain (**SEC2**) applies more gain the deeper you go, which is meant to compensate for the signal loss/decay. A **Constant** gain will apply the same amount of gain near the surface as it does deeper, allowing you to compare the relative strength of targets at different depths. The SEC2 gain is recommended for most cases, though a constant gain would be better for transillumination surveys.

5.1.12 Reset to Defaults

This will reset all system settings & preferences back to the default settings. Pressing **Reset Defaults** asks you to confirm the Reset to Defaults (Figure 5-15). After this screen, you will get another prompt asking if you want to clear all email and Wi-Fi settings (Figure 5-16). Following that, it will ask if you want to clear the list of paired devices (Figure 5-17).

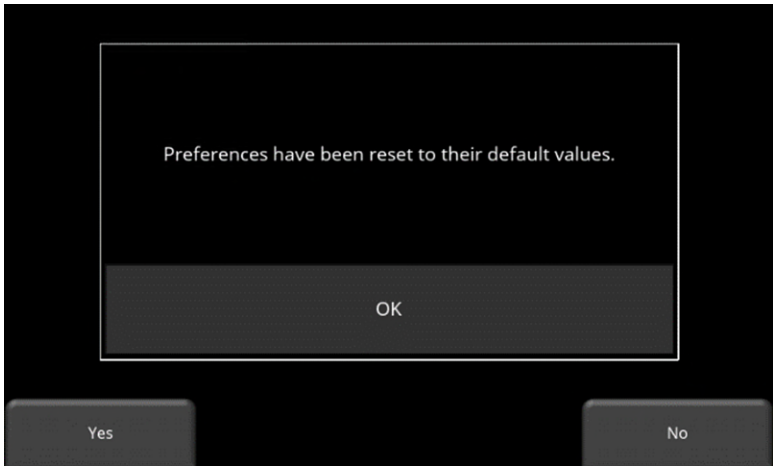


Figure 5-15: Resetting preferences to default values

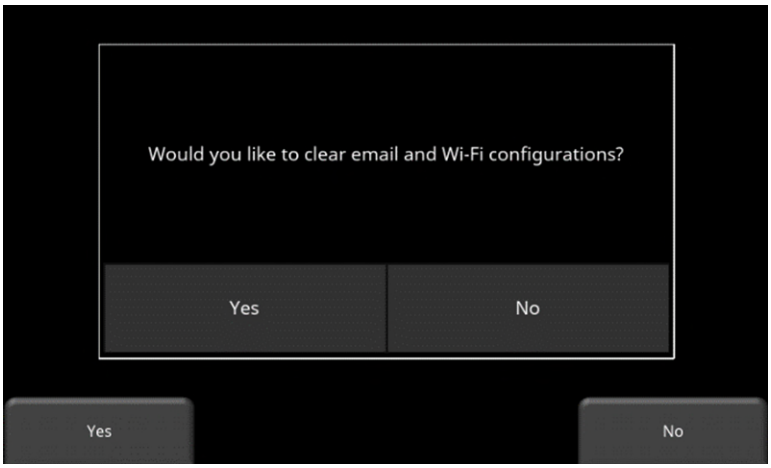


Figure 5-16: Option to clear email and Wi-Fi settings

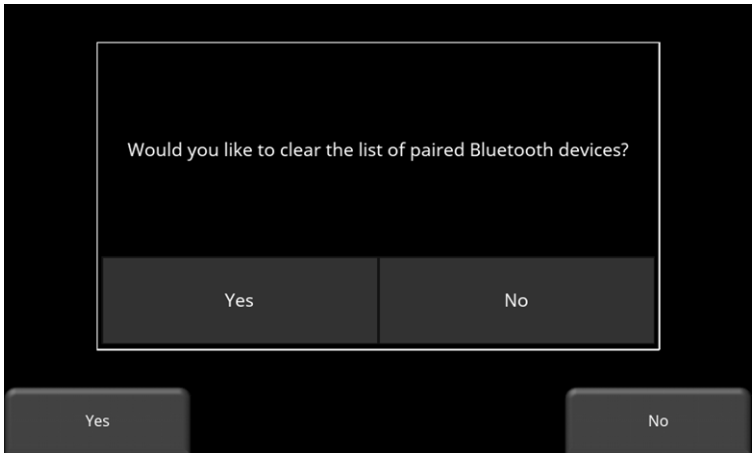


Figure 5-17: Option to remove all paired devices

5.1.13 Back

Returns to the main Tools menu shown in Figure 5-2.

5.2 System Test

The system test sub-menu (Figure 5-18) allows the user to perform certain tests to ensure proper operation of the system. Press the touchscreen directly to select which component to test or use the 4-way keypad to highlight the desired option, then press **Start** in the lower left.

After completing a test there is an indication of whether the system passed or failed the test. Each test is described in more detail.

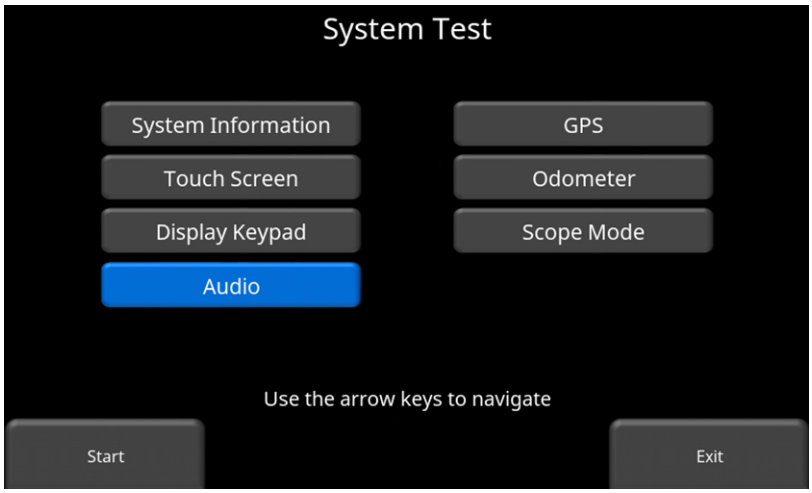


Figure 5-18: System Test menu

5.2.1 System Information

System Information is the only option in System Test which is not actually a test. Here information such as the version, serial numbers, temperature, and battery power are displayed. (Figure 5-19). If a USB key is currently inserted, the **Export** button will be enabled. Pressing this button will export a System Summary Report with this information.

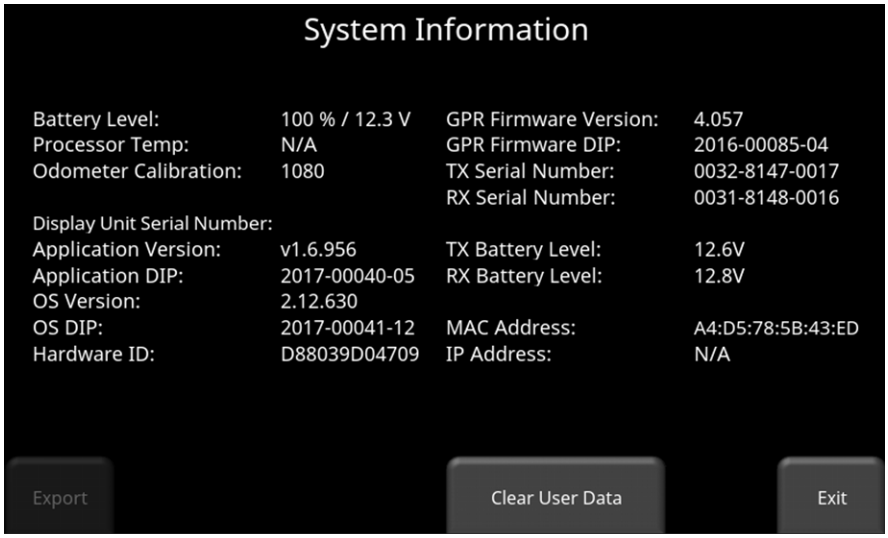


Figure 5-19: System Information screen

Clear User Data

Pressing this button will delete all saved data, system settings and e-mail addresses (however, it will not delete Wi-Fi & Bluetooth settings or usage stats). It will then confirm if you want to proceed (Figure 5-20). If you press Yes, it will re-initialize and reboot the system. Once bootup is complete, it will take you to the setup wizard.



Figure 5-20: Message advising what Clear User Data will do (L), and then confirmation message to proceed (R)

5.2.2 Touch Screen

The touch screen test checks proper operation of the touch screen (Figure 5-21). It allows you to test the screen (by pressing **Test**) or perform a calibration followed by a test (by pressing **Calibrate**). Both involve touching moving targets on the screen.

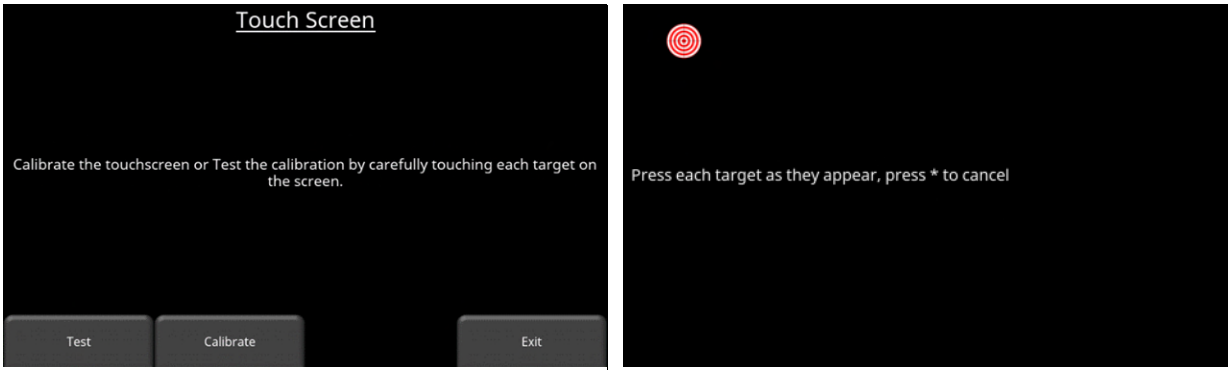


Figure 5-21: Touch Screen test

5.2.3 Display Keypad

The keypad test ensures that all buttons on the membrane keypad are working. Press **Start** to begin the test which requires the user to press each button once, within a 20 second timeframe (Figure 5-22).

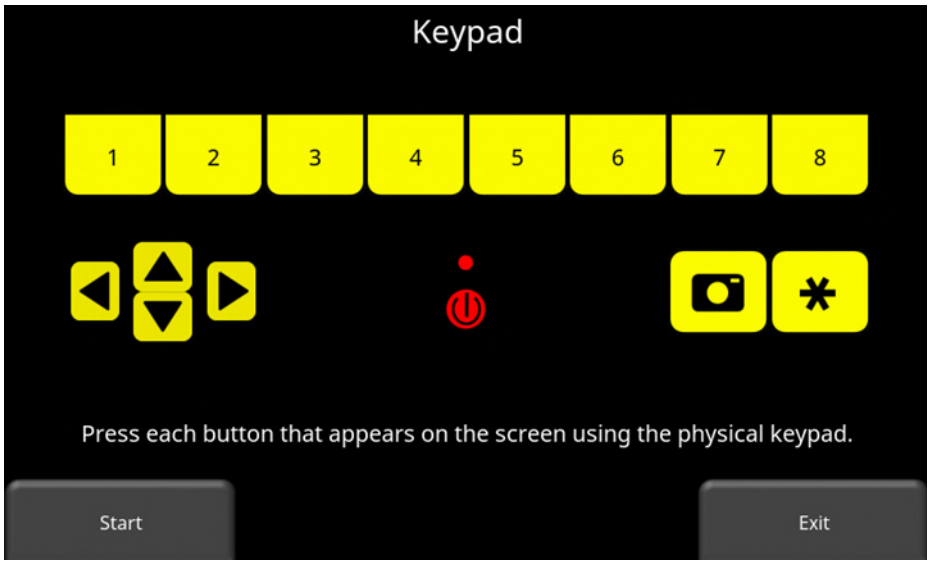


Figure 5-22: Keypad Test

Once that is complete, a short LED light test will ensue, which checks the proper operation of the LED light.

5.2.4 Audio

This test ensures that the speaker is operating properly. After starting the test, you should hear a sound with an increasing pitch (Figure 5-23).

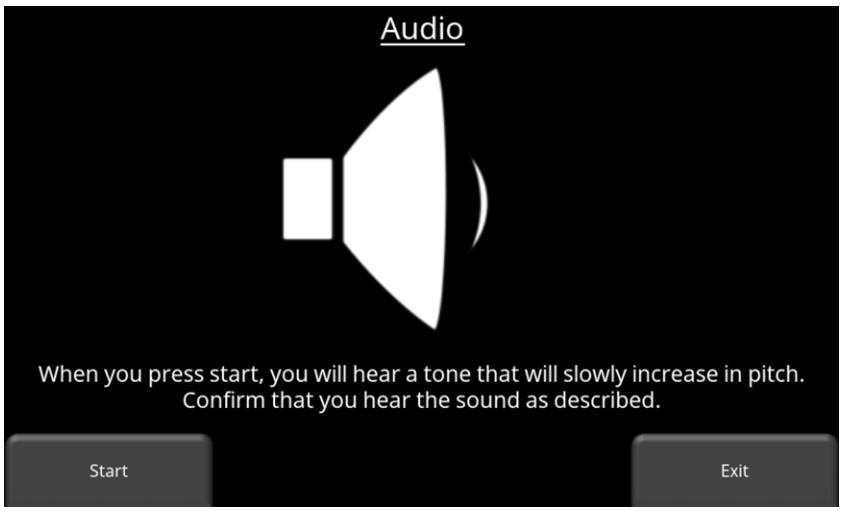


Figure 5-23: Audio Test

5.2.5 GPS

The GPS test will ensure that the system is communicating properly with the GNSS and receiving data. Pressing **GPS** will show the screen in Figure 5-24.

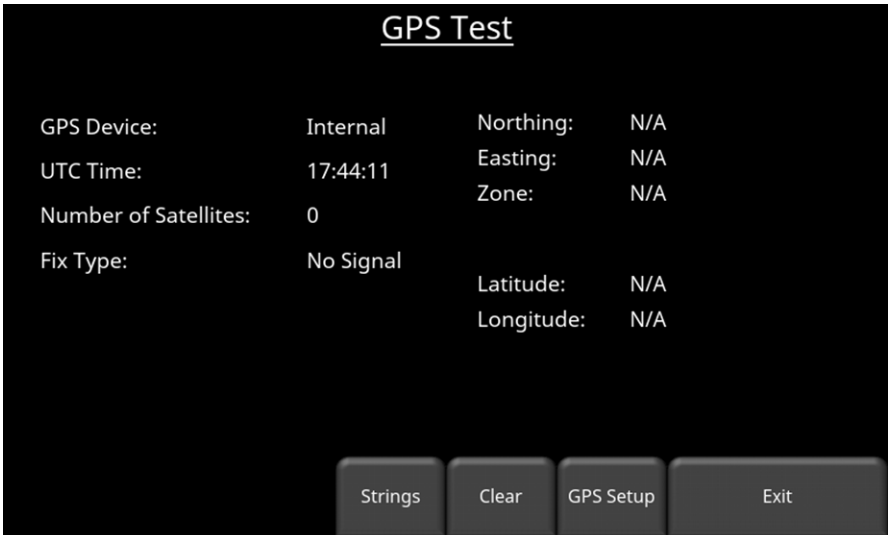


Figure 5-24: GNSS Test

The position and UTC (Universal Time Coordinated) information is displayed on the screen.

Fix Type notes the type of GNSS fix; the options are GPS, DGPS, RTK-Float, RTK-Fixed in increasing order of accuracy.

Pressing **Strings** will display the raw data strings that are outputted by the GNSS (Figure 5-25) as they scroll down the screen. The user may select this option to verify the GNSS is outputting the proper NMEA string format. Note that strings may appear even if there are no satellites available.



Figure 5-25: GNSS Strings

If the GNSS Tests and the Strings Test fail:

1) Take the GPR and GNSS outside and run the **GPS Test** to give the GNSS time to track, or lock onto, satellites. This can take up to 30 minutes, especially when the GNSS is being used at a location hundreds of kilometers from the last time it was used, for example, when you first receive the GPR system.

2) Select **GNSS Setup** and confirm the settings are correct for the GNSS being used. The most common problems are:

    a. GNSS is set to OFF in the GNSS Setup menu (see below)
    b. no power to the GNSS. Third-party GNSSs not purchased with the GPR system must have their own battery or be able to accept the power from the serial cable connected to the DVL (see below).
    c. the baud rate of the GNSS does not match the baud rate of the DVL (see below)
    d. in the case of third-party GNSSs not purchased with the GPR system, the GNSS has not been properly programmed to output GGA NMEA strings across the serial port. The GNSS manufacturer may need to be contacted to help program the GNSS to communicate with the DVL.

Pressing **Clear** will clear/refresh the screen. Press **Info** will return to the main GPS test menu.

Pressing **GPS Setup** will take you the screen shown in Figure 5-26, where you can also change the GPS being tested (Internal or External).

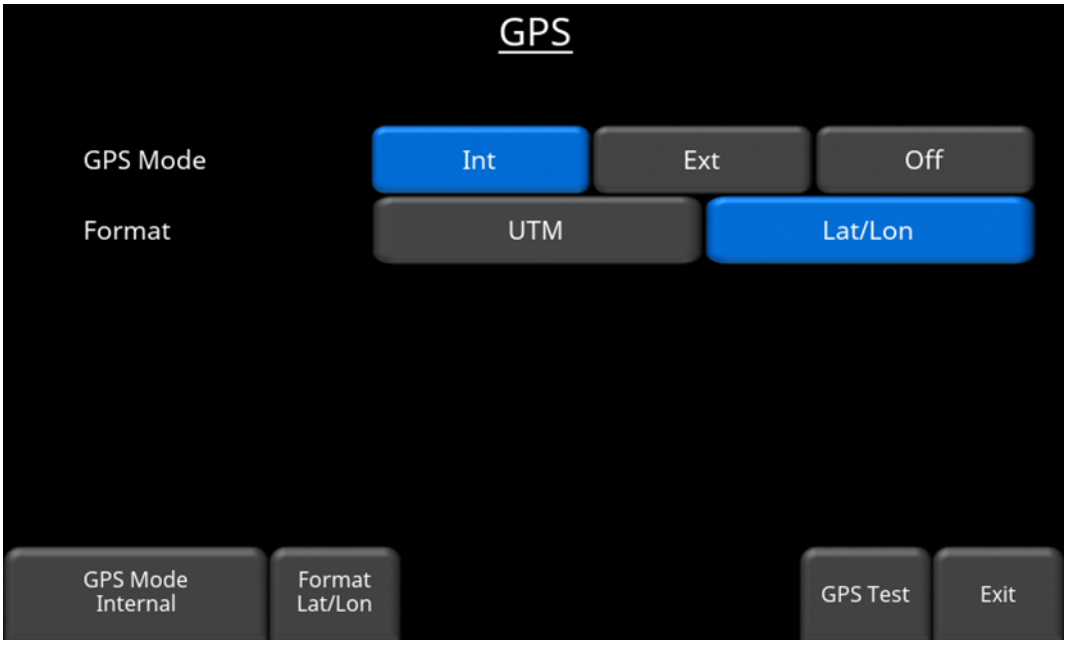


Figure 5-26: Configuring GNSS

- **GPS Mode** – pressing this button cycles between using the Internal GNSS, the (optional) External GNSS or turning the GNSS off.

The Internal GNSS is used to position Grid Scans and screenshots.

The Internal GNSS cannot be used to position Line Scans.

- **Format** – pressing this button toggles between UTM or Latitude/Longitude coordinates

- If the External GPS is selected, the screen displays additional options (Figure 5-27).

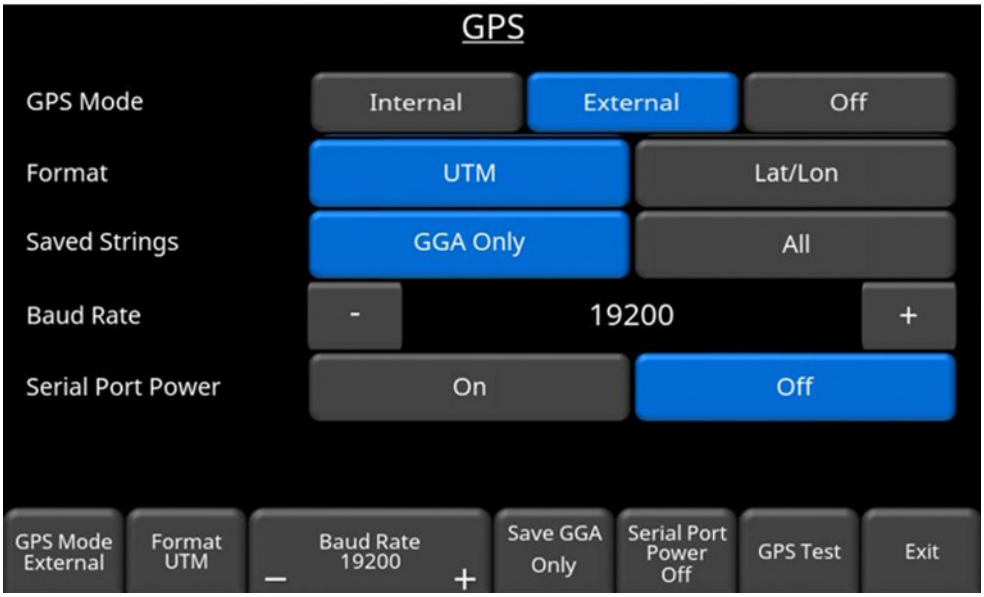


Figure 5-27: Configuring options for external GNSS

- **Baud Rate** – The baud rate is the speed that data is sent from the GNSS receiver to the serial port of the DVL. Set this in accordance with the GNSS manufacturer specifications. If you purchase a GNSS from Sensors & Software, this is already pre-set.

- **Saved Strings** – the GNSS outputs data (called “strings”) which is received by the DVL and saved along with the GPR data. The default setting for this is the **GGA Only** string which contains all the relevant positional data. For advanced users who want access to additional GNSS information for post-processing with third-party software, they can set this to **All.**

- **Serial Port Power** - the serial port on the back of the DVL can also output power, thereby enabling a single cable to be used for the GNSS (power and data).

  Set the Serial Port Power to On when the GNSS and GNSS cable was supplied by Sensors & Software.

If you use a 3rd party GNSS, see Section 3.7.4

Pressing the **Serial Port Power** button will turn power to the serial port on, but it will display a warning message first (Figure 5-28). Upon restarting, the serial port power will remain at whatever setting the user chose before restarting.

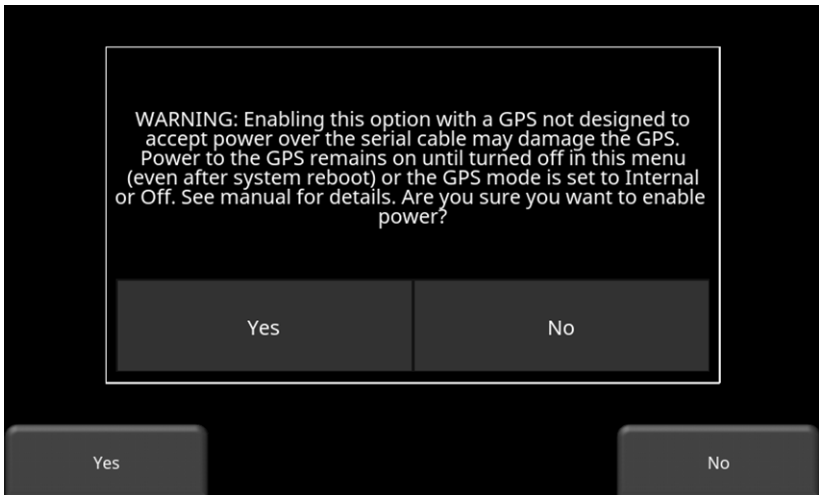


Figure 5-28: Warning message if you enable power to the serial port

5.2.6 Odometer

This option allows you to test the odometer and ensure that the odometer is calibrated properly for distance. Even though the odometer is calibrated in the factory, you must calibrate it periodically to ensure accuracy of position. This is particularly important as the calibration can change with different surface materials (e.g., pavement, grass, sandy soil). The odometer calibration value is stored in the DVL. If the DVL is changed, swapped out or has the embedded software upgraded, you will need to run the Odometer Calibration test again.

The image in Figure 5-29 is displayed when you press the **Odometer** button; the options are explained below:

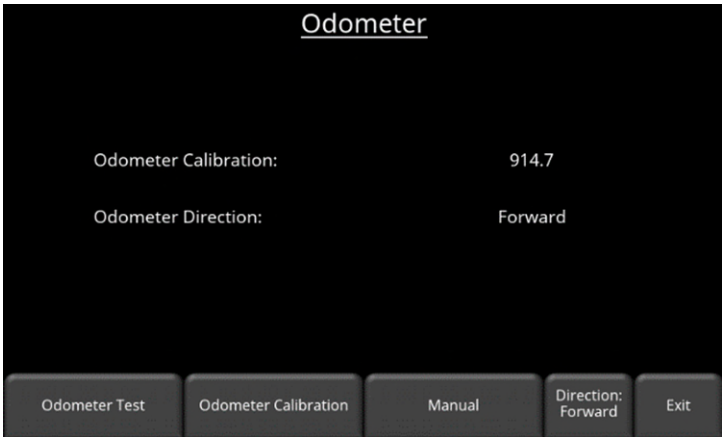


Figure 5-29: Odometer Calibration screen

- **Odometer Test** – This test verifies that the odometer is calibrated properly. It measures a set distance (5m or 10') on the surface and then moving the system over that distance. Press **Start** to begin and then press **Finish** when you have moved that distance (Figure 5-30). It will display a pass or fail, along with a percentage difference from the known value (Figure 5-31). If the test fails or the percentage difference is larger than the user would like, they should run an odometer calibration (explained below).

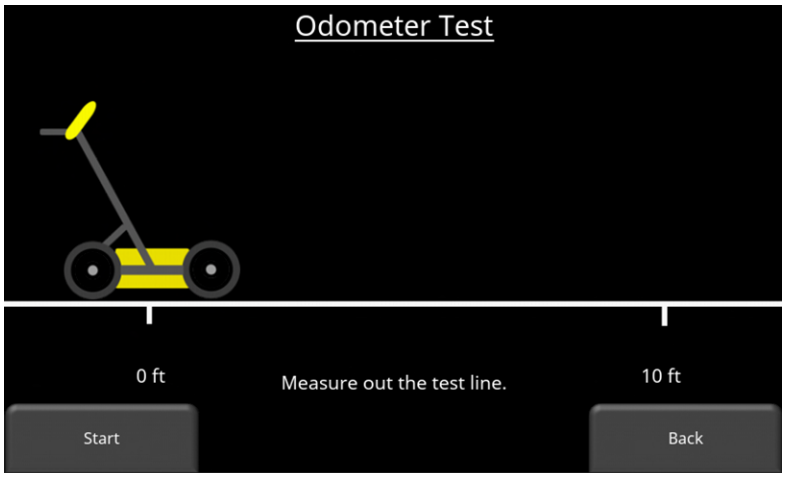


Figure 5-30: Ready to test odometer for a distance of 10 feet

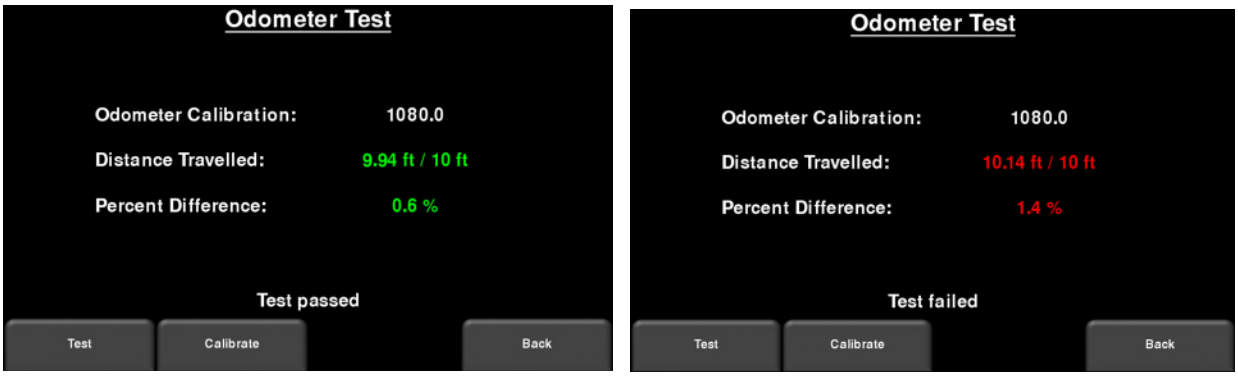


Figure 5-31: Odometer Test passed on left, failed on the right

- **Odometer Calibration** – This option calibrates the odometer. Choose a set distance on the screen, press **Start** and then move the system that exact distance, using a measuring tape or other known distance indicator. Press **Finish** when you have travelled that distance (Figure 5-32).

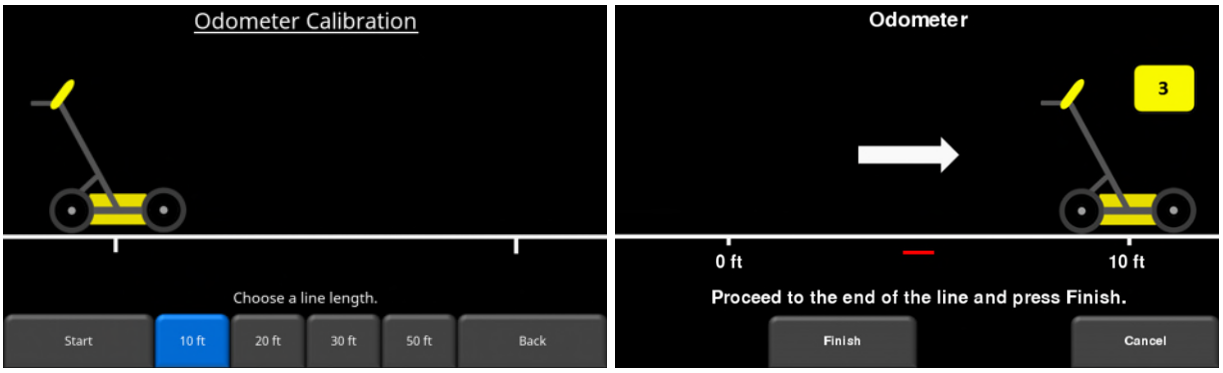


Figure 5-32: Odometer Calibration. Image on the left shows the screen where the user must select a distance. The image on the right instructs you to move that distance then press Finish.

Upon completion, it will display one of the screens shown in Figure 5-33. The new calibration value is shown, along with a message asking if you would like to accept this new value. Press **Accept** to save it or **Reject** to revert to the old value.

If the value is very different from the expected value, the calibration will fail, and it will display an error message in red. You then have the option to **Retry** or exit by pressing **Back**. If you exit this menu, the old calibration value is maintained.

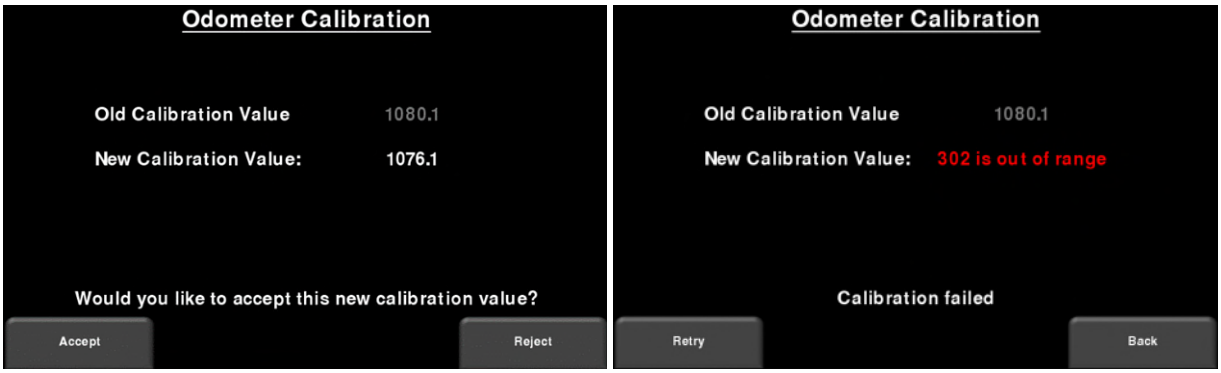


Figure 5-33: Results of Odometer Calibration. Image on right shows a failure, as calibration is way out of range

- **Manual** – Pressing this button changes the bottom menu, allowing you to manually insert a calibration value. This can be done using the buttons along the bottom of the screen to increase or decrease the calibration value (Figure 5-34).

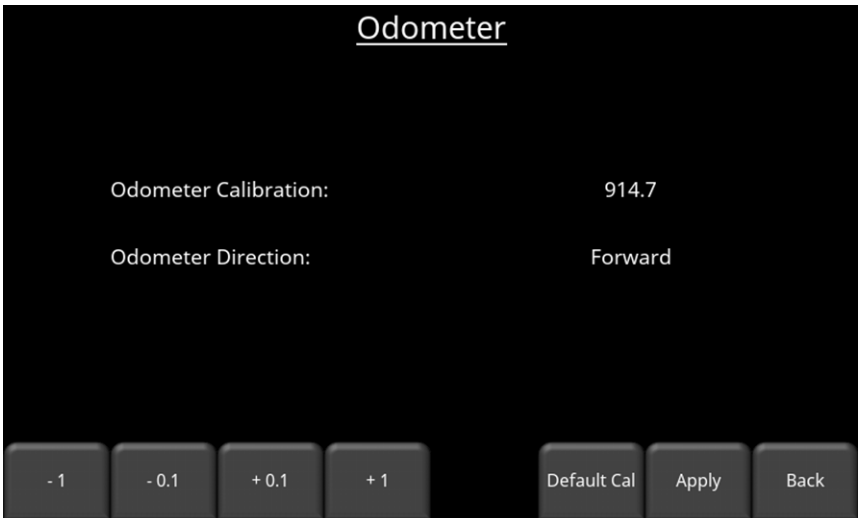


Figure 5-34: Manually setting odometer calibration value

- **Direction** – Press this button to toggle between Forward and Reverse. Forward is used if pushing the system forward (most common) or Reverse is used when pulling it backwards. Make sure to calibrate in the direction that you will be surveying in.

5.2.7 Scope Mode

Scope Mode enables you to confirm that cable connections are correct, and all survey parameters are properly set before starting data collection. A major component of this is correctly setting the First Break.

It is highly recommended to run Scope Mode before collecting any data.

When you enter Scope Mode, you will see a screen like Figure 5-35.

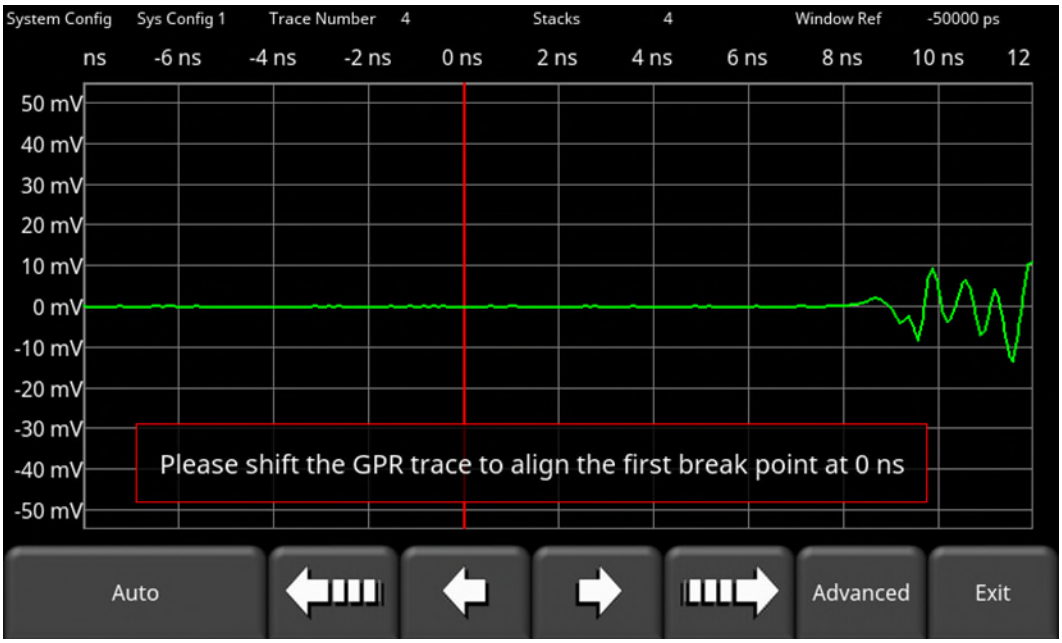


Figure 5-35: Scope mode before First Break correction

The radar pulse is shown on the screen, with the amplitude plotted on the vertical axis (in millivolts) and the time axis plotted horizontally (traditional oscilloscope format).

First Break is the first arrival of the radar wave and is used as a convenient reference point. Before leaving Scope mode, the goal is to ensure that the First Break is correctly positioned, near the beginning of red line at 0 ns. Locating the First Break to the right (further in time) of the second division has no ill effect on the data, it just means that depth readings will be incorrect and possible reflectors may be lost off the bottom of your recording window.

When using high frequency transducers, it is recommended to lift the transducers slightly off the ground. This will result in a higher amplitude waveform and make it easier for the Auto routine (described below) to locate the First Break.

- Press **Auto Detect First Break** for the system to initiate an automatic search to place the First Break at the correct position (Figure 5-36). Auto is generally the preferred method of setting the First Break, however if you are using high frequency transducers, the antenna separation is large, or there is a large amount of external noise then this automatic adjustment may fail. In this case, try raising the antennas or transducers

slightly off the ground to allow a strong air wave to travel between the units. If you are still not able to find the First Break, use the arrows to manually set it as explained below.

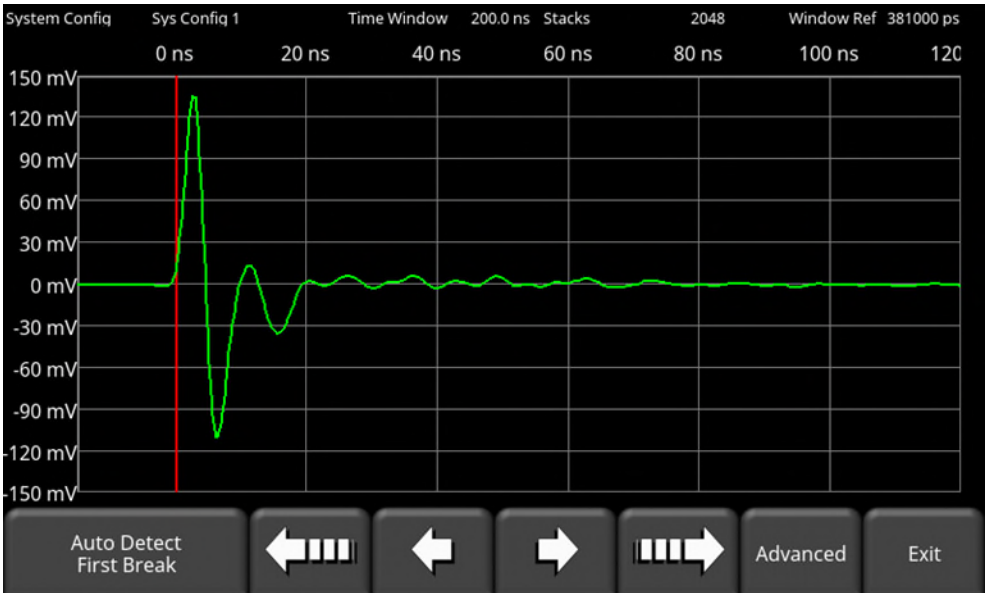


Figure 5-36: First Break at the correct position

To move the pulse manually, touch the screen and move the pulse left or right. The buttons on the bottom can also be used:

- Press the **large left** or **right arrow** to continuously move the radar pulse to the left or right. Press the same button to stop movement.
- Press the **small left** or **right arrow** to manually move the radar pulse to the left or right in small increments.
- Press **Advanced** to display more options on the bottom of the screen (Figure 5-37). If you have the Ultra Receiver, you will see the image in Figure 5-38.

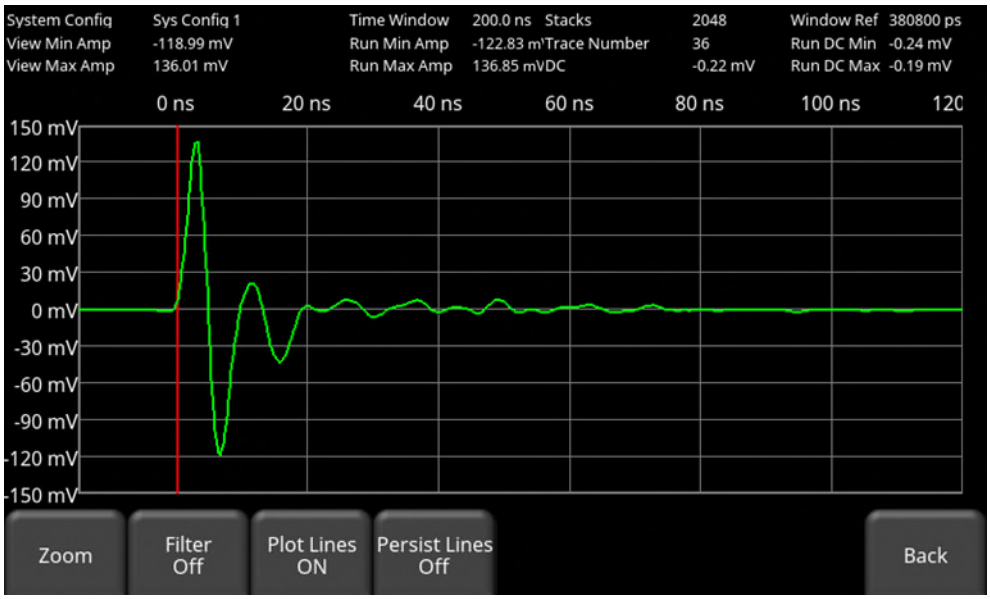


Figure 5-37: Advanced mode

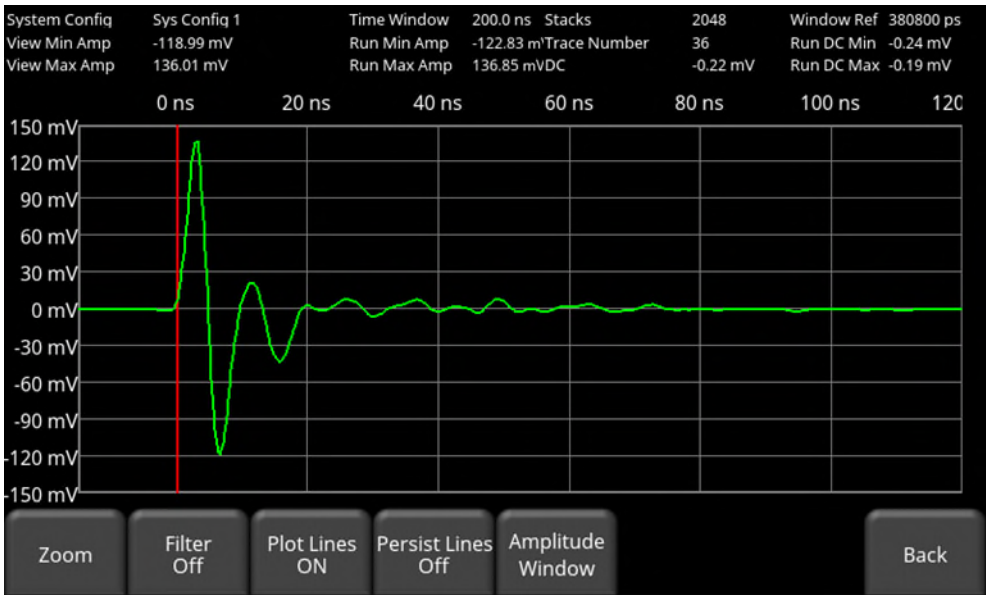


Figure 5-38: Advanced mode when an Ultra Receiver is connected.

- **Zoom** – Pressing this button changes the menu at the bottom of the screen (Figure 5-39) allowing the user to change the time window (Zoom Time, the horizontal axis) and the amplitude (Zoom Amplitude, the vertical axis).

  For the PRO receiver, the zoom amplitude shows the range of amplitudes shown (i.e., a Zoom Amplitude of 60 means it shows from -60 mV to +60 mV).

  For the Ultra receiver, the zoom amplitude shows a *percentage* of the amplitude window (i.e., if you have an amplitude window of -50 mV to +50 mV, and the Zoom Amplitude is set to 50, it means the image is zoomed in to 50%, so it will display -25 mV to 25 mV)

Press the **+** and **–** buttons to change these axis values. Press **Back** when complete.

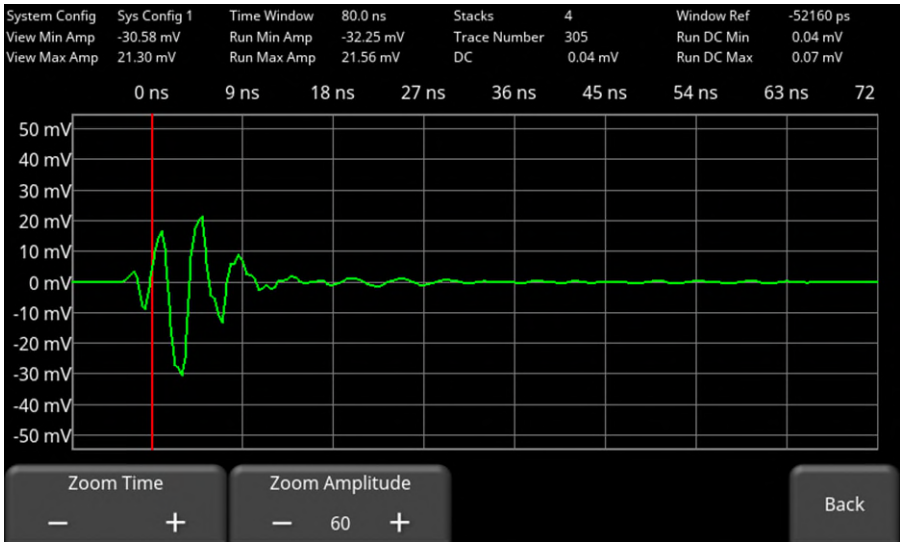


Figure 5-39: Zooming options (PRO Receiver shown)

- **Filter** – Cycles between applying a DEWOW filter, a DC filter or no filter (Off). DEWOW applies a high pass filter which suppresses the low frequency "wow" in the data. DC Filter removes the average signal level from each trace and is generally applied to high frequency data. See Appendix B for more details on GPR signal processing.
- **Plot Lines** – Toggles between plotting the axis lines on or off.
- **Persist Lines** – When this is ON, the "cumulative" radar trace remains on the screen. This is essentially plotting one trace on top of the other every time the radar pulses (Figure 5-40). If this is OFF, only the current trace is displayed.

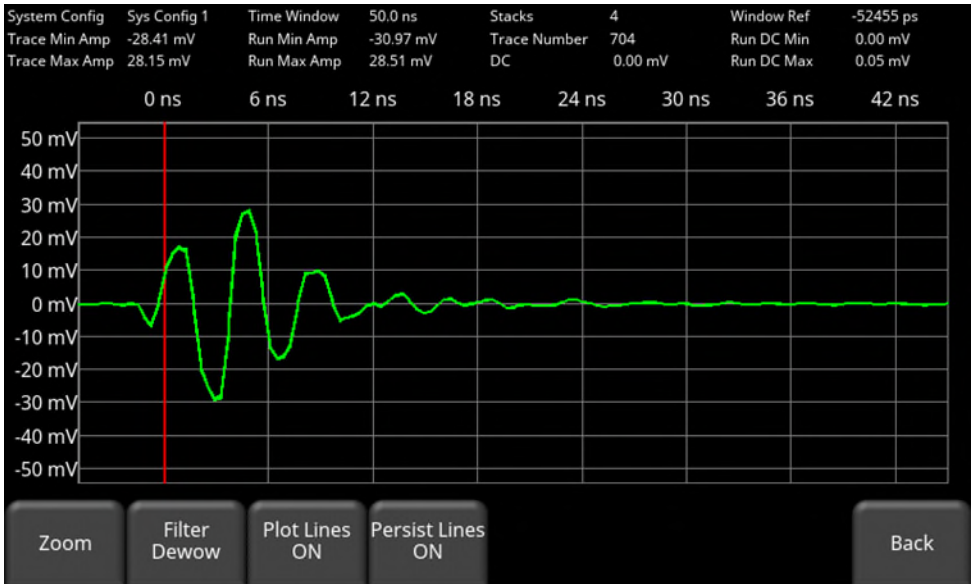


Figure 5-40: Persist Lines ON

- **Amplitude Window** (***only available with Ultra Receiver***) – The amplitude window defines the dynamic range of the signal that is recorded. The larger amplitude windows will collect a wider range of amplitude values, but smaller amplitude windows will record more precise amplitude data. This also determines the resolution of the digitally sampled signal.

  Pressing the + and - buttons under Amplitude Window in Figure 5-41 will increase or decrease the vertical scale. Remember that the value shown is the entire range, so if 1000 mV is selected, then the scale goes from -500 mV to +500 mV. Unless clipping of the signal is desired, the amplitude window should be large enough to encompass the maximum amplitude of the pulse.

- **Auto Amplitude Window** – pressing this button will automatically search for the smallest amplitude window that does not clip the signal, and adjust the scale accordingly.

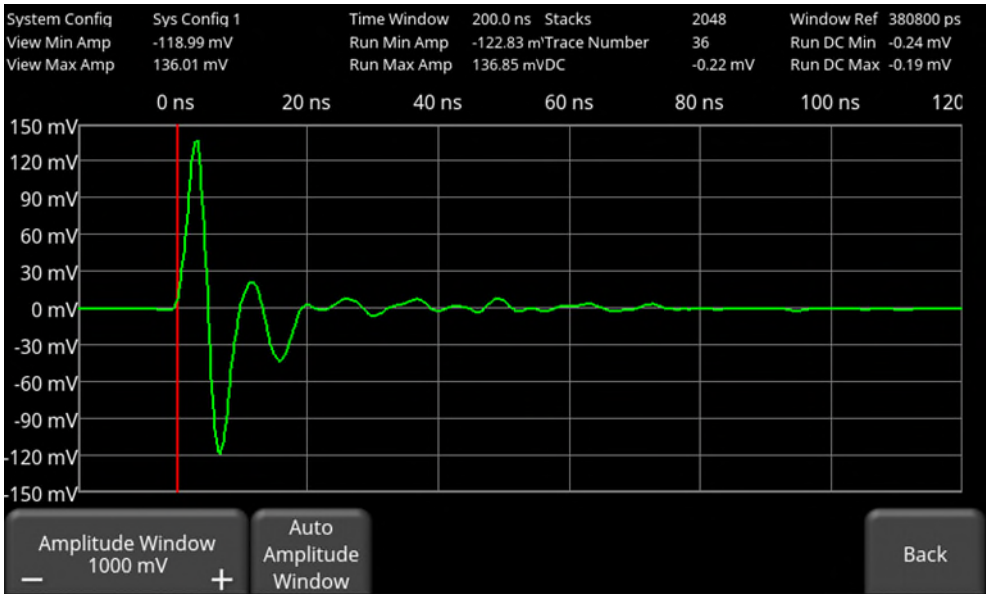


Figure 5-41: Options after pressing the Amplitude Window button

Note: if the pulse cannot be found, and all connections are made, check the batteries in the transmitter. If the batteries are OK, there could be a problem with the transmitter.

5.3 File Management

From the main Tools menu shown in Figure 5-2, press **File Management** to enter this sub-menu. From here, the user can view screenshots, access MapView, delete projects and export data (Figure 5-42).

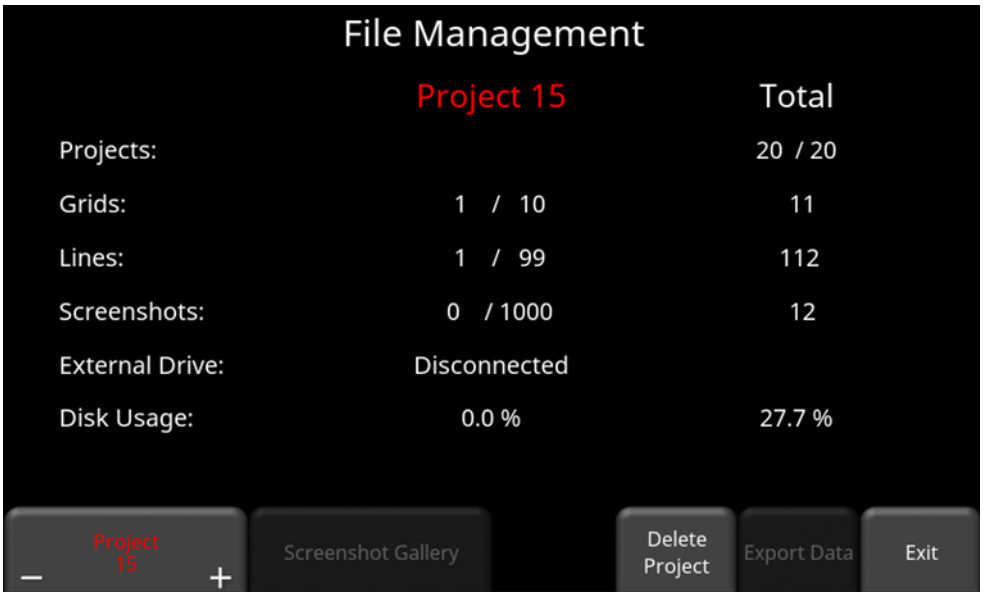


Figure 5-42: Main screen in File Management

A summary of each project is given in the middle column, showing Grids, Lines and Screenshots for that project. The column on the right shows the total saved Grids, Lines and Screenshots for the whole system.

The current disk space used is shown, expressed as a percentage of total disk space available. When the user is about to collect a line (either in line scan or grid scan) which will push the disk usage over 90% a warning message is displayed. This will happen again at the 95% threshold. The warning message is only given once for each threshold crossing.

A description of each of the buttons is given below:

5.3.1 Project

Pressing the **+** and **–** buttons cycles between Projects 1 to 20, along with the Demo project (which contains demo data). Projects that contain data are in red, whereas Projects with no data are in white.

5.3.2 Screenshot Gallery

Pressing **Screenshot Gallery** allows the user to view all screenshots that were saved to that project by pressing the Camera button during data collection (this is explained in Section 10.1). The display will show a Tile View of a maximum of four screenshots per page (Figure 5-43). If

there are more than four screenshots, swipe the screen from right to left to view the rest. Alternatively, you can also use the **Left** and **Right** arrow keys on the 4-way directional keypad

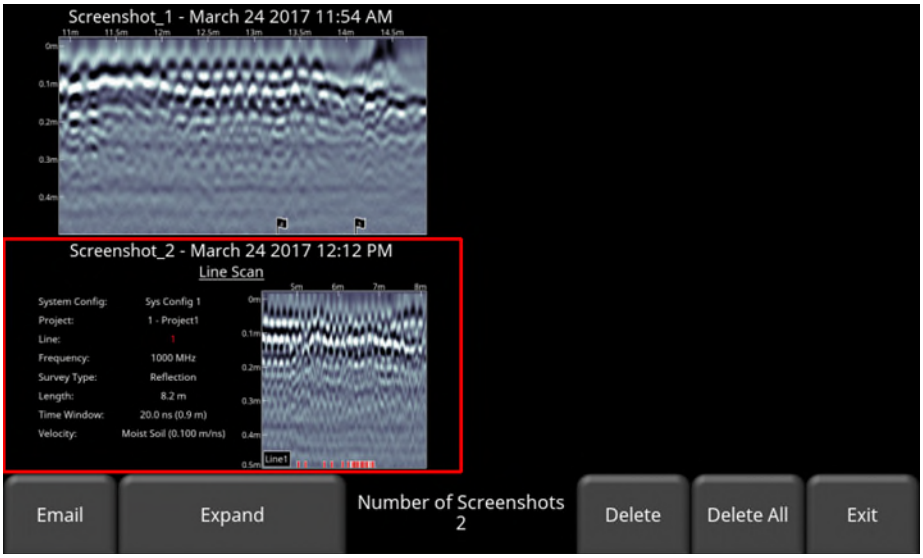


Figure 5-43: Tile View in Screenshot Gallery

From the Tile View, the user has the following options:

- **Email** – Pressing this button will email the selected screenshot (provided you are connected to a wireless network and have setup an email account to send from. Refer to Section 5.1.9). You will be prompted to enter an email address, or you may use the most recent one which will be listed by default. Pressing the "**…**" button to the left of the email address displays the last 5 email addresses used, allowing the user to select a recently used email address, rather than re-entering it.

- **Expand** – Press this button to show the selected screenshot as a full screen image (Figure 5-44). On the subsequent screen, press **Tile View** to return to the screen displaying four screenshots per page.

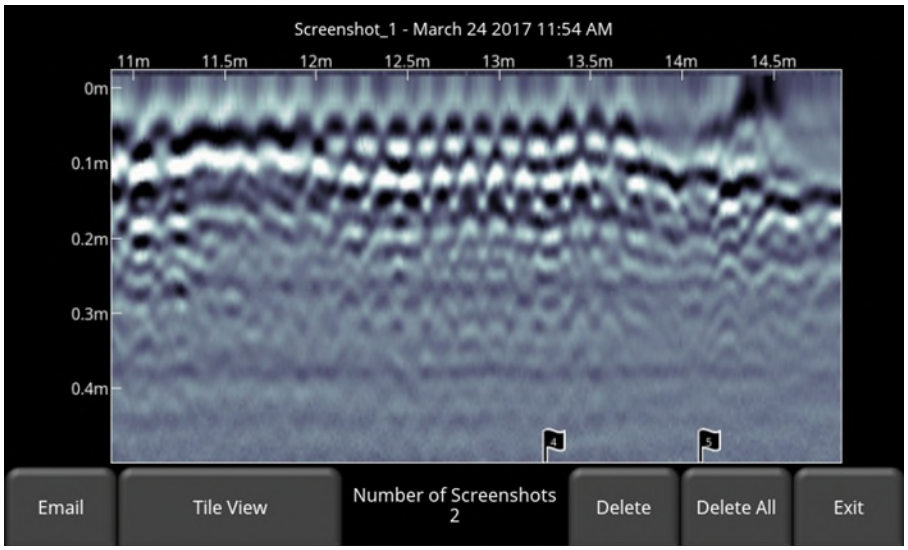


Figure 5-44: Expanded view of screenshot

- **Delete** – Pressing this button will delete the displayed screenshot. There will be a confirmation message asking if you are sure. Press **Yes** to proceed.

- **Delete All** – Pressing this button will delete all screenshots. There will be a confirmation message asking if you are sure. Press **Yes** to proceed.

5.3.3 Delete Project

Pressing this will delete the currently selected project. There is a confirmation window asking if you are sure; press **Yes** to continue deleting, press **No** to cancel.

5.3.4 Export Data

Screenshots and data are always saved to the internal memory of the DVL. When a USB drive (memory stick) is inserted into the USB port on the DVL, a message will appear asking if you would like to export all data (regardless what screen you are in). If **Yes** is selected, all data is copied to the USB stick. If you need to export data again, the USB stick will need to be removed and reinserted.

If **No** is selected, the user can enter File Management and export only data from a selected project. Pressing the **Export Data** button will copy only the data from the currently selected project to the USB-drive. If no USB-drive is inserted, this option will not be accessible.

The directory structure on the USB drive can be viewed on your PC, and will look as follows:

- GPR Data
  - pulseEKKO
    - Export01
      - Project1
        - Screen Shots
          - All Screenshots as .JPG files
        - Project1.GPZ file
        - Project1.KMZ file
        - Field Interp Report.CSV
      - Project2
        - Screen Shots
          - All Screenshots as .JPG files
        - Project2.GPZ file
        - Project2.KMZ file
        - Field Interp Report.CSV
      - System Info
        - App.log
        - System_summary.pdf
    - Exportxx
      - Projectx
        - Screen Shots
          - All Screenshots as .JPG files
        - .GPZ file
        - .KMZ file
        - Field Interp Report.CSV
      - System Info
        - App.log
        - System_summary.pdf

All screenshot files are saved as .JPG files
The actual GPR data files are all contained in a .GPZ file. This can be opened by the EKKO_Project software.
If data was collected with GNSS (internal or external), a .KMZ file is also generated. This contains positional information and can easily be opened in Google Earth™.
If any Interpretations were made, these are saved in a .CSV file. This is a spreadsheet file, which shows the positional information of any interps made.
The System Info folder contains app.log file and a system summary diagnostic report (.PDF file)
Each successive export of data will create a new directory called ExportXX, where XX is incremented by 1 from the previous directory.

6. System Configuration

The pulseEKKO system allows the user to customize GPR data collection parameters. This is done in the **System Configuration** menu.

From the main screen, press **System Configuration** to enter the menu shown in Figure 6-1.

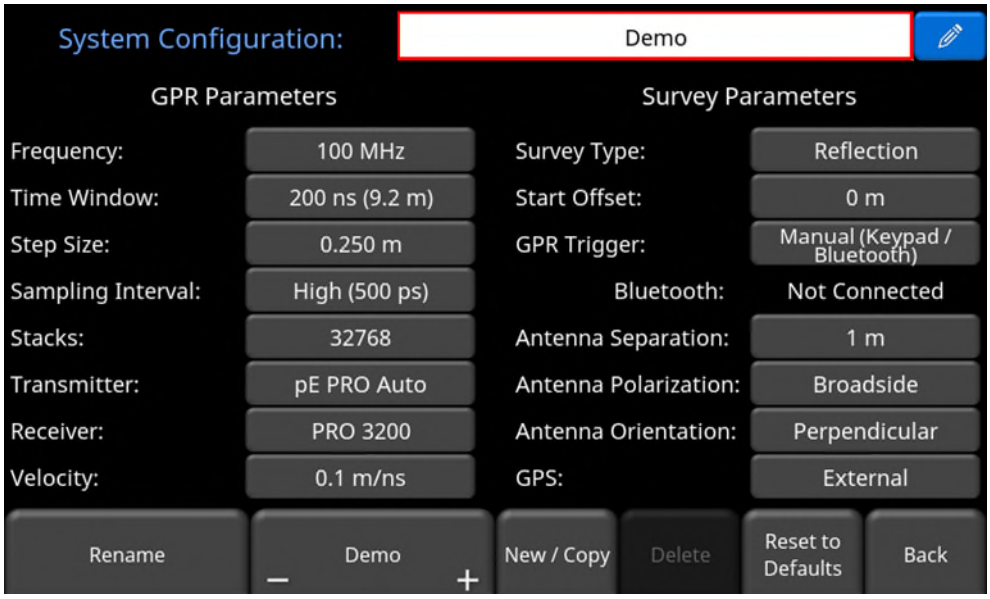


Figure 6-1: System Configuration menu

The user can save up to nine different configurations and give each a unique name. The name of the current configuration is shown at the top of the screen, and all parameters associated with this configuration are shown below.

To rename a configuration, navigate to the system configuration text box at the top of the screen with the directional-pad and press the **Rename** button on the bottom, or touch the blue button with the pencil icon  beside the configuration name at the top. Use the pop-up keyboard to edit the name and then press **OK** to accept.

To create a new configuration, press the **New/Copy** button. The user has the option to create a new configuration with default settings associated with a chosen frequency, or copy the current settings and use that as a starting point.

To select between existing configurations, press the **+** and **–** buttons under the name of the current configuration on the menu at the bottom of the screen.

To reset to the default settings for the chosen frequency, press the **Reset to Defaults** button

The screen is divided into two sections: on the left are the technical parameters related to the collection of GPR data; on the right are the setup parameters related to the physical survey. These are explained in detail below.

6.1 GPR Parameters

For each parameter described below, there is a Reset to Defaults button, which will reset that parameter to the recommended value.

6.1.1 Frequency

Pressing Frequency will take the user to a screen where they can select the frequency of the antennas/transducers they are using. Deciding which frequency to use for a survey depends on the objectives of the survey. As frequency decreases, the depth of investigation generally increases but spatial resolution decreases. Therefore, the ideal survey will be one that uses the highest frequency that adequately penetrates to the target depth.

The following table offers a guide to frequency selection. The values are based on practical experience and should be used as an approximation only.

Center Frequency (MHz)	Depth (m)
1000	0.5
500	1.0
250	2.0
100	5.0
50	10
25	30
12.5	50

The list of possible frequencies is shown in Figure 6-2.

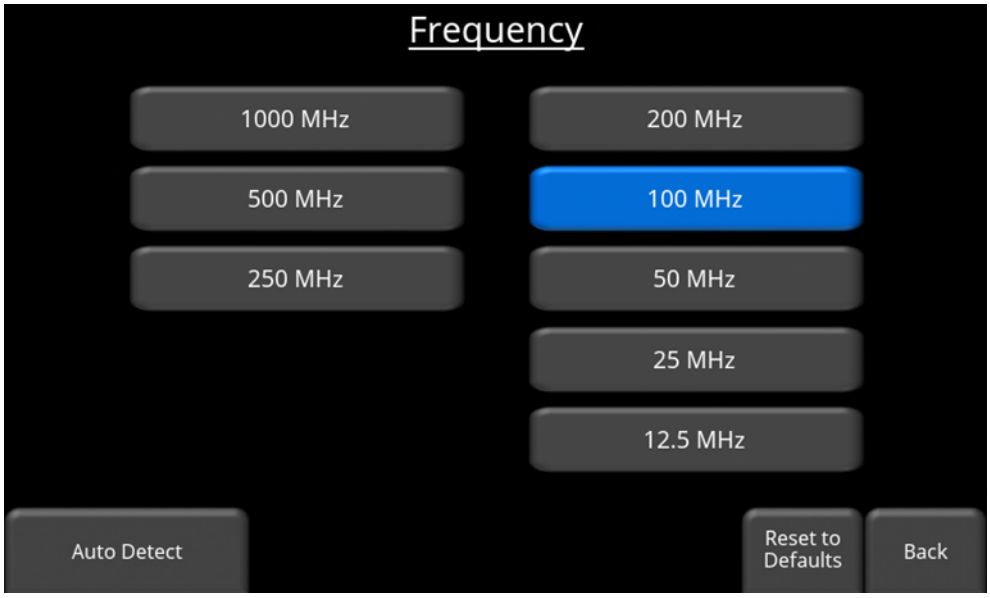


Figure 6-2: Selecting the correct frequency

The frequencies on the left are the high frequency transducers, which encompass the antenna itself, as well as a transmitter or receiver, all contained in a sealed, yellow housing. Pressing **Auto Detect** will have the system automatically detect which transducer is connected. The frequencies on the right are the antenna frequencies. Auto Detect does not apply to antennas.

Select the frequency you are using for the survey, then **Back** to return to the main system configuration menu.

6.1.2 Time Window

The Time Window setting determines how long (and therefore how deep) the GPR will collect data. It is important that it is set to a value appropriate for the depth of the survey target. An entire survey could fail if the window is not sufficiently long enough to sample to the depth of the target. Conversely, too long a time window increases the data volume and can make data hard to interpret. Remember that setting the Time Window or Depth to a certain value does NOT guarantee that the GPR signals can penetrate to that depth. It only means that the GPR receiver will "listen" for signals from that depth. If the ground material has high electrical conductivity, GPR penetration is limited, and you may not achieve the exploration depths you desire.

Press Time Window to display the screen in Figure 6-3, where you can set the Time Window in nanoseconds.

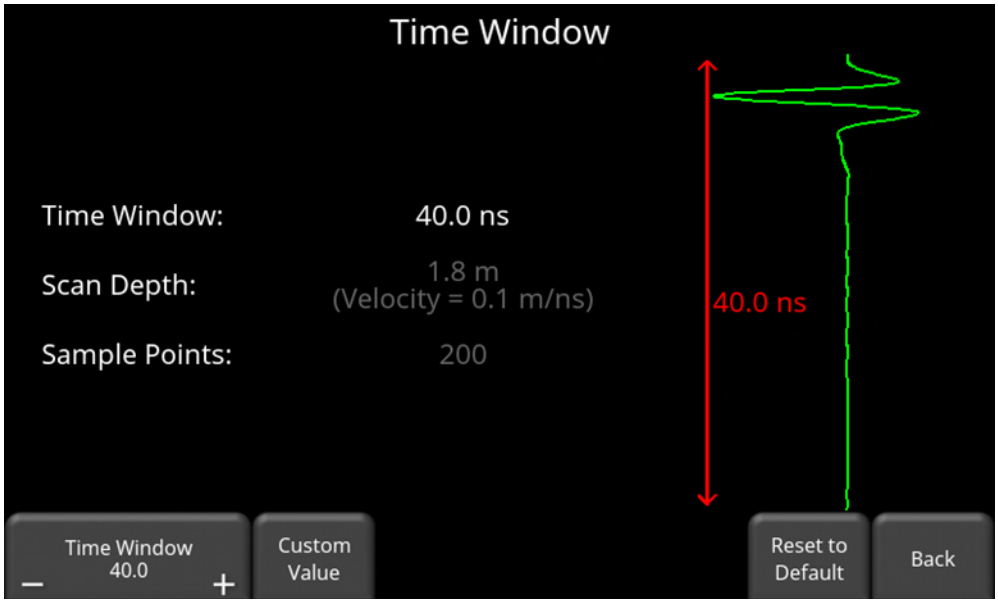


Figure 6-3: Setting the Time Window

The current Time Window is displayed. Press the **+** and **–** buttons to increase or decrease this value. Shorter time windows allow for smaller incremental changes, whereas longer time

windows permit larger incremental changes. Pressing **Custom Value** allows you to enter an exact value, which can also exceed the value obtained by just pressing the **+** button. For example, using a 100 MHz antenna, pressing the + button repeatedly will get a maximum time window of 4000 ns. However, by pressing Custom Value, it is possible to set a maximum time window up to 24,000 ns.

The maximum time window varies with antenna frequency and is shown in the table below. It is calculated based on the system collecting a maximum of 30,000 points/trace, and follows the equation:

Time window = 30,000 / Sampling Interval

The scan depth is also displayed below the time window as many users are more comfortable relating to depth. The calculated scan depth uses the velocity set in the system configuration settings, based on the (approximate) equation:

Depth = Velocity x Time / 2

The following table shows the default (and maximum) time window for each frequency, as well as the approximate scan depth, assuming a material propagation velocity of 0.1 m/ns (0.328 ft/ns).

Frequency (MHz)	Default Time Window (ns)	Approximate Depth (m)	Approximate Depth (ft)	Maximum Time Window (ns)
12.5	1600	80	262	64,000
25	800	40	131	64,000
50	400	20	66	48,000
100	200	10	33	24,000
200	100	5	16	12,000
250	100	5	16	12,000
500	50	2.5	8	6000
1000	25	1.25	4	3000

6.1.3 Step Size

Reflection Surveys

Antenna Step Size is the distance antennas are moved to collect a new trace during a survey. Select the correct Antenna Step Size to resolve subsurface targets:

- A step size that is too coarse may result in missed subsurface targets.

- A step size that is too fine a may result in large data volumes, skipped traces and slow survey productivity.

Press **Step Size** to display the screen in Figure 6-4, where this value can be set. The current Step Size is displayed in the Units selected. Press the **+** and **–** buttons to change the value, or press **Custom Value** to enter an exact value.

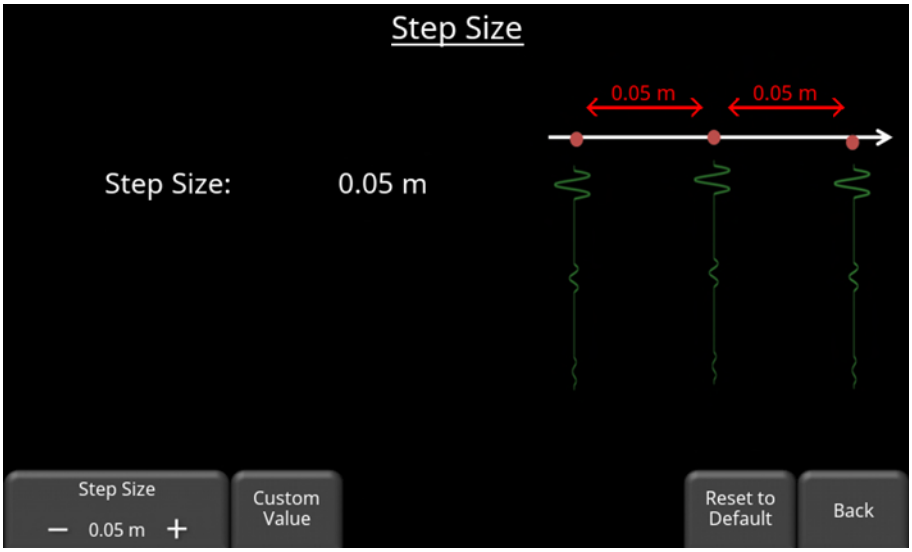


Figure 6-4: Setting the Antenna Step Size

The following table displays default values based on frequency

Frequency (MHz)	Recommended Step Size (m)	Recommended Step Size (ft)
12.5	2	5
25	1	3
50	0.5	1.5
100	0.25	1.0
200	0.1	0.5
250	0.05	0.2
500	0.02	0.1
1000	0.01	0.05

CMP or WARR Surveys

When the Survey Type (6.2.1) is set to CMP or WARR, the Step Size parameter defines the total incremental distance between the antennas as each trace is collected.

For example, for a CMP, if you plan to move the transmitting and receiving antennas each 0.1m further apart, then set the step size to 0.2m.

For a WARR, if you plan to move the receiving antenna 0.1m further apart from the fixed transmitting antenna, set the step size to 0.1m.

6.1.4 Sampling Interval

Temporal Sampling Interval defines how often the GPR wave is sampled at the GPR receiver, to accurately capture the resulting signal waveform. It is expressed as a time interval, in picoseconds, between points on a trace (1000ps = 1ns). Antenna frequency affects the sampling interval; higher frequencies are sampled at a finer time interval than lower frequencies (Figure 6-5) to accurately capture the resulting waveform.

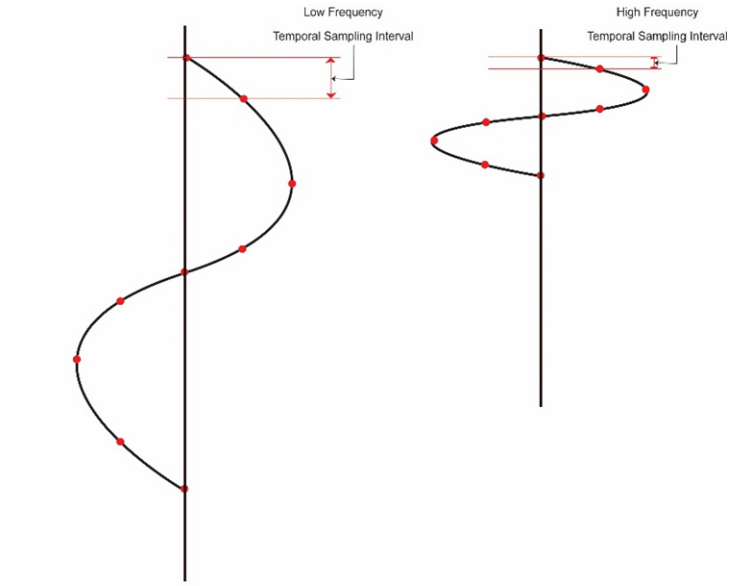


Figure 6-5: Low frequency signals require a longer sampling interval (left), whereas high frequency signals require a shorter sampling interval (right)

Press **Sampling Interval** to display the screen shown in Figure 6-6, where you can set this value.

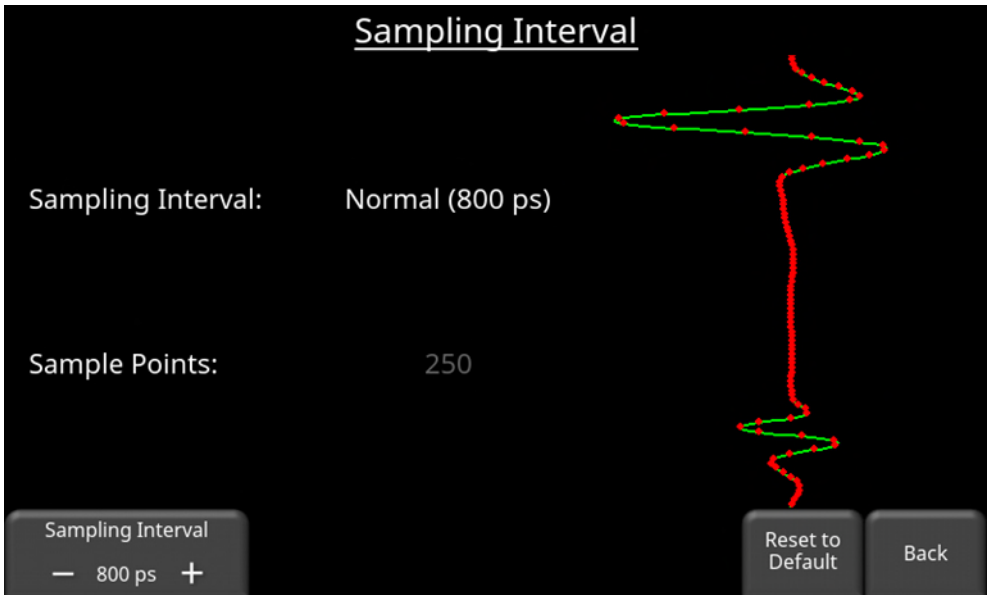


Figure 6-6: Setting the Sampling Interval

Press the **+** and **–** buttons to toggle between **Normal** and **High**. Selecting High will double the sample points if you need to have higher resolution of the reflected wave. Note that this also increases data volume and may slow down data collection.

It is rare for the user to change this value, unless they have specific requirements.

The following table displays recommended temporal sampling interval for different frequencies:

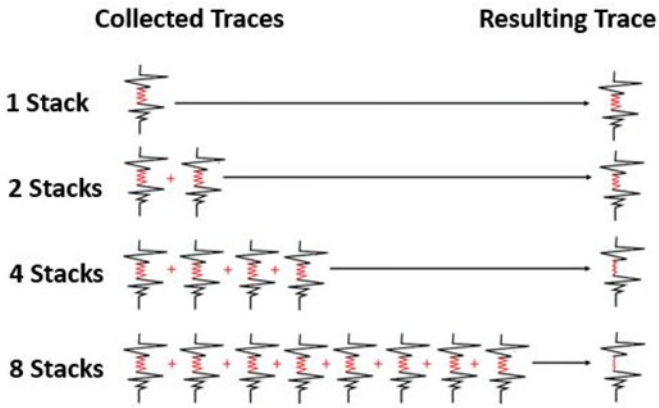
Center Frequency (MHz)	Recommended Sampling Interval (ps)
12.5	6400
25	3200
50	1600
100	800
200	400
250	400
500	200
1000	100

6.1.5 Stacks

In noisy environments, one way to improve the signal to noise ratio is to collect more than one trace at each position, average them, and then record the average trace; this is known as

“stacking”. Stacking improves data quality because noise, which is usually a random addition to the trace, tends to zero when averaged.

The following diagram displays how data is stacked. At each data collection point, the trace is collected multiple times. Traces are averaged to calculate the resulting data trace, which is saved.



Stacking improves data quality but may slow down survey production. The more stacks, the longer it takes to collect data at each survey position. It is important to find the ideal number of stacks that adequately detect the target.

Press **Stacks** to display the screen in Figure 6-7, where this value can be set. The current number of stacks is displayed. Press the **+** and **–** buttons to change the value.

With the Model 1600 receiver, stacks can be set from 1 to 2048, but most surveys see improved data quality in the range of 4 to 64 times.

With the Model 3200 receiver, stacks can be set up to 65,536 times.

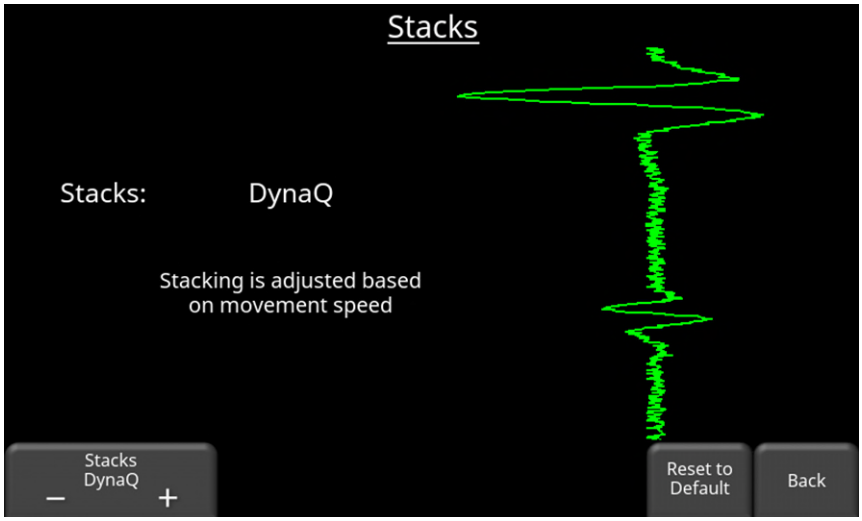


Figure 6-7: Setting Stacks

DynaQ is an option when selecting the value for Stacks. In the list it is available under stacks of 1.

DynaQ is an advanced patented technology that adjusts data quality as the system movement speed varies, essentially automatic stacking of the data.

DynaQ is only available if the Trigger is set to Odometer (6.2.3).

When using the Ultra Receiver (Model 3200), DynaQ is only available for a TimeWindow length is 1992 ns or less.

More details about DynaQ are available in the Section 7.1.1.

6.1.6 Transmitter

This setting allows you to specify which transmitter is being used for data collection. Several different transmitters can be used with a pulseEKKO system.

Press **Transmitter** to display the screen in Figure 6-8, where the type of transmitter can be set.

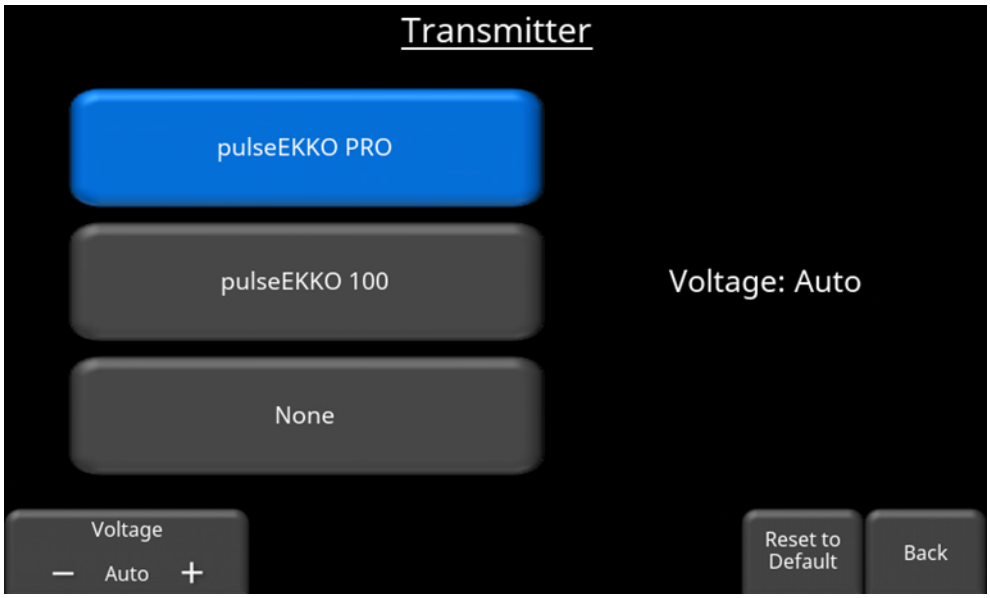


Figure 6-8: Selecting type of Transmitter. Here, the pulseEKKO PRO is selected.

If you have a **pulseEKKO PRO** transmitter, select that option. Selecting **Auto** will automatically set the voltage to the highest allowed for the frequency you are using. This is recommended setting for most users.

Some users may have the pulseEKKO PRO Variable Power (VP) Transmitter (this is not available in all regions due to local regulations). This transmitter allows you to vary the voltage manually by pressing the **+** and **–** buttons on the Voltage button on the bottom of the screen.

The voltage cycles between Level 1 and Level 5, where Level 1 is the lowest voltage used, and Level 5 is the highest. If the VP transmitter is set to Auto, it will use the highest voltage the transmitter can generate. Remember that sometimes you may want to reduce the power to prevent the receiver from being saturated at shallow depths, for example, when using 50 MHz antennas with a 0.5m antenna separation.

Unless you have a pulseEKKO PRO VP transmitter, do not change the voltage from Auto; otherwise, when you leave the System Configuration menu, an error message is displayed and you will need to come back to this menu and set it to Auto.

The **pulseEKKO 100** is an older type of transmitter for low frequency antennas that is still supported; select this option if you have this transmitter (Figure 6-9).

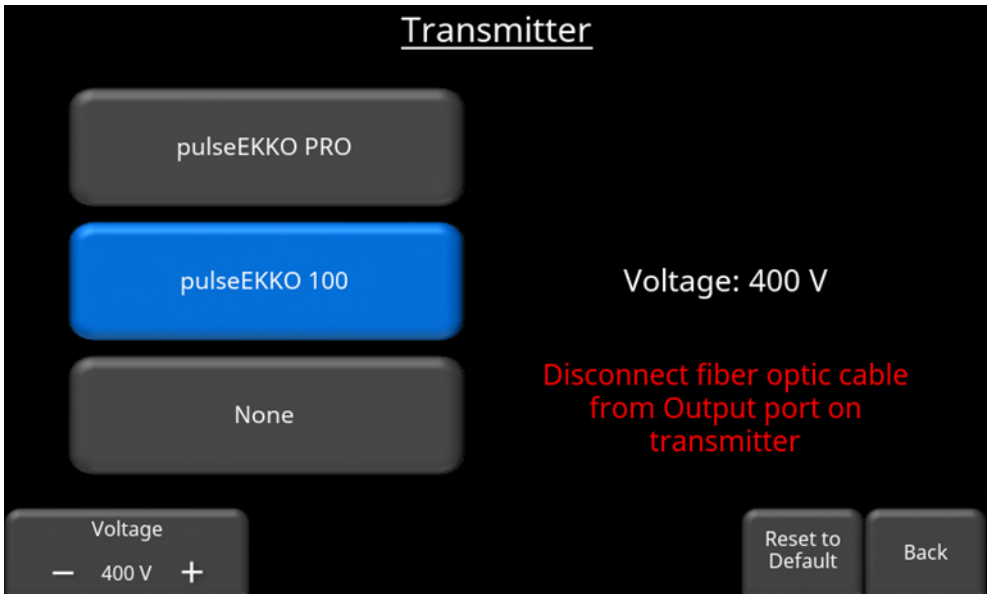


Figure 6-9: Selecting the older pulseEKKO 100 Transmitter.

Select **None** to not fire the transmitter and just listen to the background noise level.

6.1.7 Receiver

This setting allows you to specify which receiver is being used for data collection. Pressing Receiver will display the screen in Figure 6-10.

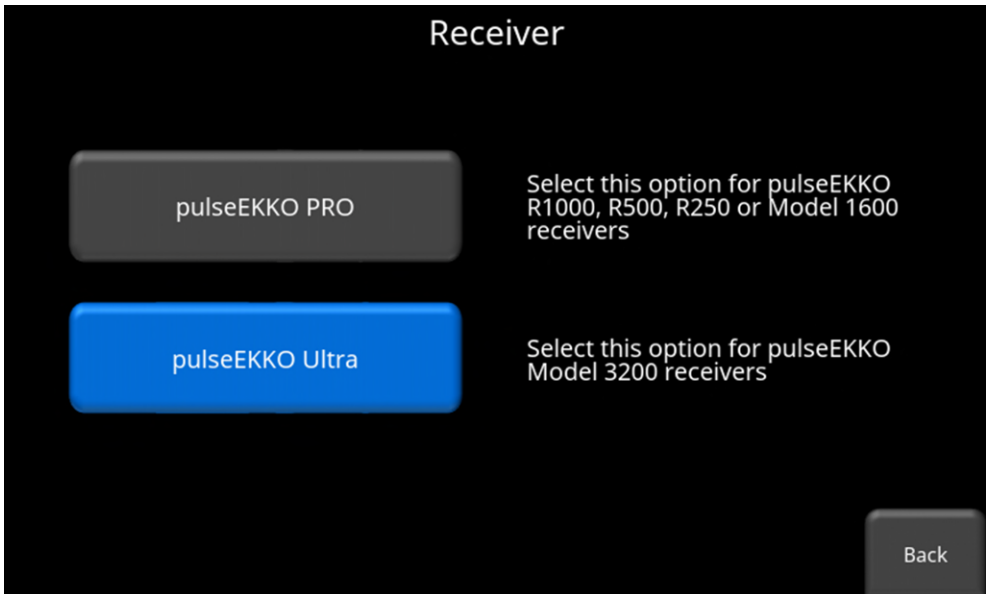


Figure 6-10: Selecting the type of Receiver.

The pulseEKKO PRO receiver is the conventional receiver used in the models specified. If this is the one connected, select this and then press **Back**.

The pulseEKKO Ultra receiver (Model 3200) allows the user to acquire data thousands of times faster than the PRO model 1600 receiver. This increased speed allows the user to stack up to 65,536 times, resulting in a reduction of the noise floor which can achieve up to double the depth of penetration in certain conditions. Collected data is recorded in a 32-bit format. If this is the one connected, select this and then press **Back**.

6.1.8 Velocity

To obtain an accurate depth axis on the display, or to calculate the estimated depth of an object, it is essential to know the propagation velocity of the GPR wave into the ground.

If you have obtained the velocity, or know the type of soil conditions, you can set it by pressing Velocity to display the screen in Figure 6-11, where the velocity can be set.

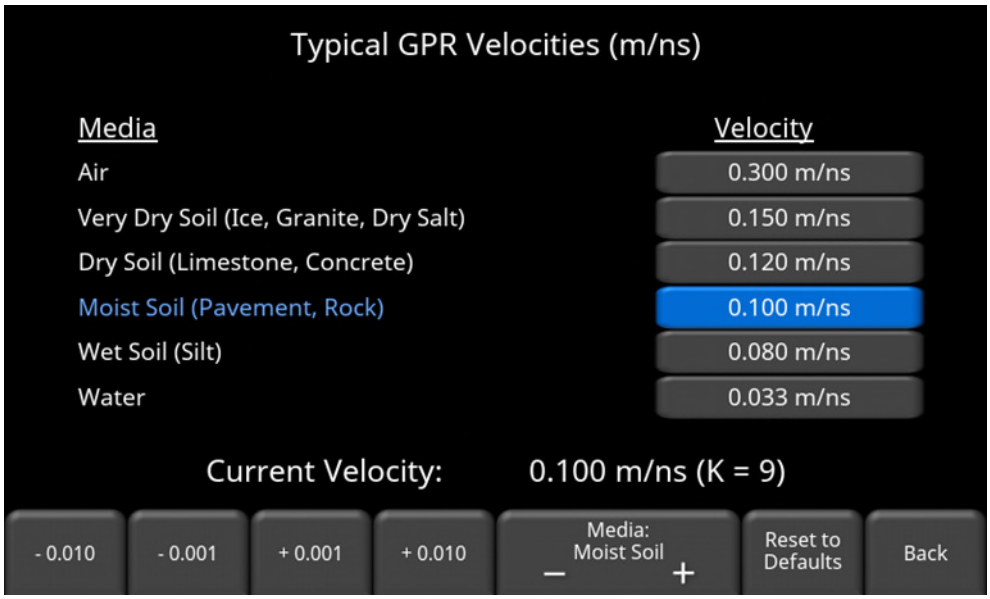


Figure 6-11: Setting GPR velocity (in US Standard units)

The table in Figure 6-11 shows typical velocity values for various soil media. It will display in whatever the selected measurement Units (5.1.2) are. The current velocity setting is shown at the bottom of the screen, along with corresponding dielectric constant (K). Velocity and dielectric constant are related by the following equation:

$$v = \frac{c}{\sqrt{K}}$$

where v is the velocity, c is the speed of light, and K is the dielectric constant.

Press the numbered buttons to increase or decrease the velocity by the listed values.

Press the **+** and **–** buttons under **Media** to select between the different soil media options shown, or directly touch the velocity value button on the screen corresponding to that media.

Refer to the chart below for a more in-depth listing of radar velocities for various materials.

Material	Velocity (m/ns)	Velocity (ft./ns)
Air	0.30	0.98
Ice	0.16-0.17	0.52 – 0.56
Dry Soil	0.15	0.419
Dry Sand	0.15	0.49
Granite	0.13	0.43
Dry Salt	0.13	0.43

Dry Rocks	0.12	0.39
Limestone	0.12	0.39
Wet Rock	0.10	0.33
Concrete	0.08-0.12	0.26-0.39
Pavement	0.10	0.33
Shale	0.09	0.30
Silt	0.07	0.23
Wet Soil	0.06	0.20
Wet Sand	0.06	0.20
Clay	0.06	0.20
Fresh Water	0.033	0.11
Sea Water	0.033	0.11

6.2 Survey Parameters

For each option described below, there is a Reset to Defaults button, which will reset that particular parameter to the default, or recommended, value.

6.2.1 Survey Type

Press **Survey Type** to display the screen in Figure 6-12 . Touch the button on the screen that corresponds to the type of survey you want to set up. When you select a survey type, it runs a short animation on the right, showing how the antennas move for that survey.

The explanation of each survey is below:

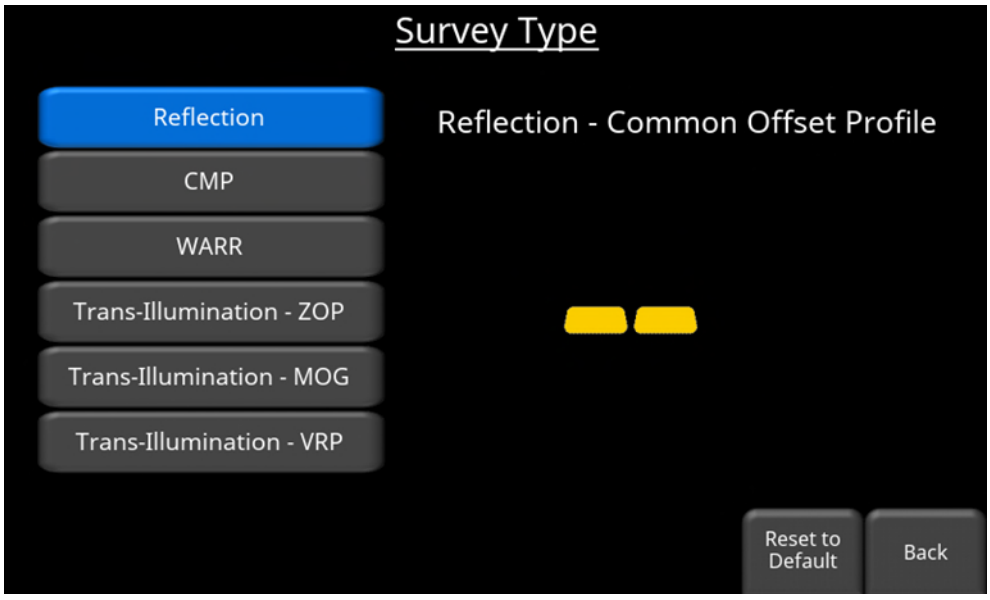


Figure 6-12: Selecting Survey Type; Reflection mode is shown

- **Reflection** – This is the most common survey method. The Transmitter and Receiver antennas are maintained at the same separation distance and are moved in tandem to create a cross-sectional profile. Whether you are using the SmartCart, SmartTow or in Bistatic mode, the principle of operation is the same.

- **CMP** – Short for Common Mid-Point, this survey is performed when you want to determine GPR velocity in an area. For best results, this survey should be performed in an area with a flat, subsurface boundary. CMP surveys work by increasing the antenna separation about a common middle point, thereby increasing the signal path length. The data collected can be analyzed to determine the velocity in the soil above that reflector (Figure 6-13).

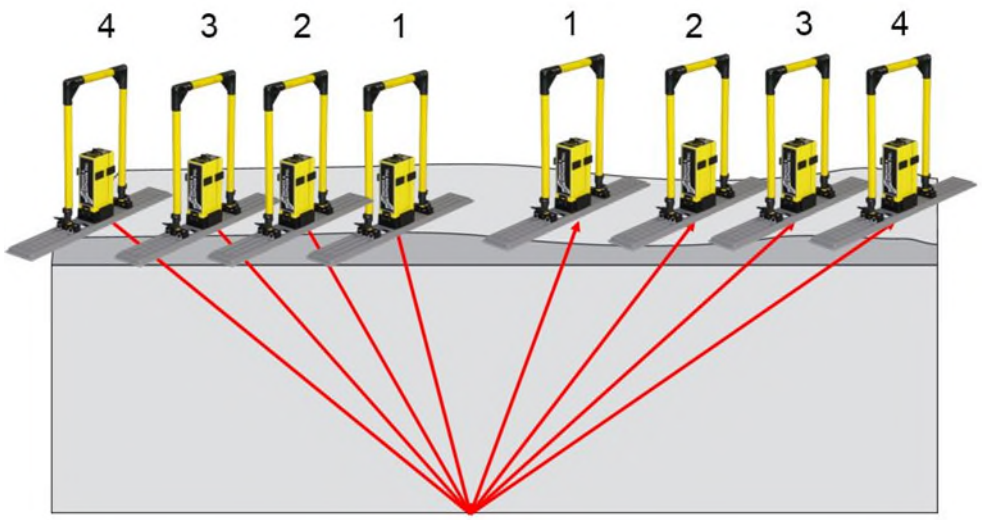


Figure 6-13: Common Mid-Point survey

Setting up a CMP survey requires the Start Offset (6.2.2), Starting Antenna Separation (6.2.4) and Step Size (6.1.3) parameters to be set.

For details of conducting a CMP survey, see Section 6.2.1. and Section 11.

- **WARR** – Short for Wide Area Reflection and Refraction. This is very similar to the CMP survey described above, except that one antenna (Transmitter or Receiver) is fixed and the other is moved away at set intervals. This can sometimes be easier where space is a constraint, since only one antenna needs to move, however you need a more uniform reflector than a CMP.

  Setting up a WARR survey requires the Start Offset (6.2.2), Starting Antenna Separation (6.2.4) and Step Size (6.1.3) parameters to be set.

  For details of conducting a WARR survey, see Section 6.2.1 and Section 11.

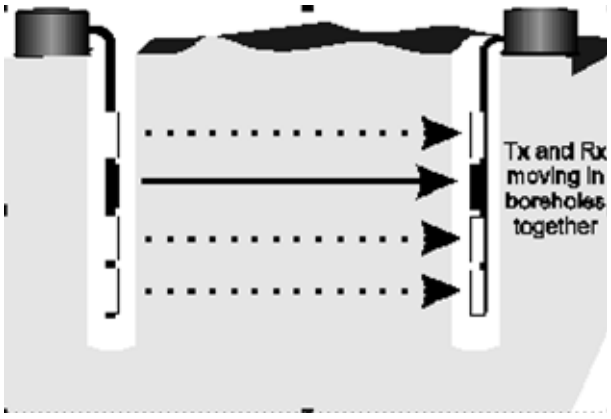
- **Transillumination (ZOP, MOG, VRP)**
  Transillumination surveys are used to study the properties of a material by placing the transmitting and receiving antennas at opposite sides of the structure. The GPR signals travel one-way through the material from the transmitter to the receiver.



Figure 6-14: Transillumination survey on a column

The most common application of Transillumination are Borehole GPR surveys, but it can also be used above the surface on objects like dams, thick walls and pillars. Transillumination surveys are less common than reflection type surveys because the data requires a fair amount of processing to get meaningful results.

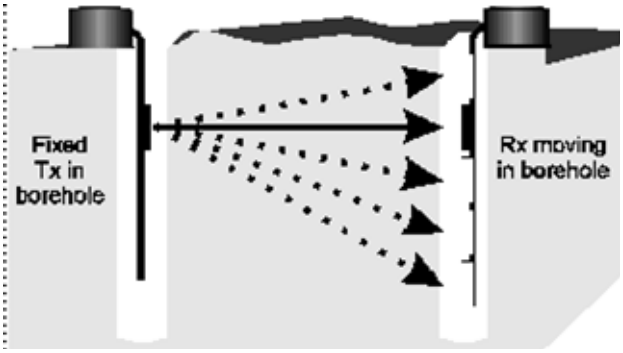
- **Transillumination – ZOP** – Short for Zero Offset Profile. The transmitter and receiver are moved in sync, or equal steps.



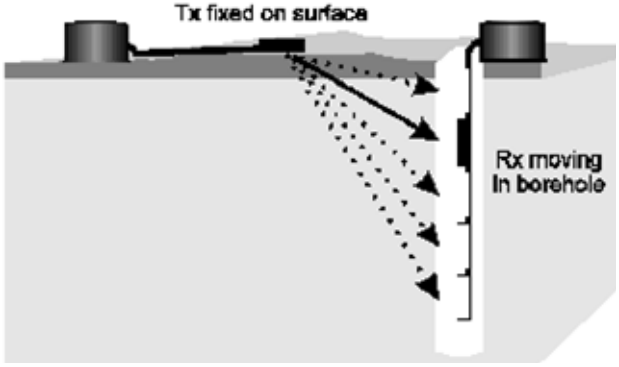
Another example is, if you are scanning a column (Figure 6-14), as you move the transmitter 10cm up the column, the receiver also moves the corresponding distance in the same direction.

- **Transillumination – MOG** – Short for Multi-Offset Gather. The goal for this survey is to generate multiple ray paths with as many different angles as possible. This is done by fixing the transmitter, then moving the receiver at regular intervals. Then the transmitter

is moved and the receiver is again moved at regular intervals (you could also have the Receiver fixed and the Transmitter moved). This process is repeated until you have achieved the desired coverage. Each time the Transmitter is moved, a new data collection line is started.



- **Transillumination – VRP** – Short for Vertical Radar Profile. In this survey, the transmitter is fixed and the receiver is moved in steps at right angles to the transmitter orientation. In the case of borehole radar, the transmitter is on the surface and the receiver is moved down the borehole. The transmitter is then moved to another position at a specified interval on the surface and the process is repeated.



Refer to the Borehole GPR manual for more details.

6.2.2 Start Offset

Reflection Surveys

Normally, most lines start at position zero; however, you may want to specify a start offset for a given line (e.g. 2m). This may be necessary if an obstruction prevents you from starting at a consistent position relative to other lines. When you start collecting data, the position axis would start at this offset value. Negative values can also be entered. Pressing **Start Offset** will display the screen in Figure 6-15.

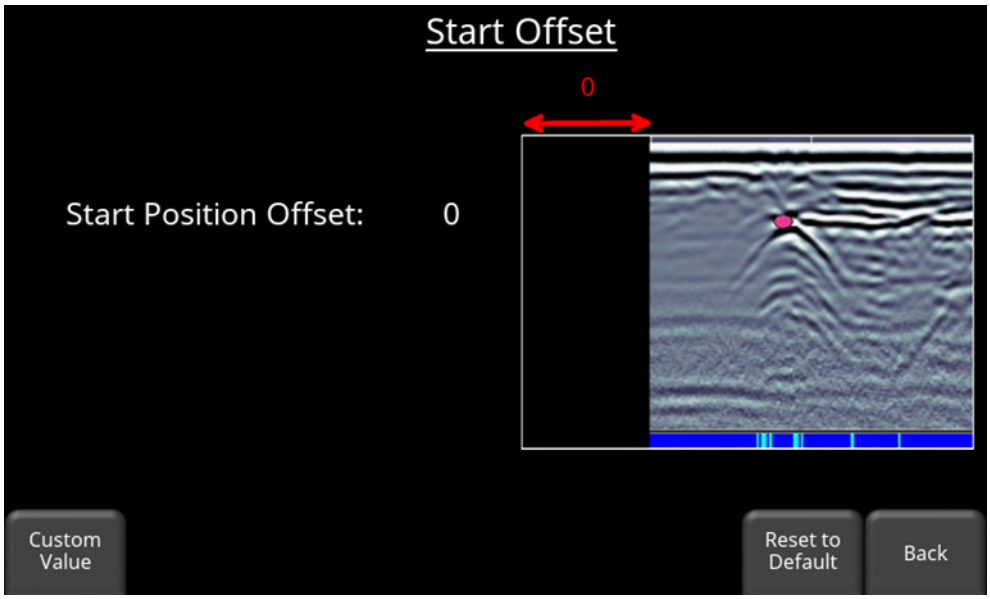


Figure 6-15: Specifying a Start Offset

Press **Custom Value** to enter a specific offset value.

CMP Surveys

If using a measuring tape to position the transmitting and receiving antennas for the survey, layout the measuring tape on the ground and set the mid-point of the survey to a nice, round number on the measuring tape, for example 20.0m. Then set the **Start Offset Position** parameter on the DVL to this value. The user interface automatically calculates the next position for the transmitting and receiving antennas on the tape measure. This makes CMP data collection easier and reduces errors in the field (see Section 6.2.1).

Another consideration for positioning a CMP survey is, you may want the survey centered at a position that corresponds to a position along a previously collected reflection survey line. If so, set the **Start Offset Position** to that value, for example, 175.5m.

WARR Surveys

If using a measuring tape to position the transmitting and receiving antennas for the survey, layout the measuring tape on the ground and set the start position to a nice, round number on the measuring tape, for example 20.0m. If the **Start Offset Position** parameter is set to this value, the user interface automatically calculates the next position for the receiving antennas on the tape measure. This makes WARR data collection easier and reduces errors in the field (see Section 11).

Another consideration for positioning a WARR survey is, you may want the survey to start at a position that corresponds to a position along a reflection survey line. If so, set the Start Offset Position to that value, for example, 175.5m.

6.2.3 GPR Trigger

This allows you to setup how the GPR system will trigger the transmitter to fire and collect a data trace. Pressing the **GPR Trigger** button will display a screen (Figure 6-16) where you can select and configure the various trigger methods.

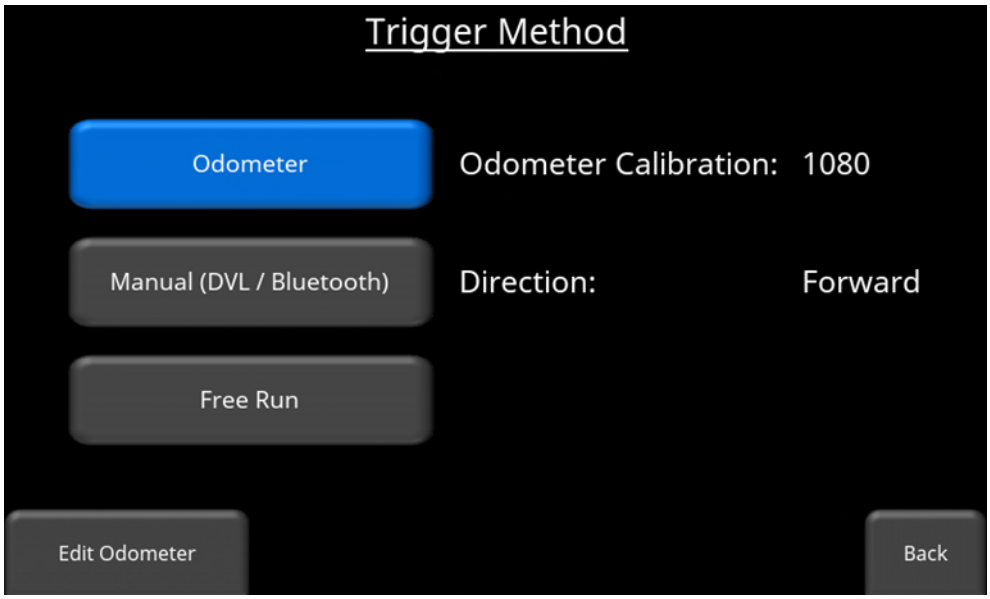


Figure 6-16: Trigger Method

- **Odometer** – If you have a setup containing a wheel, then you will likely use this option. As the odometer wheel moves one step size, it will cause the transmitter to fire. This is the easiest mode to operate in, as you don't have to worry about collecting data at equally spaced intervals. Pressing the **Edit Odometer** button takes you to the screen in Figure 6-17, where you can setup and calibrate the odometer if you haven't already. Essentially this is the same as the odometer test screen (5.2.6).

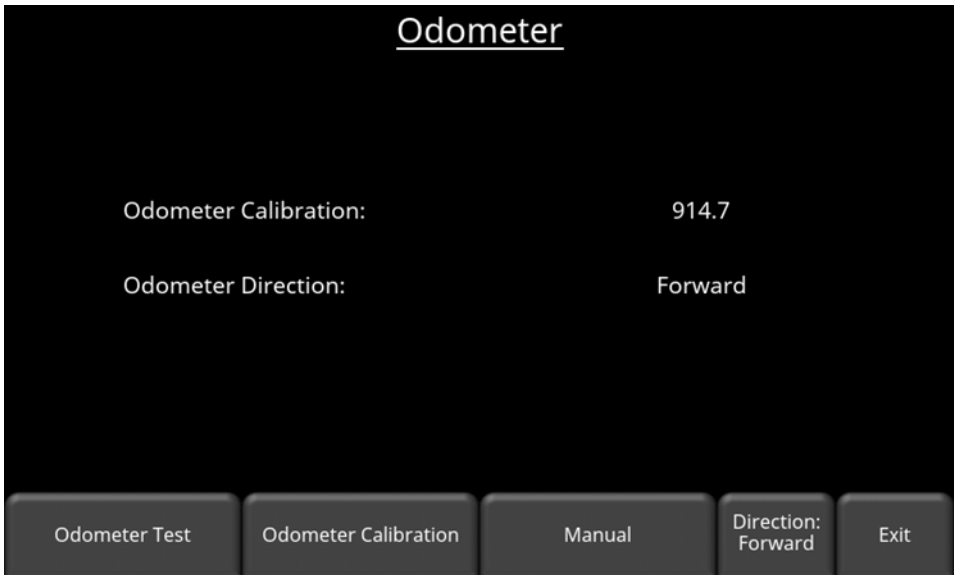


Figure 6-17: Edit Odometer screen

- **Manual (DVL/Bluetooth)** – This is typically used when surveying in difficult terrain where antennas cannot be moved easily or at regular time intervals. For the position of each measurement point, the system assumes the operator has moved the antennas one step size along the survey line.

  When this option is selected (Figure 6-18), the user can trigger the system either with a wireless remote or by pressing the **Up** or **Down** arrow buttons on the 4-way keypad (Figure 4-5).

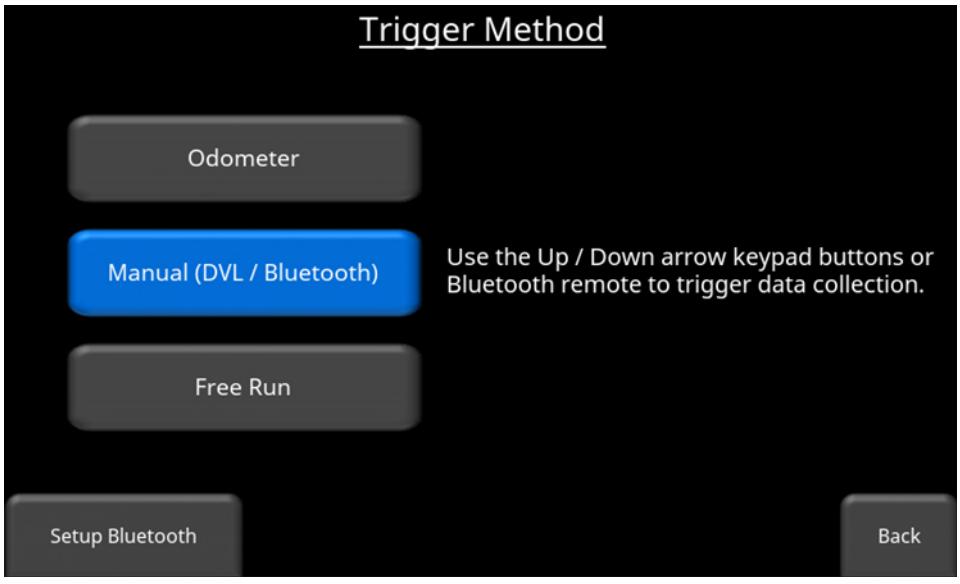


Figure 6-18: Selecting the Manual Trigger

Pressing **Setup Bluetooth** will take you to the menu in Section 5.1.7 where you can connect and test a wireless trigger device.

- **Free Run** - In some cases, collecting data with an odometer is not practical or even possible, for example when collecting from a boat. Free run mode allows the system to pulse based on a specified time interval or pulse continuously. This is best for surveys in unobstructed terrain where antennas can be moved easily. For the position of each measurement point, the system assumes the operator has moved the antennas one step size along the survey line. Pressing **Free Run** will display the screen in Figure 6-19.

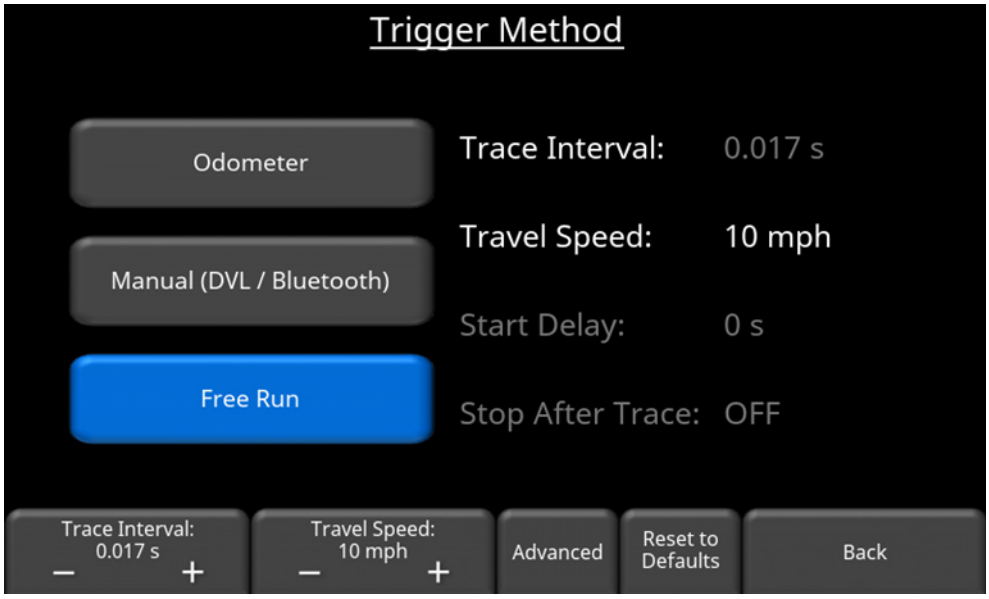


Figure 6-19: Free Run Trigger method

The trace interval (time between pulses) can be varied from a little as 0.01s up to 60s. It is based on:

Distance = Travel Speed x Trace Interval

The user has the option to control the *trace* interval or the travel *speed*, such that the programmed step size (*distance*) is maintained. In the example in Figure 6-19, the user wants to travel at 10 mph. To maintain the set step size, the trace interval will automatically be set at 0.017s.

> **Note**: If the trace interval and speed value are colored in red (Figure 6-20), it means that it's too fast for the system to collect. Reduce speed or increase the trace interval. You can also increase the step size, reduce the time window, and reduce number of stacks.

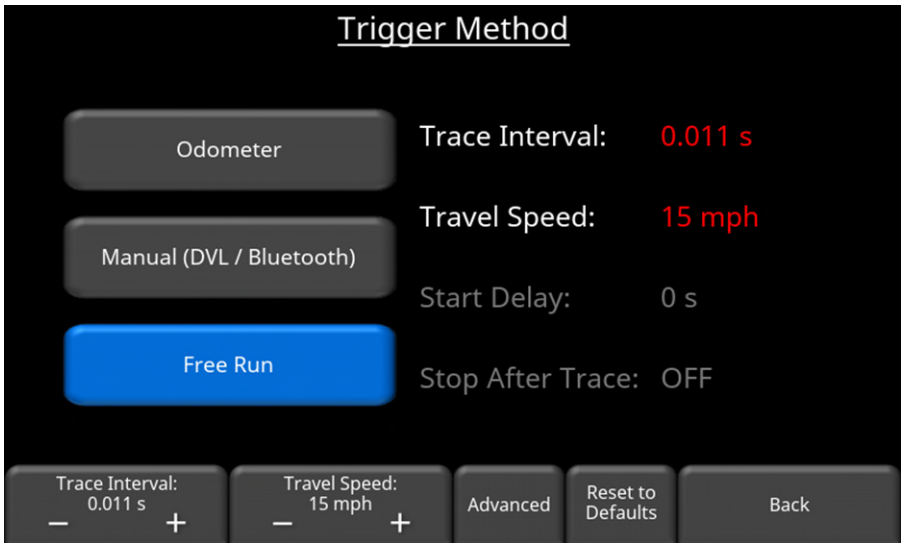


Figure 6-20: Red letters indicate that speed-interval combination is too fast. Change step size, stacks, or depth.

Pressing the **+** and **–** buttons under **Trace Interval** and **Travel Speed** allows you to set whichever parameter you want to control; the other is calculated automatically.

Remember that in Free Run mode, data is collected even when the system is not moving, so proper data collection relies on the operator moving the system at a consistent speed. Positioning this way is reasonably accurate, but not very precise because the system movement speed usually varies. It is a best practice to have a secondary means of positioning the data, for example, a GNSS or adding Flags (7.1.11) at known positions along the survey line. This way, the data can be *rubberbanded* in post-processing software. Note a grid cannot be collected in Free Run mode.

Press **Advanced** to see additional options on the bottom menu (Figure 6-21).

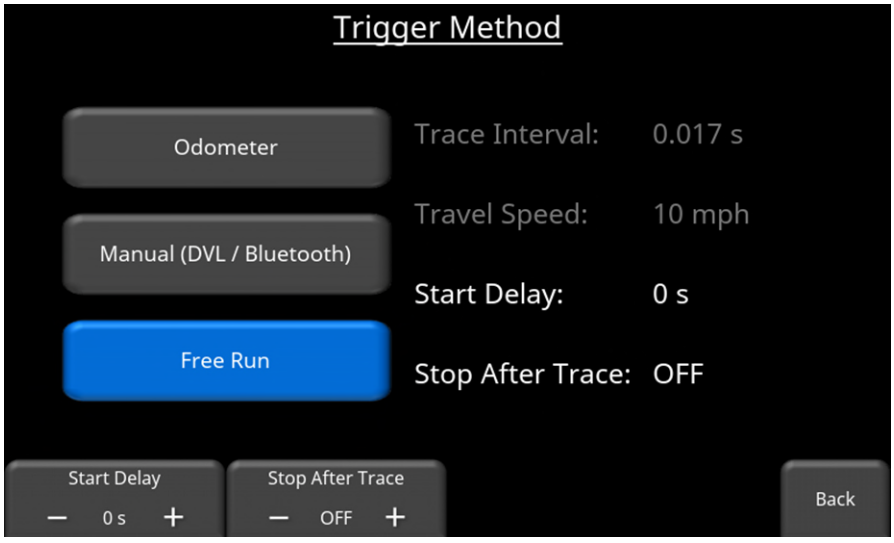


Figure 6-21: Advanced menu

- **Start Delay** – Allows the user to set an initial time delay in seconds, to give time to get setup and prepared to start the survey line. Use the **+** and **–** buttons to set the desired time.
- **Stop After Trace** – Allows the user to define a set number of traces to collect before the system stops, giving the user an opportunity to make changes or adjustments, for example. Data collection on this line cannot be continued after this; a new line must be started. Use the **+** and **–** buttons to set the desired number of traces (Figure 6-22), or it can be set to **OFF**.

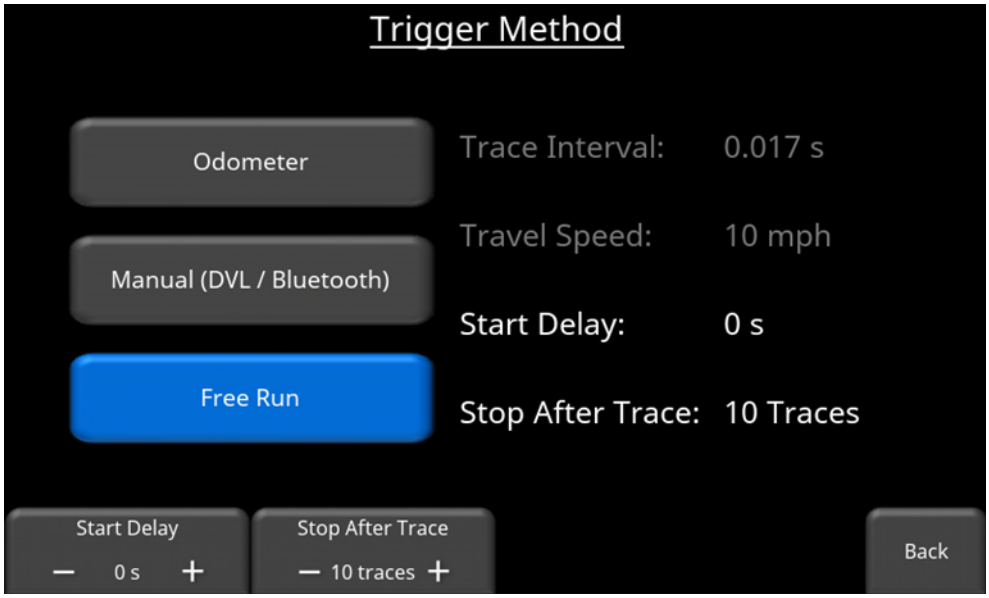


Figure 6-22: Pausing data collection after 10 traces

6.2.4 Antenna Separation

Reflection Survey

When moving transmitting and receiving antennas along a reflection survey line, it is important to maintain a fixed separation between them. Antennas mounted on a cart, tow frame or one-person handle have a fixed antenna separation. When antennas are not fixed, use a rope or measuring tape to maintain the fixed antenna separation (see Section 11).

Press **Antenna Separation** to display a screen shown in Figure 6-23:

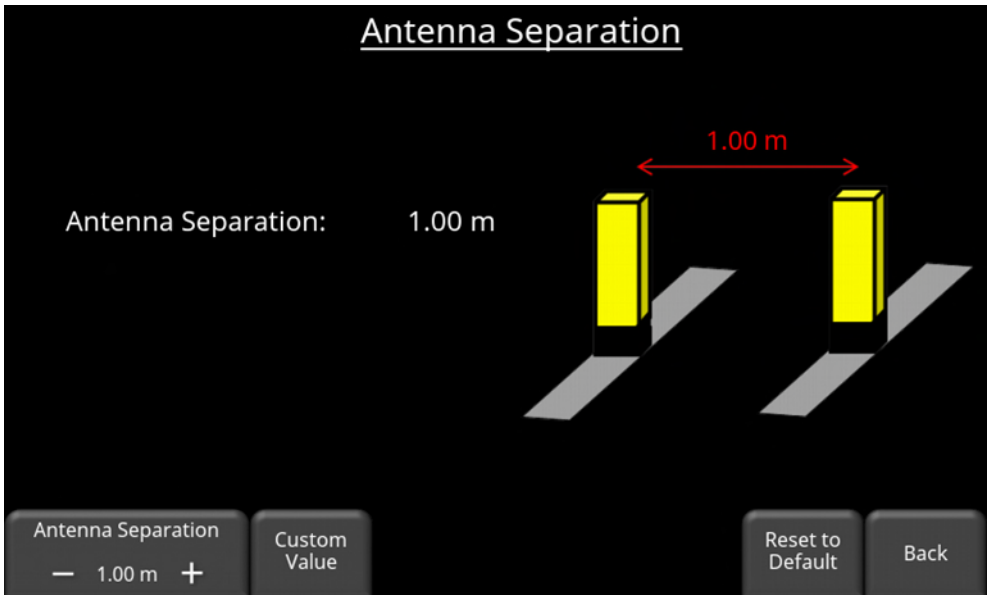


Figure 6-23: Setting Antenna Separation

Press the + and – buttons under **Antenna Separation** to set the desired separation values. It will cycle through common pre-set values. Press **Custom Value** to enter a specific antenna separation value.

In general, the recommended antenna separation should equal the antenna length. For example, for 100 MHz antennas (which are one meter long), the separation should be set one meter apart. If the antenna separation is too small, receiver electronics *may* be overloaded by the transmission signal resulting in data clipping, depending on what type of transmitter is used. For convenience and practicality, it is permissible to use a separation of 0.5 m for the 100 MHz antennas when a pulseEKKO PRO transmitter is used.

Frequency (MHz)	**Minimum Antenna Separation (m)**	**Minimum Antenna Separation (feet)**
12.5	8	25
25	4	15
50	2	5
100	1 (or 0.5)	3 (or 1.5')
200	.50	1.5
250	0.40	1
500	0.23	0.75 (9 in)
1000	0.15	0.5 (6in)

CMP or WARR Surveys

When the Survey Type is set to CMP or WARR, the Antenna Separation parameter changes to the **Starting Antenna Separation** parameter. This is the distance the transmitting and receiving antennas are separated for the first trace of the CMP or WARR survey. Based on the antenna frequency, use the recommended separation in the table above.

6.2.5 Antenna Polarization

All the pulseEKKO antennas and transducers have the flexibility to allow different orientations with respect to each other. Press **Antenna Polarization** to display the screen in Figure 6-25 where the user can set the Antenna Geometry.

Most surveys are conducted in the Broadside-Perpendicular configuration. This is because the maximum amount of energy transmitted (and received) is perpendicular to the long axis of a dipole antenna. Figure 6-24 shows the emitted (and received) radiation pattern for a pair of antennas.

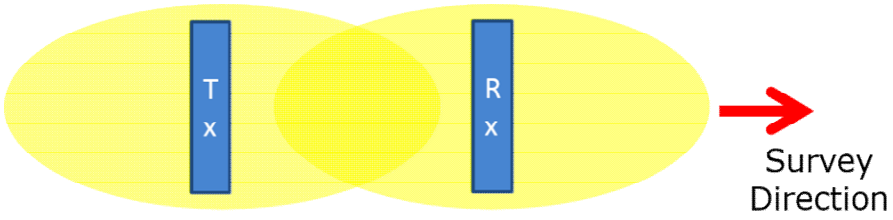


Figure 6-24: Radiation pattern for a pair of antennas

There are times, however, when the geometry needs to be changed. Factors to consider are:

1. Orientation of subsurface reflectors
2. Minimizing airwaves
3. Collecting a wider swath of data
4. Minimizing noise from external radio sources

It is important for users to understand the direction and polarization of the EM field, and the effect that antenna rotation will have on the above factors; this is beyond the scope of this manual.

Press the **Polarization** button at the bottom of the screen to select between the three options explained below:

- **Broadside** is the typical configuration that most people use for reflection surveys. This provides the best coupling between antennas and reduces reflections from targets off to the side (Figure 6-25).
- **Endfire** has the antennas in a line (Figure 6-26). This is sometimes used for larger antennas where space is a consideration.

- **Cross-polarization** orients one of the antennas (transmitter or receiver) 90 degrees with respect to the other (Figure 6-27).

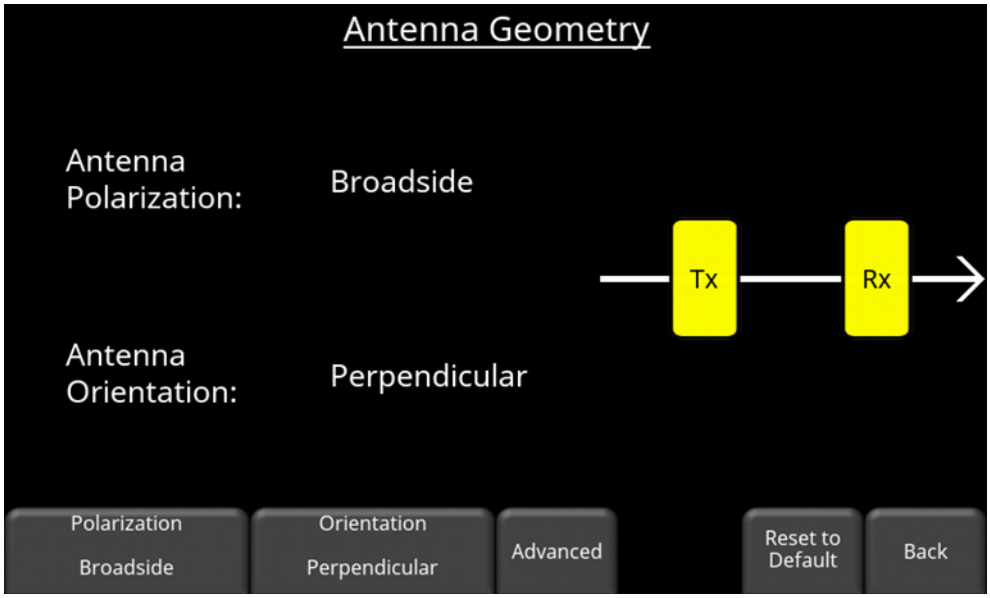


Figure 6-25: Antenna Geometry is Broadside Perpendicular

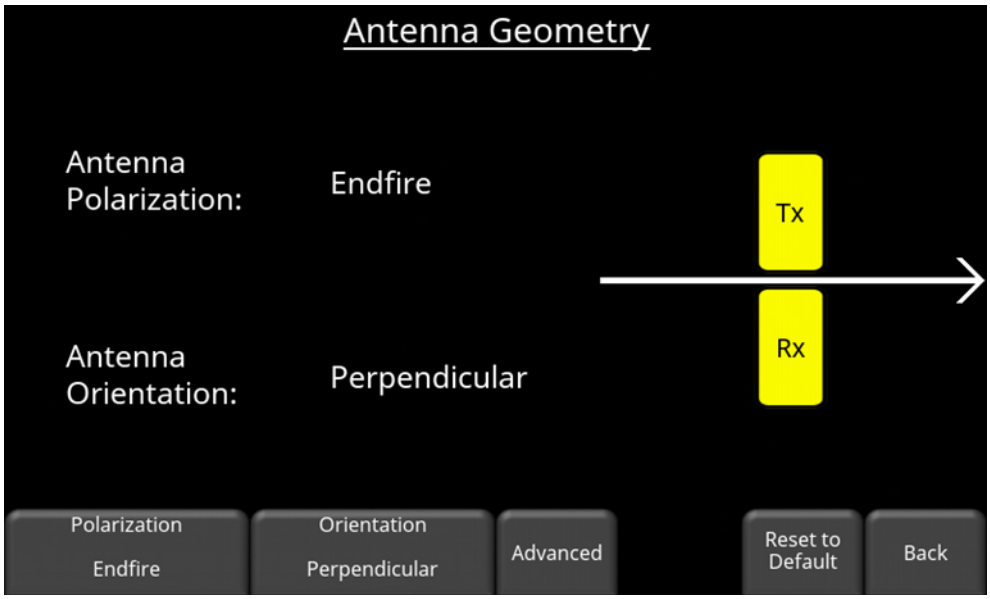


Figure 6-26: Antenna Geometry is Endfire Perpendicular

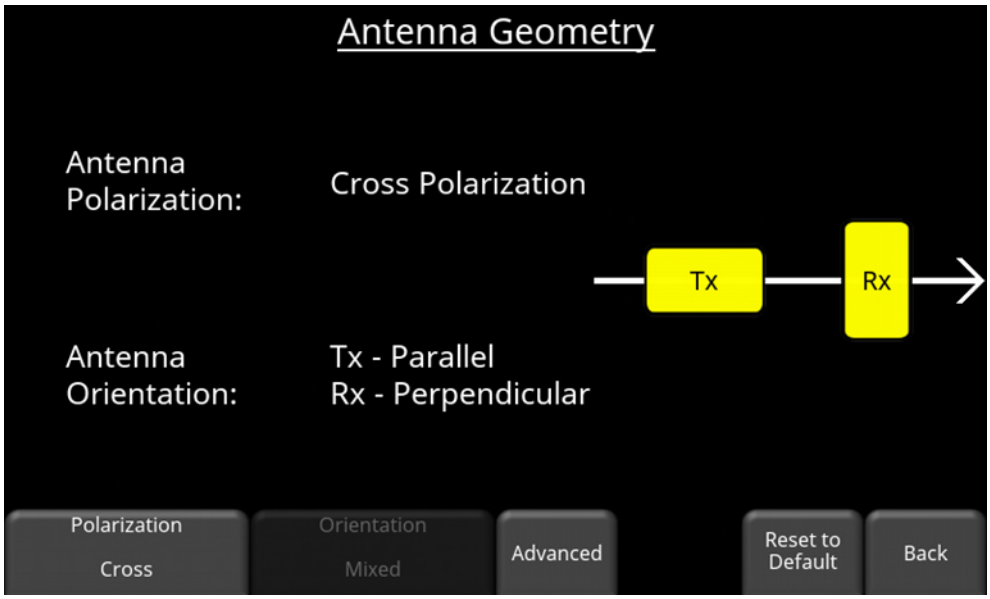


Figure 6-27: Antenna Polarization is Cross polarization (Tx – Parallel, Rx – Perpendicular)

Press **Orientation** to toggle between Parallel and Perpendicular. This refers to the orientation of the antenna relative to the survey direction.

Press **Advanced** to display the change the bottom menu as shown in Figure 6-28. This allows the user to control the placement and rotation of each antenna. The black arrow shown represents the direction of the Electric Field vector (E).

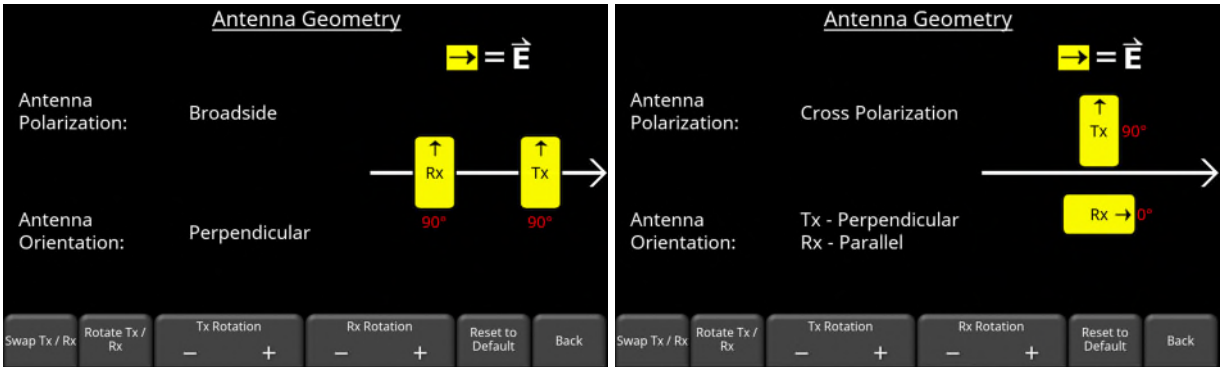


Figure 6-28: Advanced menu for setting antenna orientation

- Press **Swap Tx/Rx** to switch the positions of the Transmitter and Receiver antenna
- Press **Rotate Tx/Rx** to rotate them both by 90 degrees. Successively pressing this will also switch the positions of the Tx and Rx once it reaches 270 degrees
- Press the **+** and **–** buttons under Tx Rotation to rotate the Transmitter by 90-degree values
- Press the **+** and **–** buttons under Rx Rotation to rotate the Receiver by 90-degree values
- Press **Reset to Default** to return them to the standard orientation with no rotations.

The direction of the E field is indicated on all pulseEKKO transmitters, receivers and transducers (Figure 6-29):



Figure 6-29: Transducer showing the Electric field vector.

6.2.6 GPS

Press **GNSS** to enter a menu where you can setup and configure the GNSS (Figure 6-30). This is same menu for the GPS test, see Section 5.2.5 for more details.

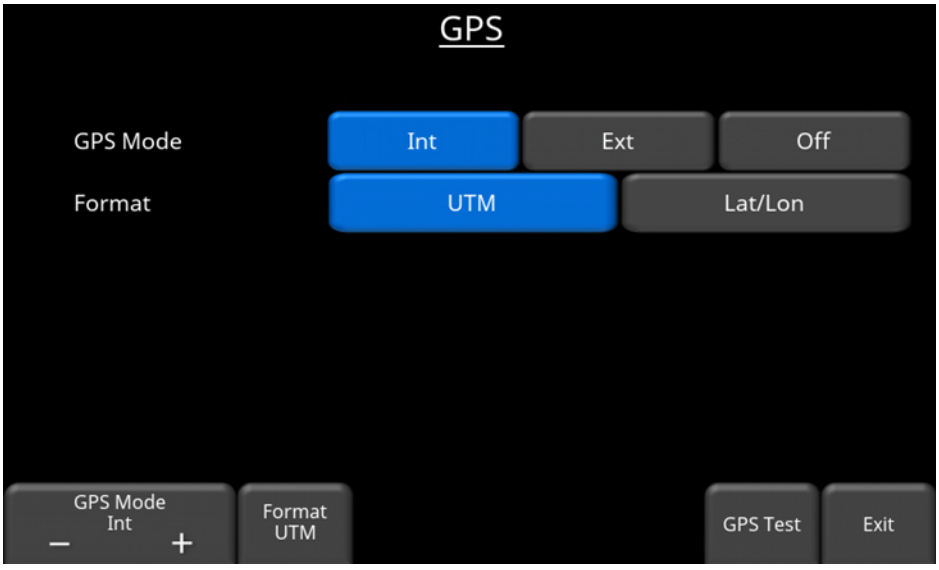


Figure 6-30: GPS Configuration

6.3 Incompatible Settings

When the user presses Exit, there may be a warning message that appears if any incompatible settings exist. It is recommended to go back into System Configuration and correct the settings. If you exit without fixing, the warning message will appear again when you go to collect data.

In Figure 6-31, the user received an error message when they tried to set Stacks to DynaQ with the Trigger option set to Manual.

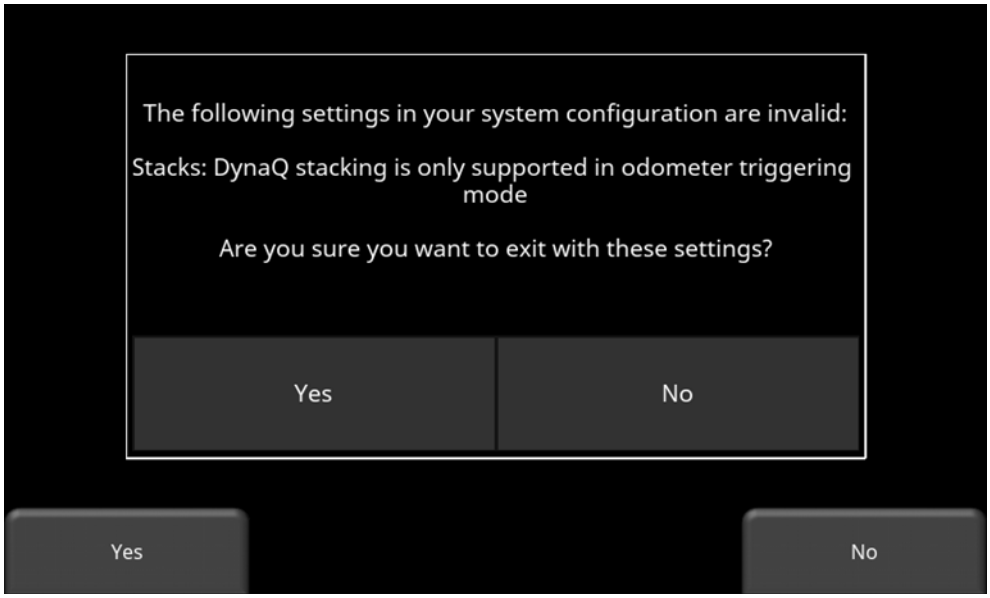


Figure 6-31: Warning message when exiting System Configuration

7. Collecting Data

From the main menu, press **Run System**. This takes you to the screen shown in Figure 7-1. Data is organized into Projects, numbered from 1 to 20. Projects can be given a custom name by pressing the pencil icon  beside the project name; this opens a keyboard where the user can type in a name. The project will always be referenced by the number and name shown at the bottom.

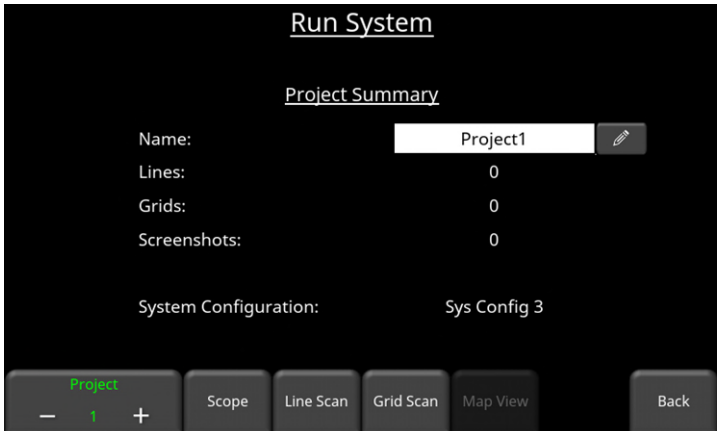


Figure 7-1: Preparing to collect data

The user has the option to collect Lines and/or Grids in each project, depending on the survey type selected. Grids can only be collected in reflection mode surveys. Line Scan and Grid Scan operation are described below.

If no antenna or transducer is detected, you will see the screen in Figure 7-2. The only difference is that the Scope button is replaced with a **Turn On GPR** button. Make sure antenna or transducer is connected; if it's an antenna, make sure both the Transmitter and Receiver are turned on.

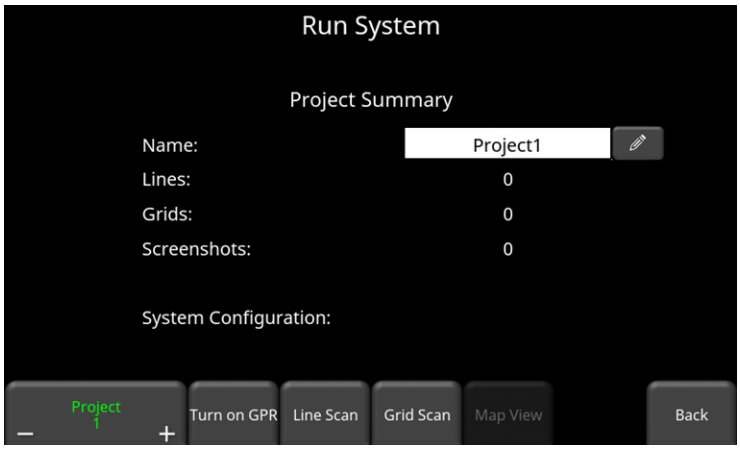


Figure 7-2: Turn on GPR button is shown instead of Scope

> **It is highly recommended to Scope the system before data collection. Scope mode ensures the GPR pulse is properly positioned within the recording time window. Press the Scope button to enter Scope Mode. The details of scope mode are described in Section 0.**

7.1 Line Scan

Line Scan mode allows the operator to acquire data along a line and examine it as a cross-section image. Line Scan mode can be used to identify the alignment of subsurface features, check for linearity and acquire accurate depth measurements.

Once you are in the desired project number then press the **Line Scan** button to enter this mode. You will then see the screen in Figure 7-3.

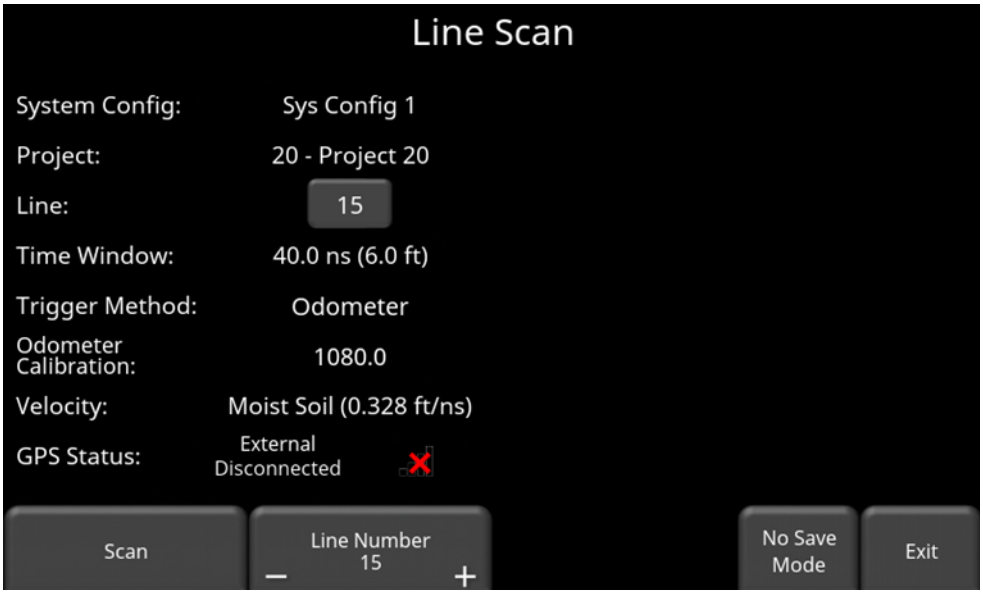


Figure 7-3: Preparing to Line Scan

Some details about the system configuration are displayed, along with the project number/name and line number. Press the **+** and **–** buttons under Line Number to switch to a different line number. Press **Start** to enter data collection mode. To collect data without saving, press **No Save Mode** (Section 7.1.16).

The GPS Status indicates which GNSS is currently selected.

It is a common error to have an External GNSS attached but have the Internal GNSS selected in the GPS menu on the DVL (see Section 5.2.5). Confirm the DVL screen says "External".

The screen displays the quality of the GNSS signal, which is based on the number of satellites that it sees. The chart below explains what the colors and bars mean:

Indicator Color	# of bars	# of Satellites
Red	1	4
Orange	2	5
Green	3	6,7
Green	4	8,9
Green	5	10+

7.1.1 Collecting Data in Reflection Mode

In the data acquisition screen, the parameters for the data collection are initially displayed in the left of the window. Press **Start** to begin collecting data.

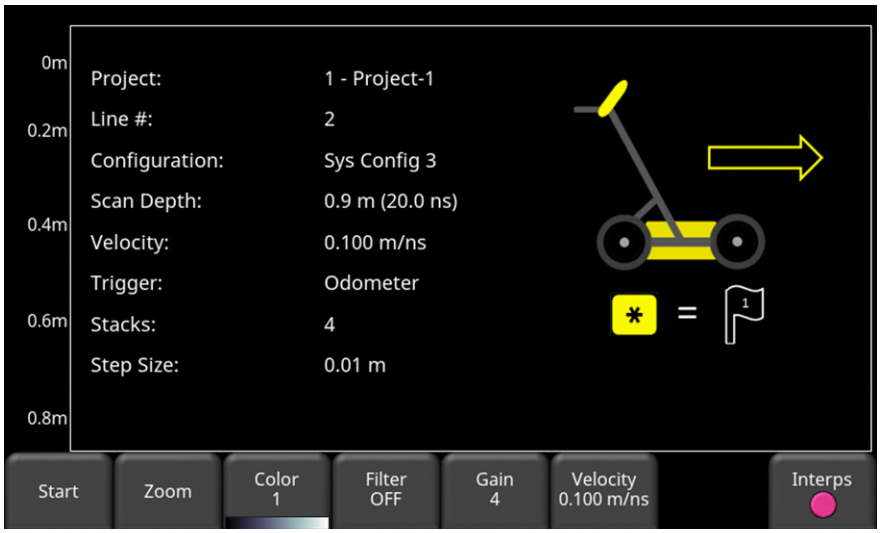


Figure 7-4: Beginning of data acquisition

As the system is pushed or pulled along a straight line, the collected GPR data scrolls onto the screen from the right and moves to the left. Figure 7-5 shows the depth scale along the side of the GPR Line image and the position scale along the top of the image. The units are set to Metric or US Standard units based on the setting in the Section 5.1.2.

The depth scale can also be changed to a time scale, with units of nanoseconds (ns). Tap the vertical scale to switch back and forth between depth and time.

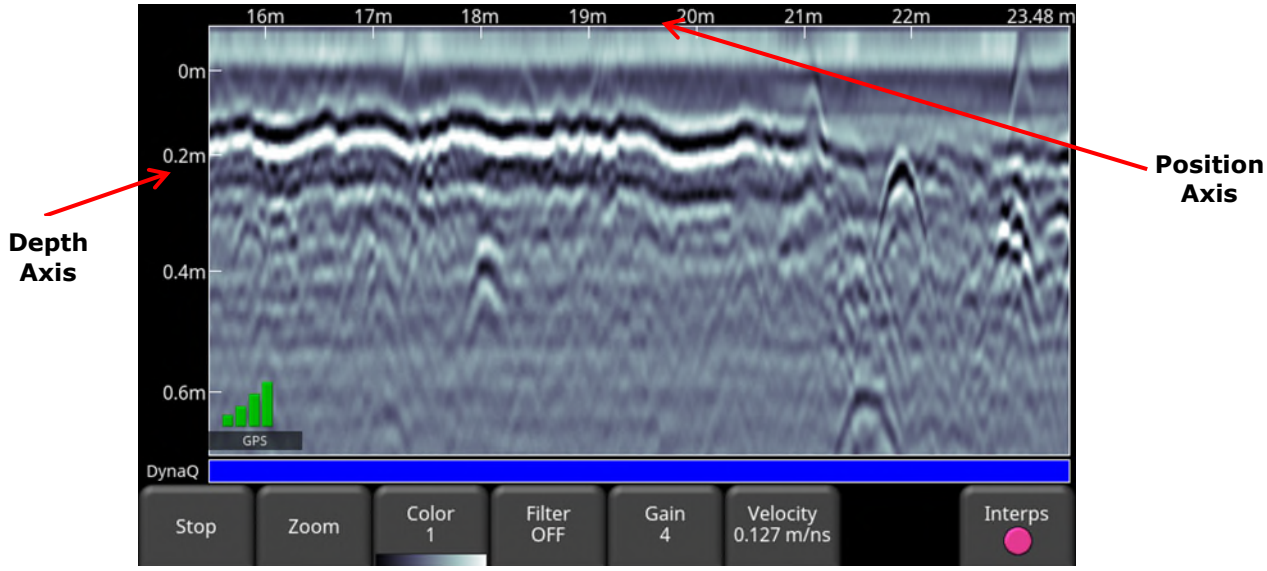


Figure 7-5: Line Scan acquisition mode, showing collected data and axis labels. Touch the vertical scale to switch from depth to time. DynaQ indicator is shown at the bottom above the menu options (odometer trigger only).

If Auto-Hide Buttons is set to ON, the menu at the bottom of the screen disappears as soon as you start collecting new data, thereby maximizing the data display area. When the user stops, backs up, touches the screen or presses a button on the keypad the menu reappears.

If the user collects data too fast for the given settings, the system may skip data traces. This usually happens if one or more of the following conditions exist:

1. The Scan Depth (time window) is set to a deep value
2. Step size is less than the recommended value
3. Stacking is set to a high value

Where the traces skipped, there are small red bars at the bottom of the data (Figure 7-6). If the total number of skipped traces is greater than 10% of the total number of traces, a warning message will appear (Figure 7-7) when the line is stopped.

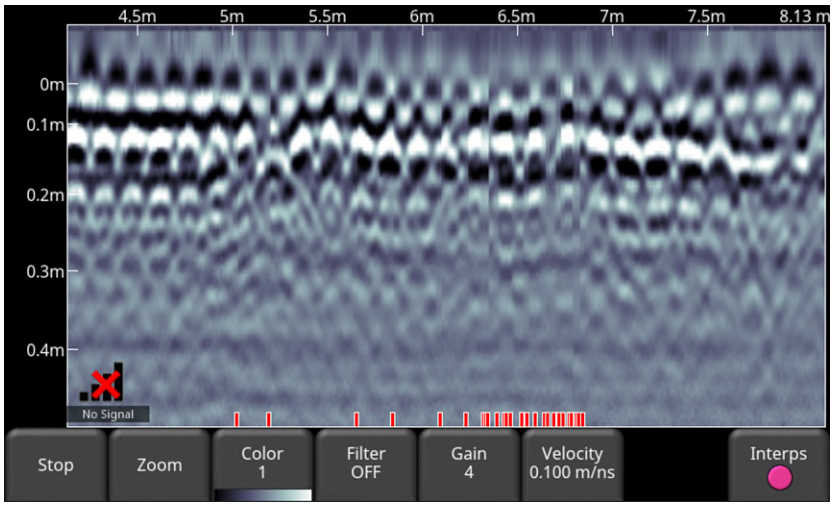


Figure 7-6: Skipped traces shown in red at bottom of screen

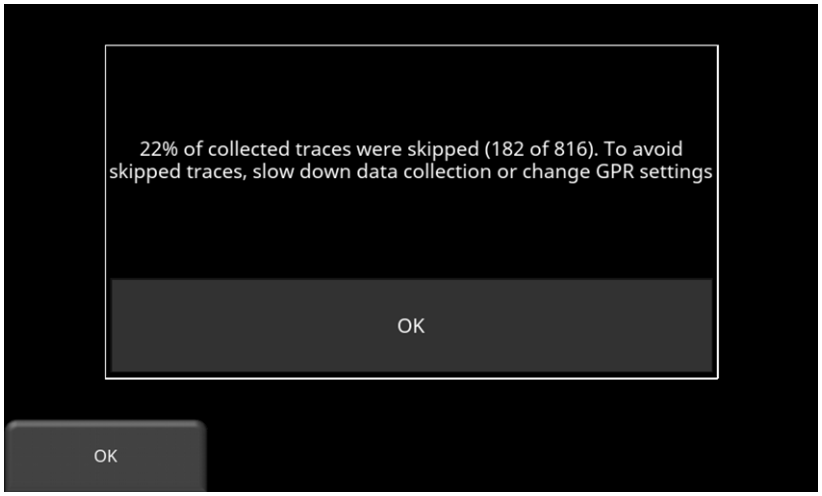


Figure 7-7: Warning message when more than 10% of traces are skipped

7.1.2 DynaQ Bar

If Stacks are set to DynaQ, a colored bar, called the DynaQ Bar is displayed under the GPR cross-section as it scrolls across the screen (Figure 7-5). DynaQ is only available if the GPR Trigger is set to Odometer.

DynaQ is an advanced patented technology that adjusts data quality as the GPR system movement speed varies. In most situations, moving the system at a comfortable walking speed generates data of good quality. In situations where target resolution or maximum penetration depth is critical, moving slower increases data quality. This is essentially automatic stacking of the data.

The color of the bar indicates the quality of the data at that point along the line:

Number of stacks	Colour Code
0	White
1-3	Yellow
4-7	Blue
8-511	Dark Blue
512-2049	Purple
2050-8191	Light Green
8192-65,536	Dark Green

The higher the number of stacks, the better the quality of data. You should avoid getting a DynaQ colour of white or yellow, which means the speed of movement is too fast for the data being collected.

DynaQ can be selected for all pulseEKKO frequencies, however you will never get light or dark green colours on the DynaQ Index Bar unless a Model 3200 Ultra Receiver is used.

7.1.3 Back-up Indicator

Line Scan mode incorporates a back-up feature to enable you to accurately locate targets and mark them on the ground. The back-up indicator is only available for a survey where the trigger is set to Odometer.

After acquiring some data on the screen, move the system backwards over the line (Figure 7-8). During back-up mode, there will be two indicators:

- **Position Indicator**: The red vertical line corresponds to the location at the center of the GPR sensor. As you pull the system backwards, the Position Indicator moves to

mark the current location of the cart in the image. A box appears with the current position, relative to the start of the line, listed as the top number.

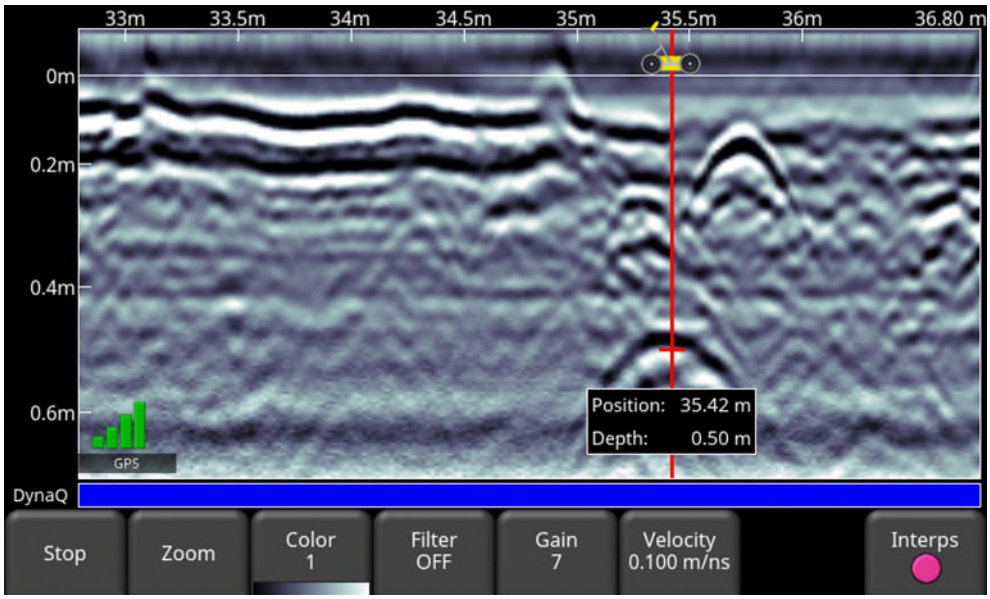


Figure 7-8: Back-up Indicator and Depth Indicator shown

- **Depth Indicator**: A short red horizontal line corresponds to the current depth value, as shown in the bottom number in the box. To determine the depth of an object, move the indicator up or down by touching and dragging the horizontal line to the desired location. Alternatively, you can also use the **Up** and **Down** arrows on the 4-way directional keypad. Note: make sure you have calibrated for velocity to ensure depth accuracy (Section 7.1.9).

To locate a feature, simply roll the system back along the same path until the red vertical line is exactly over the response (usually a hyperbola). You can mark the location of the object on the ground and push the system forward to continue data collection. Once you reach the point where you initially started backing up, the system will continue acquiring new data.

7.1.4 Depth and Position Dialog Box

You can obtain depth and position information anywhere on the Line Scan by touching the screen and holding for about two seconds. A crosshair appears where you touched the screen, with a box displaying the position and depth (Figure 7-9). To get the position and depth information about a different point on the screen, simply touch and drag the box or crosshair to the desired position. This is available regardless of what trigger is selected.

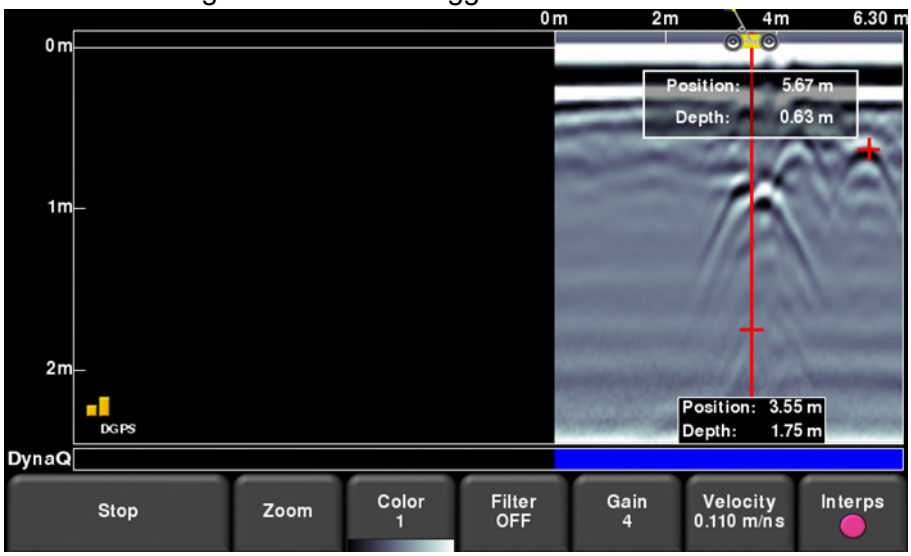


Figure 7-9: Touch the screen for 2 seconds to get depth and horizontal position at any point

7.1.5 Zoom

This button controls the horizontal and vertical scaling of the displayed GPR data. Pressing the **Zoom** button opens a sub-menu with new buttons, which are explained below:

- **Depth** – Pressing **+** and **-** under the **Depth** button allows you to change the maximum displayed depth (Figure 7-10). This is based on time window (6.1.2) set in the System Configuration menu, as well as the currently selected velocity.

  Just be clear, the zoom depth setting does not affect the depth (time window) of the collected data; it only affects the depth *display* of the data. In other words, it is possible to record data to a depth of 5m but only display the top 3m.

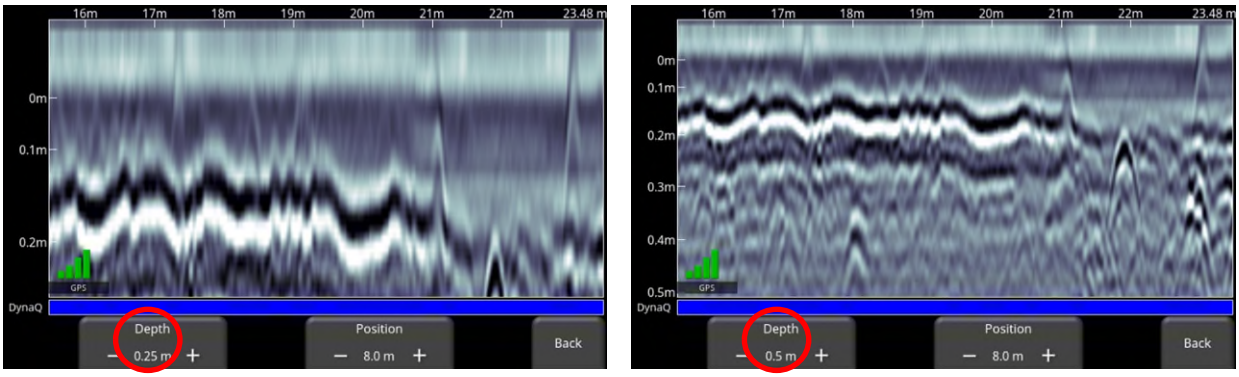


Figure 7-10: Changing the displayed depth

Time – if the user changes the vertical axis to show time (in nanoseconds), then the screen will appear like Figure 7-11, where pressing the + and – buttons under Time will allow them to change the displayed time window.

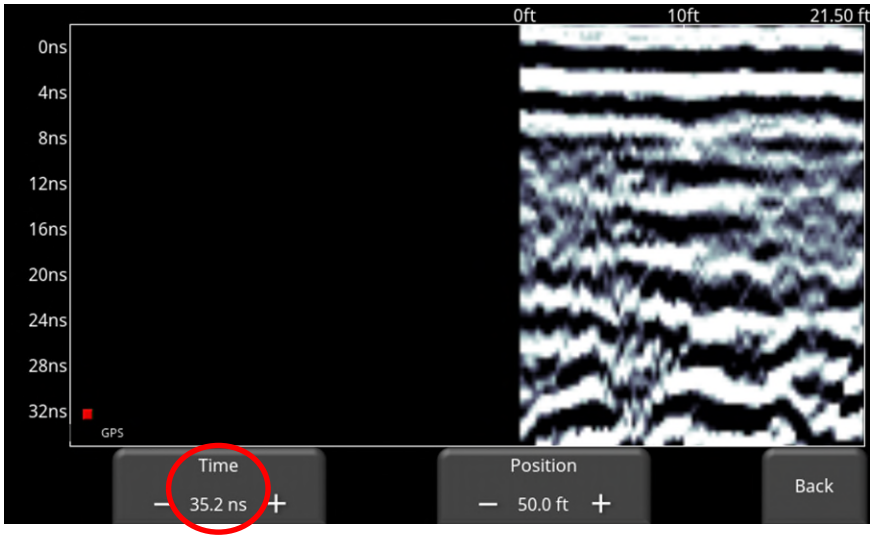


Figure 7-11: Changing the displayed time

- **Position** – Pressing **+** and **-** under the **Position** button allows you to change the length of data display on a single screen. This is also known as horizontal scaling. One reason for setting this higher would be to fit more data on the screen and look for consistency among hyperbolas that were crossed (Figure 7-12).

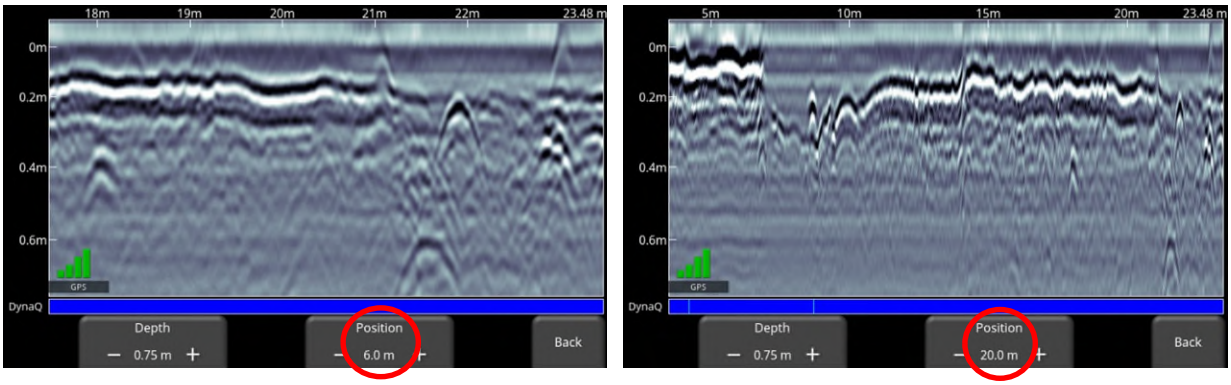


Figure 7-12: Varying the position, or horizontal scaling

7.1.6 Color

Pressing **Color** changes the color palette for the GPR Line. There are 9 different color palette options. The image is automatically re-displayed as the color palette changes. A few sample color palettes are shown in Figure 7-13.

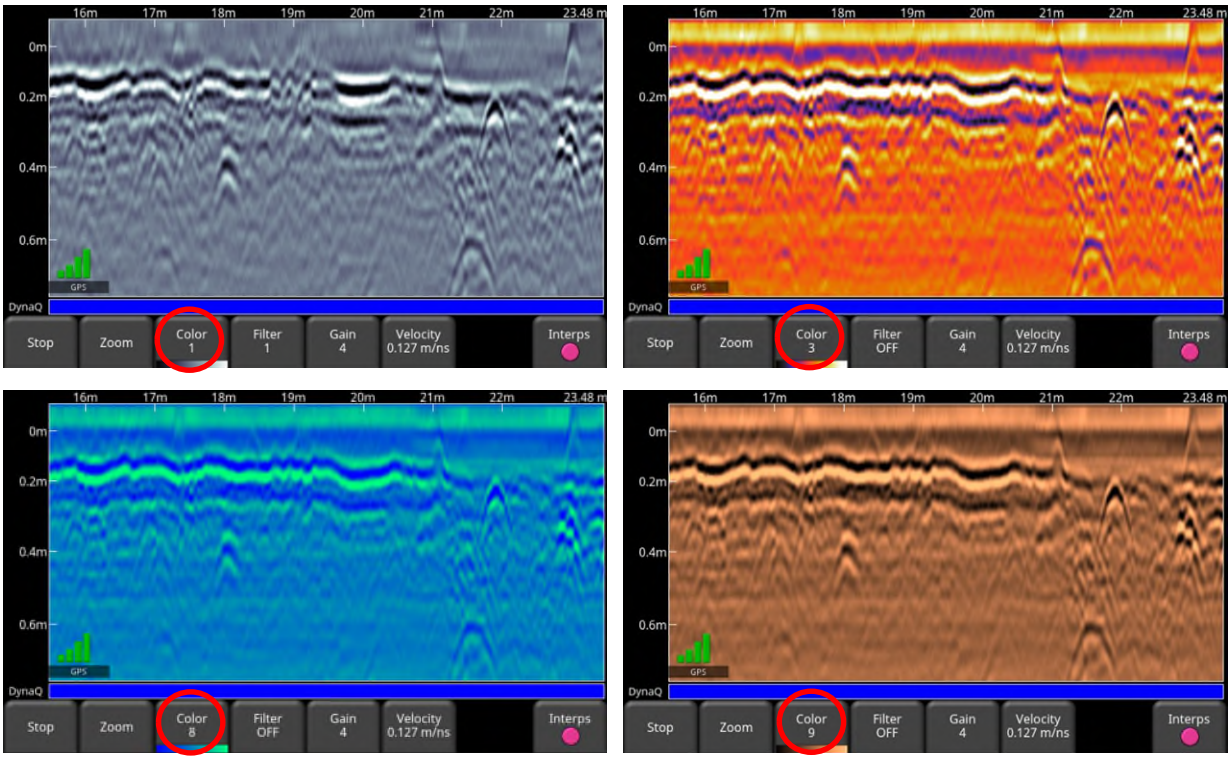


Figure 7-13: Changing color palettes

7.1.7 Filter

The Filter is a background subtraction filter used for removing flat-lying responses in the data. Filtering helps identify shallow targets that might be masked by the strong signals at the top of the image, as well as possibly enhancing the visibility of hyperbolas further down in the data. However, it will also filter out other flat-lying responses, such as soil boundaries, so be careful when using the filter option if your target is flat.

It works by applying a running-average background subtraction to the data set, defined by the filter width or a window. This window “moves” across the data and the result is subtracted for every trace in the data set. The Filter is variable and pressing this button cycles between **OFF** and values **1** to **5** (Figure 7-14).

The lower the number, the longer the filter width, and the more “relaxed” the filter. Only the longer flat-lying features get removed.

The higher the number, the shorter the filter width, and the more “aggressive” the filter. This results in the removal of long and short flat-lying features.

Pressing **OFF** turns the filter off completely.

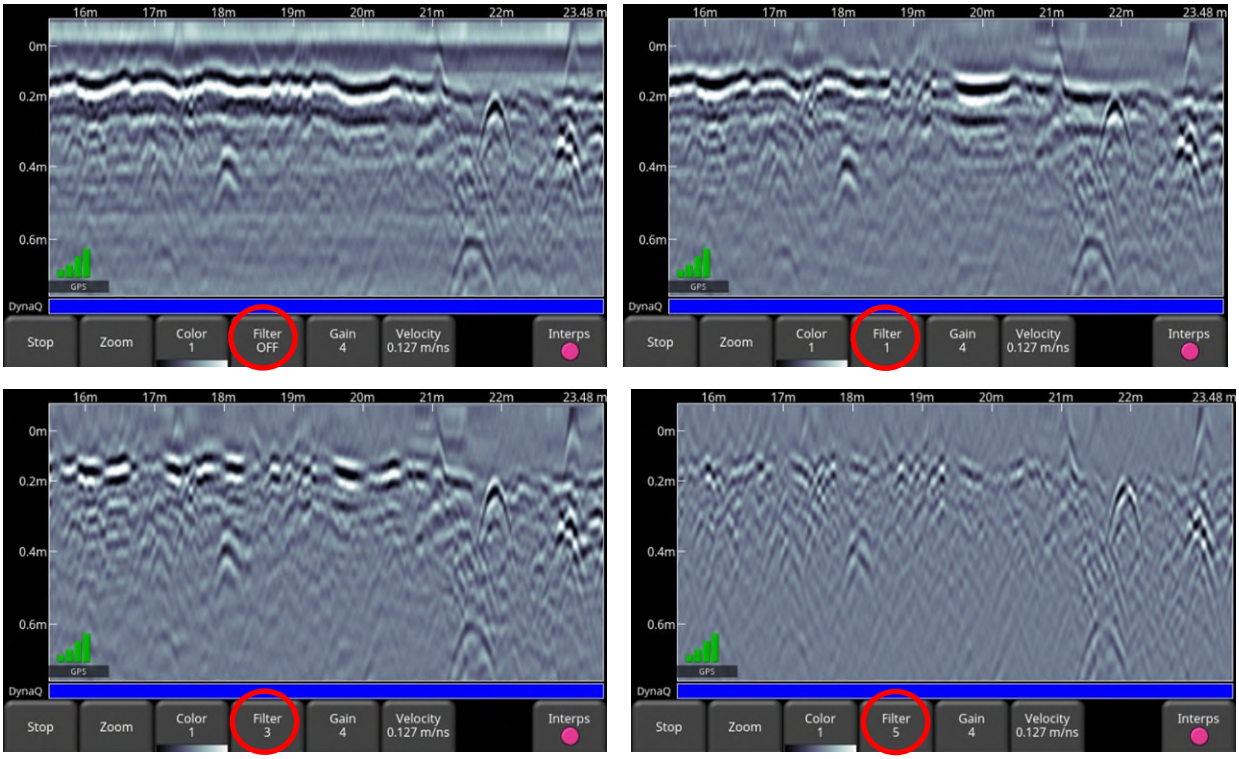


Figure 7-14: Showing variable filter lengths, and Filter Off.

7.1.8 Gain

Since the material being scanned absorbs the GPR signal, deeper targets return weaker signals. Gain acts like an audio volume control, amplifying signals and making deeper targets appear stronger in the image. Gain values vary from 1 to 9 where 1 means a minimal amplification has been applied and 9 means that maximum amplification has been applied. Pressing this button increments the gain; once you reach 9, it cycles back to 1. Avoid over-gaining the data as it can make interpretation difficult (Figure 7-15). In general, soils that are more electrically conductive (e.g. clays) will require a higher gain compared to soils that are less electrically conductive (e.g. sand). The type of gain used is what is set under Gain Type in GPR Plot Options (5.1.11).

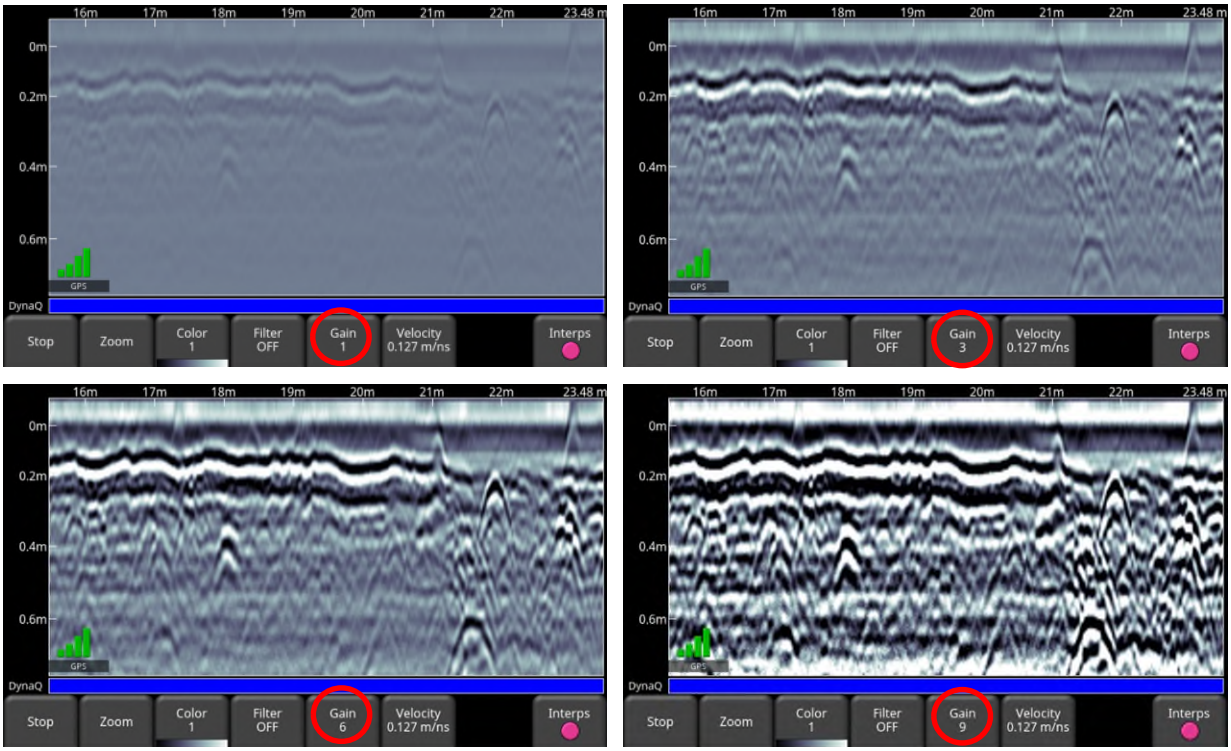


Figure 7-15: Varying the Gain

7.1.9 Velocity

Velocity is used to convert measured time into accurate depths. The best way to determine velocity is by using the hyperbola-fitting method, since it is based on data collected in the area. The current velocity value is displayed on that button beneath the word Velocity.

Crossing linear targets like pipes or cables at a 90-degree (or right) angle produces a hyperbola suitable for velocity calibration. The value obtained is used to compute a depth estimate of a target. These depths will be *incorrect* if the calibration is performed on a target hyperbola produced at an oblique angle, rather than a right angle.

Once you have a hyperbola on the screen from a subsurface target, press **Velocity**. The menu at the bottom of the screen will change (Figure 7-16), giving you the option of specifying a soil media or adjusting the velocity using the hyperbola-fitting method. These options are explained below:

- **Media** – If there are no targets to calibrate to, and you know the type of soil, press this button to vary between the following mediums: water, very wet soil, wet soil, moist soil, dry soil, very dry soil and air. There is an associated approximate velocity (and hyperbola shape) for each media type.
- **Velocity** – Allows you to use hyperbola-fitting to determine a more accurate velocity. The options are slightly different, depending whether or not you are in backup mode.

If the backup indicator is on the screen when you press velocity, then you can only adjust the vertical position of the horizontal scroll bar, since it is presumed you have backed-up so that the system is right over the hyperbola in question. The scroll bar can be moved up and down by touching the screen and dragging it or using the up and down keypad arrows such that it lines up with the top of the hyperbola (Figure 7-16).

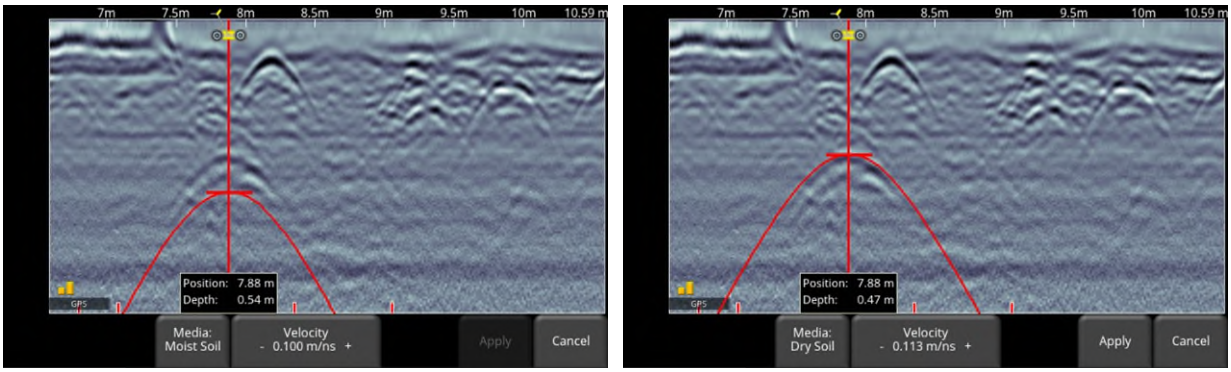


Figure 7-16: Adjusting Velocity while in backup mode. Image on left shows initial hyperbola that appears, while the one on the right has the correct hyperbola fit.

On the other hand, if you press **Velocity** while you are collecting data or have pressed Stop, you will see a red hyperbola in the middle of the screen. Touch and drag the hyperbola so it lies over a hyperbola in the data image (Figure 7-17). You can use the 4-way keypad arrows to fine tune the position of the red hyperbola.

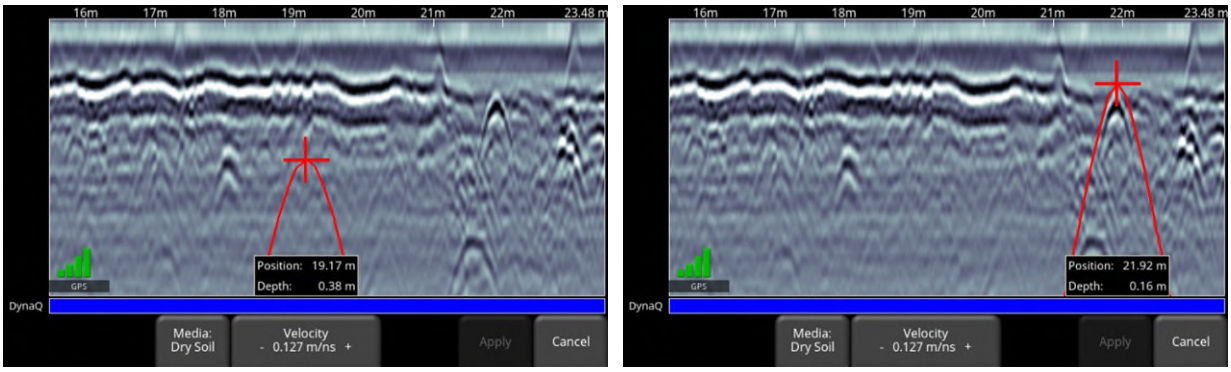


Figure 7-17: Adjusting Velocity, without backing up. Image on left shows initial hyperbola that appears, while the one on the right has the correct hyperbola fit

For either scenario above, once the red hyperbola is properly positioned, you can now use the **+** and **–** buttons on the **Velocity** button to widen or tighten the shape. Once the shape is matched (right sides of Figure 7-16 and Figure 7-17), you now have the correct velocity and the measured depths will be most accurate. Press **Apply** to use this value.

If you get a Velocity near 0.300 m/ns, this could be an Air Wave response (the hyperbola is from an object on the surface, NOT in the subsurface) and you should calibrate using a different hyperbola.

7.1.10 Interpretations (Interps)

Short for field interpretation, Interps are used to mark subsurface features. Seven colors are available, which allow you to designate different types of subsurface objects.

During collection, back-up or when reviewing a collected line, you can touch anywhere on the screen to add an Interpretation (Figure 7-18). This appears as a dot of the current Interp color. To change the color, press the **Interp** button to see a selection of colors and to select a new one (Figure 7-19).

To remove an Interp, ensure the same color is currently active and simply touch the Interp to delete it.

These field interpretations get exported with the data as a .CSV file, which show the positional information of all interps. They can be used to check if a feature is linear (in Map View or in Google Earth™), but usually only if the more accurate external GNSS is used.

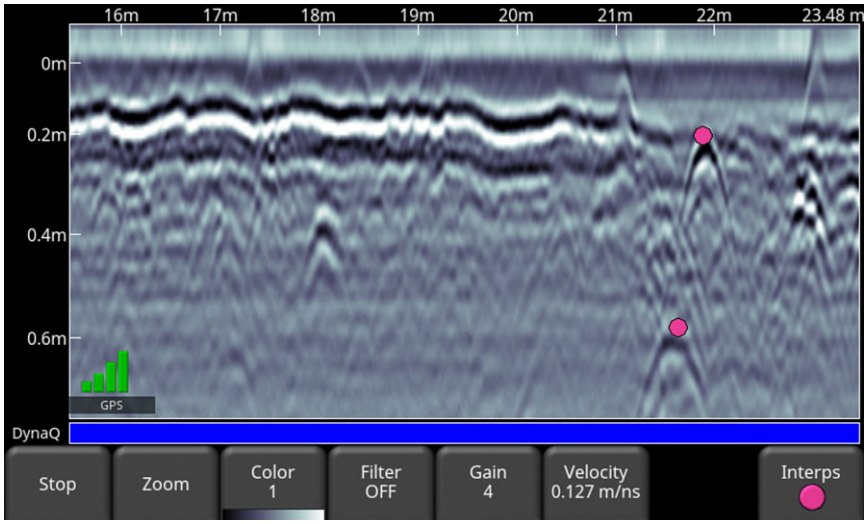


Figure 7-18: Touching the screen to add Interps.

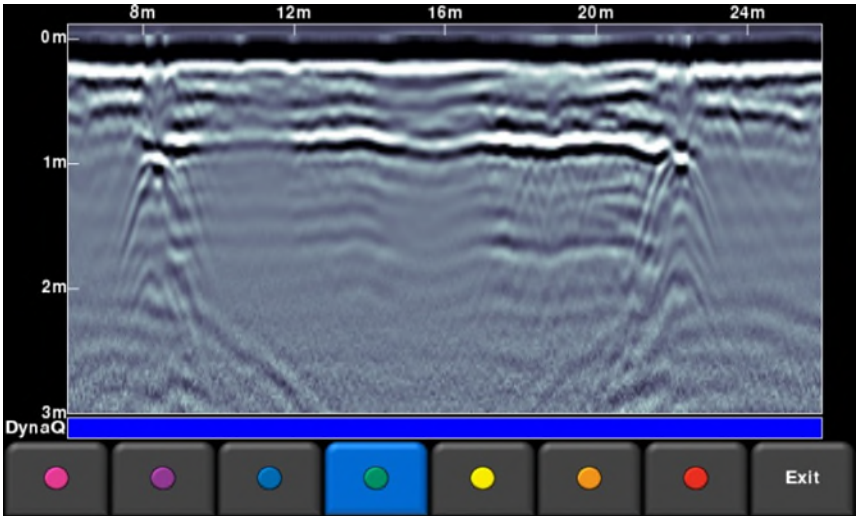


Figure 7-19: Select the Interps button to select a color for Interps.

7.1.11 Flags

Flags are often inserted to mark noteworthy surface features, such as poles, sidewalks, changes in terrain etc. These markers may help you correlate subsurface targets with above ground features. It is good practice to record the position and name of the object encountered at each marker in your field notebook or voice recording.

When a GPR line is collected in Free Run, flags are often added to mark known positions. This allows the GPR line to be "rubberbanded" in post-processing to correct the position of the traces and the length of the line.

Pressing the **asterisk** button on the keypad will insert a flag at your current position, either during forward data acquisition or when backed-up. Flags are sequentially numbered (Figure 7-20).

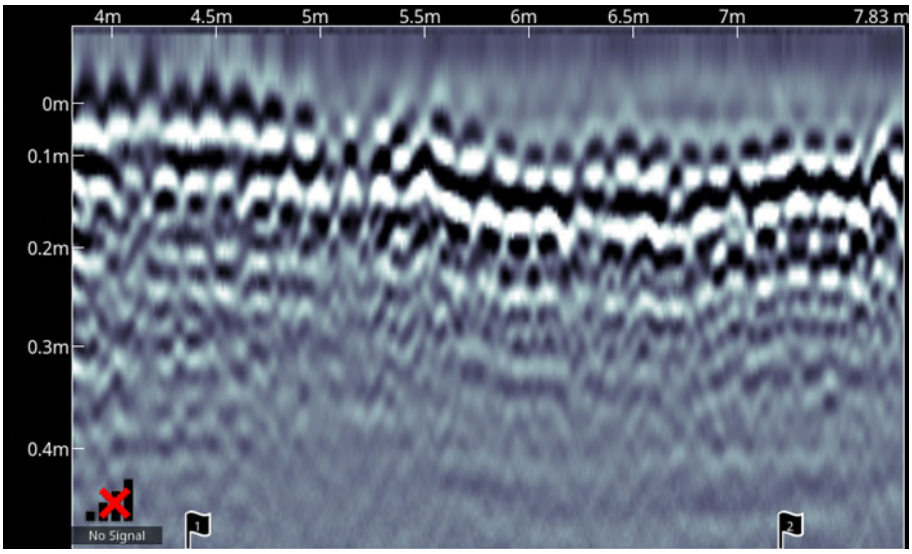


Figure 7-20: Inserting Flags

7.1.12 Ending the Line

Pressing **Stop** ends the line. This line is saved internally on the system and data cannot be added to it. The data saved is the raw data; all the viewing parameters that were changed do not alter the saved data in any way. Use the **Left** and **Right** directional arrow buttons to scroll and view data not currently displayed on the screen.

Press **Back** to exit this screen.

7.1.13 Viewing collected lines

Once you've exited the collection screen, you may choose to view previously collected lines.

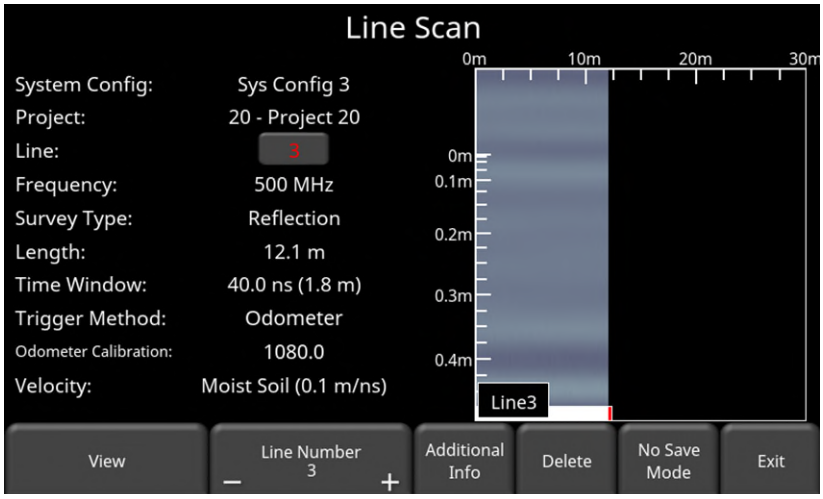


Figure 7-21: Showing a collected line

To select the desired line, press the **+** and **-** buttons under **Line Number** on the bottom of the screen. You can also move to any line number by pressing the **Line Number** button near the top of the screen and entering the line number. This button is typically used to avoid pressing the Line Number + or – button many times to move to a particular line number. Lines that contain data have red numbers and have a preview of the line scan image on the right (Figure 7-21).

- Press **View** to open the selected Line in Line Scan mode. You cannot add data to it, but you can change some of the viewing parameters and add Interps.
- Press **Additional Info** to see extra information regarding the collected line (e.g. Antenna geometry, step size etc.), Figure 7-22.

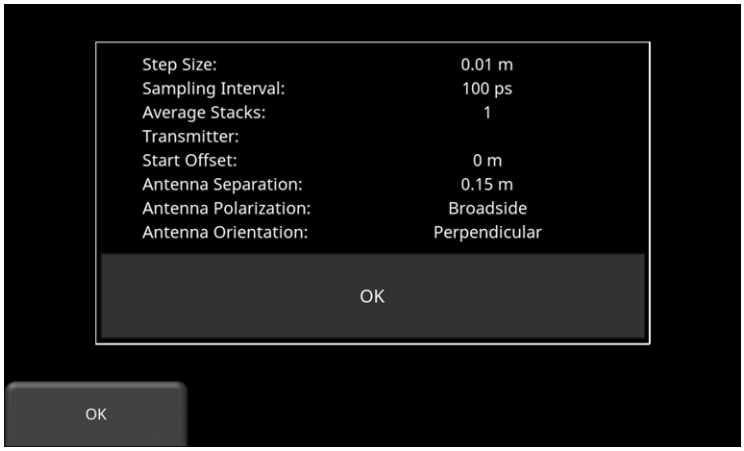


Figure 7-22: Pressing additional information

- Press **Delete** to delete this line.

7.1.14 Collecting Data in CMP/WARR modes

To properly set up the parameters for a CMP survey, see Section 6.2.1. In the data acquisition screen, the parameters for the data collection are initially displayed in the left of the window. The right side of the window displays a graphic showing the initial antenna separation and the current positions of the transmitting and receiving antennas.

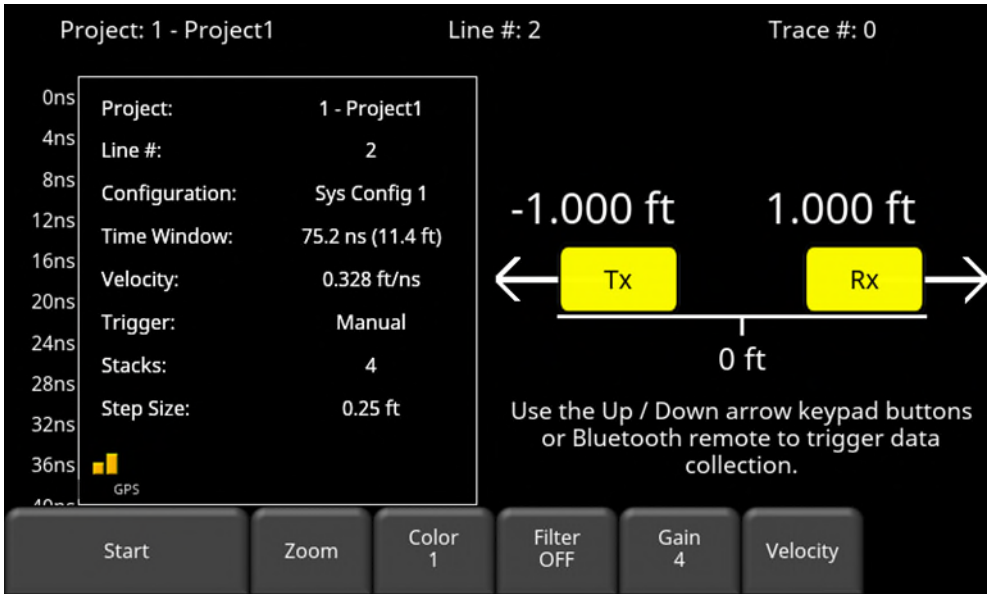


Figure 7-23: Collecting line data in a CMP survey

Press **Start** to begin collecting data, then press the wireless remote button or the DVL keypad buttons to fire the transmitter. As each trace is collected, the transmitting and receiving antenna positions update; move the antennas accordingly and fire the transmitter again. Repeat this process until your CMP survey is completed. Note that for a CMP survey, Interps are not available.

If a CMP is done correctly over a constant subsurface reflecting layer, you should see an image similar to the one in Figure 7-24. The result of the antenna move-out is a curve which should allow you to determine velocity.

The horizontal axis displays total antenna separation. In Figure 7-24, the antenna separation is 17’ from the starting position, giving a total cross-section distance of 34’.

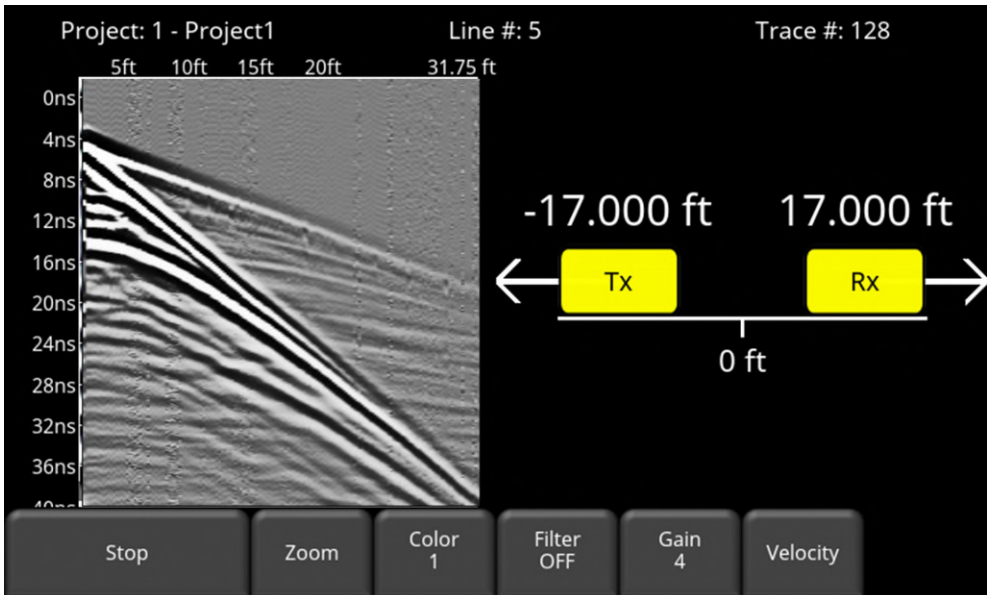


Figure 7-24: Collected CMP data

The process for WARR will be the same, except that one of the antennas is in a fixed position.

To properly set up the parameters for a WARR survey, see Section 6.2.1.

7.1.15 Collecting Data in Transillumination

To properly set up the parameters for a transillumination survey, see Section 6.2.1.

In the data acquisition screen, the parameters for the data collection are initially displayed in the left of the window. The right side of the window displays a graphic showing the initial position of the antennas (Figure 7-25,left). In this example, a Zero Offset Profile (ZOP) is shown.

Press **Start** to begin data collection. As you collect data, the new positions of the transmitting and receiving antennas are shown. For transillumination surveys, Velocity and Interps are not available.

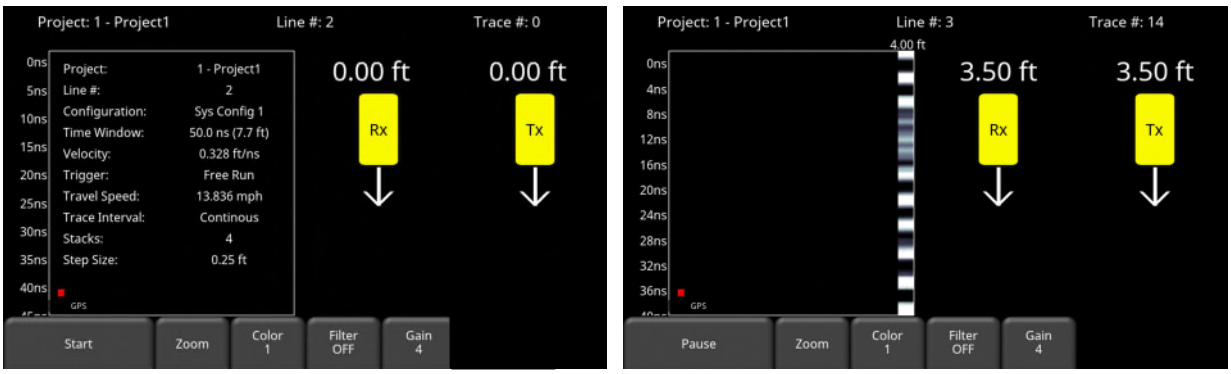


Figure 7-25: Start of Transillumination survey-ZOP (left); after collecting some data, showing antenna positions (right)

For Transillumination-MOG, you will see the screen in Figure 7-26. The image on the left shows the initial screen before you start collecting data. Starting antenna positions can be changed by pressing the **+** and **–** buttons under the Tx and Rx positions respectively.

Press **Star**t to the begin the survey. After all receiver positions are collected with the transmitter fixed, the transmitter will then be moved, and the process repeated (image on the right).

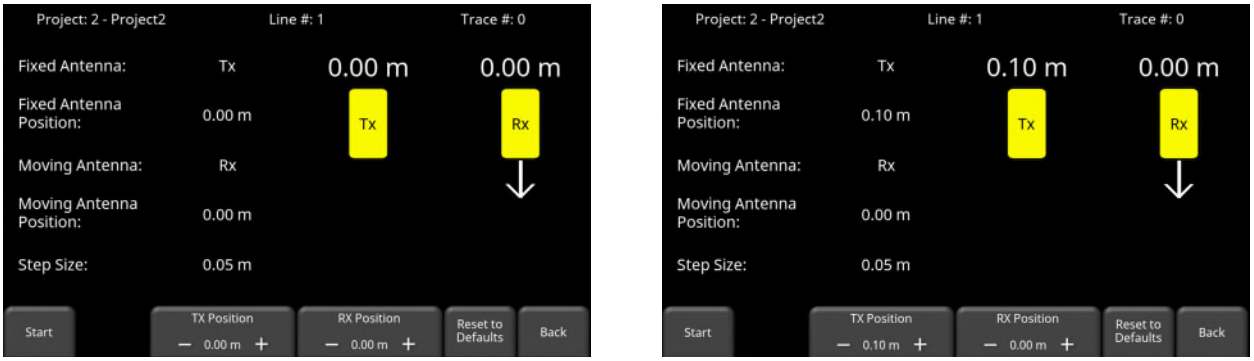


Figure 7-26: Start of Transillumination-MOG (left). After all receiver positions are collected, the transmitter is moved 0.1m (right), and the process repeated.

7.1.16 No Save Mode

From the Line Scan menu (Section 7.1), there is the option to collect data in No Save Mode. No Save Mode means that data collected is NOT saved, but screenshots can still be taken with the **Camera** button. These screen shots get placed in the currently selected project. No save mode has exactly the same options as the regular data collection screen, with the following difference:

There is no option for adding Interps in this mode, as the data is not being saved. However, you do have the ability to draw arrows on the screen (Figure 7-27).

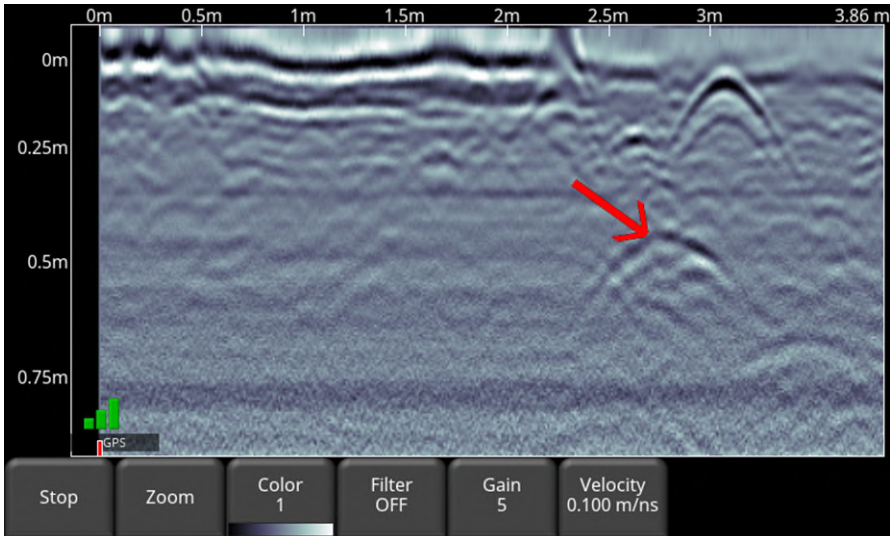


Figure 7-27: Drawing arrows on the screen to highlight targets and features

Touch the screen where you want the head of the arrow to appear and then drag away in the direction of the shaft. In the example above, the user touched near the hyperbola, then swept their finger towards the top left to create the arrow. The direction of the arrow can be changed by dragging your finger at right angles to the arrow shaft before lifting your finger from the screen. Just like Interps, any number of arrows can be drawn on this screen. Touch any arrow a second time to remove it.

7.2 Grid Scan

Acquiring GPR data in an organized grid over a defined area allows the data to be presented as plan maps or in 3D. This is useful for locating all subsurface objects, as well as their orientation, in a graphical manner that is easy to interpret.

From the main menu, ensure you are in the desired project then press the **Grid Scan** button to enter the Grid setup menu.

7.2.1 Grid Setup

The setup screen in Figure 7-28 allows you to set the parameters of the grid, before data acquisition begins. Information about the grid (grid number, size, spacing, time window, etc.) is displayed on the left side of the screen.

The right side of the screen shows an image of the grid setup and lines to be collected, including direction. It also shows the diagonal measurement which is valuable when you are measuring out your grid to ensure the corners are square.

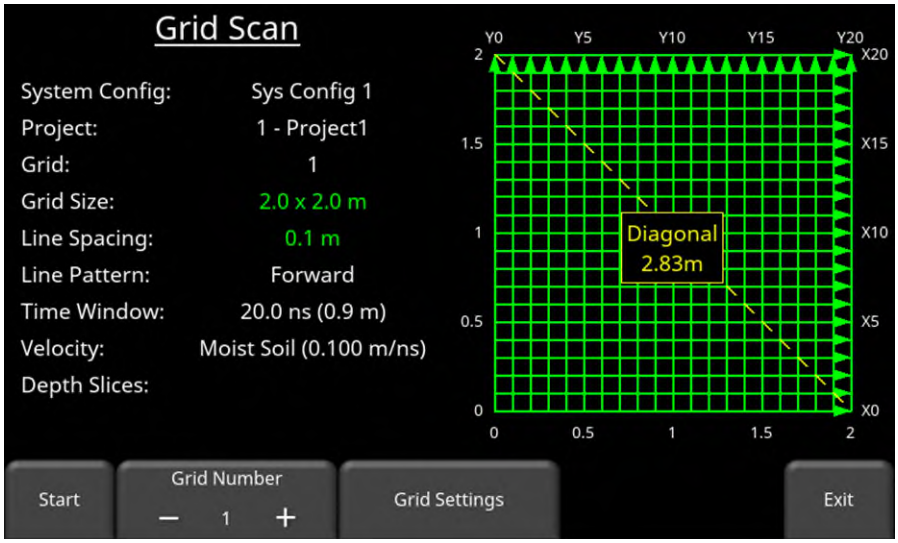


Figure 7-28: Grid setup menu

Grid Number - To select a grid number, press the **+** and **-** buttons under **Grid Number** at the bottom of the screen. Grids containing data will have the text and grid lines shown in red (on the right side). Grids that are partially complete will also show the uncollected lines in green on the right side.

7.2.2 Grid Settings

Pressing the **Grid Settings** button will change the bottom menu, allowing you to set specific parameters for your grid (Figure 7-29). When doing this, keep in mind the size and orientation of objects that you are looking for, as well as the frequency of the sensor you are using.

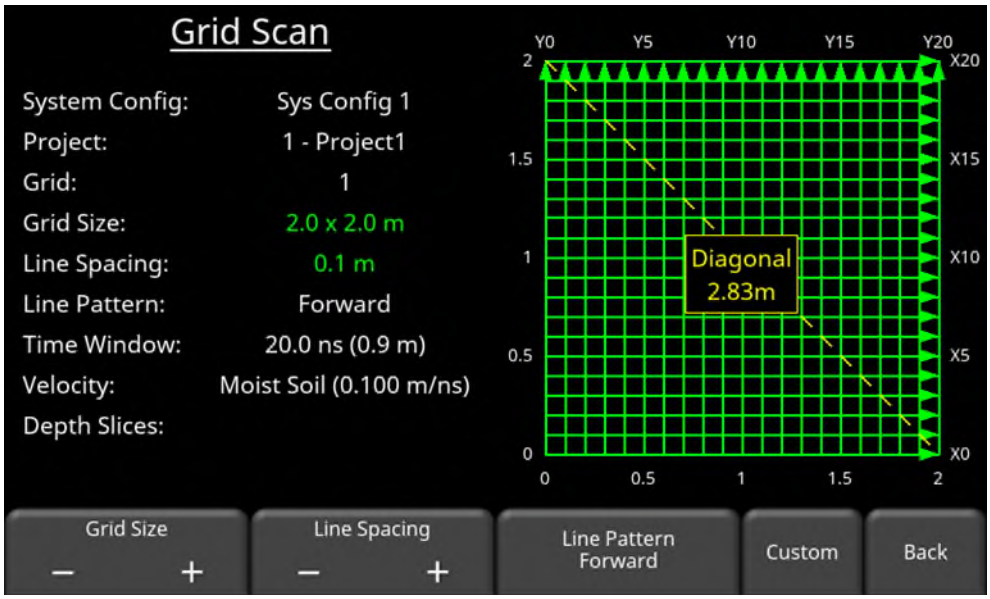


Figure 7-29: Grid settings

Grid Size – Press the **+** and **-** buttons to cycle between pre-set sizes. These are all square grids. If the grid size becomes too large, it cannot be processed on the DVL, and it will display a message in red beside the Depth Slices field saying “EKKO_Project Only”. This means that, based on the size of the grid, it cannot be processed into depth slices on the DVL; the grid must be exported from the DVL and processed in the EKKO_Project PC software.

Line Spacing – Press the **+** and **-** buttons to vary the spacing between adjacent lines.

> **Note**: Target size determines line spacing. In most cases the system must pass over a target to detect it; line spacing needs to be on the order of the size of the target or smaller when practical. Line spacing can be further apart for larger targets or targets with a linear extent. These rules may have to be relaxed for practical purposes such as survey production rates. Tighter line spacing takes longer to collect and may not be economically possible in all circumstances.

Line Pattern - Grid lines can be collected in one direction (Forward) or in a back-and-forth pattern (Alternating) (Figure 7-30). Collect lines in forward mode when possible, to reduce errors due to a poor odometer calibration. Press the Line Pattern button to toggle between modes.

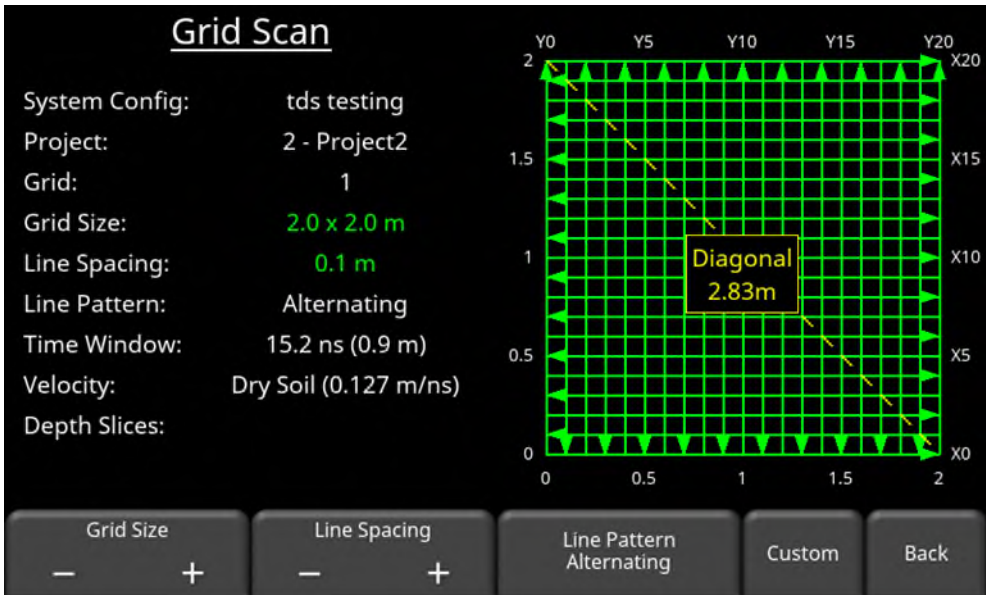


Figure 7-30: Forward/Reverse grid line collection

Custom – Press this button to customize some further settings (explained in next section)

7.2.3 Grid Settings - Custom

Pressing **Custom** from the previous screen changes the bottom menu, allowing you to define a custom grid size and line spacing (Figure 7-31).

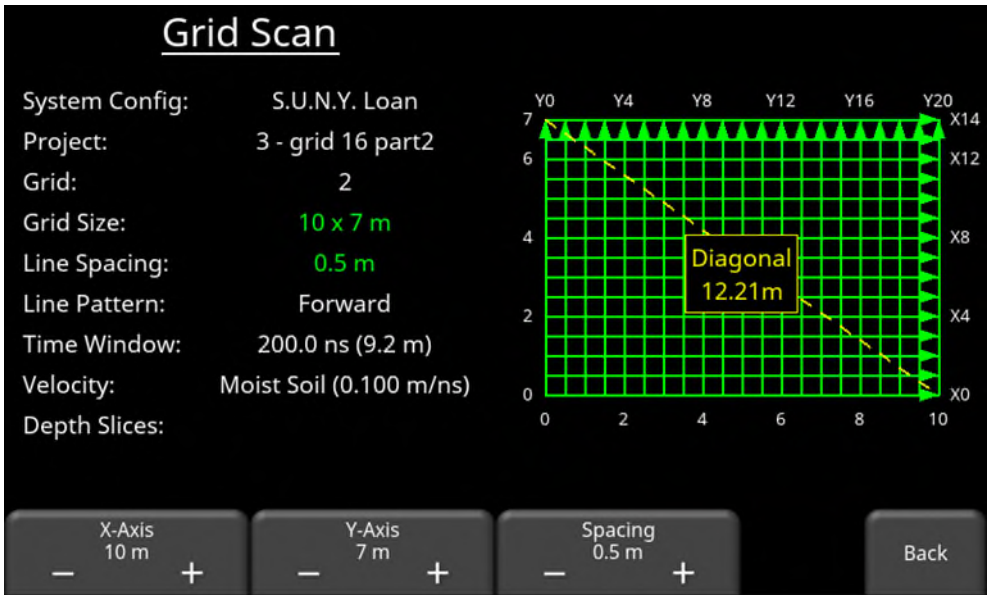


Figure 7-31: Custom grid setup, can vary dimensions of X & Y axes, as well as line spacing.

X-Axis – Press the **+** and **–** buttons to adjust the dimension of the X-axis. This will add or subtract lines along the Y-axis, in multiples of the current Line Spacing.

Y-Axis – Press the **+** and **–** buttons to adjust the dimension of the Y-axis. This will add or subtract lines along the Y-axis, in multiples of the current Line Spacing.

Line Spacing – Press the **+** and **–** buttons to adjust the line spacing. This will update the X-Axis and Y-Axis dimensions to the nearest multiple of Line Spacing.

7.2.4 Starting (or Resuming) Grid Data Collection

Press **Start** when all the grid parameters are setup and data collection is ready to begin.

If you select a previously-collected, partial grid (Figure 7-32), pressing **Start** takes you into that grid and data collection resumes where you left off. Most configuration settings will need to be the same in order to continue a previously started grid (e.g. frequency, step size etc.).

If at least 3 lines are collected in that grid, the **Slice View** button is enabled. Slice View (8) is described in the next section.

Press **Delete** to delete all collected lines in that grid.

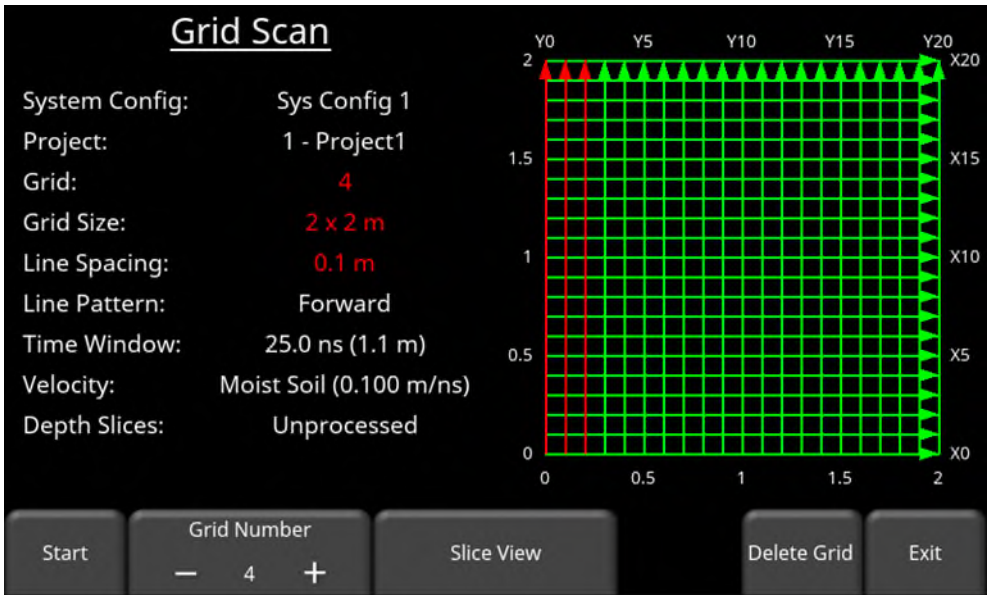


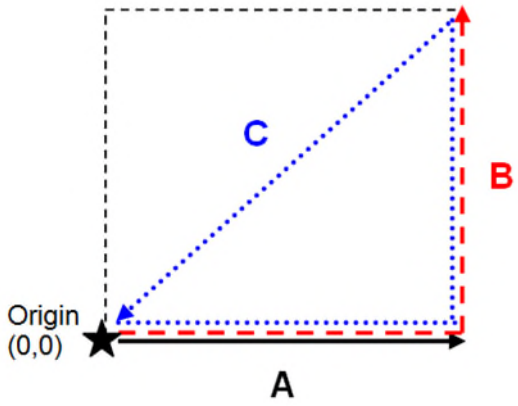
Figure 7-32: Grid already containing data

7.2.5 Laying out the grid

Positional accuracy of each line is vital to locating targets of interest once data has been processed.

For linear targets such as pipes and utilities, the best GPR responses occur when the GPR survey line crosses the target at right angles. Keep this in mind when laying out the grid and the orientation. Sometimes, laying out a grid with straight lines and corners at 90-degree angles can be difficult. The easiest and most accurate way is using a single, long tape measure to create a right-angle triangle. In the diagram below, start at the origin and measure out A and B. C is calculated on the DVL screen (using the formula $C^2 = A^2 + B^2$). Add the length of C to your measurement, and pull the tape so that it returns back to the origin. A table with calculated distances is shown for some different grid dimensions.

Grid Size			Setup Dimensions		
Length (m)	Width (m)	Area (m^2)	Distance A (m)	Distance B (m)	Distance C (m)
5	5	25	5	10	17.07
5	6	30	5	11	18.81
5	7	35	5	12	20.60
5	8	40	5	13	22.43
5	9	45	5	14	24.30
5	10	50	5	15	26.18
10	10	100	10	20	34.14
10	12	120	10	22	37.62
10	14	140	10	24	41.20
10	16	160	10	26	44.87
10	18	180	10	28	48.59
10	20	200	10	30	52.36
15	15	225	15	30	51.21
15	20	300	15	35	60.00
20	20	400	20	40	68.28



Once the grid is measured, the line spacing needs to be marked on the ground, either with paint or using flags (Figure 7-33). Make sure you mark both ends, so that the operator has a point to aim for and can keep the line straight.

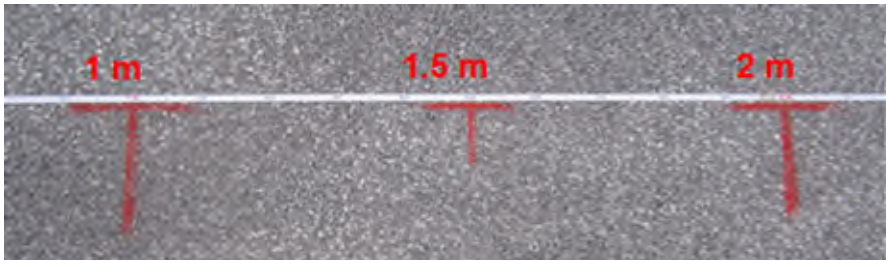


Figure 7-33: Marking grid line positions on the ground

An example grid layout is shown in Figure 7-34.



Figure 7-34: Example of a grid survey. The red lines are superimposed just to illustrate the concept.

7.2.6 Physical Data collection

It is critical that the starting position is consistent on every line. Line up the mid-point of the pulseEKKO antennas or transducers with the starting line (Figure 7-35), and then press **Start**. Wait for the screen to change as shown in Figure 7-36. Then push the system straight towards the end of the line. It is helpful to have a marker at the end, so you have something to aim for.

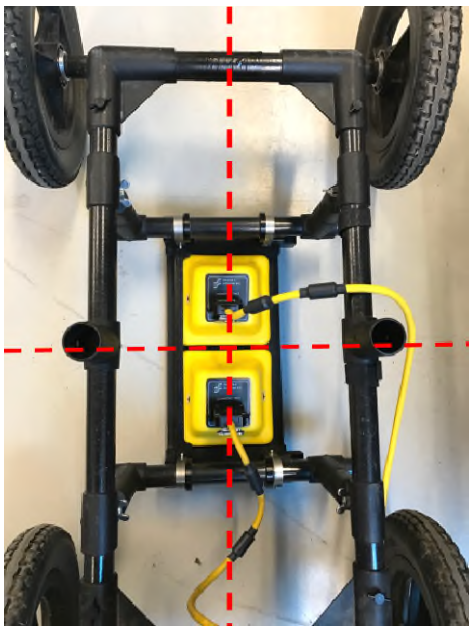


Figure 7-35: Lining up Cart properly on grid lines, shown as red dashed lines.

Not all lines have to be finished; if there is an obstruction preventing you from finishing the line, you can simply press **Stop** and end the line early. Do not try to steer the system around the obstruction, as this will throw off the positioning of the data. You can also collect a line from the other direction into the obstruction; this is explained in Section 7.2.10.

In addition, not all lines have to be collected. Use the 4-way directional keypad to advance to the next line you are able to collect.

7.2.7 Data collection on the DVL

The data collection screen is shown in Figure 7-36. The right half of the screen is a graphic representation of the grid, illustrating the size of the grid and the lines that need to be collected. The left half of the screen initially displays some parameters related to the grid.

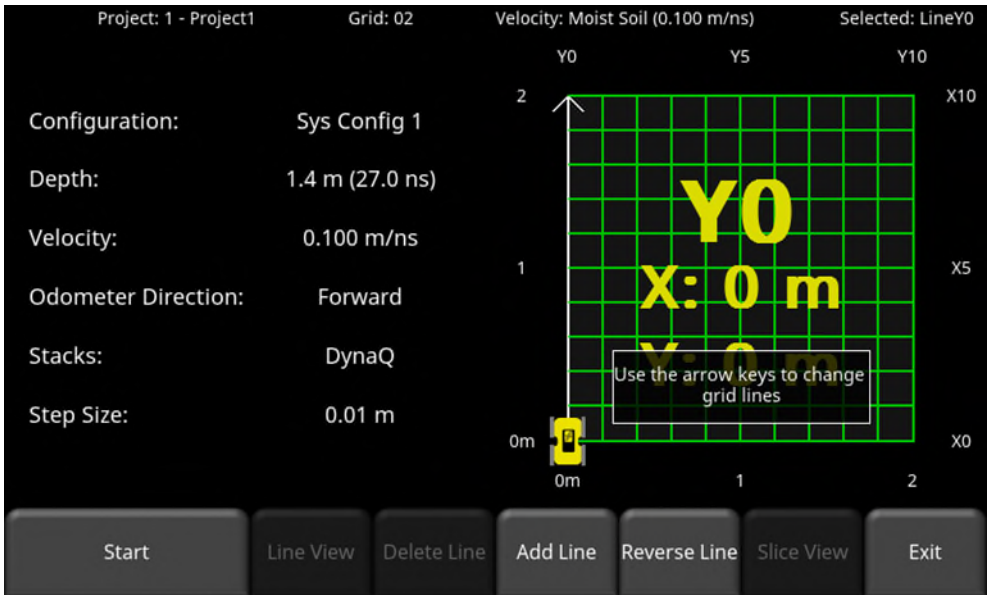


Figure 7-36: Grid collection screen prior to any data collection

Press **Start** when you are positioned at the start of the line. Push the system in a straight line towards the end of the line (Figure 7-37). If Grid Line Stop (5.1.11) is set to Auto, the system will automatically stop acquisition once that distance has been covered. If **Grid Line Stop** is set to Manual, you will have to manually press **End Line** when you are done. You can collect up to a maximum of 50% beyond the normal line length. For example, if the grid is 20m x 20m, and Grid Line Stop is set to Manual, the user can collect any line up to 30m long. Sometimes you might want to collect a little more data if there is an interesting feature at the end of your line.

As you are collecting a line, you must move in a forward direction. If you back up more than two step sizes during collection, it will stop the line.

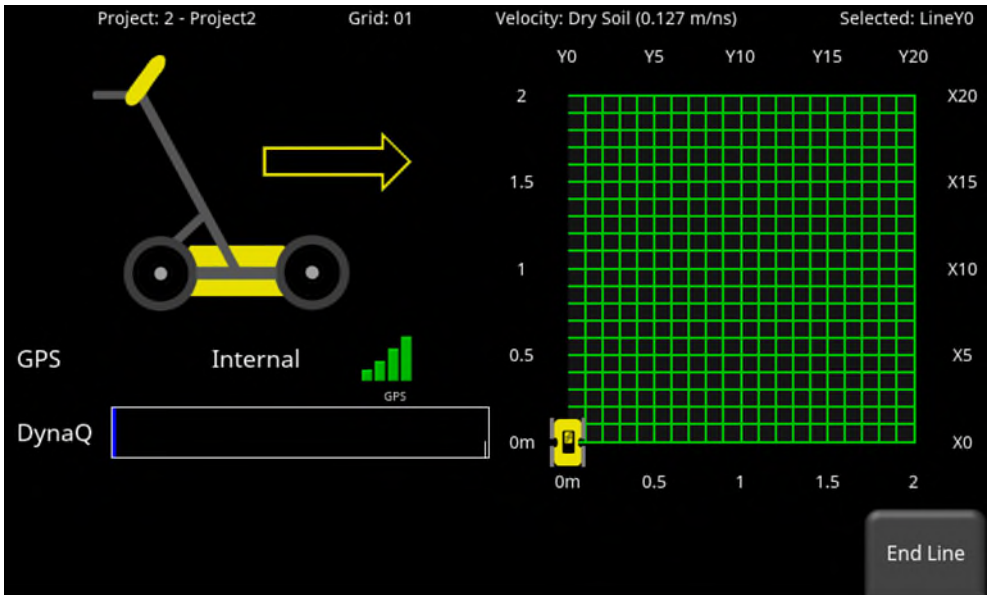


Figure 7-37: Collecting a line in the grid

Once the line is collected, the Grid Line will turn red, and the system will beep twice and the cross-section will be shown on the left. The grid image on the right will show the next line to be collected, in white. The remaining lines to be collected are shown in green (Figure 7-38).

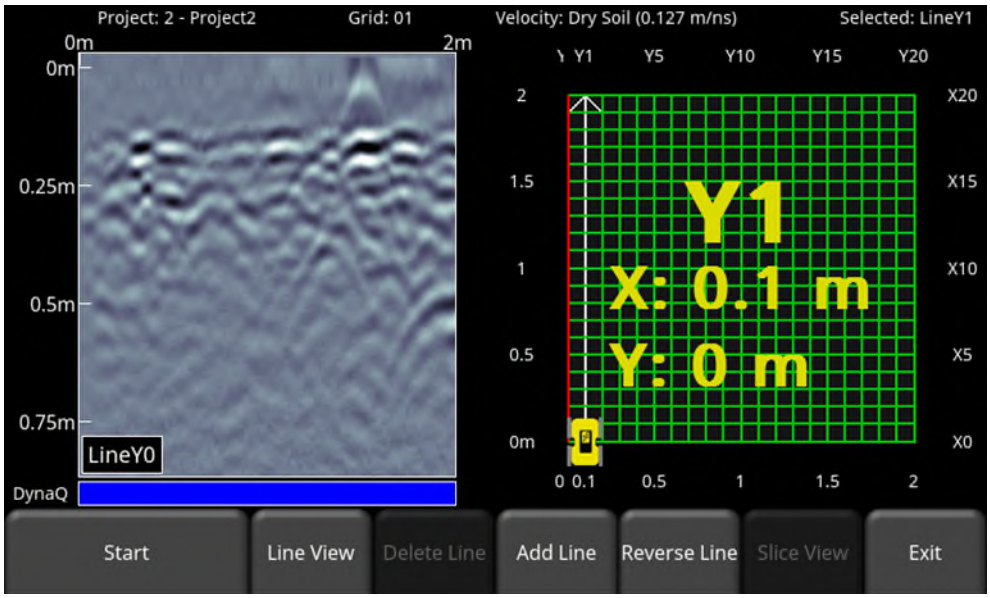


Figure 7-38: After first line has been collected

Move to the start of the next line and repeat the process. The grid image will always display the line number (e.g., Y1) and the position of your line, relative to your origin. Once all the lines are done in one direction, it will automatically prompt you to collect lines in the other direction.

If you only need to collect data in one direction, everything is configured the same way, but you would just stop here and not collect lines in the other direction.

> **Note**: Periodically ensure that the line you are collecting matches what is displayed on the screen. This is especially important as the grid sizes get larger and you may misplace your position.

7.2.8 Viewing & Recollecting lines

Use the **4-way** directional keypad to select different X and Y lines. The selected line will always be in white. Collected lines are red and lines remaining to be collected are green. It may be necessary to recollect a line if you make a mistake. To recollect a line, select it and press **Start**. You will be prompted with a message asking if you want to overwrite that line (Figure 7-39). Press **Yes** to proceed.

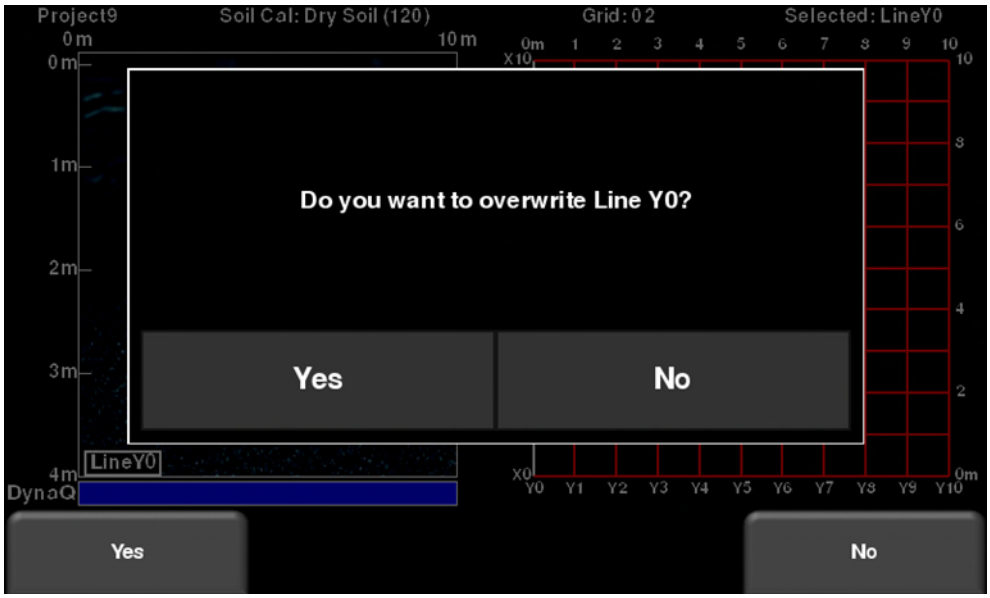


Figure 7-39: Overwriting a line

To change the way a line is viewed/displayed, select it and press **Line View**. This displays the selected line in the Line Scan screen (Figure 7-40). From here you have the option of modifying the image by changing the Zoom, Color, Filter and Gain values, adding Interps, as well as calibrating for velocity (see Section 7.1.1).

If the line is long and not displayed on one screen, use the **left** and **right** arrows on the directional keypad to scroll through the line.

It is also possible to switch to the other collected grid lines using the **up** and **down** arrows on the directional keypad.

To exit from the Line View screen and return to Grid View, press the **Back** button. The Grid View screen respects any display settings changed while in Line View. If the velocity is changed, the depth slices are reprocessed.

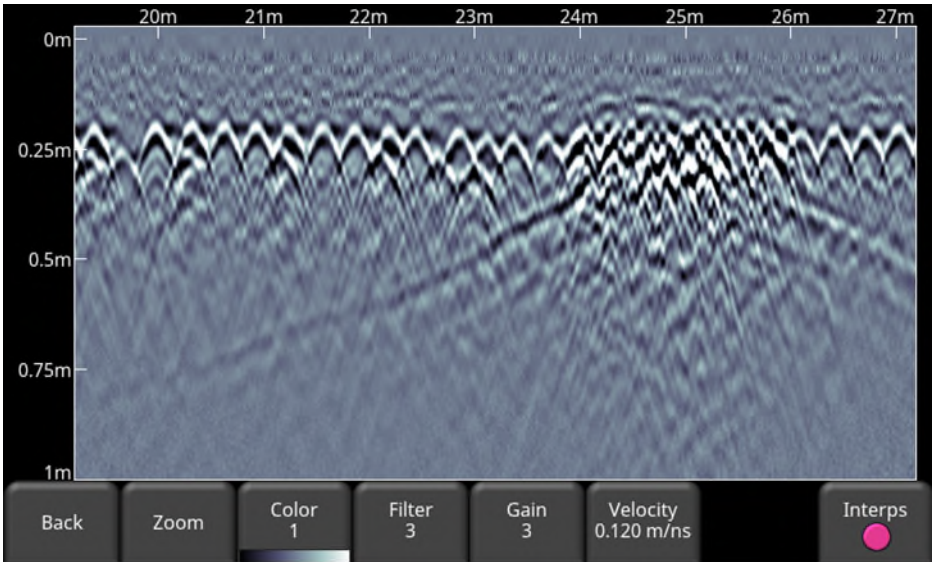


Figure 7-40: Viewing a grid line in full screen, with the Line Scan menu options at bottom

7.2.9 Adding a line

During data collection, you may realize that you want to expand the search area of your grid. Press **Add Line** to do this. This takes you to a screen shown in Figure 7-41.

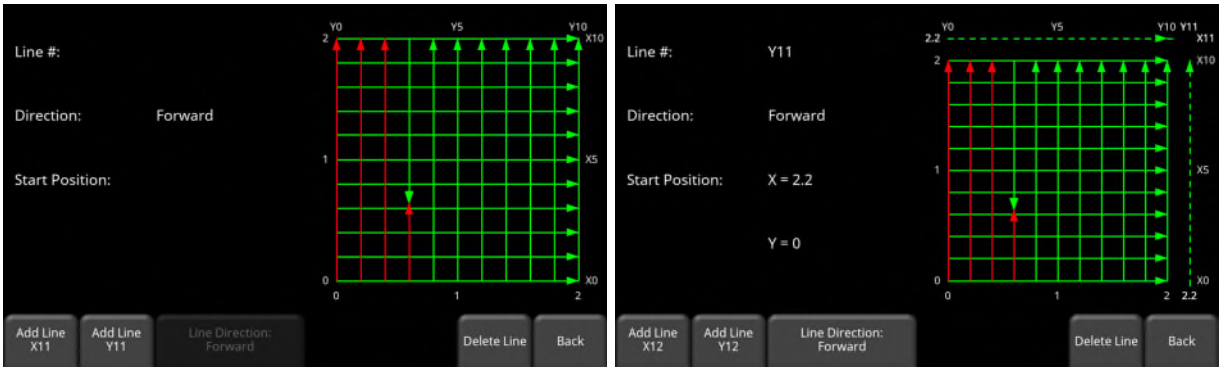


Figure 7-41: Addling lines to a pre-defined grid; before adding lines (left) and after (right)

Pressing **Add X Line** or **Add Y Line** adds a respective line in the X or Y directions at the end of the grid. Press the same button repeatedly to add multiple lines.

There is the option of specifying the direction of the newly added line by pressing the **Line Direction** button, which toggles between forward and reverse.

Note that any added lines are not be included when the depth slices are generated on the DVL. Depth slices are restricted to the originally defined grid size. To generate depth slices for the complete grid, including all the added lines, export the data to a PC and use the EKKO_Project software SliceView module.

7.2.10 Collecting Around an Obstruction

From time to time, there may be an obstruction (such as a tree or rock) in your survey area. There is a temptation to pick up the system, move it around the obstruction and continue collecting. This is wrong!

The correct way is to approach the obstruction from both directions. Granted, there will not be data where the obstruction is, but there will be data before and after it.

When you approach the obstruction, terminate the line by pressing **End Line**. If you collect less than 95% of the expected line distance, the system assumes there is an obstruction and will give you the option to collect a reverse line. For example, in Figure 7-42, LineY3 was incomplete, so it gives the user the option of collecting a reverse line, called LineY3R.

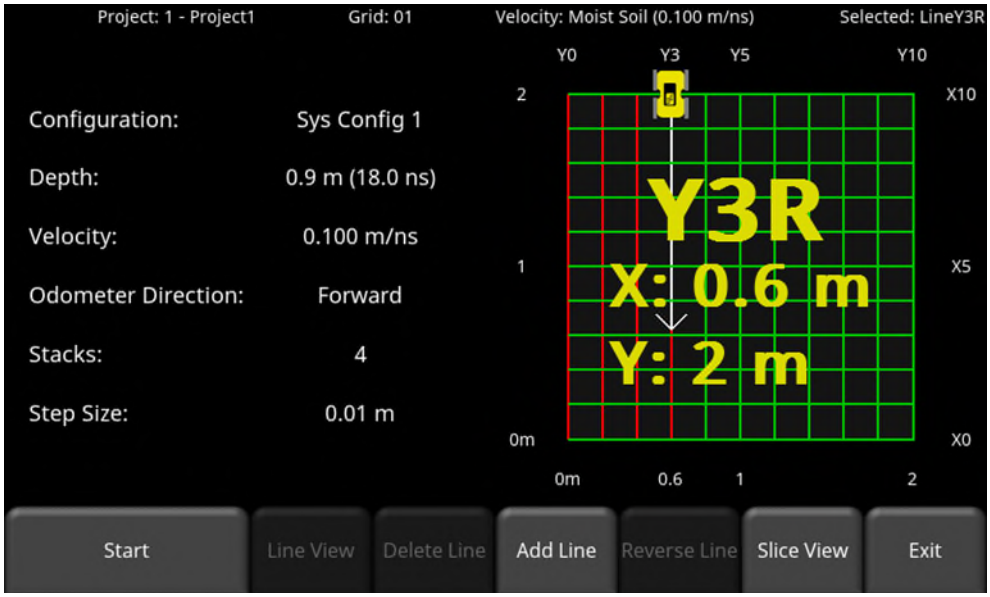


Figure 7-42: Collecting a reverse line around an obstruction

7.2.11 Reversing a Line

During data collection, you can reverse a line (or multiple lines) to collect from the other direction. Press **Reverse Line** when that line is selected to collect from the other direction.

7.3 Processing Data

Once you have finished collecting all the lines in the grid, press **Slice View** at the bottom of the screen. Before the data is processed and the depth slices are created, you must ensure the velocity is accurate; this will result in the most accurate and sharpest depth slice images.

A message displays the velocity value that will be used (Figure 7-43). If you have adjusted this already for the ground at the survey site, press **OK** to proceed and create the depth slices.

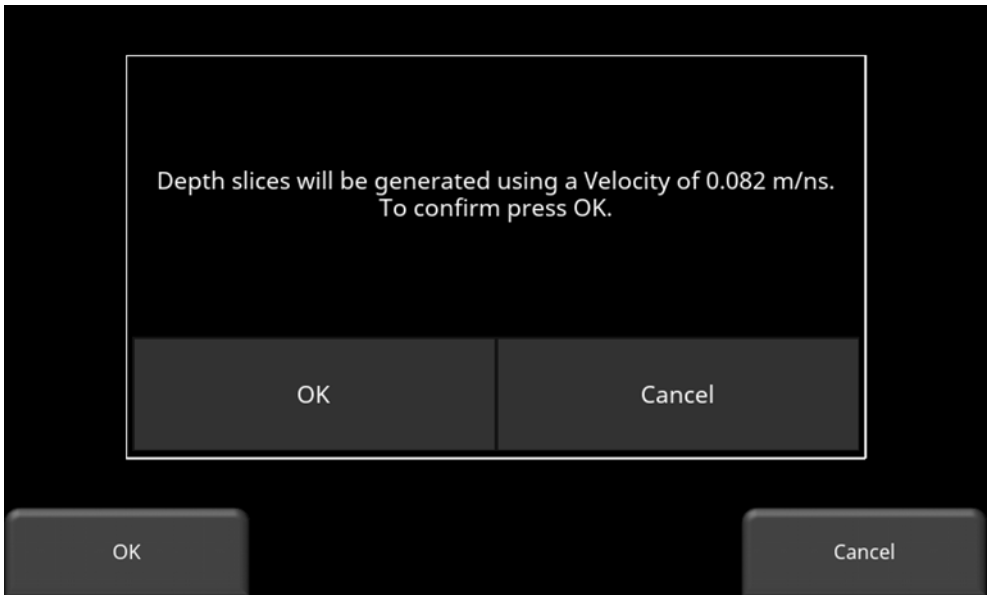


Figure 7-43: Processing depth slices with the correct velocity value

If not, then it is recommended to press **Cancel** and adjust the velocity by using a representative hyperbola on one of the collected lines. Then return and press **Slice View** and press **OK** to proceed and create the depth slices.

If the collected grid is too large to process the depth slices on the DVL (which it would have indicated on the Grid setup screen), then the Slice View button will remain greyed out. The data must be exported to a computer and opened in the EKKO_Project software Slice View module to create the depth slices.

See the next section on using Slice View.

8. Slice View

Slice View displays data collected in a grid as a series of depth slices moving deeper into the subsurface. Objects and features appear in plan view, which can be an easier way of visualizing the data.

When entering Slice View, the screen will be displayed as shown in Figure 8-1.

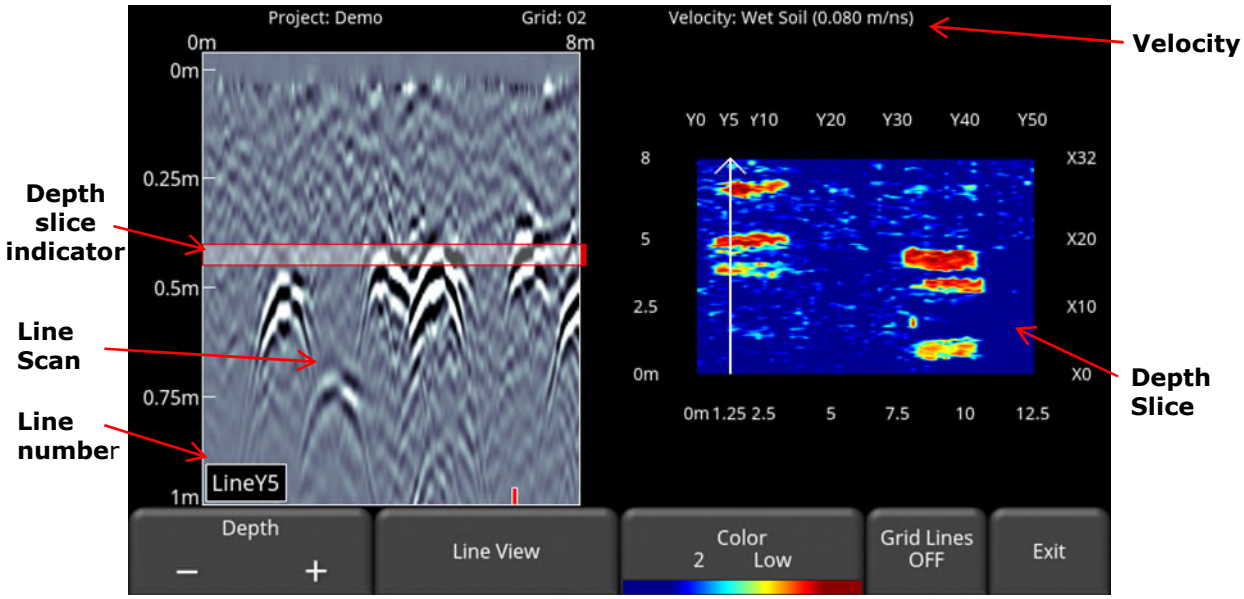


Figure 8-1: Slice View screen

The right half of the screen shows one of the depth slices. The top and right sides of this image show the X and Y line numbers, while the dimensions of the grid are shown on the bottom and left sides.

The left half of the screen displays one of the grid lines, and any flags or interpretations that were made. The line number is overlaid on the bottom of the image and corresponds to the white line on the grid (LineY5 in Figure 8-1). To move to another grid line, use the **4-way** directional keypad on the DVL; the highlighted line is white.

The shaded area in between the horizontal red lines corresponds to the depth slice range shown on the right and is referred to as the Depth Slice Indicator.

At the top of the screen, the grid number is listed, along with the velocity value.

The functionality of the buttons at the bottom of the screen are explained below.

8.1 Depth

Pressing the **+** and **-** buttons on the **Depth** button will increase or decrease the depth of the depth slice currently displayed. You can also touch and drag the depth slice indicator on the

line scan image. This allows the user to “slice through” the ground and locate features that appear at different depths. It is recommended that the user go through all slices and try to correlate features with the line scans images on the left to ensure that they didn’t miss anything.

You can only slice down to the zoomed depth range displayed in Line View. Increasing the depth range in Line View will recalculate and re-process the depth slices.

8.2 Line View

Pressing the **Line View** button displays the currently selected GPR line as a full screen image. All the functionality of Line Scan (such as Zoom, Color, Filter, Gain, Velocity and Interps) are available here (Figure 8-2). Use the **4-way** directional keypad to change to a different line.

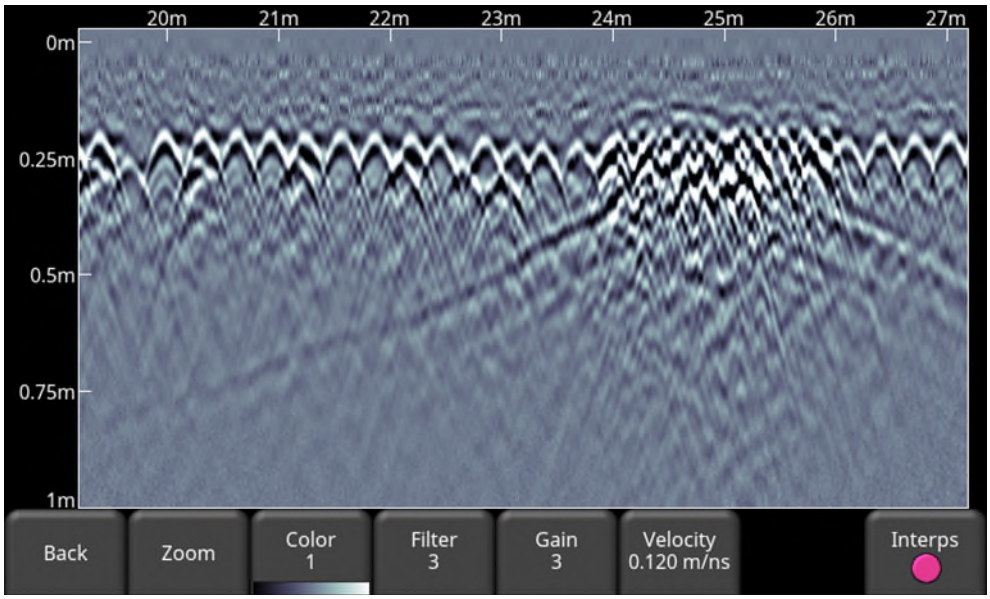


Figure 8-2: Changing Line View settings from within Slice View

Press **Back** to return to Slice View. Any changes made are reflected on the GPR line in Slice View mode. For example, if you change the zoom depth in Line View, the lines and depth slices in Slice View use the new depth setting. If you change the velocity, this causes the depth slices to be re-processed.

Users may want to change the display settings to make it easier to correlate line scan data with depth slices.

8.3 Color

This heading has two button functions beneath it:

a) **Color Palette** - The number corresponds to the color palette used for the depth slice image. Pressing this button cycles between the 9 available color palettes available on the system.

b) **Gain Function** - cycles between **LOW**, **MEDIUM** and **HIGH**. A setting of HIGH is useful for revealing weaker targets which may be difficult to see. Setting to LOW will help "clean up" the data and only show the strong targets but will hide some of the weak signals; so be careful when setting to LOW. Figure 8-3 shows the variations in color sensitivity.

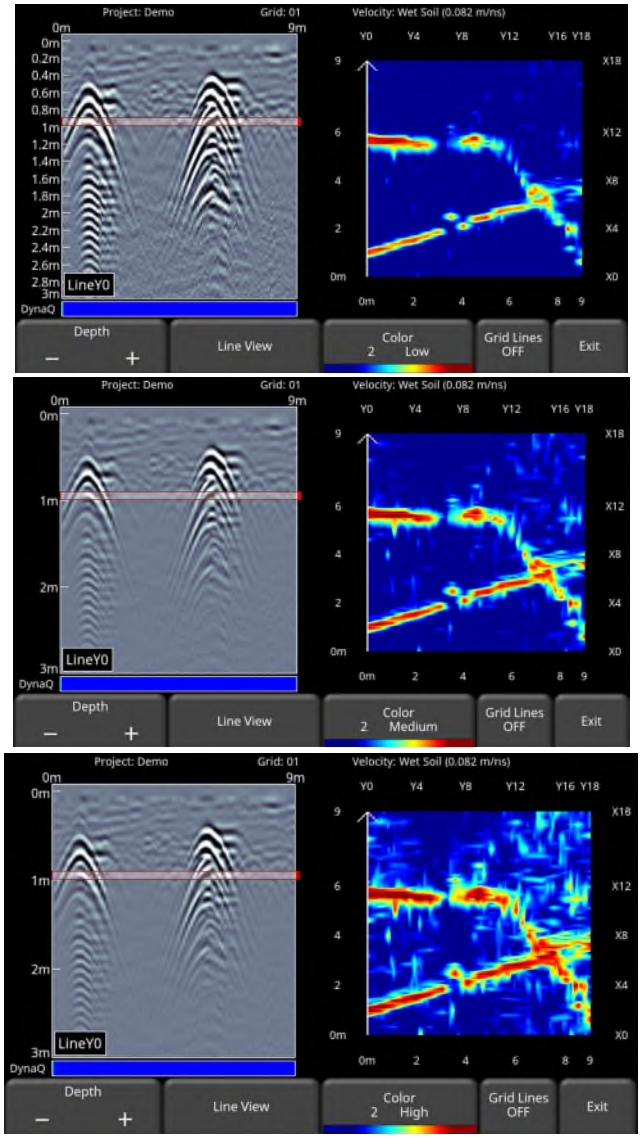


Figure 8-3: Varying the sensitivity, from top to bottom: Low, Medium, and High settings. High shows more subtle targets but may sometimes appear cluttered, while the Low setting only displays the strongest targets, so be cautious when using it.

8.4 Grid Lines

Pressing this button overlays grid lines on the depth slice image, and cycles between **ON**, **PARTIAL** or **OFF**. When set to ON, all the collected lines are displayed. When set to PARTIAL, only some of the grid lines are displayed. This may be necessary for some larger grids as having all the grid lines ON tends to obscure the image beneath (Figure 8-4). When set to OFF, only the currently selected line is displayed. The currently selected line is always shown in white.

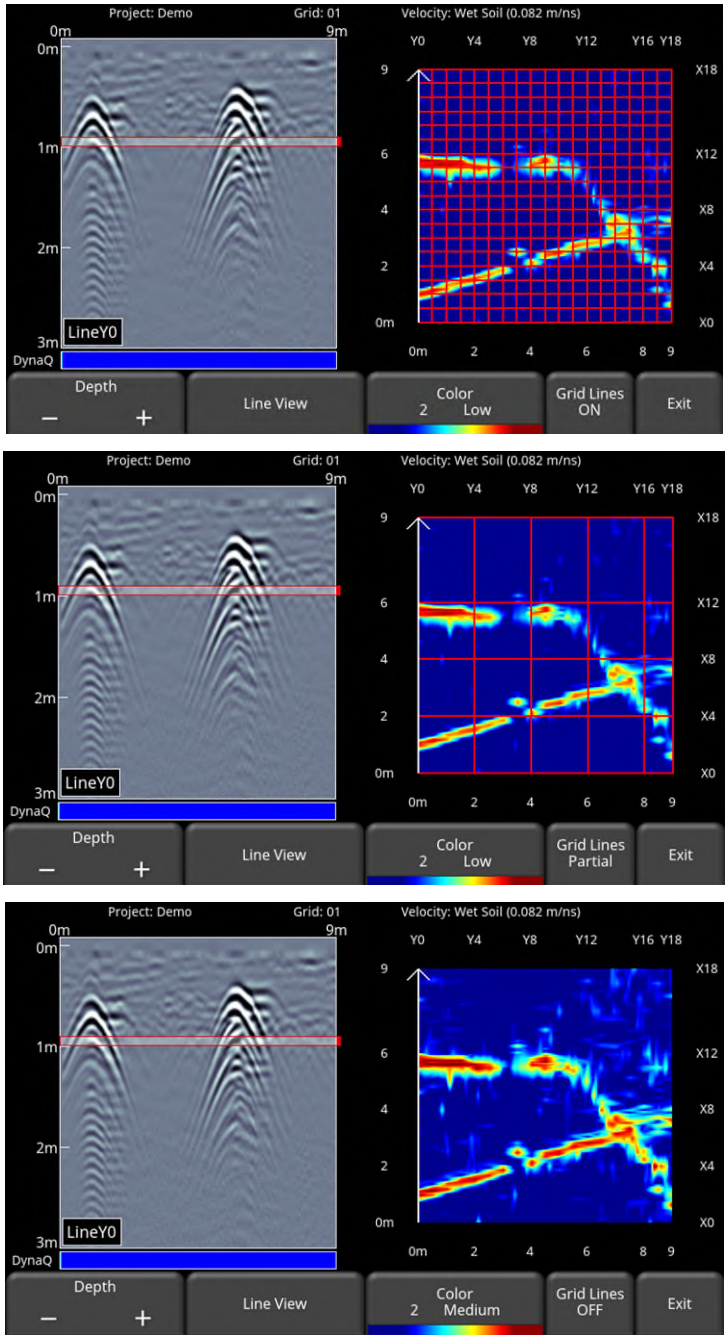


Figure 8-4: Varying the Grid Lines, from top to bottom: ON, PARTIAL and OFF settings

8.5 Recollecting lines

After looking at the grid data in Slice View you may discover that one or more grid lines need to be recollected (for example, maybe the starting position was offset). If so, you need to enter the Grid Scan (7.2) menu again and select the appropriate grid number and press Start (the grid number will be in red, since data exists).

Select the grid line that needs to be recollected. When you press **Start**, it will display a prompt confirming if you want to overwrite the line. After recollecting the grid line(s), press the **Slice View** button to re-process the grid data into depth slices.

9. Map View

Map View is a unique feature that allows the user to graphically view the survey path and any flags or interpretations added. This is helpful in determining the linearity and consistency of buried objects.

A common use of this feature is to snake back and forth over a given area. Each time you cross a target producing a hyperbola, click on the top of the hyperbola to add an interpretation. If the object is a linear feature (such as a pipe), all the interpretations will line up when viewed in Map View.

Map View is only available if GNSS data is collected with the GPR data. It is the GNSS that is used to position lines and/or grids correctly.

If you use the internal GNSS, only grid data will be shown in Map View. If an external GNSS is connected, both line and grid data will be shown.

9.1 Accessing Map View

Map View is project-based and displays all grids and lines collected in a project. A project will typically contain all the data collected at a given site.

Map View can be accessed either from the **Run System** screen (Figure 7-1) or from the **File Management** menu (Figure 9-1). The **Map View** button is only available if data exists in the project AND it was collected with the GNSS enabled; otherwise, it will be greyed out.

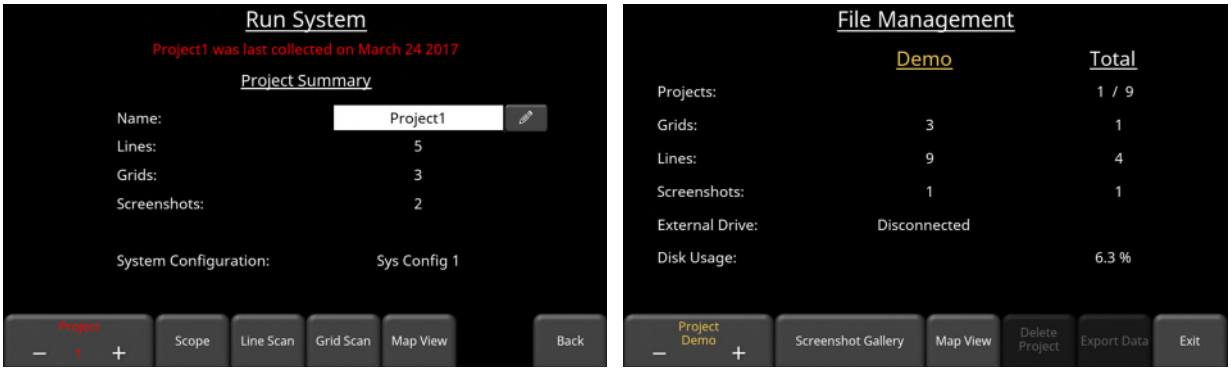


Figure 9-1: Accessing Map View either from the Run System screen (left) or File Management menu (right)

Irrespective of how you get there, entering **Map View** shows an image similar to Figure 9-2. Dragging your finger around the screen moves the entire map around and can be used for centering the map. Pressing the **+** and **–** buttons under the **Zoom** button zoom in and out of the image. The scale is shown in the bottom corners in US Standard (bottom left) and Metric (bottom right) units.

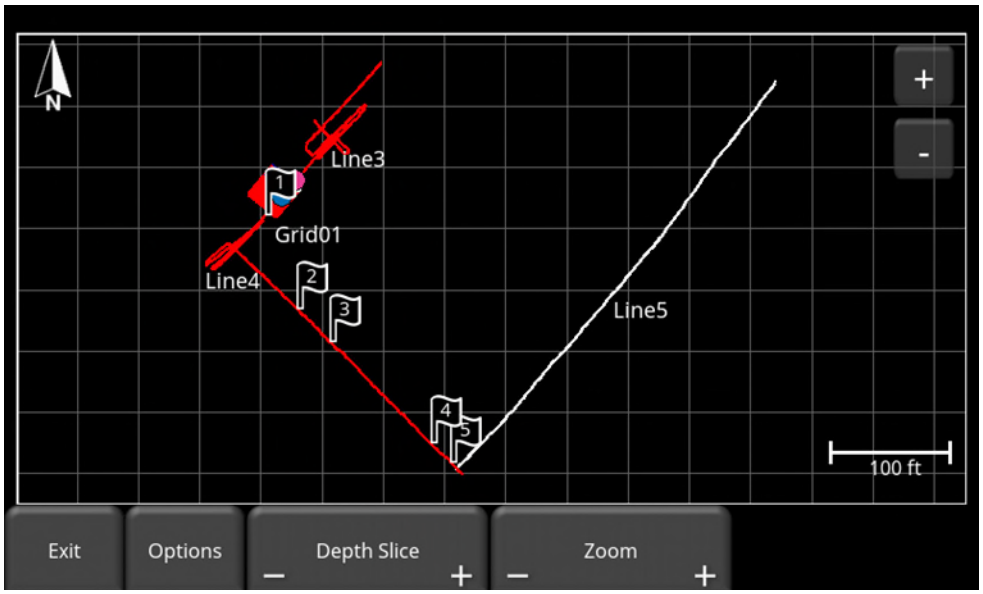


Figure 9-2: Map View showing the position of a grid and two lines, as well as flags and interps.

Pressing the **Options** button changes the bottom menu (Figure 9-3), allowing you to turn on/off various items in the MapView image:

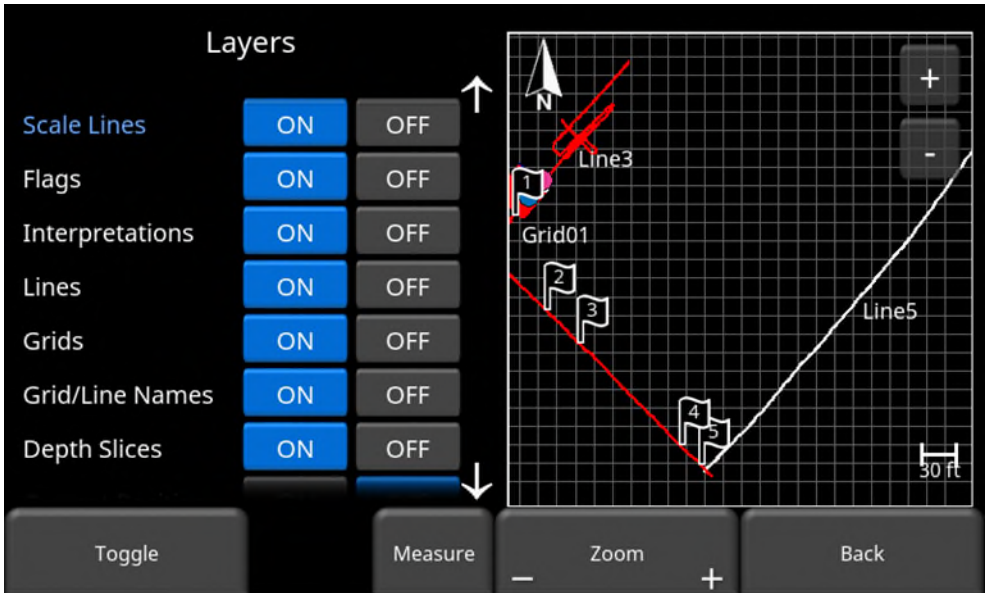


Figure 9-3: Pressing the Layers button reveals further options; currently all are turned on.

- **Scale Lines – Toggles –** Toggles background grid lines ON or OFF.
- **Flags –** Toggles flags ON or OFF.
- **Interpretations** – Toggles Field Interpretations ON or OFF.
- **Lines** – Toggles Line Scans ON or OFF.

- **Grids** – Toggles Grid Scans On or OFF.
- **Grid/Lines Names** – Toggles Line and Grid names ON or OFF.
- **Depth Slices** – Toggles Depth Slices ON or OFF.

When the **Measure** button is pressed, it is highlighted in blue. During this time, you can touch the screen and drag your finger a certain distance to get a measurement value for that distance (yellow line pointed at by the white arrow in Figure 9-4). The distance value is displayed in the top right corner. Pressing the Measure button again exits from Measure mode and removes the yellow measured line and the measured value.

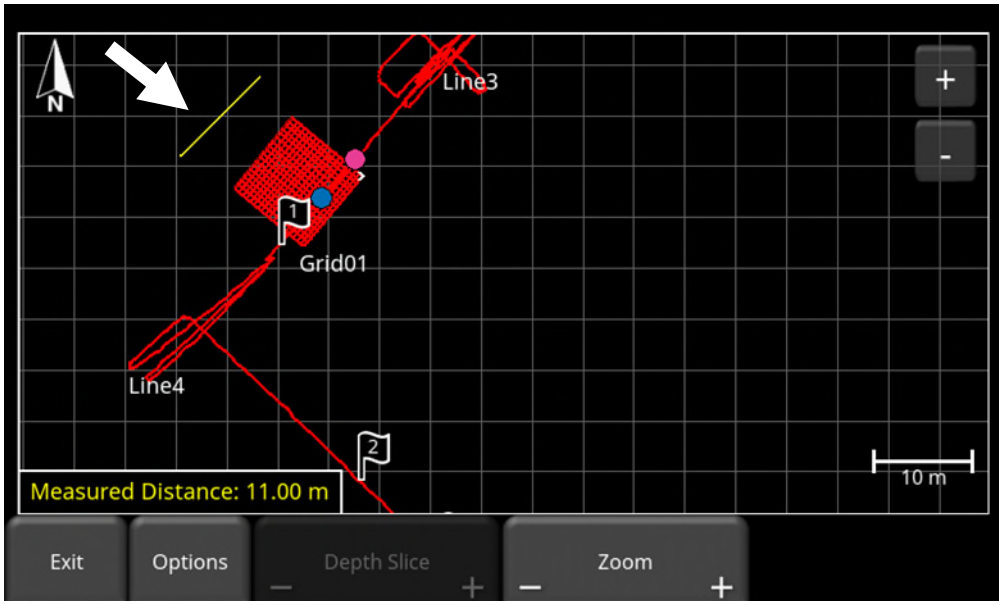


Figure 9-4: The white arrow points to the measure line. The measured distance is shown in the bottom left corner.

10. Managing Data

10.1 Screenshots

The DVL allows you to take a screenshot of nearly every screen available. To save an image of the current screen press the **Camera** button on the DVL. This saves the screen as a Screenshot image (.JPG), which can be viewed in any third-party viewing software. If GNSS is enabled, the screenshot image for depth slices will also contain a geo-tagged reference.

If you are not connected to a Wi-Fi network, a message appears confirming the project and filename of the saved image (Figure 10-1). This will be saved in the same project number as the data.

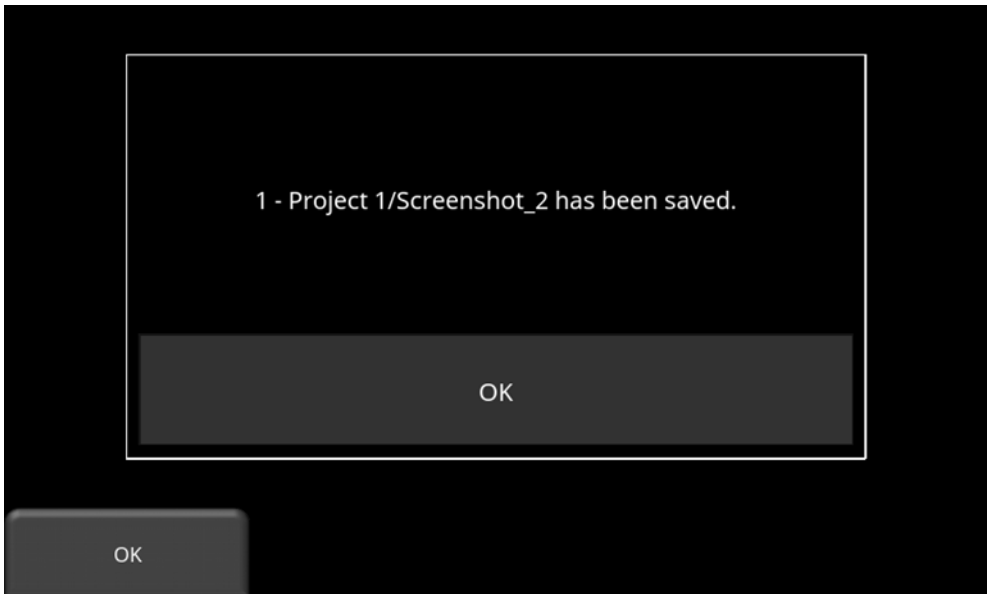


Figure 10-1: Message displayed after pressing the camera button on the DVL to capture the screen (no Wi-Fi present).

If you are connected to a wireless network and have a sending email address configured, the user sees the message in Figure 10-2, asking if you would like to email the screenshot and prompts you to enter the email address. The email address defaults to the last one entered. Tapping on the address box brings up an on-screen keyboard to enter a new email address. Pressing the "**…**" button to the left of the email address displays the last 5 email addresses used, allowing the user to easily select a recent email, rather than re-entering it.

Screenshots can always be emailed at a later time from the Screenshot Gallery (5.3.2).

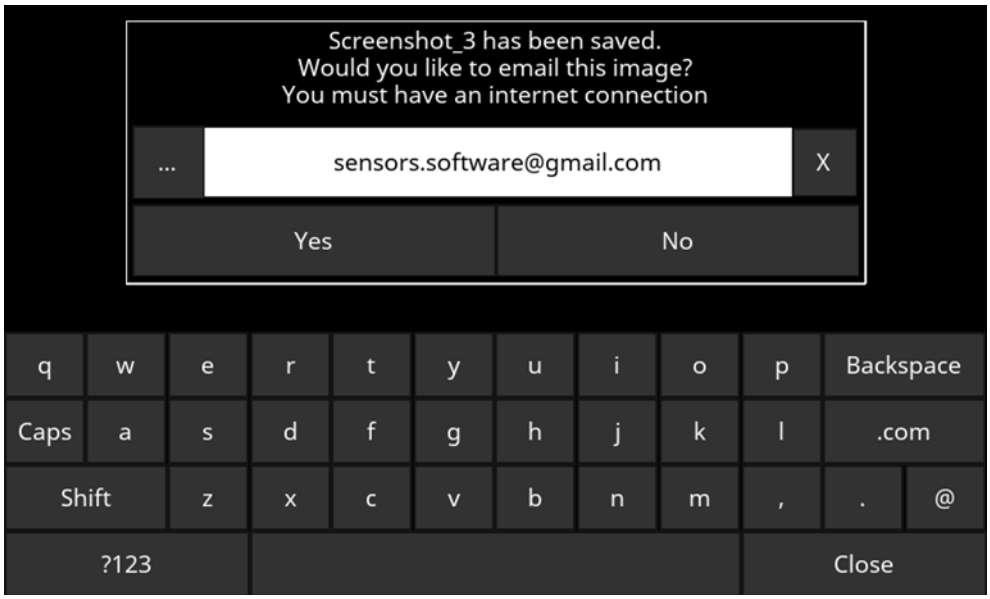


Figure 10-2: Message after pressing the Camera button on the DVL when connected to a wireless network. The user can enter an email address to send the mini-report to.

10.2 Emailing Mini-Reports

When a screenshot is emailed, it is sent as part of a mini report. This mini report also contains a table with information about the collected data including the settings used, date & time (Figure 10-3).

pulseEKKO Mini Report

Project	1 - Project1
System Configuration	Sys Config 1
Screen Capture Number	3
Date Collected	March 24 2017 4:04 PM
Mode	Line Scan
Line	5
Depth	1.0 m
Line Color Palette	1
Filter	OFF
Gain Level	5
Velocity	Moist Soil (0.1)

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Your screen capture is attached to this email.

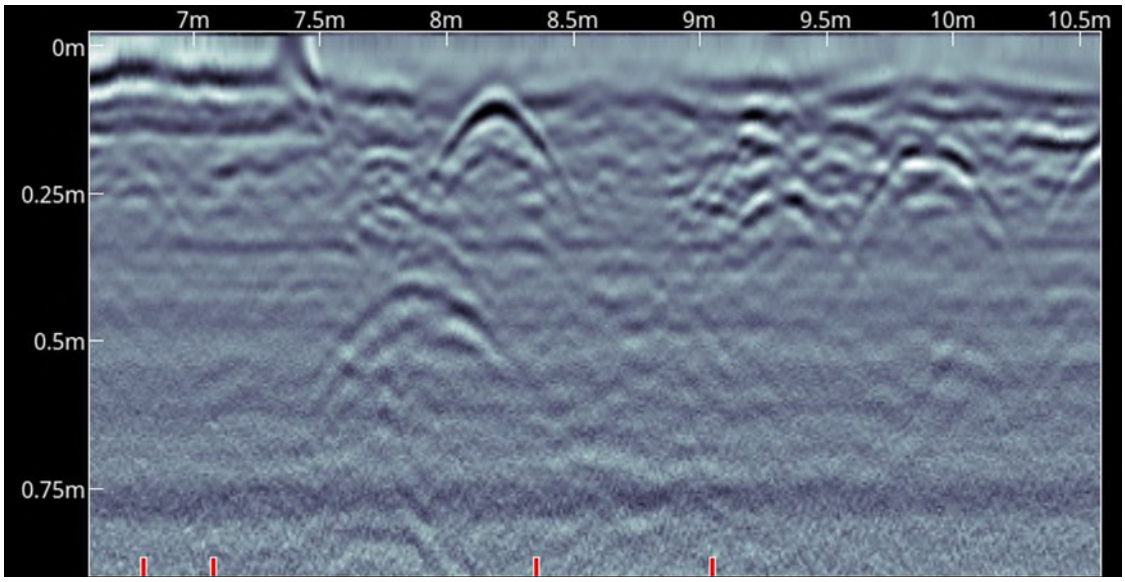


Figure 10-3: Example of a Mini-Report

10.3 Using the Hotspot on your Smartphone

If a Wi-Fi signal in unavailable, you may be able to use your Smartphone as a Wi-Fi access point, by creating a Personal Hotspot. If you are having trouble connecting to a cell phone Personal Hotspot, ensure that the phone is in discovery mode while connecting. On iPhone (iOS 9.0), for example, this involves going to **Settings - Personal Hotspot** (Figure 10-4). Ensure that the Personal Hotspot setting is turned on and wait on this screen until the connection has been established. Once you have received confirmation on the DVL, the cell phone can resume normal use.

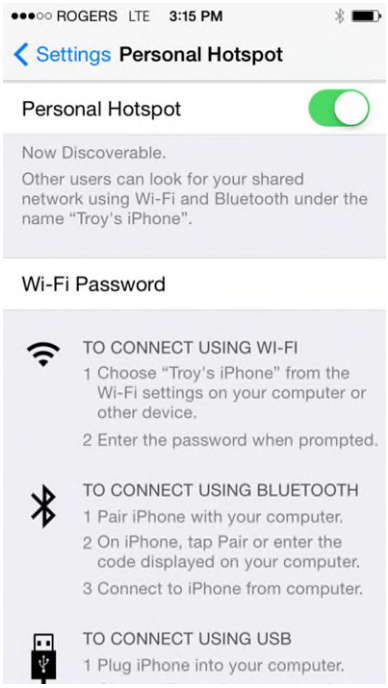


Figure 10-4: Setting up hotspot on an iPhone

Note that when setting up a Personal Hotspot, you may be disconnected from any Wi-Fi networks. Vice-versa, if you have a Personal Hotspot setup, attempting to connect to a Wi-Fi network may disconnect your personal hotspot.

10.4 Transferring Data to a PC

Data can be exported to a PC by inserting a USB memory stick into the USB port (Figure 10-5).



Figure 10-5: Insert a USB memory stick into the USB port on the DVL to export data.

Once the USB memory stick is recognized, a message appears, informing you that a drive has been inserted and will ask if you wish to export all the data on the DVL to it (Figure 10-6). Click **Yes** if you wish to proceed.

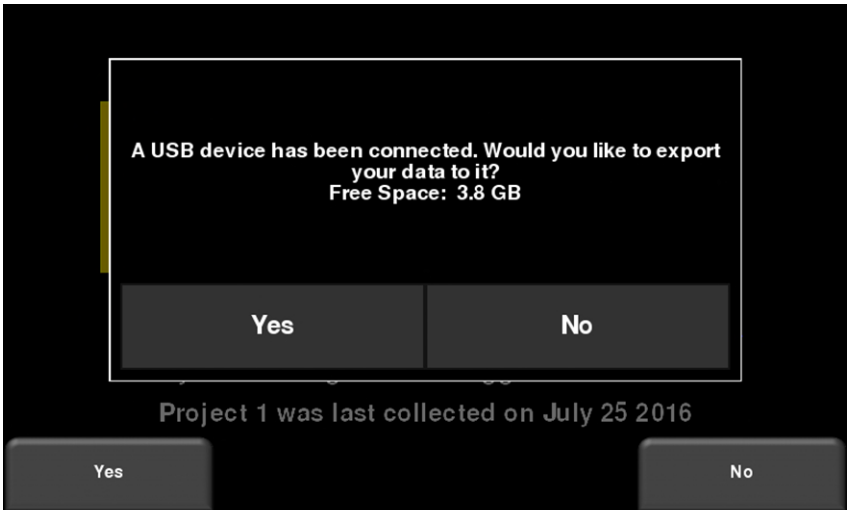


Figure 10-6: When a USB memory stick is connected to the DVL, a message opens asking if you would like to export all your data to it.

Alternatively, if you want to export the data later, you can select **No**. Later, when you are ready to export your data, go into **File Management** and press **Export Data** (Section 5.3.4). From there, you can export selected projects, rather than all the projects currently on the system.

10.4.1 Formatting USB Memory Sticks for the DVL

There may be times when a USB memory stick is not recognized by the DVL. In this case, you may need to format the USB memory stick.

Ensure that it's formatted as FAT/FAT32 (NTFS will not work).

Also ensure that there are no hidden or write-protected partitions on the USB drive. If the problem persists after formatting, try another USB stick.

10.4.2 GPR Data Folder Structure on USB Memory Stick

The folder structure on the USB memory stick can be viewed on your PC, and will look as follows:

- GPR Data
  - pulseEKKO
    - Export01
      - Project1
        - Screen Shots
          - All Screenshots as .JPG files
        - Project1.GPZ file
        - Project1.KMZ file
        - Field Interp Report.CSV
      - Project2
        - Screen Shots
          - All Screenshots as .JPG files
        - Project2.GPZ file
        - Project2.KMZ file
        - Field Interp Report.CSV
      - System Info

All screenshot files are saved in the Screen Shot folder as .JPG files.

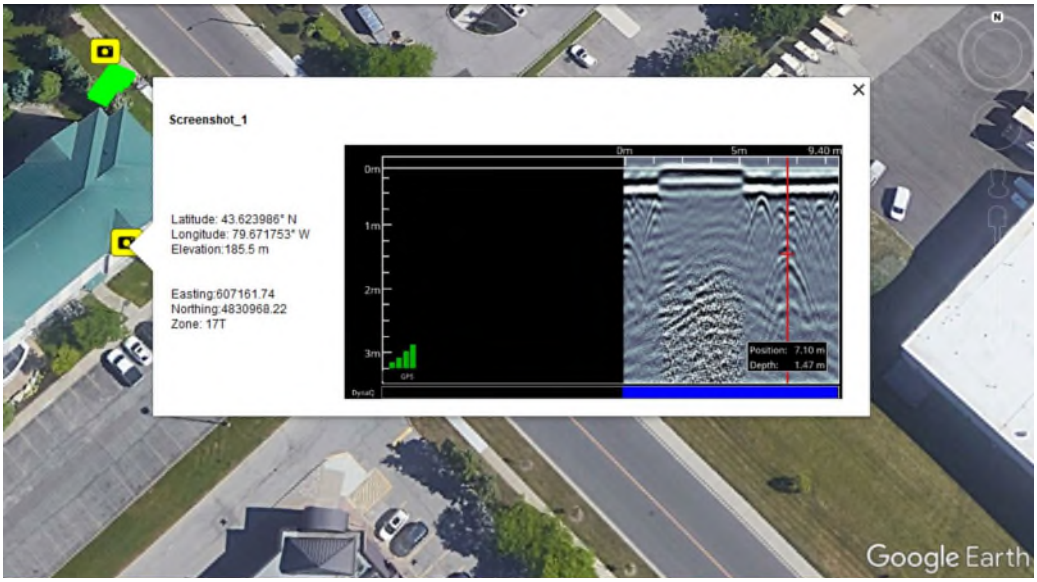
The GPR data and other support files such as GPS files are all contained in a .GPZ file. This file is opened with the EKKO_Project PC software.

Each successive export of data will create a new folder called ExportXX, where XX is incremented by 1 from the previous folder.

10.4.3 Google Earth™ (KMZ) File

If the GPR data was collected with GNSS (internal or external), a .KMZ file is also generated. This contains positional information and can easily be opened in Google Earth™.

If the internal GNSS was used, you will only see screenshots and grids. It will NOT show Line Scans as the internal GNSS is not accurate enough to plot the path. Clicking on the yellow camera icon in Google Earth™ will display the screenshot image



Data collected with an external GNSS will also show the path of Line Scans, as well as grids, Field Interpretations and Flags.



10.4.4 Field Interpretations (CSV) file

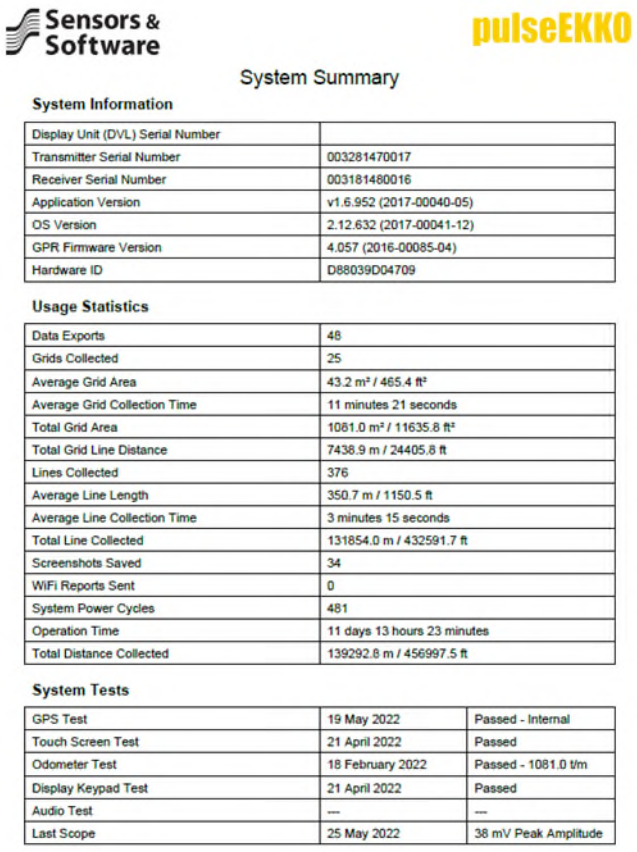
If any interpretations are added to the data during collection, a Field Interp Report file is created. This file is a CSV (Comma separated values) format, commonly opened with Microsoft Excel.

The file will list any Interps and Flags added to data in the field. The position, depth, and colour of each Interp is listed, along with GNSS positions (if a GNSS was connected). A sample output for this file is shown below.

	A	B	C	D	E	F	G	H	I	J	K
1	Name	Count									
2	Pink	5									
3											
4	Tool	Interpretation	GPR Line	Position (m)	Depth (m)	Velocity	GPS-Easting (29S)	GPS-Northing (29S)	Latitude	Longitude	GPS-Elevation
5	Point	Pink	Lineset/line4	2.01	0.48	Wet Soil (0.08 m/ns)	484187.65	4298429.14	38.8345202	-9.1821844	16.63
6	Point	Pink	Lineset/line4	3.02	0.32	Wet Soil (0.08 m/ns)	484187.81	4298429.13	38.8345201	-9.1821826	16.6
7	Point	Pink	Lineset/line4	4.21	0.27	Wet Soil (0.08 m/ns)	484188.05	4298428.97	38.8345187	-9.1821798	16.59
8	Point	Pink	Lineset/line4	5.16	0.51	Wet Soil (0.08 m/ns)	484188.38	4298428.8	38.8345172	-9.1821759	16.56
9	Point	Pink	Lineset/line4	6.89	0.62	Wet Soil (0.08 m/ns)	484188.38	4298428.8	38.8345172	-9.1821759	16.56
10											

10.4.5 System Summary PDF Report

Any time data is transferred to a USB memory stick, a folder called **System Info** is generated. The **System Info** folder contains a System Summary PDF file that provides detailed information about your system and the history of the system.



Sensors & Software

pulseEKKO

System Summary

System Information

Display Unit (DVL) Serial Number	
Transmitter Serial Number	003281470017
Receiver Serial Number	003181480016
Application Version	v1.6.952 (2017-00040-05)
OS Version	2.12.632 (2017-00041-12)
GPR Firmware Version	4.057 (2016-00085-04)
Hardware ID	D88039D04709

Usage Statistics

Data Exports	48
Grids Collected	25
Average Grid Area	43.2 m² / 465.4 ft²
Average Grid Collection Time	11 minutes 21 seconds
Total Grid Area	1081.0 m² / 11635.8 ft²
Total Grid Line Distance	7438.9 m / 24405.8 ft
Lines Collected	376
Average Line Length	350.7 m / 1150.5 ft
Average Line Collection Time	3 minutes 15 seconds
Total Line Collected	131854.0 m / 432591.7 ft
Screenshots Saved	34
WiFi Reports Sent	0
System Power Cycles	481
Operation Time	11 days 13 hours 23 minutes
Total Distance Collected	139292.8 m / 456997.5 ft

System Tests

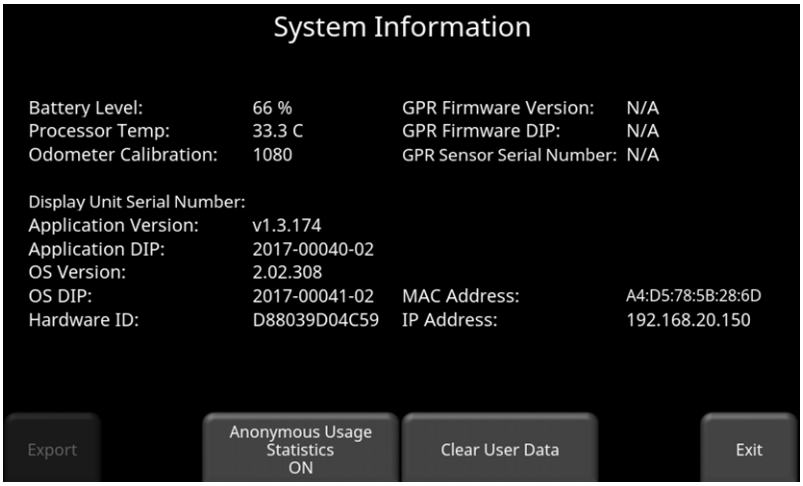
GPS Test	19 May 2022	Passed - Internal
Touch Screen Test	21 April 2022	Passed
Odometer Test	18 February 2022	Passed - 1081.0 t/m
Display Keypad Test	21 April 2022	Passed
Audio Test	---	---
Last Scope	25 May 2022	38 mV Peak Amplitude

10.4.6 LOG Files for System Diagnostics

Any time data is transferred to a USB memory stick, a folder called **System Info** is generated. The **System Info** folder contains a LOG file with information such as the version, serial numbers, temperature and battery power. This information can be very useful for service technicians to diagnose a problem with your system.

If there is a problem with the system, please send the LOG file along with a description of the problem.

Note that the LOG file can also be exported to the USB memory stick from the **Tools > Systems Tests > System Information** menu option (Section 5.2.1). If a USB key is currently inserted, the **Export** button will be enabled. Pressing the Export button will export a System Summary Report with this information.



10.5 EKKO_Project

Any line and grid data collected in a project are saved as a single .GPZ file (e.g. Project1.GPZ), which opens in the EKKO_Project PC software.

EKKO_Project is powerful software that allows you to view, edit, process and create reports from your GPR data. Grid data that is processed in the field will show up as depth slices in EKKO_Project, as well as the path travelled in MapView.

From the main screen (Figure 10-7), you can access various views and launch modules that give you access to further functionality. For more information, consult your EKKO_Project manual or contact Sensors & Software (www.sensoft.ca).

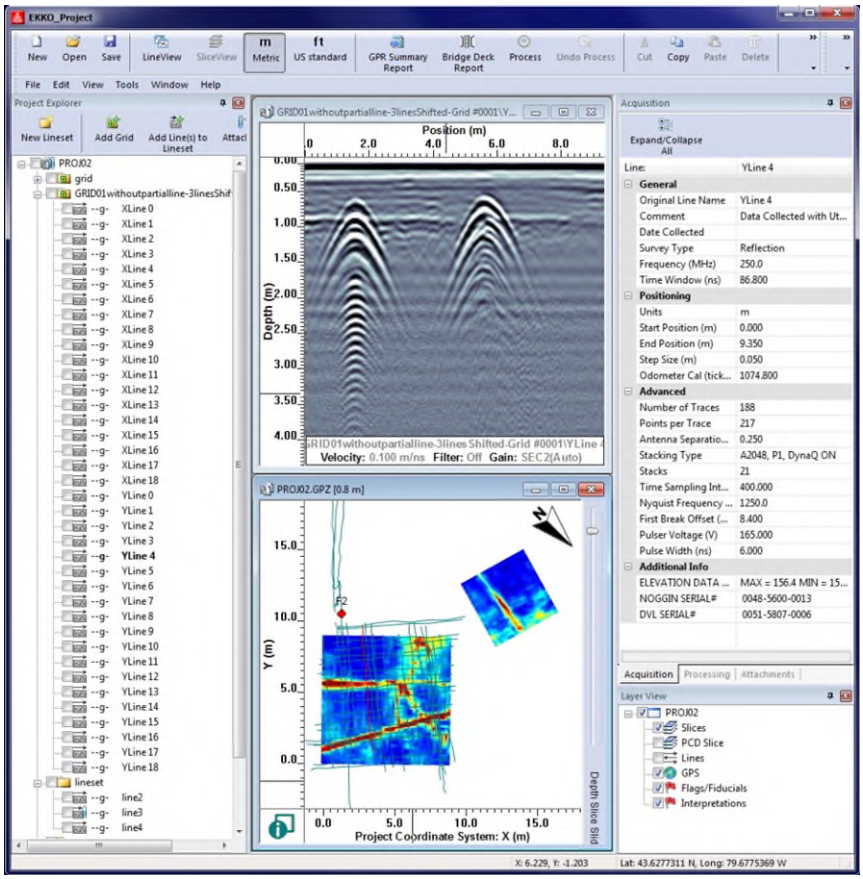


Figure 10-7: Main screen of EKKO_Project

11. Surveying Techniques & Tips

11.1 Low Frequency Full Bistatic Operation

The most common method of data acquisition in rough terrain will be with two people in a configuration shown below (Figure 11-1). The person carrying the DVL has a belt battery fastened around their waist to power the DVL. The optional Harness shown is not a necessity for the DVL operator. They may be just as comfortable carrying the DVL in their hands.

Data collection can be controlled by setting the Trigger Method (6.2.3) to **Manual** and have the DVL operator using the DVL buttons or a wireless trigger. It is also possible for the operator moving the antennas to use the wireless trigger to collect data.

Another option is to set the Trigger Method (6.2.3) to **Free Run** mode with a time delay between traces. The antenna operator needs to move the antennas one step size to the new position and have the antennas on the surface in the delay time before the system automatically triggers and collects the next data trace.



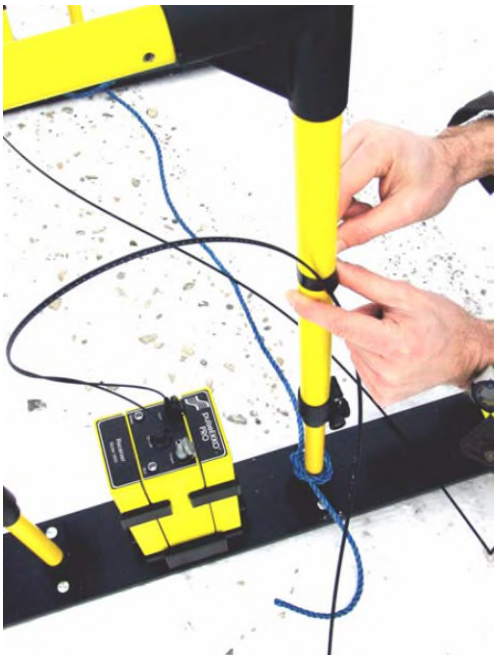
Figure 11-1: Two-person data collection with the pulseEKKO system. The antenna operator moves the antennas one Step Size to each new data collection position.

The antennas can be held at a constant separation by using a rope tied between them (Figure 11-2). Antennas should not move while data are being collected, as indicated by the duration of the beeping tone. Keeping the antennas static assures the highest quality data. When the beep stops, the antennas can be moved to their next position in preparation for the next trace.



Figure 11-2: Using string to keep antennas at fixed separation

Fibre optic cables can be broken or damaged if care is not taken. The most common breakage point is right at the connectors when the cables are snagged or pulled hard. Protect the fibre optic cables by making a strain relief. Take an extra loop of cable and fix it to the handle using a Velcro strap. That way, if the cable gets pulled, the strain is taken up by the strap and not the cable.



11.2 Triggers

While the Odometer trigger is self-explanatory, the other Trigger Methods require a brief description below:

11.2.1 Manual / Wireless Triger

If the Trigger Method (6.2.3) is set to Bluetooth (using the wireless trigger) or manual (using the DVL buttons), the following data collection sequence is followed:

a) Set the antennas at the correct separation and centred on the starting position for the survey line.
b) The data collection screen on the DVL should display “Press Trigger”.
c) The operator presses the up or down button on the DVL, or they can use the wireless trigger.
d) The system starts to beep, indicating the data trace is being collected. The antennas should be kept in contact with the ground surface while the system is beeping.
e) When the beeping stops, one trace has been collected.
f) Move the antennas together along the survey line a distance equal to the Step Size distance.
g) Repeat from step b)

11.2.2 Free Run

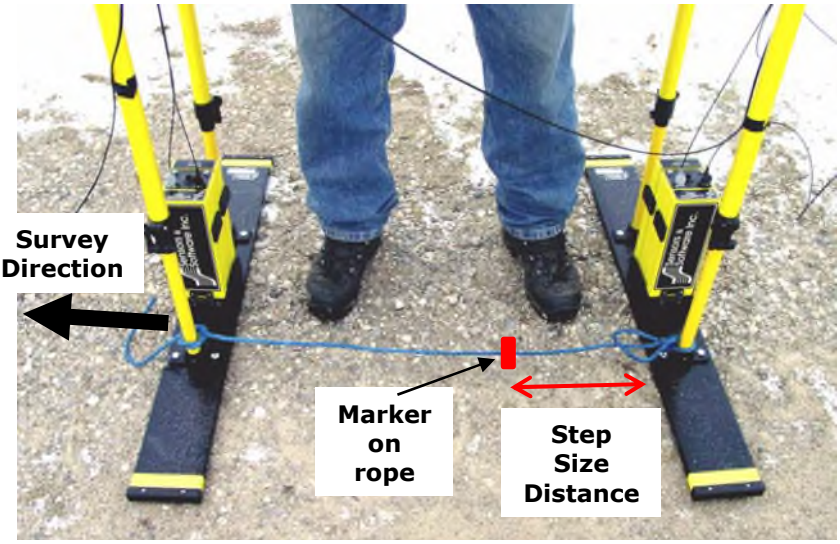
If the Trigger Method (6.2.3) is set to Free Run, the following data collection sequence is followed:

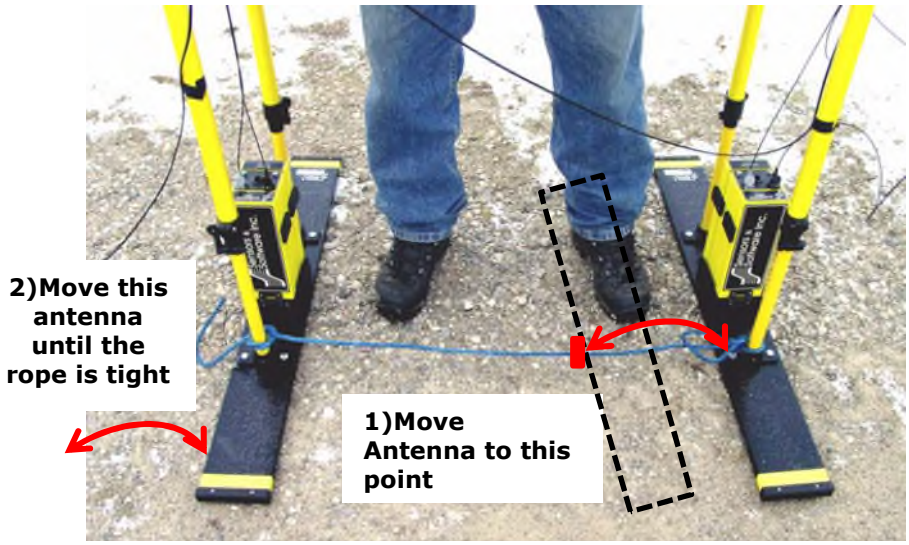
a) Set the antennas at the correct separation and centred on the starting position for the survey line.
b) Press the Start button on the DVL screen.
c) The system starts to beep, indicating a data trace is being collected. The antennas should be kept in contact with the ground surface while the system is beeping.
d) When the beeping stops, one trace has been collected.
e) Move the antennas together along the survey line a distance equal to the Step Size distance. If you are moving the system in a vehicle or boat, for example, make sure you maintain the constant speed that was set.
5. Then back to c) to repeat the cycle.

11.3 Measuring Position

A critical part of GPR surveys is accurately locating subsurface objects. When an odometer is used (as in the SmartCart, SmartTow or SmartChariot systems), this is easy as the GPR is triggered via the odometer at regularly spaced intervals. However, when using a full bistatic configuration, the user needs to manually trigger the system at periodic intervals. In most cases, a measuring tape is used to control position. In this case, make sure it is NOT metal or does NOT have a metal center. Some cloth tape measures do have metal centers. Odd effects can appear in data when such measuring tapes are used.

When collecting a GPR line where the accuracy need only be accurate to the nearest metre, set the step size equal to some fraction of your antenna spacing. On the rope used to hold the antennas at a fixed spacing, mark the step size with tape or a zip tie. Each time the antennas are moved mark the ground (take note of a mark or feature) where the next antenna placement will be based on the mark on the string.





For accurate positioning a tape measure laid out on the survey line is most effective.

11.4 Low Frequency on a SmartCart

When the 1-meter separation bars are used, the front end of the SmartCart gets quite heavy and can be damaged if the front is tilted up. To maneuver the cart, lift the back end and rotate to change the cart direction (Figure 11-3).

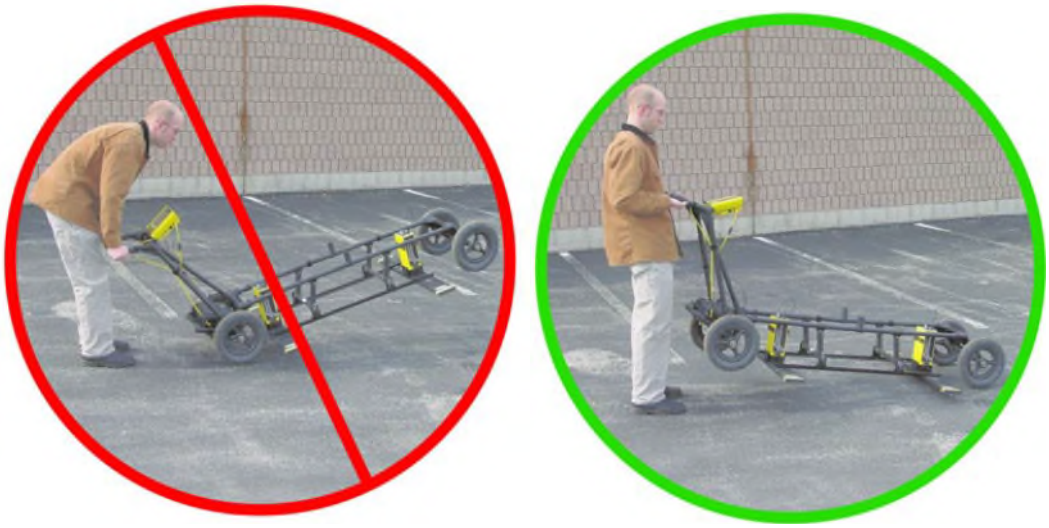


Figure 11-3: Incorrect way (left) and correct way (right) to maneuver SmartCart when lifting.

11.5 Antenna Geometry

Both the high and low frequency, bistatic antennas of the pulseEKKO system have the flexibility to allow different orientations with respect to one another. Antenna polarization can be Broadside, Endfire and Cross Polarization. Antenna orientation can be Parallel or Perpendicular. Details are explained in Section 6.2.5.

The most common setup is the perpendicular-broadside configuration. This orientation provides the best coupling between antennas and linear targets perpendicular to the survey line. It also provides the most coverage of the radiation pattern along the survey line (Figure 11-4).



Figure 11-4: Antennas are held at the proper antenna separation for the selected frequency and perpendicular to the survey line direction.

11.6 Common Mid-Point (CMP) Surveys

A **Common Mid Point (CMP)** survey is performed to measure GPR velocity in the survey area. A CMP survey is best done in an area with flat lying reflectors and relies on changing the antenna separation to increase the signal path length from the mid-point reflector (Figure 11-5 & Figure 11-6).

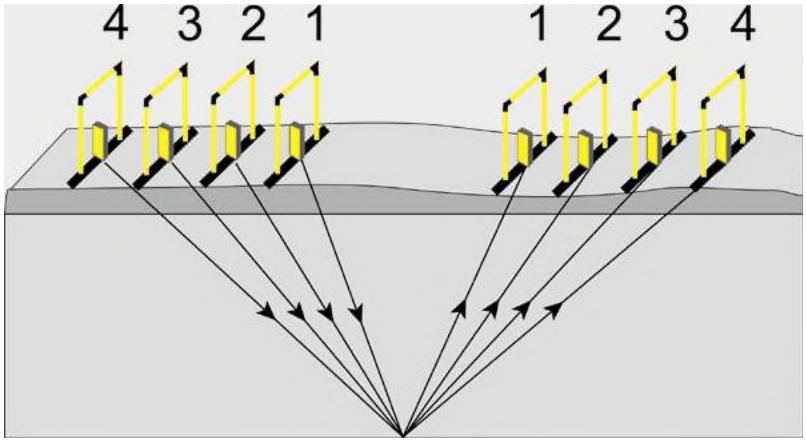


Figure 11-5: Illustration of a CMP Survey



Figure 11-6: Actual CMP Survey

The resulting data can then be processed using a semblance analysis routine to extract average GPR velocities to the reflectors (Figure 11-7). The extracted velocities are used for adding an accurate depth axis for other GPR survey lines collected in the area of the CMP.

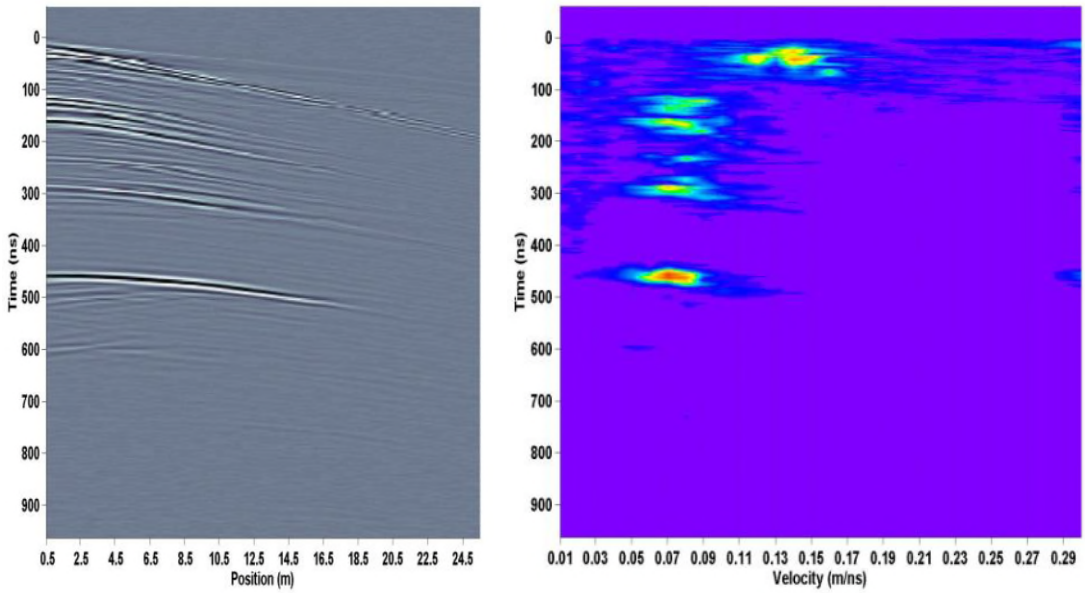


Figure 11-7: Data from CMP survey (left) and semblance analysis used to extract velocity (right)

12. Troubleshooting

The pulseEKKO system is designed to minimize user problems; however, all electronic devices are subject to possible failure. The following are troubleshooting hints if your system fails to operate.

If there is an issue, an error message is usually displayed, indicating the possible cause of the problem.

12.1 Initializing

If a problem occurs during system initialization, the first step is to check the connections. Make sure that cable connections are tight, and fibre optic cables are connected correctly with the strain relief color matching the receptacle door color (Figure 12-1) and that they have “clicked” into place.



Figure 12-1: Make sure fibre optic strain relief color matches the receptacle door color (grey to grey and black to black).

Also, ensure that the software settings for the transmitter are correct for the transmitter that you are using with the system

Reset the System by Powering Down: If the connections are OK but the error persists, try powering down the system completely. This power down will include turning off the DVL as well as the transmitter and receiver. Then power everything back on and see if the system runs.

12.2 Power Supplies

Another common problem that can occur while trying to run a system is insufficient power. The battery may be dead or have a low voltage. If the system is being run from AC, there may be a problem with the AC power supply or adapter.

12.2.1 DVL Power Requirements

The DVL is designed to operate from a 12-volt DC, such as batteries or power supply. The input voltage tolerance is 10.2 volts to 15 volts. If the DVL turns on, the battery level can be monitored from the Swipe Down menu (4.4). Warning messages will appear as the battery level decreases to 20% of its full charge.

If the battery voltage is less than about 10.2 volts, the DVL may not turn on.

Test the battery

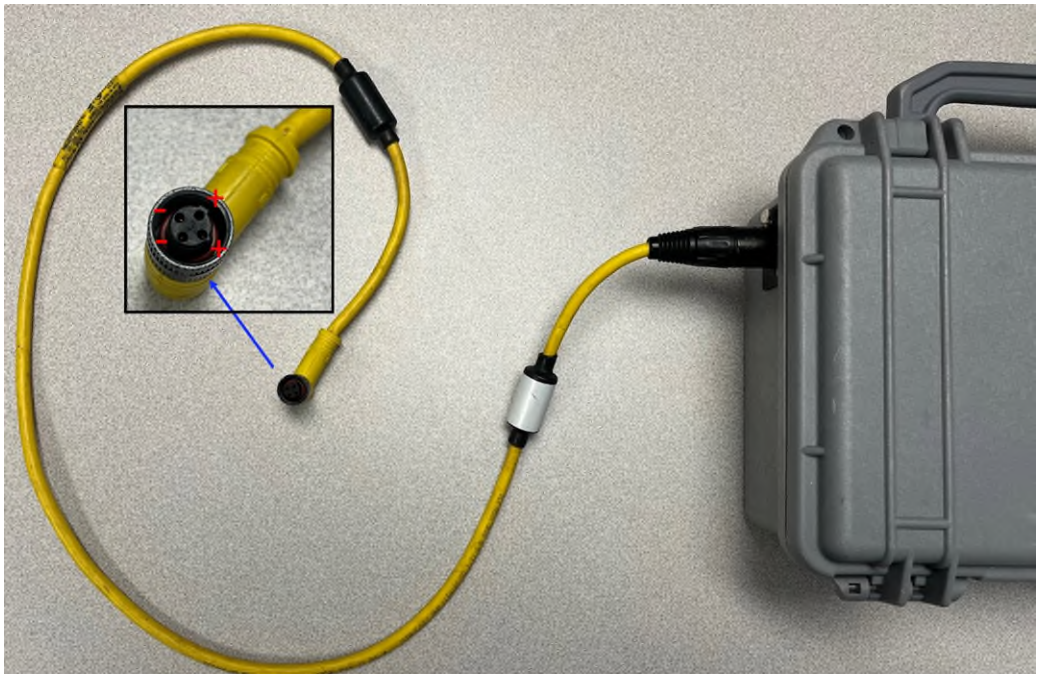
1) Check that the fuse, inside the battery case, has not blown. If so, replace the 10 Amp fuse with one of the spare fuses inside the battery case.

2) Use a multimeter with fine tipped probes (1mm or 0.04 inches) to measure the battery voltage at the connector on the outside of the battery case. Measure the voltage between socket #1 (ground, using the black probe) and socket #4 (power, using the red probe). If the voltage is less than 10.5 volts, there is a problem with the battery.



Test the Power Cable

Insert the power cable into the battery and test the power cable. Use a multimeter to measure the battery voltage at the connector at the end of the power cable. Measure the voltage between either socket labelled negative (-, using the black probe) and either socket labelled positive (+, using the red probe). If the voltage is less than 10.5 volts, there is a problem with the power cable.



4) 250, 500 or 1000 MHz transducers: Check the Transducer Cables and Connectors

The pulseEKKO transducers do not require separate batteries for their operation. They are powered by the same 12 V battery that powers the DVL. Power is sent to the transducers through the transducer cables.

Turn off the DVL and disconnect the battery before disconnecting the transducer cables that connect the DVL to the pulseEKKO transducers.

a) On the back of the DVL, check the 15-socket transmitter and receiver ports, ensuring that none are blocked with debris. If so, clean out the debris, reconnect the cable and try powering the system again.

b) Check both ends of the transducer cables.

   On the male end with pins, ensure none of the 15 pins are missing, bent, or recessed. Look at the pins on an angle to confirm they are all flush with one another. If one is bent or recessed, gently bend the pin back straight and flush with the other pins. Then reconnect the cable and try powering the system again.



On the female end of the cable, check all 15 sockets, ensuring that none are blocked with debris. If so, clean out the debris, reconnect the cable and try powering the system again.



5) Replace the Cable
If you have a spare transducer cable, replace the current cable. If the system does not power on or if the transducer is not detected with either cable, please contact your GPR supplier for further assistance.

12.2.2 DVL Screen turns White After Powering Up

If the DVL screen turns completely white after powering up the system, the battery does not have enough voltage to completely power the system. Recharge or replace the battery

12.2.3 Low Frequency Transmitter & Receiver Power Requirements

The pulseEKKO low frequency receiver and transmitter both use two 12-volt sealed lead acid batteries. The transmitter will, under normal conditions, run for about 4 hours or more on a pair of 2.3 AH batteries. The regular (Model 1600) receiver should run about twice that time on a pair of batteries. However, the Ultra Receiver (Model 3200) draws more current and will not run as long. Extra batteries are usually necessary and highly recommended.



Low Battery Indicators

There are 2 ways that a low battery voltage is communicated to the operator:

e. When the transmitter and receiver battery voltages drop below 11.4 volts, the DVL displays a warning message as the system initializes at the start of the GPR survey line. The operator can continue to collect data but should consider changing or charging the batteries as soon as possible.

f. The receiver and transmitter also contain a voltage monitoring circuit that causes the Power LED light on top of the units to slowly flash when the battery voltage is very low, usually around 10.2 volts and below. When this occurs, batteries should be replaced soon, or data quality will be reduced.

If the batteries are not replaced and the voltage continues to drop, the unit will eventually turn off.

pulseEKKO 100 Transmitter

When a pulseEKKO 100 transmitter is being used with a pulseEKKO system (Section 6.1.6), the pulseEKKO 100 transmitter is unable to communicate the proper battery voltage to the DVL. As a result, the DVL low battery warning message from number 1 above is displayed before every survey line is collected. In this case, it is OK to ignore the message and continue with data acquisition. The low battery indicator in number 2 above can still be used.

12.2.4 Testing Transmitter & Receiver Batteries

If you are experiencing reduced operation time with either your pulseEKKO Receiver or Transmitter, the problem may be the result of a damaged 12 V battery or a poor battery connection in one of the battery compartments.

All battery compartments should be checked periodically for proper operation. Take a known good pair of batteries and install them into the battery compartments (Section 2.1.3). Ensure the power light activates with no intermittent operation. If the power light will not activate, look in the

battery compartment and check the battery contact for signs of excessive stress. Also check the condition of the 2 Amp fuse inside the battery compartments and replace if necessary.

Contact Sensors & Software Inc. should all the above fail to resolve the problem.

12.3 Communication Errors

If the battery is OK and the DVL turns on, but the GPR sensor does not scan, there may be a communication failure between the DVL and the transducers/antennas. Power off the system and disconnect the battery.

Make sure cables are not visibly damaged. Check that all pins are straight, and there is no dirt or debris in the connector. Ensure that the cable connections are tightly secured. Sometimes vibrations cause the cable connections to slightly loosen and break contact leading to errors. Disconnecting the cable and reconnecting it may provide a better contact and solve the problem. Plug in the battery, turn on the system and try scanning again.

12.4 Receiver Related Errors

If a receiver error is encountered, check that the receiver is turned on, that the batteries for the receiver are properly charged and that the receiver fibre optic cable is not damaged and is properly connected.

Perform the following checks:

1. Check that the red POWER light on the top of the receiver is ON. If not, then press the ON/OFF switch once to see if the light comes ON. If it does, restart the DVL and retry the system to see if it will run. If the red POWER light still does not light up or flashes, check to make sure the batteries are fully charged.

2. Check the condition of the fibre optic cables. Look for any sign of stress or damage. If possible, replace the fibre optic cable.

If neither of the above solutions solve the problem, contact Sensors & Software Inc.

12.5 Transmitter Related Errors

If there is no signal on the screen, go to Scope mode (5.2.7) and try the Auto search. Keep the antennas about one antenna length apart. If the pulse still cannot be found do the following checks:

1. Make sure the transmitter batteries are properly charged and connected.
2. Check the condition of the single fibre optic cable to the transmitter, looking for any signs of stress or damage. Replace or repair if needed.

3. Check that the brass antenna sockets in the bottom of the transmitter and receiver and ensure that the brass antenna pins in the top of the antennas are properly tightened. Also check that there is a good contact between them.
4. With the system running, find the fibre optic cable from the transmitter, disconnect it at the DVL and look for a red light coming from the top hole in the Fibre Optic Converters (Section 2.1.5). Plug this cable back in and unplug the Input (black) cable at the transmitter. Check for a red light coming from the cable.

12.6 Time Zero Jitter

If Scope mode shows the first break shifting up and down as shown in Figure 12-2, this is an indication that the fibre optic cables are damaged.

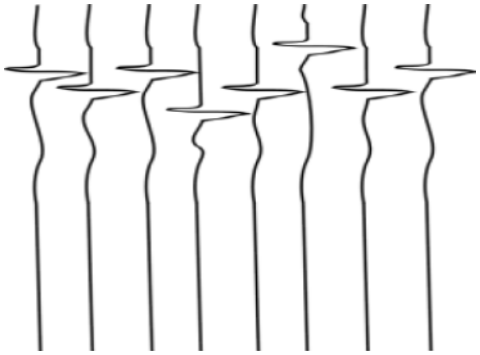


Figure 12-2: Time zero jitter is caused by damaged fibre optic cables.

Check all cables. There are also short fibre optic cables located inside the transmitter and receiver that may be causing the problem (see item K in Figure 13-4). Before attempting to clean or replace these cables, contact Sensors & Software.

12.7 System Overheating

The pulseEKKO system is designed to operate to a maximum *internal* temperature of 70 C or 158 F. In situations of high ambient temperatures or long exposure to direct sun, this maximum internal temperature may be exceeded and cause the system to fail. While the temperature displayed on the DVL indicates the internal temperature of the DVL (in System Information under System Test) and not the GPR system, this temperature should give an idea of whether the pulseEKKO transmitter and receiver are overheating. If you suspect that the system is overheating, shut it off and give it a chance to cool down in a shady location before trying to run it again.

If the situation is such that the high temperatures or direct sun cannot be avoided, it may be a good idea to put some sort of shade over the system. Contact Sensors & Software Inc. if the problem persists as there may be defective electronic components.

12.8 Creating a Test Line for Data Quality

After receiving the system and getting comfortable with its operation, one of the best ways to detect any future problems is to collect a line of data at a convenient, easily accessible location. The line does not have to be too long, but one screen is a good guide. This data line should be saved electronically and perhaps plotted out on paper and dated. If there is a suspected problem with the system later, this test line could be collected and compared with earlier tests. When comparing data, consider weather and environmental conditions, which could skew the comparisons slightly.

12.9 Contacting the Vendor for Service

Return the system to the vendor from whom you purchased it. Have the following information available:

1) GPR sensor Serial Number displayed at the top of the **System Settings Screen**.
2) A brief description of when the error is happening and the operating conditions (temperature, humidity, sunshine, system settings, etc.).
3) System log files – these are downloaded to your computer during data export (5.3.4)

Manufacturer's Address
Sensors & Software Inc.
1040 Stacey Court
Mississauga, Ontario
Canada L4W 2X8
Tel: (905) 624-8909
Toll Free: 1 800-267-6013
Email: sensoft_service@spx.com
Website: http://www.sensoft.ca/

13. Care & Maintenance

13.1 General

When operating the pulseEKKO GPR system in a geophysical field environment, exercise the normal care afforded to other field instrumentation.

All the equipment is water resistant but will not tolerate total immersion in water. If the equipment is immersed in water, open the affected components (if possible) and dry it out before operating. If the equipment is operated in very humid conditions, again open the affected components (if possible) occasionally to allow the components to dry out.

If the antennas are moved across a surface with puddles of water, water may seep under the antenna block that the transmitter and receiver attach to and get into the connection with the brass pins. Detach the transmitter and receiver and leave the antennas in a dry location, preferably with circulating air, to give them a chance to completely dry out. Corrosion in the antenna at the base of the brass pins or corrosion in the transmitter/receiver at the base of the brass sockets caused by water can cause serious damage to your system. Allow them to dry out after a survey in wet conditions.

The interior of the transmitter and receiver can become very hot very quickly if exposed to strong, direct sunlight. High temperatures can affect system electronics and may lead to failures. If a suspected heat failure does occur, stop the system and allow it to cool down before retrying.

13.2 Cable Care

The cable connectors, fibre optic converters, the transmitter, the receiver, transducers, and the DVL need to stay clean and free of dust and moisture. Use a brush or air spray to clean dust, lint, and other foreign particles from these connectors.

When the system is not being used, make sure the connections are protected to prevent dust and moisture from collecting inside. If the connectors are exposed, cover them with some sort of dust cap.

Connectors are weak points in any system. When using this product in rough, dusty, and outdoor environments, you can minimize potential down time if you take care of the cables and connectors.

Cables are designed to be as tough as practical. Careless use of cables, such as using them to carry loads that they are not designed for, can cause internal damage.

Cables and connectors are not designed to suspend, tow, or otherwise carry the weight of systems. They are part of the electronic circuit and should be treated accordingly. When not in use cables and connectors should be placed in their storage box.

After working in rainy conditions, disconnect the cables and check for water in the receptacles. Remove the water or allow to air dry, if necessary. Never allow the system to sit in rainy conditions for long periods of time.

13.2.1 Fibre Optic Cables

The fibre optic cables are the most fragile component in the system. They can be easily damaged by misuse. When handling the fibre optic cables always roll and unroll them as if they were on a spool. DO NOT roll them around your arm like a rope or extension cord. Also, these cables do not twist, therefore laying the roll on the ground and pulling the cable off will cause the cables to tangle.

Always push in and remove the cable by holding the strain relief jacket or the plastic end connector. Pulling on the cable will loosen the crimp and damage the cable. After connecting the fibre optic cables to the antenna electronic boxes, loosely loop the cable and tape off some slack onto the handles. Most breaks occur right at the cable ends when they are accidentally pulled.

These cables can stand a great deal of abrasive wear but the user should avoid sharp bends in the cable, pulling the cable at right angles close to the fibre optics connectors, or allowing the unprotected ends to get dirty or scratched. Erratic Time Zero jumps usually indicate a cracked cable. If problems are encountered with the fibre optics cables, repair is very straightforward and is outlined in detail below. The best policy is to carry spares. Short fibre optic cables are located inside each of the units (see item K in Figure 13-4). These short cables may need cleaning and polishing from time to time.

13.2.2 Fibre Optic Cable Repair

A picture of the Low Frequency Handle Spare Parts kit is shown in Figure 13-1, item number 100-54-0121. This is standard with the LF Handle package. This kit can be used to repair existing fibre optic cables. A crimping tool (not shown) may be needed in some cases.

Other repair kits are also available that include lengths of fibre optic cable. Contact Sensors & Software for information and availability.

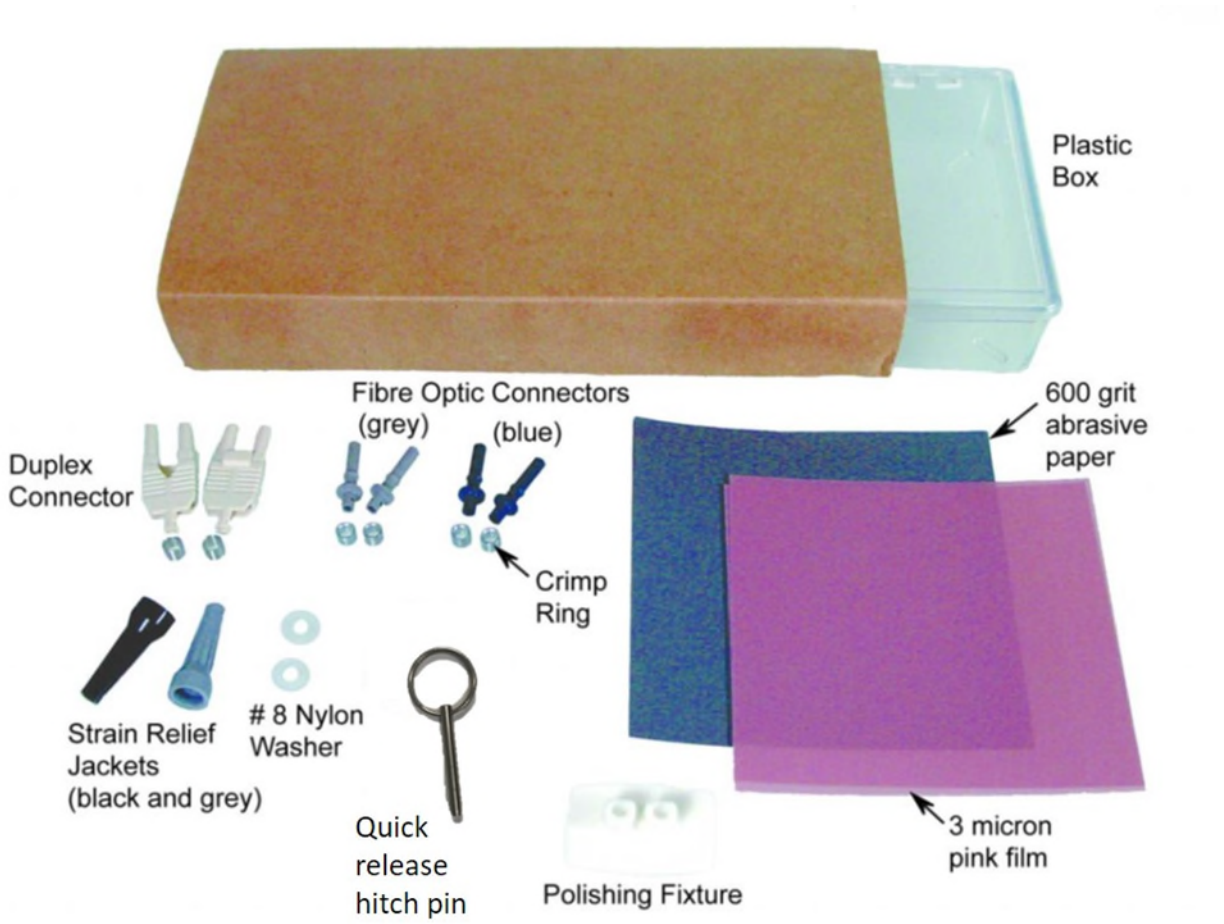


Figure 13-1: Fibre optic cable repair kit

The following procedure describes how to repair the fibre optics cables that link the pulseEKKO unit to the transmitter and receiver units. The procedure and materials used are described in the Hewlett-Packard Opto-Electronic Data Book excerpts of which are provided in Appendix A: Excerpts from the HP Fibre Optic Handbook.

The polishing kit consisting of polishing fixture, 600 grit abrasive paper and 3-micron pink lapping film. No adhesive material is needed to secure the cable and the connector can be used immediately after polishing.

Connectors may be easily installed on the cable end with readily available tools. Materials needed for the procedure are:

- Fibre optic cable
- Polishing Kit
- Grey/Blue connector and crimp ring
- Grey and black strain relief jackets
- #8 nylon washers

- Industrial razor blade or wire cutters (not supplied)
- 16 gauge latching wire strippers (not supplied)
- Crimp tool (not supplied but available from Sensors & Software)

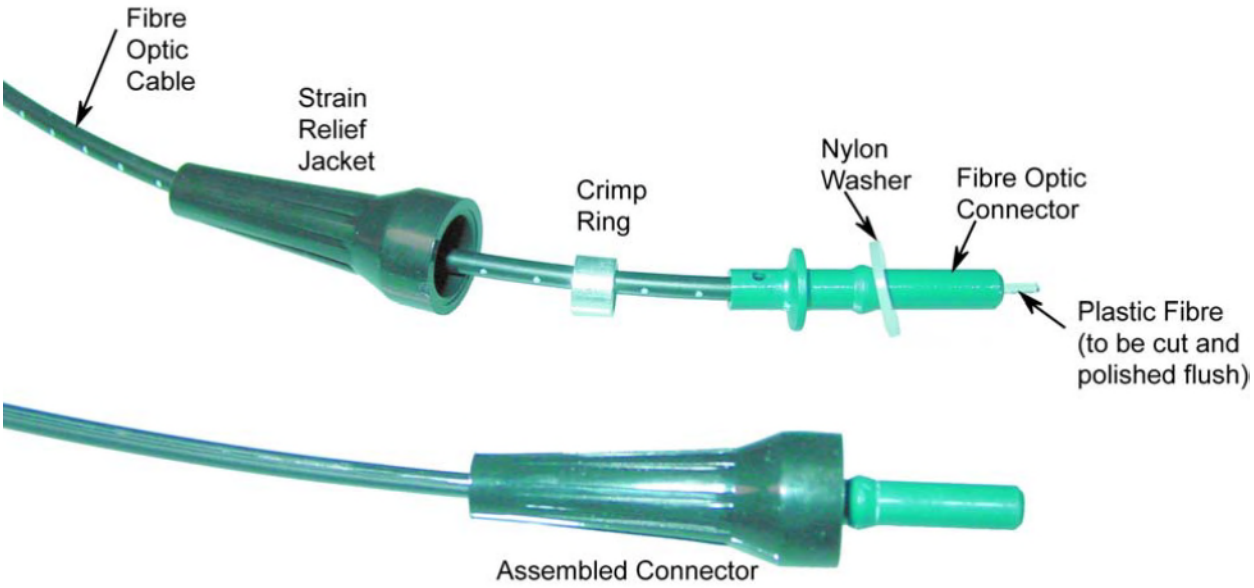


Figure 13-2: Assembling fibre optic connectors

Step 1
If the duplex cable is being connected, split the two fibres 2 to 3 inches back from the ends. Trim off any excess webbing and strip off about 0.3 inch (8 mm) of the outer jacket with the 16-gauge wire strippers.

Step 2
Slide the two strain relief jackets over the fibres remembering that the blue fibre optic connector will correspond with the black strain relief jacket and the grey fibre optic connector with the grey strain relief jacket.

Step 3
Place the crimp ring and the connector over the end of the cable; the fibre should protrude about 0.12 inch (3 mm) through the end of the connector. Carefully position the ring so that it is entirely on the connector and then crimp the ring in place with the crimping tool.
NOTE: Place the grey connector on the cable end to be connected to the fibre optic output (grey strain relief jacket) and the blue connector on the cable end to be connected to the fibre optic input (black strain relief jacket) to maintain the color coding (both connectors are the same mechanically).

Step 4
Slide one of the plastic washers provided in your pulseEKKO spares kit over the fibre optic connector. This washer will now be inserted into the strain relief jacket.
NOTE: You may also use #8 stainless steel flat washers should you run out of the nylon ones. Being very careful not to damage or bend the cable, force the washer into the strain relief jacket. You may find it useful to use a 3/16-inch nut driver to push the washer into its strain relief jacket as the fibre optic connector will slide inside the driver and even force can be applied to the washer.

Step 5
Any excess fibre protruding from the connector may be cut off; however, the trimmed fibre should protrude at least 0.04 inch (1 mm) from the connector end. Insert the connector fully into the polishing fixture with the connector end protruding from the bottom of the fixture.

NOTE: The four dots on the bottom of the fixture are wear indicators. Replace the fixture when the dots are no longer visible.

Place the 600-grit abrasive paper on a flat smooth surface. Pressing down on the connector, polish the fibre and the connector until the connector is flush with the end of the polishing fixture. Wipe the connector and the fixture with a clean cloth or tissue.

Step 6
Place the flush connector and the polishing fixture on the dull side of the 3-micron pink lapping film and continue polishing the fibre and the connector for approximately 25 strokes. The fibre end should be flat, smooth and clean. The cable is now ready for use.

13.3 Battery Care

pulseEKKO GPR systems can use a few different 12-Volt sealed lead acid batteries – one for the DVL and two 2.3 Amp-hour batteries each for the low frequency transmitter and receiver:



If batteries are maintained in a charged condition, they will give long life and reliable service. Improper use and maintenance will greatly reduce their life. Sealed lead acid batteries should **NEVER** be left in a discharged condition for any period. Charge the batteries as soon as possible after use (Figure 13-3).



Figure 13-3: Battery charger for the low frequency transmitter and receiver batteries.

Charge batteries at room temperature whenever possible.

Do not mix charged and discharged batteries and DO NOT attempt to use discharged batteries a second time.

If a battery has been deeply discharged or left in a discharged condition for some period, it may not accept a charge immediately when it is connected to the charger (the fast charge LED will not light). Leave it to attempt to charge it, but if the fast charge light does not come on within 6-hours the battery should be considered damaged and properly discarded.

Do not assume that a battery that is still charging after 8 hours is nearing the end of its charge cycle. Typical charging time for an empty battery is 12 hours from start of fast charge. When charging a depleted battery, it is normal for the charge light to go out after 6-8 hours. The charger has gone into trickle mode only and the battery must remain in the charger for the minimum 12 hours required.

Ensure that the batteries are fully charged before storing. If practical, store the batteries in a cool place, 10 C (a refrigerator is ideal), but make sure the temperature is not likely to drop below -30 C or the electrolyte may freeze and possibly split the case.

The large battery and belt batteries are fused to protect the system. For the belt battery, remove the battery from padded casing and check the 5 Amp fuse. Replace the fuse if necessary. For the larger SmartCart battery, open the battery case and check that the 10 Amp fuse is OK. If necessary, replace it with one of the spare fuses available inside the battery case.

The low frequency transmitter and receiver batteries are also fused. The fuses are located inside the battery compartments and should be checked and, if necessary, replaced, if power problems occur.

13.4 Spare Parts

The low frequency pulseEKKO system comes with spare parts for repairing latches, keepers, hinges sockets and fuses on the transmitter and receiver, replacing pins on the antennas and quarter-turn studs on the adjustable handles. The positions of most of the items pictured in Figure 13-4, are shown as assembled in Figure 13-5. Use item number 100-54-0097 when ordering the electronic spares.

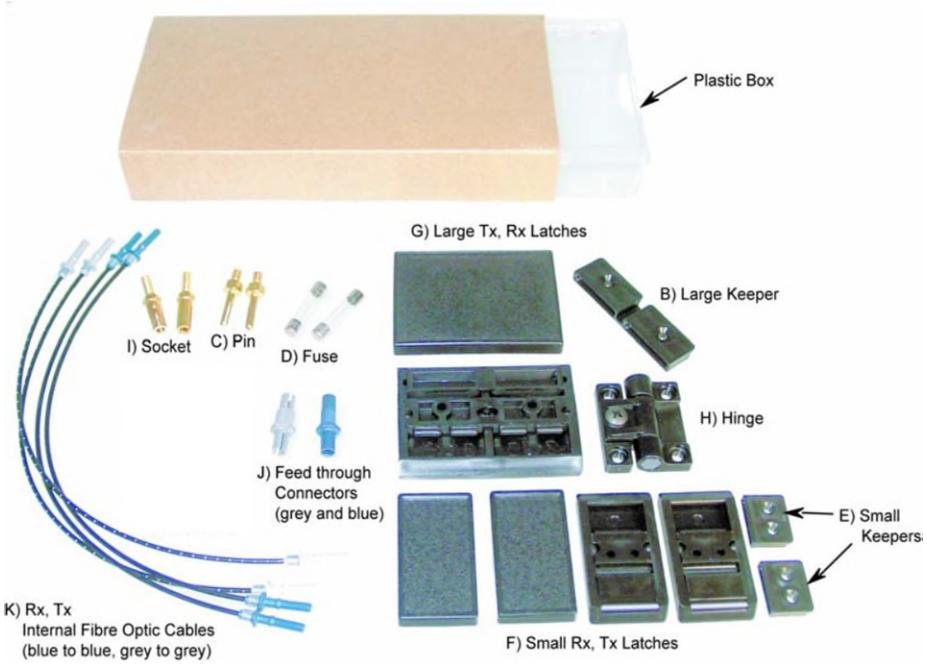


Figure 13-4: Electronic Spares Kit

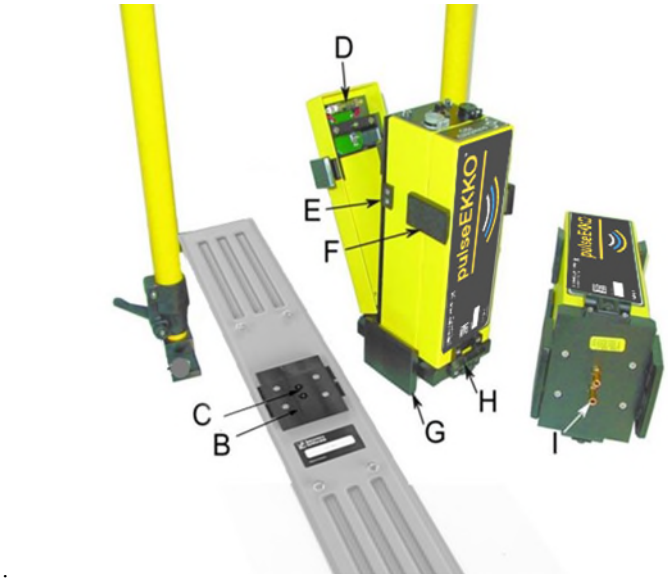


Figure 13-5: Location of spare parts shown in Figure 13-4

13.4.1 General Spares

When going out on a trip, make sure you have plenty of spares. It is much easier to carry a spare fibre optic cable than try and repair one in the field. Same applies to batteries, always have spares. Remember fuses and a Philips screwdriver. A volt/ohm meter is also useful.

13.5 Storage Cases

Equipment that is transported and stored loosely is more susceptible to damage. All equipment should be stored in its shipping case or a storage box. Sensors & Software has optional shipping cases available for some components and systems.

13.6 Upgrading DVL Software

From time to time, Sensors & Software release new software for the DVL. The latest release of the pulseEKKO system software is available for download at www.sensoft.ca under **Support > Software Downloads > GPR System Software > pulseEKKO**.

Instructions for installing the pulseEKKO system software onto the pulseEKKO DVL-500 are available at the same location.

14. Technical Specifications

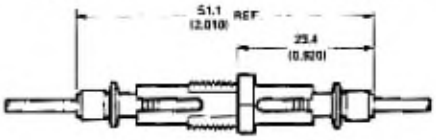
The technical specifications for pulseEKKO GPR systems are found on the Sensors & Software website, www.sensoft.ca under **Products > pulseEKKO > Specifications**.

https://www.sensoft.ca/products/pulseekkopro/specification/

Appendix A: Excerpts from the HP Fibre Optic Handbook

The following diagram displays an in-line splice t=for HFBR-35XX/36XX fibre optic cable with HFBR-4501/4511 simplex connectors:

IN-LINE SPLICE FOR HFBR-35XX/36XX FIBER OPTIC CABLE WITH HFBR-4501/4511 SIMPLEX CONNECTORS



DIMENSIONS IN MILLIMETRES (INCHES)

Connector Mechanical/Optical Characteristics 25°C Unless Otherwise Specified.

Parameter	Part Number		Sym.	Min.	Typ.	Max.	Units	Ref.
Retention Force Connector to HFBR-152X 153X/ 252X/253X Modules	Simplex	HFBR-4501/4511	F_{R-C}	7	8		N	Note 4
	Simplex Latching	HFBR-4503/4513		47	80			
	Duplex	HFBR-4506		7	12			
	Duplex Latching	HFBR-4516		50	80			
Tensile Force Connector to Cable	Simplex	HFBR-4501/4511	F_T	8.5	22		N	Notes 3, 4
	Simplex Latching	HFBR-4503/4513		8.5	22			
	Duplex	HFBR-4506		14	35			
	Duplex Latching	HFBR-4516		14	35			
Adapter Connector to Connector Loss	HFBR-4506/4515 with HFBR-4501/4511		α_{CC}	0.7	1.5	2.8	dB	Notes 1, 5
Retention Force Connector to Adapter	HFBR-4506/4515 with HFBR-4501/4511		F_{R-B}	7	8		N	Note 4
Insertion Force Connector to HFBR-152X/153X/ 252X/253X Modules	Simplex	HFBR-4501/4511	F_I		8	12	N	Notes 2, 4
	Simplex Latching	HFBR-4503/4513			16	35		
	Duplex	HFBR-4506			13	46		
	Duplex Latching	HFBR-4516			22	51		

Notes:

1. Factory polish or field polish per recommended procedure.
2. No perceivable reduction in insertion force was observed after 2000 insertions. Destructive insertion force was typically at 178N (40 lbs).
3. For applications where frequent temperature cycling over temperature extremes is expected please contact Hewlett-Packard for alternate connectoring techniques.
4. All mechanical forces were measured after units were stored at 70°C for 168 hours and returned to 25°C for one hour.
5. Minimum and maximum limits of α_{CC} are for 0°C to 70°C temperature range. Typical value of α_{CC} is at 25°C.

Connectoring

The following easy procedure describes how to make cable terminations. It is ideal for both field and factory installation. If a high volume connectoring technique is required please contact your Hewlett-Packard sales engineer for the recommended procedure and equipment.

Connectoring the cable is accomplished with the Hewlett-Packard HFBR-4593 Polishing Kit consisting of a Polishing Fixture, 600 grit abrasive paper and 3-μm pink lapping film (3M Company, OC3-14). No adhesive material is needed to secure the cable in the connector, and the connector can be used immediately after polishing. Improved connector to cable attachment can be achieved with the use of a RTV (GE Company, RTV-128) adhesive for frequent, extreme temperature cycling environments or for elevated temperature operation.

Connectors may be easily installed on the cable ends with readily available tools. Materials needed for the terminating procedure are:

1) Hewlett-Packard Plastic Fiber Optic Cable
2) HFBR-4593 Polishing Kit
3) HFBR-4501/4503 Gray Simplex/Simplex Latching Connector and Silver Color Crimp Ring
4) HFBR-4511/4513 Blue Simplex/Simplex Latching Connector and Silver Color Crimp Ring
5) HFBR-4506 Parchment Duplex Connector and Duplex Crimp Ring
6) Industrial Razor Blade or Wire Cutters
7) 16 Gauge Latching Wire Strippers
8) Crimp Tool, HFBR-4597

Step 1

The zip cord structure of the duplex cable permits easy separation of the channels. The channels should be separated approximately 50 mm (2.0 in.) back from the ends to permit connectoring and polishing.

After cutting the cable to the desired length, strip off approximately 7 mm (0.3 in.) of the outer jacket with the 16 gauge wire strippers. Excess webbing on duplex cable may have to be trimmed to allow the simplex or simplex latching connector to slide over the cable.

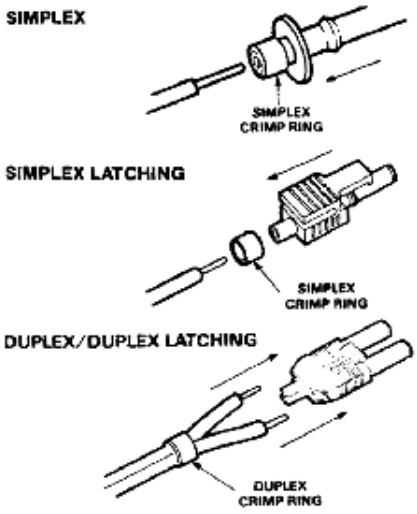
When using the duplex connector and duplex cable, the separated duplex cable must be stripped to equal lengths on each cable. This allows easy and proper seating of the cable into the duplex connector.



Step 2

Place the crimp ring and connector over the end of the cable; the fiber should protrude about 3 mm (0.12 in.) through the end of the connector. Carefully position the ring so that it is entirely on the connector with the rim of the crimp ring flush with the connector, leaving a small space between the crimp ring and the flange. Then crimp the ring in place with the crimping tool. One crimp tool is used for all connector crimping requirements.

Note: *Place the gray connector on the cable end to be connected to the transmitter and the blue connector on the cable end to be connected to the receiver to maintain the color coding (both connectors are the same mechanically). For duplex connector and duplex cable application, align the color coded side of the cable with the appropriate ferrule of the duplex connector in order to match connections to the respective optical ports. The simplex connector crimp ring cannot be used with the duplex connector. The duplex connector crimp ring cannot be used with the simplex or simplex latching connectors. The simplex crimp has a dull lustre; the duplex ring is shiny and has a thinner wall.*



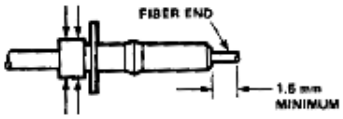
Step 3

Any excess fiber protuding from the connector end may be cut off; however, the trimmed fiber should extend at least 1.5 mm (0.06 in.) from the connector end.

Insert the connector fully into the polishing fixture with the trimmed fiber protruding from the bottom of the fixture. This plastic polishing fixture can be used to polish two simplex connectors or two simplex latching connectors simultaneously, or one duplex connector.

Note: *The four dots on the bottom of the polishing fixture are wear indicators. Replace the polishing fixture when any dot is no longer visible.*

Place the 600 grit abrasive paper on a flat smooth surface. Pressing down on the connector, polish the fiber and the connector using a figure eight pattern of strokes until the connector is flush with the bottom of the polishing fixture. Wipe the connector and fixture with a clean cloth or tissue.

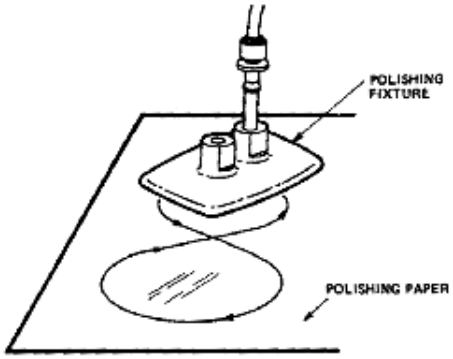


Step 4

Place the flush connector and polishing fixture on the dull side of the 3 micron pink lapping film and continue to polish the fiber and connector for approximately 25 strokes. The fiber end should be flat, smooth and clean.

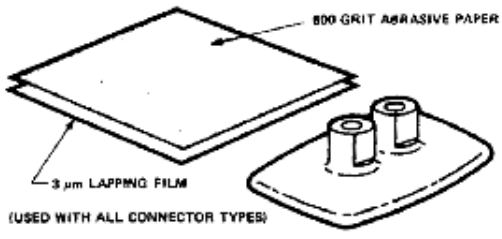
The cable is now ready for use.

Note: *Use of the pink lapping film fine polishing step results in approximately 2 dB improvement in coupling performance of either a transmitter-receiver link or a bulkhead/splice over 600 grit polish alone. This fine polish is comparable to Hewlett-Packard factory polish. The fine polishing step may be omitted where an extra 2 dB of optical power is not essential, as with short link lengths. Proper polishing of the tip of the fiber/connector face results in a tip diameter between 2.8 mm (0.110 in.) minimum and 3.2 mm (0.125 in.) maximum.*



For simultaneous multiple connector polishing techniques please contact Hewlett-Packard.

HFBR-4593 POLISHING KIT



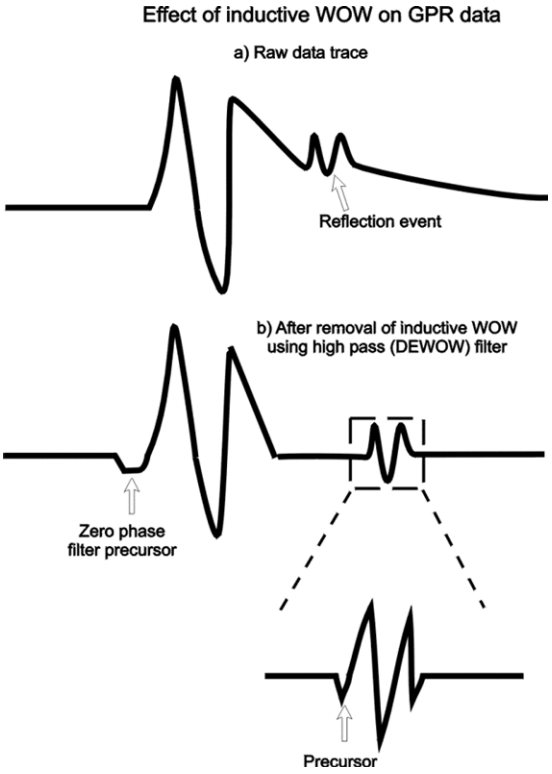
Appendix B: GPR Signal Processing Artifacts

14.1 Wow

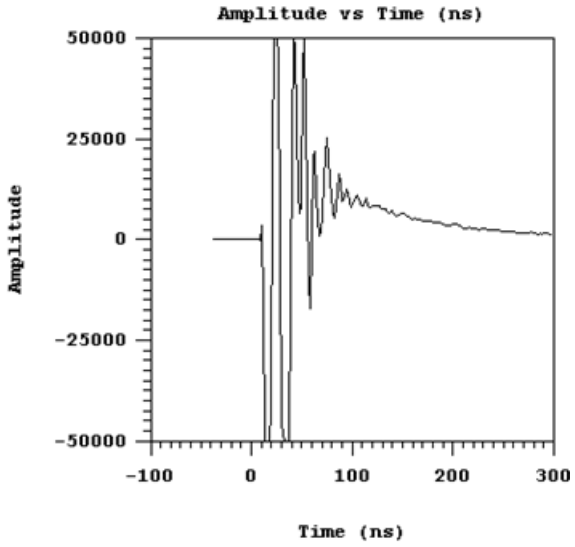
All GPR data contains a low frequency component; the magnitude of the low frequency component and how it manifests itself in the data depends on the ground conditions around the antennas and the distance between the antennas. In general, the low frequency component of the radar signal does not propagate but diffuses into the ground. In other words, the lower end of the spectrum sees an inductive (eddy current) type response as opposed to a propagating (displacement current) type response.

The result is that the large transmit pulse emitted by the radar can be followed by a slowly decaying transient.

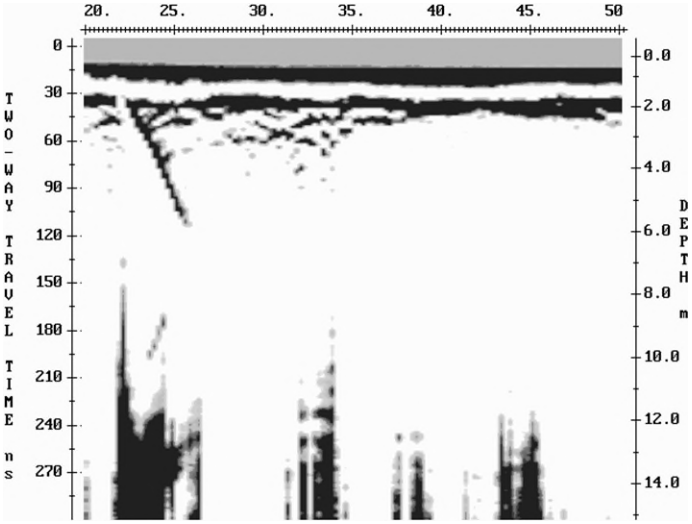
The following diagram shows the effect of inductive Wow on GPR data:



The following image displays a single data trace with the low frequency WOW component present:



The following image displays a data section with the low frequency WOW component present:



Compare these plots to the plots shown in the Dewow filter section below where WOW has been removed with the DEWOW high pass filter.

Decaying transient is usually referred to as wow; sometimes it is referred to as system saturation recovery. These terms are historical in nature because the response was often caused by system response characteristics rather than being a ground induced response.

14.2 Dewow Filter

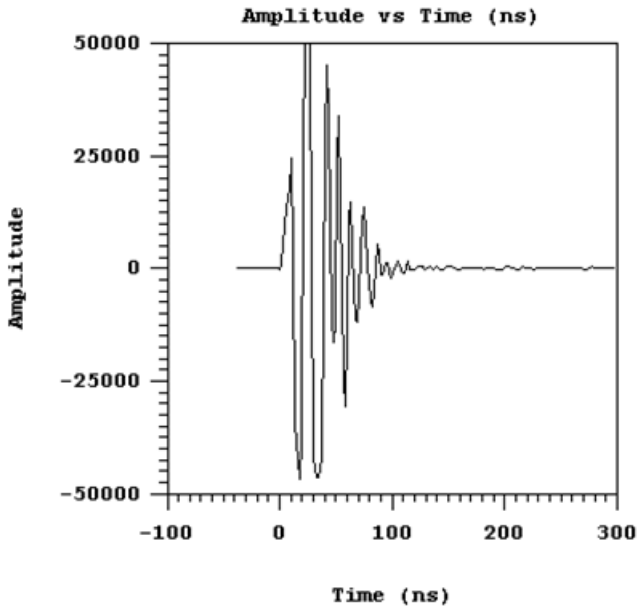
Since wow usually present in GPR data, it is a best practice to high pass (DEWOW) filter GPR data.

DEWOW is a high pass filter optimized to pass the transmitted signal spectral peak for the specific antenna center frequency with fidelity and suppress the low frequency wow in the data. The wow is removed from the data by applying a running average filter on each trace. A window with a width the same as that of one pulse width at the nominal frequency is set on the trace.

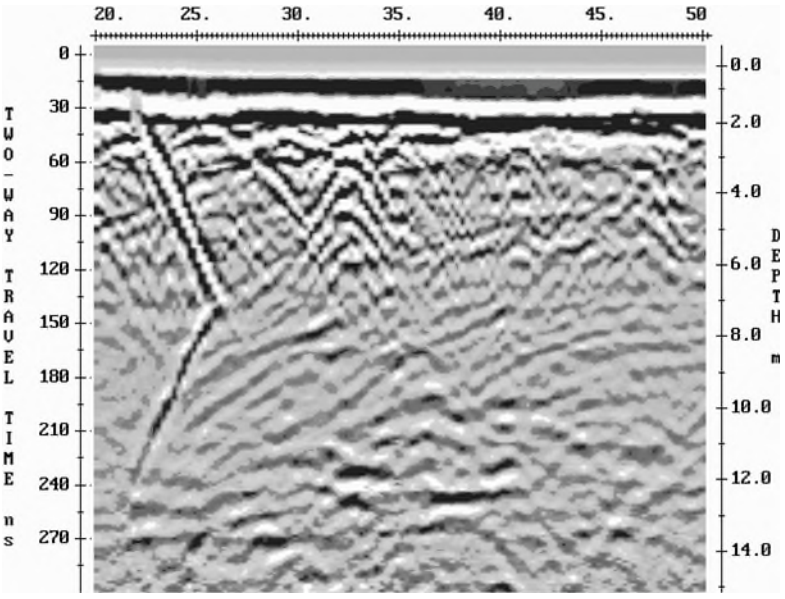
The average value of all the points in this window is calculated and subtracted from the central point. The window is then moved along the trace by one point and the process is repeated.

In the initial software releases, high pass filtering was integral to all of the plotting and display programs. As a result the operator was, in many situations, unaware of this wow or low frequency component in the data. The raw recorded data, however, always retained this information.

The following diagram displays a single data trace where Wow has been removed with the Dewow high pass filter:

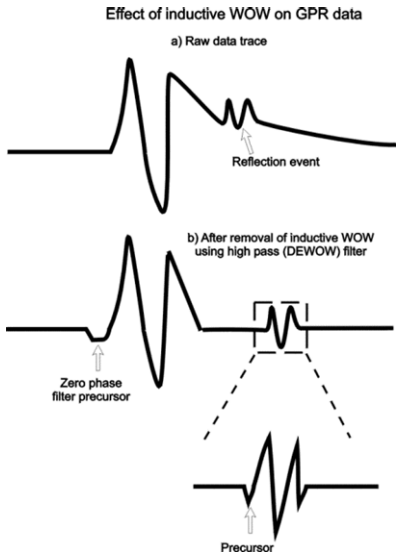


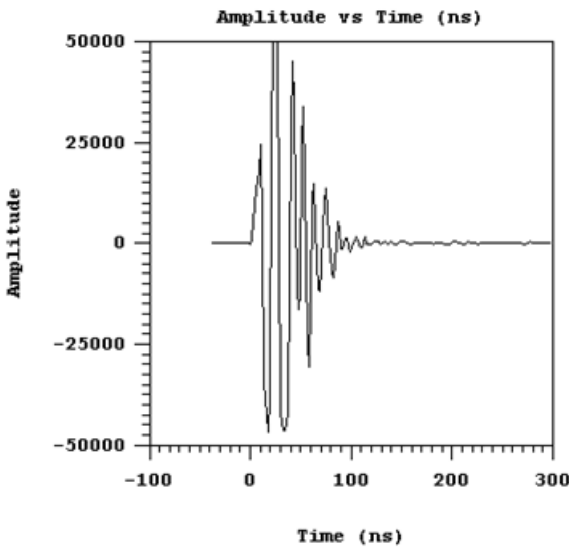
The following image displays a data section where Wow has been removed with the Dewow high pass filter:



14.3 Pulse Precursor

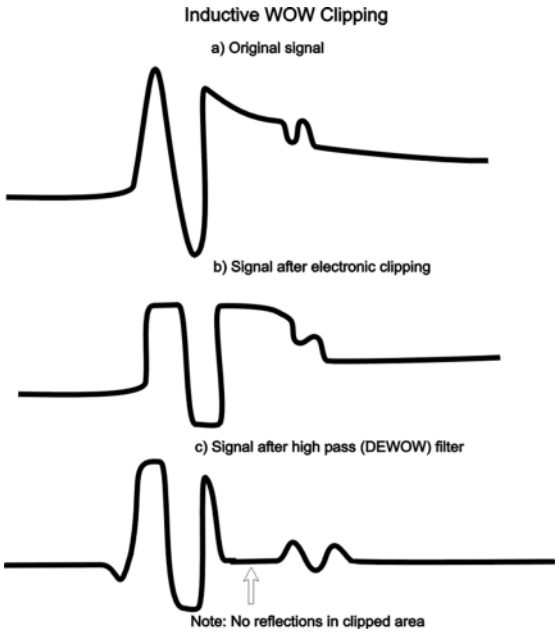
The result of high pass filtering can induce two types of artifacts into the plotted data sections. The first is a pre-cursor to the onset of a pulse (see the following diagrams). When the original data is high pass filtered, the wavelet is stretched in time with additional oscillations occurring before and after the original pulse. This gives rise to a pre-cursor in the data before Time Zero when looking at the plotted sections.





14.4 Clipping

The second artifact is caused by electronic clipping. The basic concept is depicted in the following diagrams:



The original signal acquired by the antenna and then sent to the receiver electronics is similar to diagram **a)** above.

The radar electronics clip any signals above the 50 millivolt level. Diagram **b)** shows the type of result that will be measured if clipping occurs in the signal pre-conditioning circuitry. When this data is finally high pass filtered, a blank zone in the area where the original signal had a large wow above the clipping level of the electronics can appear. This results in a blank section on the record with no reflections visible.

In the second case where signal saturation clipping occurs, there is no software correction for this. You must be aware that this can occur in some geologic settings and the antenna spacing should be increased to reduce the wow signal amplitude below the clipping level of the receiver electronics. You can also reduce the transmitter voltage if you are using a Variable Power (VP) transmitter. As a best practice use an antenna separation at least equal to the length of the antenna being employed. For example, 100 MHz antennas should have an antenna spacing of at least one meter, a 50 MHz antenna system should use an antenna spacing of two meters. This rule depends on the level of wow or inductive response present at the particular site. Processing affects only displayed data, not recorded data.

Other Types of Filters

For dealing with the inductive wow response, high pass filtering is necessary. If an alternative high pass filter is available or you want to try a different type of high pass filtering, the raw data contains all of the information and experimentation can be carried out using the raw data.

A DC removal can also be used to remove a DC level from all the traces in the input data set. This is done by taking all the points in each trace and calculating the average signal level for that trace. This value is then subtracted from each point in the trace. This process is repeated for each trace in the data set. Typically, traces will have approximately the same DC shift in a given data set. DC removal, in some cases, can be used instead of DEWOW. For example, a DC shift correction applied to high frequency radar data rather than a DEWOW correction may be more effective in reducing artifacts.

If you are unsure about which correction to apply use DEWOW.

Appendix C: GPR Knowledge

While this manual explains operation of your pulseEKKO system, knowing GPR theory and principles will help in making your survey successful. Our website (www.sensoft.ca) contains a wealth of information, case studies and support.

Click here to visit the FAQ (Frequently Asked Questions) page on our website to learn more topics, such as:

1. Basic GPR Theory
2. How deep can GPR see?
3. What creates GPR Reflections
4. How do I select a GPR frequency?
5. How can velocity be extracted from hyperbolas?

Click here to see a Glossary of GPR terms and mathematical symbols.

Appendix D: Health & Safety Certification

Radio frequency electromagnetic fields may pose a health hazard when the fields are intense. Normal fields have been studied extensively over the past 30 years with no conclusive epidemiology relating electromagnetic fields to health problems. Detailed discussions on the subject are contained in the references and the web sites listed below.

The USA Federal Communication Commission (FCC) and Occupational Safety and Health Administration (OSHA) both specify acceptable levels for electromagnetic fields. Similar power levels are mandated by corresponding agencies in other countries. Maximum permissible exposures and time duration specified by the FCC and OSHA vary with excitation frequency. The lowest threshold plane wave equivalent power cited is 0.2 mW/cm^2 for the general population over the 30 to 300 MHz frequency band. All other applications and frequencies have higher tolerances as shown in graphically in Figure B-1.

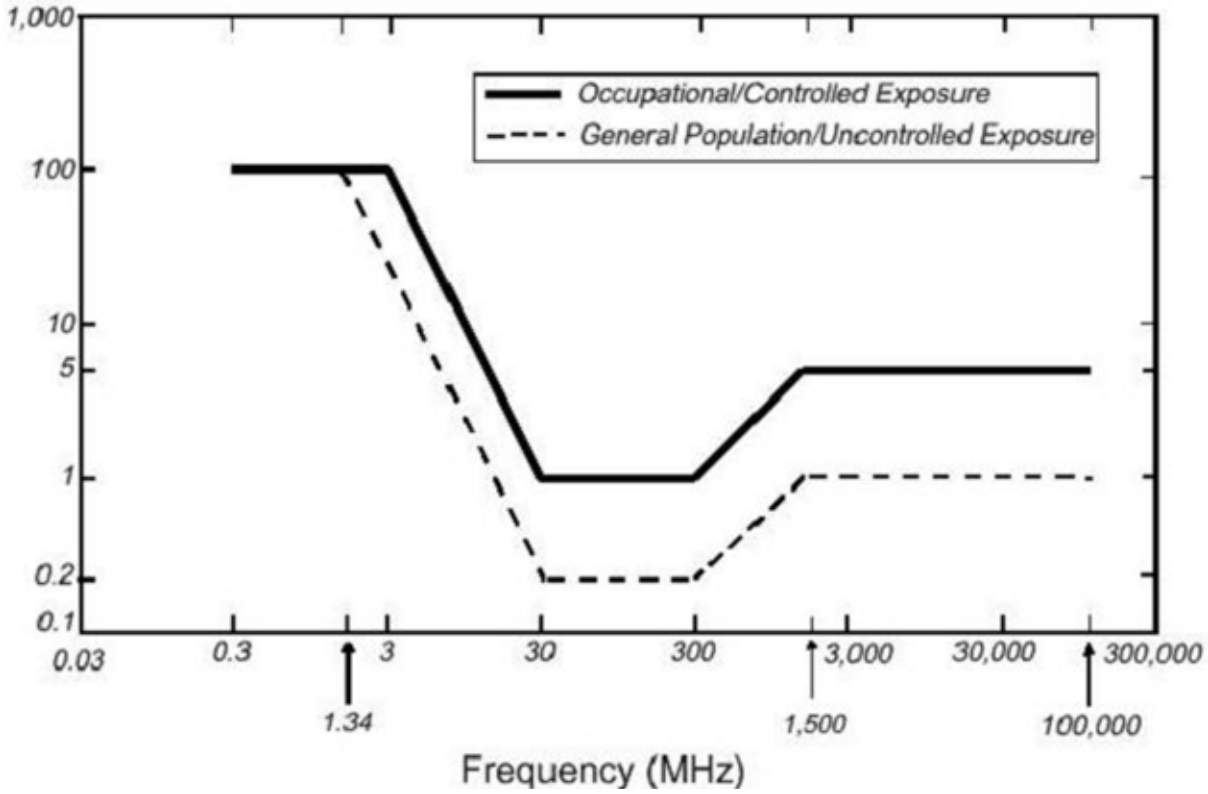


Figure B-14-1: FCC limits for maximum permissible exposure (MPE) plane-wave equivalent power density mW/cm^2.

All Sensors & Software Inc. GPR products are normally operated at least 1 m from the user and as such are classified as “mobile” devices according to the FCC. Typical power density levels at a distance of 1 m or greater from any Sensors & Software Inc. products are less than 10^{-3} mW/cm^2 which is 200 to 10,000 times lower than mandated limits. As such, Sensors & Software Inc. products pose no health and safety risk when operated in the normal manner of intended use.

References

1. Questions and answers about biological effects and potential hazards of radio-frequency electromagnetic field:

   USA Federal Communications Commission, Office of Engineering & Technology OET Bulletin 56 (Contains many references and web sites)

2. Evaluation Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields.

   USA Federal Communications Commission, Office of Engineering & Technology OET Bulletin 56 (Contains many references and web sites)

3. USA Occupational Safety and Health Administration regulations paragraph 1910.67 and 1910.263

Appendix E: GPR Emissions, Interference and Regulations

All governments have regulations on the level of electromagnetic emissions that an electronic apparatus can emit. The objective is to assure that one apparatus or device does not interfere with any other apparatus or device in such a way as to make the other apparatus non-functional.
The manufacturer test their GPR products using independent professional testing houses and comply with latest regulations of the USA, Canada, European Community, and other major jurisdictions on the matter of emissions.
Electronic devices have not always been designed for proper immunity. If a GPR instrument is placed in close proximity to an electronic device, interference may occur. While there have been no substantiated reports of interference to date, if any unusual behavior is observed on nearby devices, test if the disturbance starts and stops when the GPR instrument is turned on and off. If interference is confirmed, stop using the GPR.
Where specific jurisdictions have specific GPR guidelines, these are described below.

E-1 FCC Regulations

This device complies with Part 15 of the USA Federal Communications Commission (FCC) Rules. Operation in the USA is subject to the following two conditions:
this device may not cause harmful interference and

this device must accept any interference received, including interference that may cause undesired operation.

Part 15 – User Information

This equipment has been tested and found to comply with the limits for a Class A digital device, where applicable, and for an ultra-wide bandwidth (UWB) device where applicable, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his/her own expense.

WARNING

Changes or Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.
Certification of this equipment has been carried out using approved cables and peripheral devices. The use of non-approved or modified cables and peripheral devices constitutes a Change or Modification outlined in the warning above.

Operating Restrictions

Operation of this device is limited to purposes associated with law enforcement, firefighting, emergency rescue, scientific research, commercial mining, or construction. Parties operating this equipment must be eligible for licensing under the provisions of Part 90 of this chapter.

FCC Interpretation of Operation Restrictions issued July 12, 2002

(FCC Order DA02-1658, paragraph 9)

The regulations contain restrictions on the parties that are eligible to operate imaging systems (See 47 C.F.R. 5.509(b), 15.511(b), and 15.513(b)). Under the new regulations, GPRs and wall imaging systems may be used only by law enforcement, fire and emergency rescue organizations, by scientific research institutes, by commercial mining companies, and by construction companies. Since the adoption of the *Order*, we have received several inquiries from the operators of GPRs and wall imaging systems noting that these devices often are not operated by the users listed in the regulations but are operated under contract by personnel specifically trained in the operation of these devices. We do not believe that the recent adoption of the UWB rules should disrupt the critical safety services that can be performed effectively only through the use of GPRs and wall imaging systems. We viewed these operating restrictions in the broadest of terms. For example, we believe that the limitation on the use of GPRs and wall imaging systems by construction companies encompasses the inspection of buildings, roadways, bridges and runways even if the inspection finds no damage to the structure and construction does not actually result from the inspection; the intended purpose of the operation of the UWB device is to determine if construction is required. We also believe that the GPRs and wall imaging systems may be operated for one of the purposes described in the regulations but need not be operated directly by one of the described parties. For example, a GPR may be operated by a private company investigating forensic evidence for a local police department.

FCC Permitted Mode of Usage

The GPR antenna must be kept on the surface to be in compliance with FCC regulations. Use of the antenna is not permitted if it is lifted off the surface. Use as a through-the-wall imaging device is prohibited.

GPR Use Coordination

FCC regulation 15.525(c) (updated in February 2007) requires users of GPR equipment to coordinate the use of their GPR equipment as described below:

TITLE 47--TELECOMMUNICATION
CHAPTER I--FEDERAL COMMUNICATIONS COMMISSION
PART 15_RADIO FREQUENCY DEVICES
Subpart F_Ultra-Wideband Operation Sec.
15.525 Coordination requirements.

(a) UWB imaging systems require coordination through the FCC before the equipment may be used. The operator shall comply with any constraints on equipment usage resulting from this coordination.

(b) The users of UWB imaging devices shall supply operational areas to the FCC Office of Engineering and Technology, which shall coordinate this information with the Federal Government through the National Telecommunications and Information Administration. The information provided by the UWB operator shall include the name, address and other pertinent contact information of the user, the desired geographical area(s) of operation, and the FCC ID number and other nomenclature of the UWB device. If the imaging device is intended to be used for mobile applications, the geographical area(s) of operation may be the state(s) or county(ies) in which the equipment will be operated. The operator of an imaging system used for fixed operation shall supply a specific geographical location or the address at which the equipment will be operated. This material shall be submitted to:

Frequency Coordination Branch, OET
Federal Communications Commission
445 12th Street, SW, Washington, D.C.
20554

Attn: UWB Coordination
(**Sensors & Software Inc. Note**: The form given on the following page is a suggested format for performing the coordination.)

(c) The manufacturers, or their authorized sales agents, must inform purchasers and users of their systems of the requirement to undertake detailed coordination of operational areas with the FCC prior to the equipment being operated.

(d) Users of authorized, coordinated UWB systems may transfer them to other qualified users and to different locations upon coordination of change of ownership or location to the FCC and coordination with existing authorized operations.

(e) The FCC/NTIA coordination report shall identify those geographical areas within which the operation of an imaging system requires additional coordination or within which the operation of an imaging system is prohibited. If additional coordination is required for operation within specific geographical areas, a local coordination contact will be provided. Except for operation within these designated areas, once the information requested on the UWB imaging system is submitted to the FCC no additional coordination with the FCC is required provided the reported areas of operation do not change. If the area of operation changes, updated information shall be submitted to the FCC following the procedure in paragraph (b) of this section.

(f) The coordination of routine UWB operations shall not take longer than 15 business days from the receipt of the coordination request by NTIA. Special temporary operations may be handled with an expedited turn-around time when circumstances warrant. The operation of UWB systems in emergency situations involving the safety of life or property may occur without coordination provided a notification procedure, similar to that contained in Sec. 2.405(a) through (e) of this chapter, is followed by the UWB equipment user.[67 FR 34856, May 16, 2002, as amended at 68 FR 19751, Apr. 22, 2003]

Effective Date Note: At 68 FR 19751, Apr. 22, 2003, Sec. 15.525 was amended by revising [[Page 925]] paragraphs (b) and (e). This amendment contains information collection and recordkeeping requirements and will not become effective until approval has been given by the Office of Management and Budget.

FCC GROUND PENETRATING RADAR COORDINATION NOTICE
NAME:
ADDRESS:
CONTACT INFORMATION [CONTACT NAME AND PHONE NUMBER]:
AREA OF OPERATION [COUNTIES, STATES OR LARGER AREAS]:
FCC ID: QJQ-NG250
EQUIPMENT NOMENCLATURE: NG250

Send the information to:
Frequency Coordination Branch., OET
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554
ATTN: UWB Coordination
Fax: 202-418-1944

INFORMATION PROVIDED IS DEEMED CONFIDENTIAL

E-2 ETSI Regulations for the EC (European Community)

In the European Community (EC), GPR instruments must conform to ETSI (European Technical Standards Institute) standard EN 302 066-1 v1.2.1. Details on individual country requirements for licensing are coordinated with this standard. For more information, contact Sensors & Software's technical staff.

All Sensors & Software ground penetrating radar (GPR) products offered for sale in European Community countries or countries adhering to ETSI standards are tested to comply with EN 302 066 v1.2.1.

For those who wish to get more detailed information, they should acquire copies of the following documents available from ETSI.

ETSI EN 302 066-1 V1.2.1 (February 2008) Electromagnetic compatibility and Radio spectrum Matters (ERM); Ground and Wall- Probing Radar applications (GPR/WPR) imaging systems; Part 1: Technical characteristics and test methods

ETSI EN 302 066-2 V1.2.1 (February 2008) Electromagnetic compatibility and Radio spectrum Matters (ERM); Ground and Wall- Probing Radar applications (GPR/WPR) imaging systems; Part 2: Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive

ETSI TR 101 994-2 V1.1.2 (March 2008) Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics for SRD equipment using Ultra Wide Band technology (UWB); Part 2: Ground- and Wall- Probing Radar applications; System Reference Document

E-3a Industry Canada Regulations - English

Industry Canada published it regulations for ground penetrating radar (GPR) on Mar 29, 2009 as part of the RSS-220 titled 'Devices Using Ultra-Wideband (UWB) Technology'.
Industry Canada has made a unique exception for GPR by not requiring user licensing. The user does have to comply with the following directives:
This Ground Penetrating Radar Device shall be operated only when in contact with or within 1 m of the ground.
This Ground Penetrating Radar Device shall be operated only by law enforcement agencies, scientific research institutes, commercial mining companies, construction companies, and emergency rescue or firefighting organizations.
Should the ground penetrating radar be used in a wall-penetrating mode then the following restriction should be noted by the user:
This In-wall Radar Imaging Device shall be operated where the device is directed at the wall and in contact with or within 20 cm of the wall surface.
This In-wall Radar Imaging Device shall be operated only by law enforcement agencies, scientific research institutes, commercial mining companies, construction companies, and emergency rescue or firefighting organizations.
Since operation of GPR is on a license-exempt basis, the user must accept the following:
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.

E-3b Règlement d'Industrie Canada - Français

Industrie Canada a publié des règlements pour les appareils géoradar (GPR) le 29 mars 2009, dans le cadre du RSS-220 intitulé "Dispositifs utilisant la bande ultra-large (UWB)".
Industrie Canada a faite une exception unique pour GPR en n'exigeant pas de licence par utilisateur. L'utilisateur doit se conformer aux directives suivantes:
Ce géoradar périphérique doit être utilisé que lorsqu'il est en contact avec ou moins de 1 m du sol.
Ce géoradar périphérique doit être utilisé que par les organisations d'application de la loi, les instituts de recherche scientifique, des sociétés minières commerciales, entreprises de construction et de secours d'urgence ou des organisations de lutte contre les incendies.
Si le géoradar est utilisé dans un mode de pénétration au mur, la restriction suivante est à noter par l'utilisateur:
Ce dispositif d'imagerie radar doit être utilisé lorsque l'appareil est orienté vers le mur et en contact avec ou dans les 20 cm de la surface du mur.
Ce dispositif d'imagerie radar doit être utilisé que par les organisations d'application de la loi, les instituts de recherche scientifique, des sociétés minières commerciales, entreprises de construction et de secours d'urgence ou des organisations de lutte contre les incendies.
Parce que l'exploitation de GPR est sur une base exempte de licence, l'utilisateur doit accepter le texte suivant:
La fonctionnement est soumis aux deux conditions suivantes: (1) cet appareil ne peut pas provoquer d'interférences et (2) cet appareil doit accepter toute interférence, y compris les interférences qui peuvent causer un mauvais fonctionnement du dispositive

Appendix F: Instrument Interference

Immunity regulations place the onus on instrument/apparatus/device manufacturers to assure that extraneous interference will not unduly cause an instrument/apparatus/device to stop functioning or to function in a faulty manner.

Based on independent testing house measurements, Sensors & Software Inc. systems comply with such regulations in Canada, USA, European Community and most other jurisdictions. GPR devices can sense electromagnetic fields. External sources of electromagnetic fields such as TV stations, radio stations and cell phones, can cause signals detectable by a GPR which may degrade the quality of the data that a GPR device records and displays.

Such interference is unavoidable but sensible survey practice and operation by an experienced GPR practitioner can minimize such problems. In some geographic areas emissions from external sources may be so large as to preclude useful measurements. Such conditions are readily recognized and accepted by the professional geophysical community as a fundamental limitation of geophysical survey practice. Such interference being present in the GPR recordings is not considered as an equipment fault or as a failure to comply with immunity regulations.

Appendix G: Safety around Explosive Devices

Concerns are expressed from time to time on the hazard of GPR products being used near blasting caps and unexploded ordnance (UXO). Experience with blasting caps indicates that the power of Sensors & Software Inc.'s GPR products is not sufficient to trigger blasting caps. Based on a conservative independent testing house analysis, we recommend keeping the GPR transmitters at least 5 feet (2m) from blasting cap leads as a precaution. Some customers do experimental trials with their particular blasting devices to confirm with safety. We strongly recommend that GPR users routinely working with explosive devices develop a systematic safety methodology in their work areas.
The UXO issue is more complex and standards on fuses do not exist for obvious reasons. To date, no problems have been reported with any geophysical instrument used for UXO. Since proximity and vibration are also critical for UXO, the best advice is to be cautious and understand the risks.

Appendix H: Wi-Fi Module

FCC Notice:
NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his/her own expense.

Industry Canada Notice:
This device complies with Industry Canada's license-exempt RSSs. 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.

Appendix I: GPR System Calibration

This Ground Penetrating Radar (GPR) system has been manufactured according to Sensors & Software's strict quality standards. All components used in the manufacture of this product are obtained from qualified vendors.

This product has been through a stringent set of tests to ensure all quality requirements are met, which includes final system calibration and configuration.

This system is equipped with built-in diagnostic tests. By running the tests and getting a passing result, you can be confident that the system is operating within specification. No further user calibration is required.

SENSORS & SOFTWARE
from RADIODETECTION

SPX TECHNOLOGIES

Our Mission

Provide best in class equipment and solutions, to prevent damage to critical infrastructure, manage assets and protect lives.

Our Vision

To be the world's leader in the management of critical infrastructure and utilities.

Our locations



USA

Raymond, ME
Kearneysville, WV

Canada

Mississauga, ON



Europe

United Kingdom **HQ**
France
Germany
The Netherlands



Asia Pacific

India
China
Hong Kong
Indonesia
Australia

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Scan to see a full list of our office locations

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