SENSORS & SOFTWARE®
from RADIODETECTION

NOGGIN®

Ground Penetrating Radar

Operation manual

2016-00098-05

SPX
TECHNOLOGIES

Product Registration

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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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Product Warranty and Limited Liability

Please refer to the terms and conditions included as part of your order acknowledgement and/or invoice for full details of the product warranty and limited liability.

Important Safety Information

Use the Display Unit 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 Display Unit 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.

Table of Contents

1. Overview

The manual references embedded software version V1 R4. To see which software version is installed on your system, see the Swipe Down menu in Section 4.4.

The Noggin system is built for the professional, multi-application user in mind, providing maximum flexibility by allowing you to:

- switch transducer frequencies for different applications
- change deployment configurations
- setup different triggering methods
- configure many settings during data acquisition

Features of the Noggin system include:

- High visibility, touch screen display (DVL)
- Display depth slices from collected grids, right in the field
- UWB (ultra-wide band) Antenna producing highest data quality
- Built-in Wi-Fi capability
- Mass data export via USB
- Integrated GPS receiver with optional external GPS for increased positional accuracy for geo-referencing data
- Ability to mark surface flags and subsurface interpretations directly in the data
- Display your travelled path and targets in MapView
- Seamless integration into EKKO_Project software for further data analysis

The following chart summarizes how the data is managed:

How is data saved?	Screenshots (.JPG) and .GPZ files
How much data can be saved?	9 Projects each with: • 10 grids • 99 lines • 999 screenshots
File organization	Projects containing Lines, Grids & Screenshots
PC-based data display	Data can be opened in EKKO_Project

This manual describes assembly of the various Noggin configurations, operating the system and collecting data. There is also a section that describes the basics of GPR theory and techniques for proper surveying.

2. Assembly

Noggin GPRs come in various configurations and frequencies. This section will identify the main parts of the GPR system, as well as describe assembly of each configuration.

2.1 Noggin Components

Noggin GPR sensors are named after the center frequency of the GPR signals, in MHz. There are four systems available: 100 MHz, 250 MHz, 500 MHz, and 1000 MHz.

All systems are shielded, except for the Noggin 100 MHz. Due to the design of the Noggin 100, the following sections will usually show the setup of the Noggin 100 separately.

The images in Figure 2-1 and Figure 2-2 display the key components of the Noggin 250 sensor (the 500 and 1000 are identical, just smaller)

Figure 2-1: Noggin Components

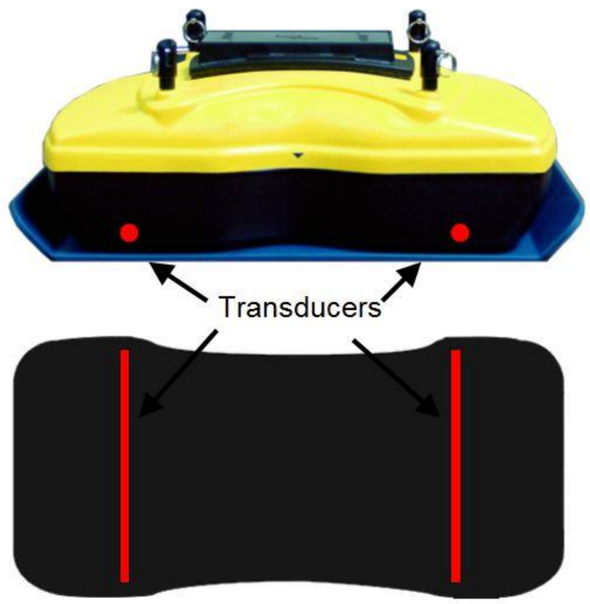


Figure 2-2: Location of Noggin Transducers

2.2 Assembling the Base Noggin

2.2.1 Noggin 250, 500 and 1000 MHz

The Base Noggin is the name given to the simplest configuration. This is often purchased by people looking to custom design their own mounting platform. The image in Figure 2-3 displays the parts of the Base configuration, applicable to the 250, 500 and 1000 MHz systems.

Figure 2-3: Base Noggin Configuration

To assemble, connect the 37-pin connector on the black cable to the 37-socket connector on the Noggin. Close the latch to secure this connection, by turning the keeper (key) until it locks tight (Figure 2-4).

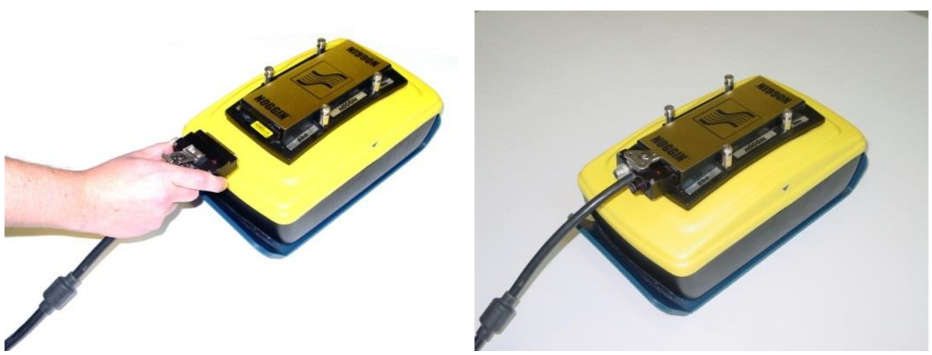


Figure 2-4: Connecting cable to Noggin (left) then tightening the keeper (right)

Attach the other end of this cable to the 37-pin connector on the back of the DVL and tighten the latch on top (Figure 2-5).

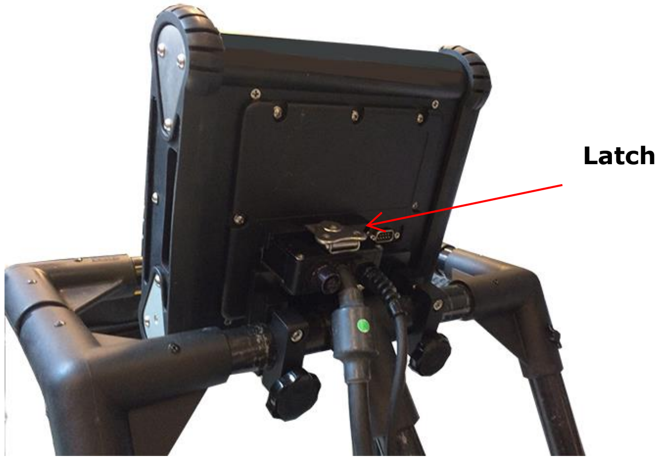


Figure 2-5: Connecting main cable to DVL

The main cable from the back of the DVL also has a 4-pin cable for power connected to it. Connect this cable to a power supply (usually a belt battery or a large battery). The belt battery is shown in Figure 2-6.

Figure 2-6: Connecting to belt battery

2.2.2 Noggin 100 and Noggin Ultra 100 MHz

Unlike the higher frequency Noggins, the Noggin 100 antennas and electronics are shipped as separate units that need to be assembled.

Space the 100 MHz antennas about 0.5 meters apart with the mounting blocks facing up (Figure 2-7).

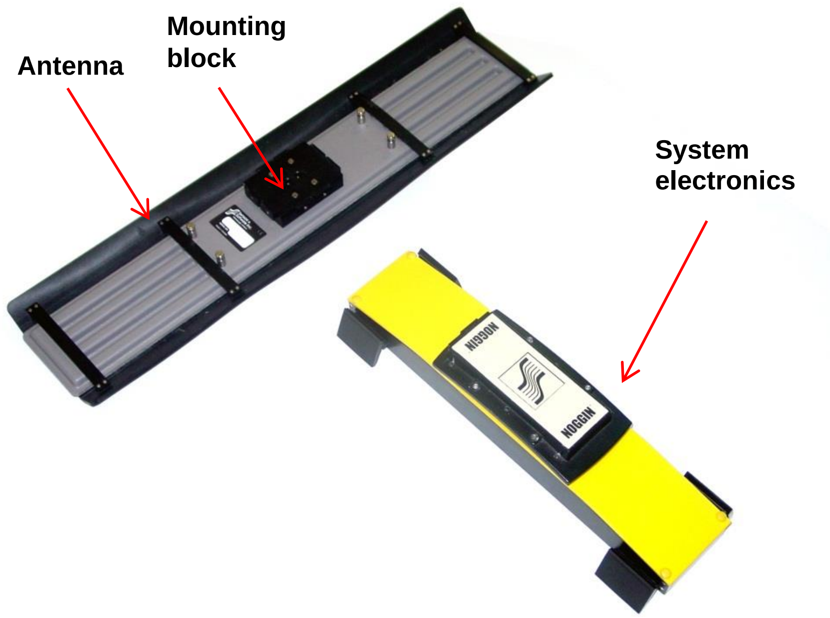


Figure 2-7: Attaching system electronics to mounting block

Place one end of the Noggin 100 system electronics over one of the antennas.

Connect the two brass sockets in the bottom of the electronics with the two brass pins in the antenna mounting block (Figure 2-8). Make sure to hand-tighten the brass pins prior to connecting to the antennas each time.

Press down on the Noggin 100 electronics until it is firmly connected to the antennas.

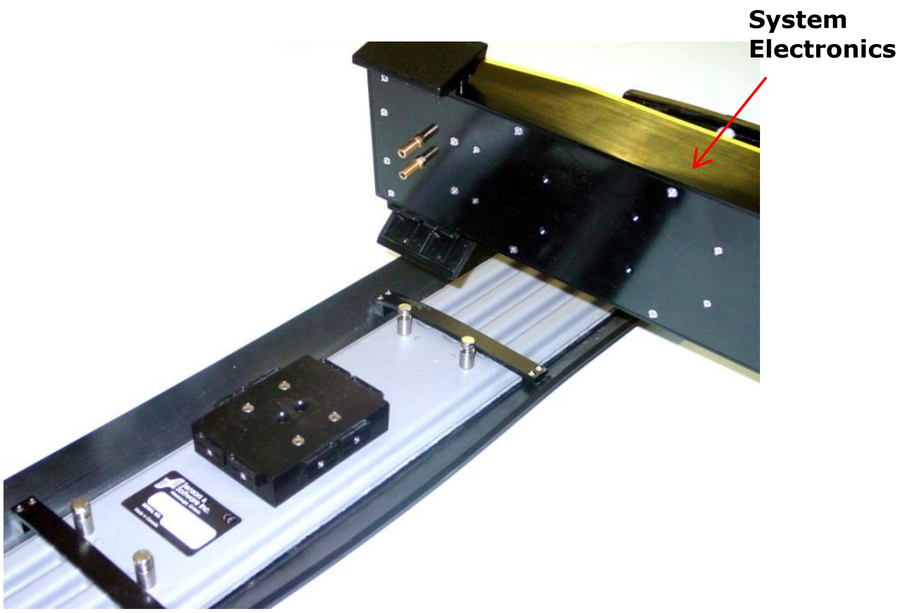


Figure 2-8: Connecting Noggin 100 system electronics to antennas

Secure the electronics to the antenna by closing the two plastic latches (Figure 2-9).

Figure 2-9: Securing latches to the Noggin 100 antennas

Repeat above steps to connect the electronics to the second antenna.

The following image displays the key components of the assembled Noggin 100 (Figure 2-10):

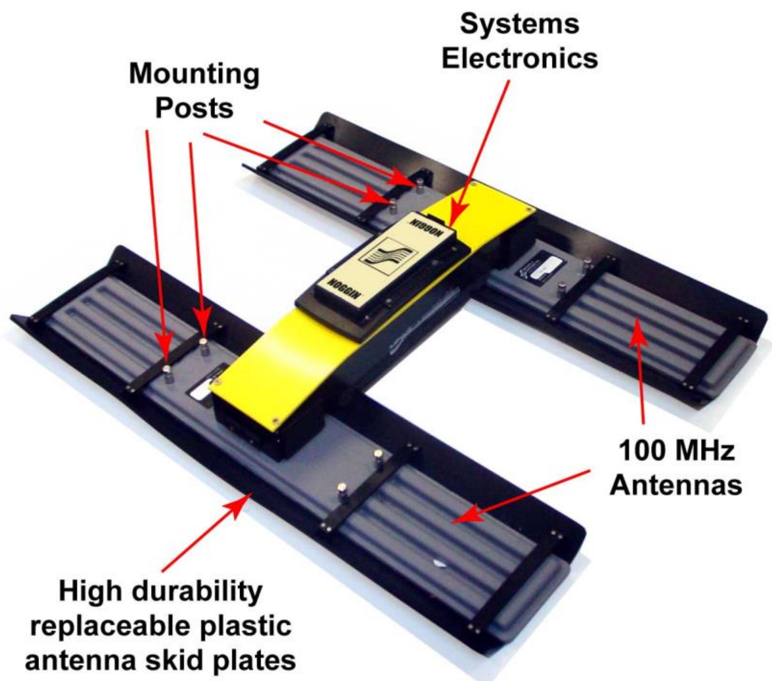


Figure 2-10: Assembled Noggin 100 antennas and electronics

2.3 Assembling the SmartCart

The SmartCart is the most popular configuration, and can accommodate any Noggin sensor: 100, 250, 500 and 1000 MHz.

The Noggin sensors are not connected to the SmartCart when they are initially shipped. Refer to Figure 2-11, and the steps below, while unfolding your SmartCart.

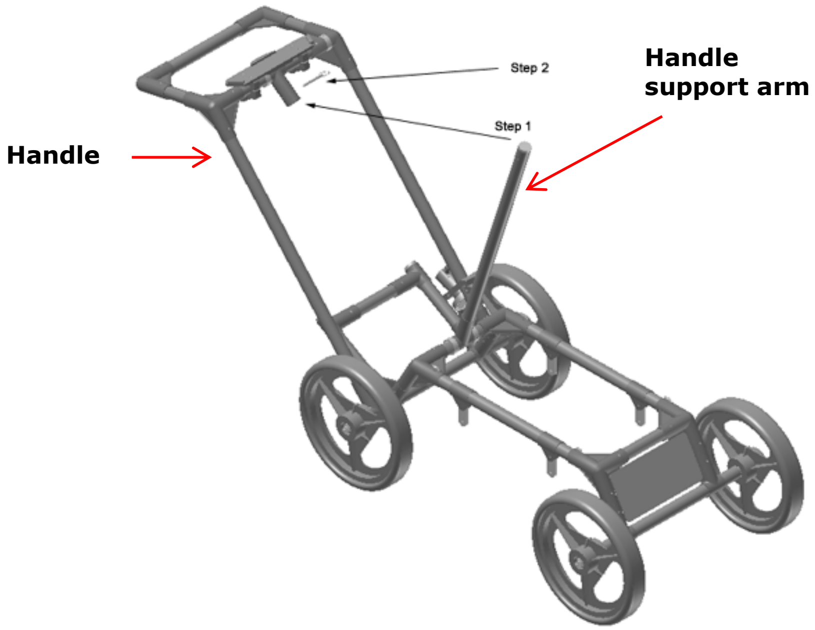


Figure 2-11: Assembling the SmartCart

1. Remove the pin from the handle support arm.
2. Raise the handle support arm.
3. Raise the handle.
4. Place the open end of the T-shaped tube on the handle onto the end of the support arm (see **Step 1** in figure above).
5. Lock the handle into position:

Align the hole in the support arm to the hole in the T-shaped tube.

Insert the handle pin (see **Step 2** in figure above).

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

2.3.1 Attaching the Wheels

SmartCarts are usually shipped with the wheels attached. If your wheels arrive un-attached, complete the following procedure to attach them to your SmartCart:

1. Press the button on the end of the wheel axle to unlock the axle catches.

2. Insert the axle through the wheel and into the SmartCart frame (Figure 2-12)

Figure 2-12: Attaching wheel to SmartCart

3. Make sure the odometer wheel makes good contact with the side of the cart wheel (Figure 2-13). The odometer wheel is the one which has a "scuffed" inside rim, to reduce wheel slippage in wet conditions.

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

   a) If the odometer wheel is loose, use a 3/16-inch Allen (hexagonal) wrench to loosen the screws on the side of the odometer.
   b) Pivot the odometer until the small odometer wheel makes good contact with the side of the cart wheel.

Figure 2-13: Close-up of wheel connected to odometer

c) Tighten the screws to lock the odometer wheel in this position (Figure 2-14).

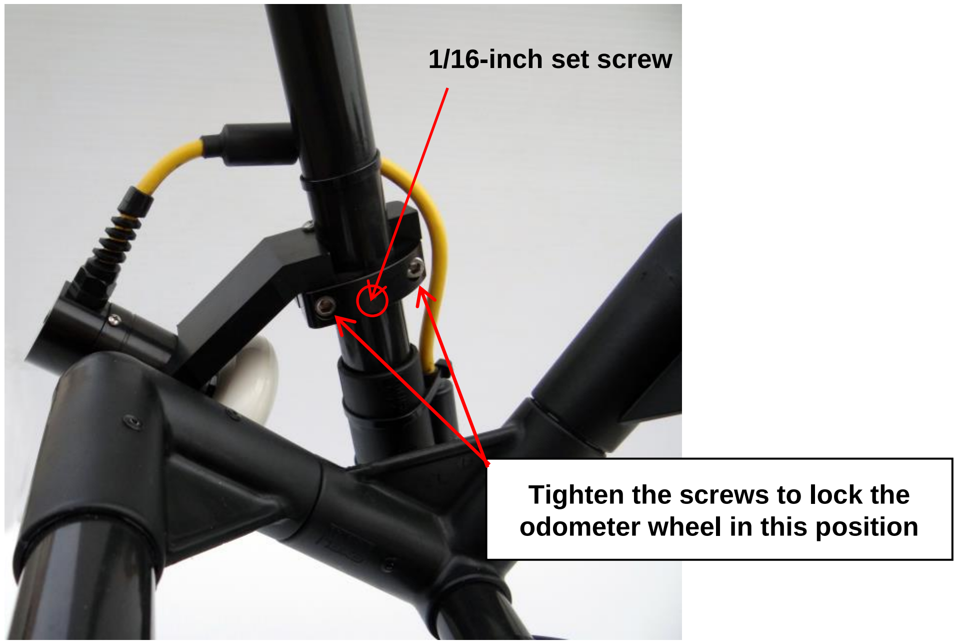


Figure 2-14: Adjusting and tightening odometer wheel bracket

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

2.3.2 Attaching the Separation Bars (250, 500 & 1000)

The SmartCart separation bars keep the Noggin systems suspended over the surface.

SmartCarts are shipped with separation bars attached. If your separation bars arrive un-attached or you purchase a different size to accommodate a different system, complete the following procedure to attach them to your SmartCart.

> **Note**: The Noggin 100 separation bars must be assembled before attaching them to the SmartCart. For details, see Attaching Antenna Separation Bars.

If you are disassembling the SmartCart, detach the Display Unit and the battery from the SmartCart as the back half of the cart may fall to the ground and be damaged during the removal and installation of the separation bars.

Use the four thumbscrews to attach the SmartCart separation bars to the SmartCart front and rear ends (Figure 2-15).

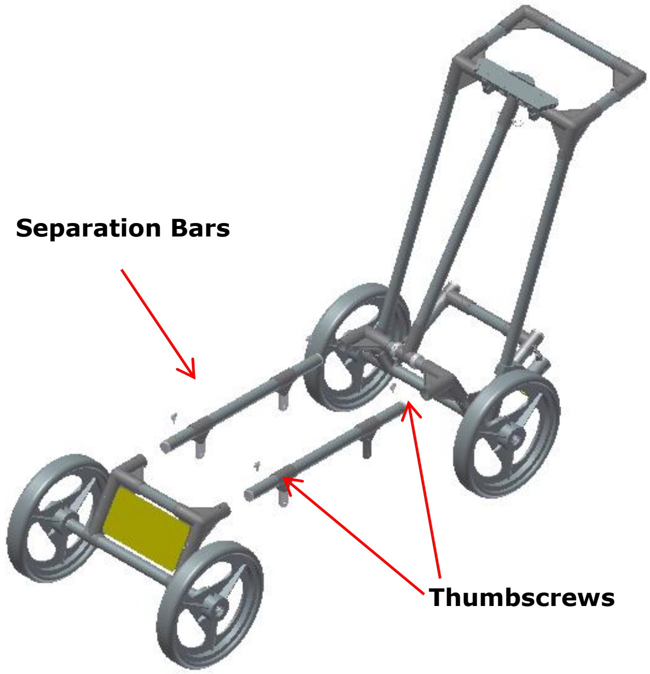


Figure 2-15: Attaching separation bars to SmartCart

> **Note**: For the Noggin 500 separation bars the long end of the bars must be placed towards the back of the cart. This will prevent the Noggin 500 sensor from hitting the back of the cart during operation. See Figure 2-16.

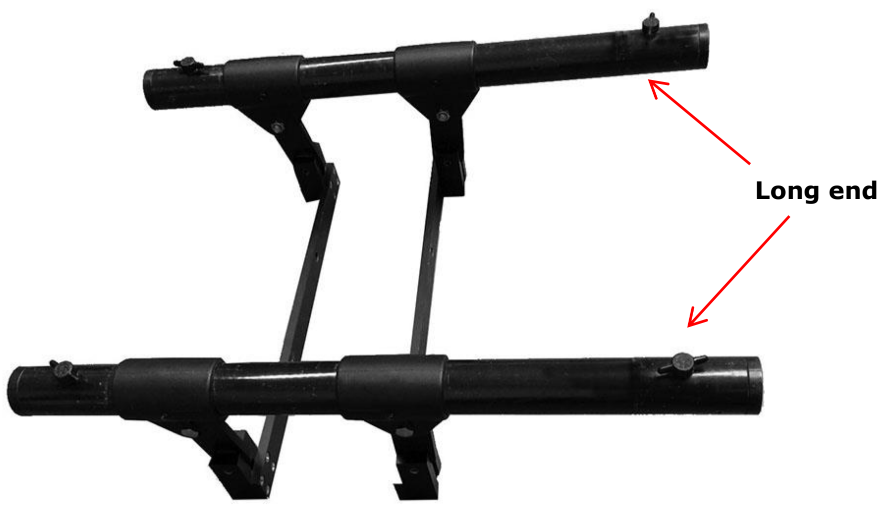


Figure 2-16: Noggin 500 separation bars

Be careful when aligning the thumb screws and the separation bars:

- If the hole and insert are not aligned, the thumbscrew will bind after half a turn and damage the insert by cross-threading it.

- Forcing the thumbscrew to turn can also cause damage. If you have damaged the insertion point, run a 10-32 tap through the insert to re-tap the hole.

2.3.3 Attaching the Separation Bars (100)

To assemble the Noggin 100 separation bars, you need two user-supplied 10mm wrenches for tightening lock nuts onto the bolts.

The image in Figure 2-17 displays the parts of the Noggin 100 SmartCart Separation bars.

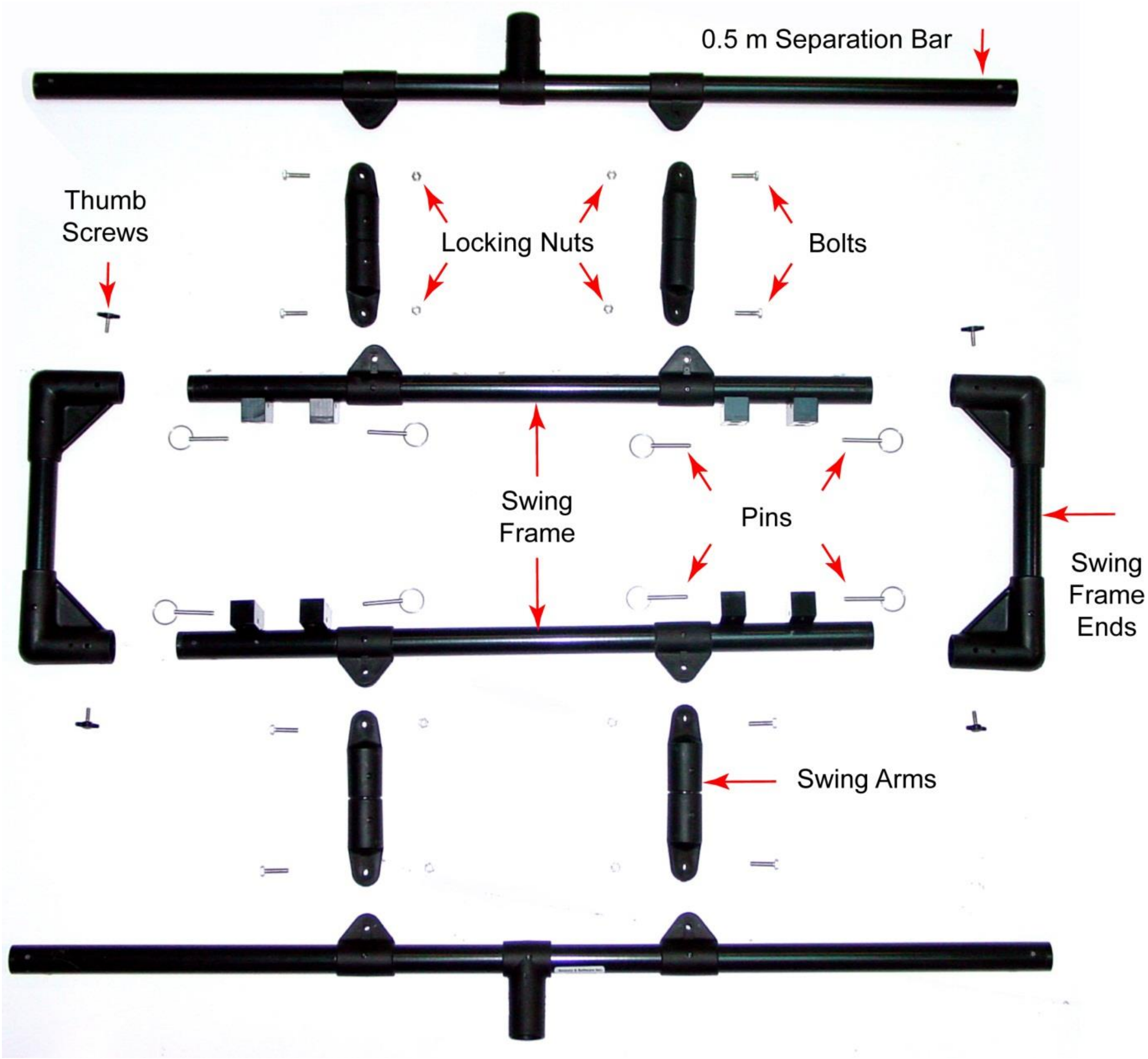


Figure 2-17: Parts of the Noggin 100 separation bars

Refer to Figure 2-18 when assembling the Noggin 100 SmartCart Separation Bars:

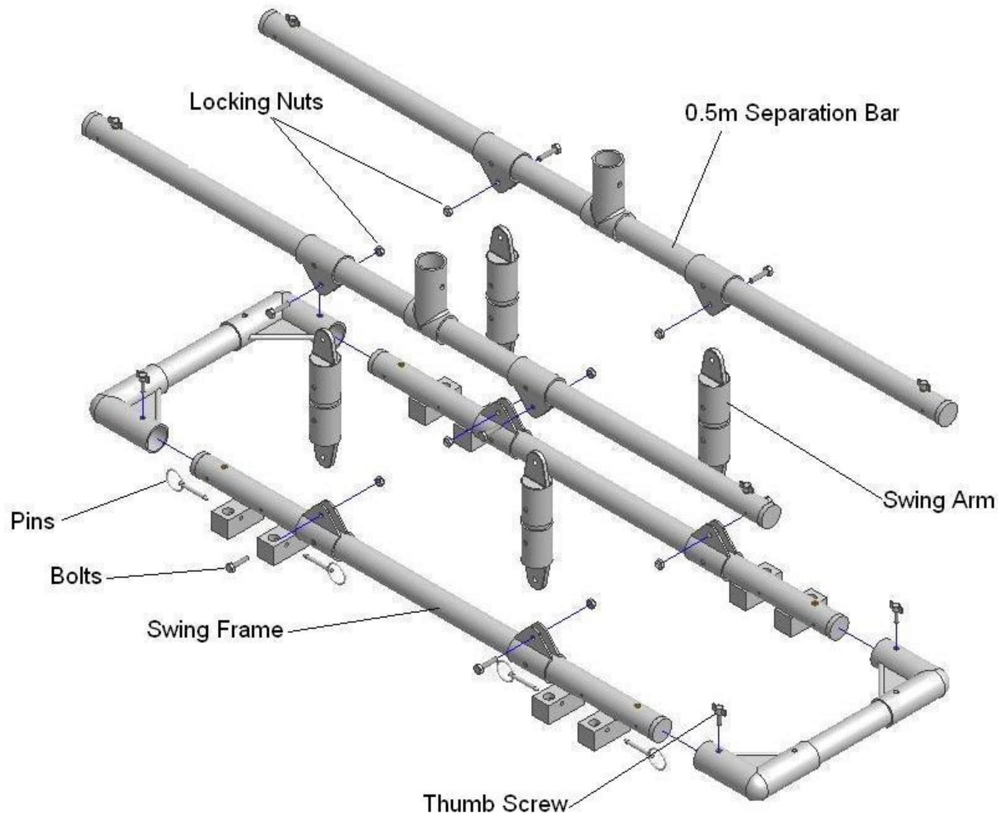


Figure 2-18: Assembly of Noggin 100 separation bars

Connect the **Swing Frame end** with the four thumbscrews (Figure 2-19). Be careful to not strip the threads.

Figure 2-19: Connecting the thumbscrew

Make sure the **Swing Arm bolt head** is caught by the plastic ridge so it cannot rotate (Figure 2-20).

Figure 2-20: Securing the Swing Arm

Do not over-tighten; the Swing Arm needs to move freely. The completed separation bars assembly is shown in Figure 2-21.

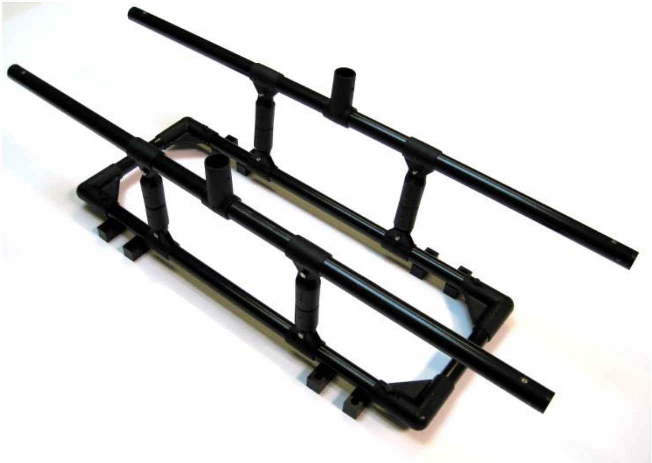


Figure 2-21: Completed Noggin 100 separation bars

Attach the separation bars to the SmartCart using the thumbscrews provided. The completed assembly is shown in Figure 2-22.

Figure 2-22: Separation bars attached to the SmartCart

2.3.4 Attaching Swivel Adaptors

SmartCarts are shipped with swivel adaptors attached. If your swivel adaptors arrive un-attached, complete the following procedure to attach them to your SmartCart.

Before attaching the Noggin 250, 500, or 1000 to the SmartCart, attach the four swivel adaptors (with attached pins) to the Noggin mounting posts (Figure 2-23).

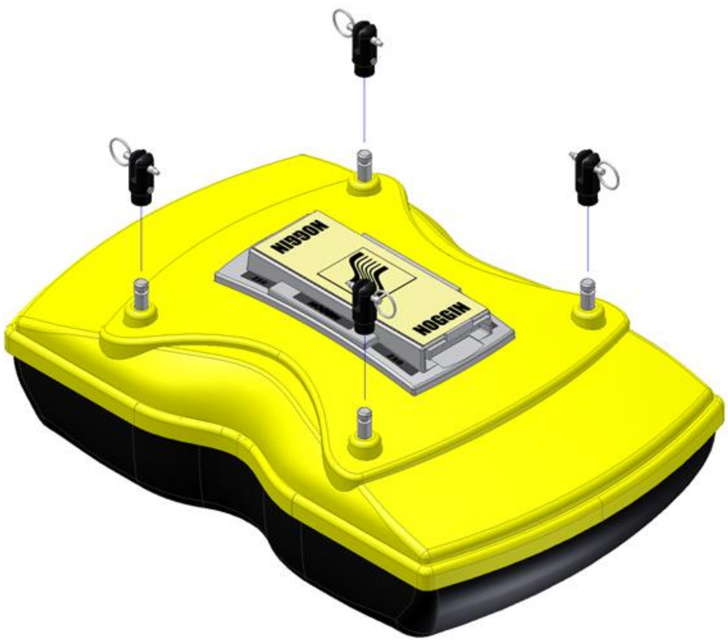


Figure 2-23: Swivel adaptors attaching to mounting posts

Loosen the Allen (hexagonal) screw use the 1/8" Allen (hexagonal) wrench provided with the assembly package to slide the swivel adaptor down into the proper position

Tighten each screw and then loosen it ¼ turn so the swivel adaptors are firmly attached to the post but can still rotate.

> **Important**: Do not over-tighten the screws.

2.3.5 Attaching a Noggin to the SmartCart

Noggin 250

1. Align the Noggin beneath the SmartCart so the long axis is parallel to the SmartCart wheels.

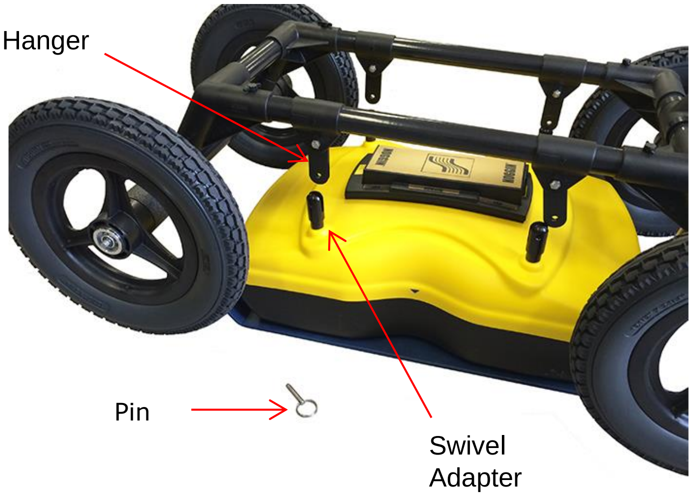


Figure 2-24: Attaching the Noggin 250 to the SmartCart

2. Make sure the Noggin 37-socket female electrical receptacle faces the back (handle end) of the cart so the cable reaches the receptacle.
3. Remove the quick release pin from the swivel adaptors.
4. On the bottom of the cart, locate the four oval, moveable hangers suspended from the separation bars of the cart. Each hanger has a hole in it (Figure 2-24).
5. To attach the Noggin to the cart, place each hanger into the slot on the top of the swivel adaptors.
6. Line up the holes and insert the pins.

Noggin 500 & 1000

1. Align the Noggin so the long axis is parallel to the SmartCart wheels.
2. Make sure the Noggin 37 socket female electrical receptacle faces the back (handle end) of the cart so the cable reaches the receptacle.
3. Remove the pins from the swivel adapters.
4. On the bottom of the cart, locate the two flat, moveable crossbars suspended from the separation bars. Each crossbar has two holes, one on each side (Figure 2-25).

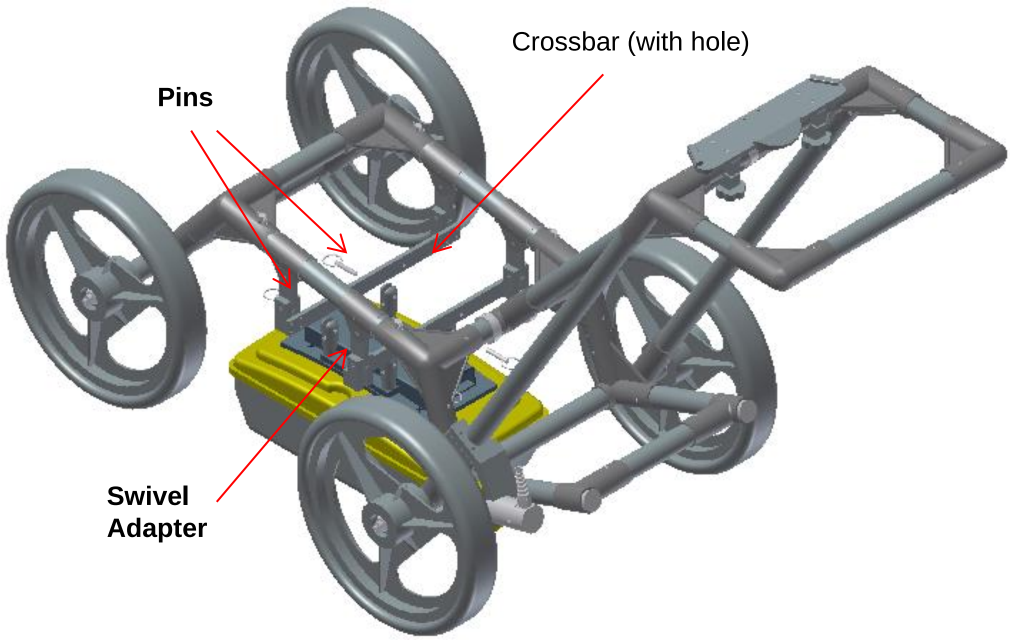


Figure 2-25: Attaching the Noggin 500 and Noggin 1000 to the SmartCart

5. To attach the Noggin 500 or 1000 to the cart, place the crossbars into the slots on the top of the swivel adapters.
6. Line up the holes and insert the pins.

Noggin 100 and Noggin Ultra 100

Unlike the higher frequency Noggins, the Noggin 100 comes with the antennas and electronics as separate units that need to be assembled. Before attaching the Noggin 100 to the SmartCart, assemble the Noggin 100 electronics and antennas (to learn more, see Assembling the Noggin 100 MHz).

Assemble the Noggin 100 separation bars before attaching them to the SmartCart.

To attach your Noggin 100 to the SmartCart, place the SmartCart over the Noggin 100.

Make sure the 37-socket cable connection on the Noggin 100 electronics faces the back (handle end) of the SmartCart so that the cable can connect properly.

Align and then insert the eight antenna post blocks on the frame into the antenna mounting posts on the 100 MHz antennas. Make sure they go inside the skid plate cross braces, and not on top of them.

Secure the SmartCart Separation Bars to the Noggin 100 by inserting the pins into the eight post blocks (Figure 2-26).

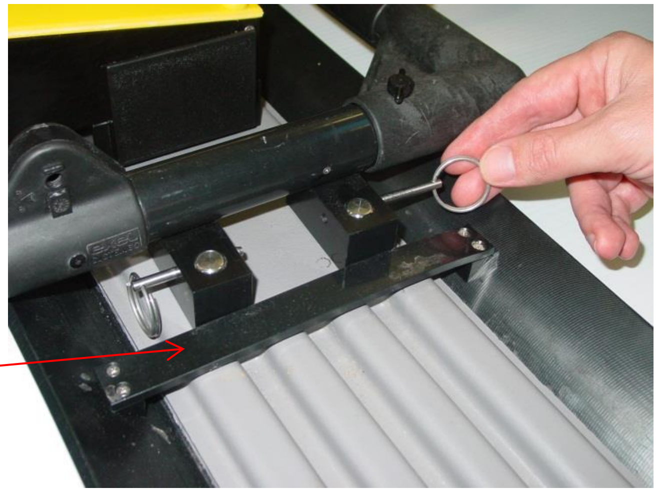


Figure 2-26: Attaching Separation Bars to Noggin 100 antennas

2.3.6 Connecting the Noggin Cable

The SmartCart cabling is factor installed to route along the bottom fibreglass bar with Velcro strips.

1. Connect the 37-pin end of the Noggin-to-DVL cable to the receptacle on the Noggin.
2. Secure the attachment with the latch (Figure 2-27).
3. Leave enough slack on the cable to reduce stress on the cable during data collection.
4. When using a Noggin 100, ensure the Noggin cable can reach the additional length required to connect to the Noggin 100. Attach the odometer extension cable (100-52-0091) to the standard odometer cable that is secured to the SmartCart and connected to the Noggin cable (Figure 2-28).
5. The first Velcro strap is then used to secure the now extended odometer cable to the SmartCart. Route the cable along the frame using Velcro straps.

Figure 2-27: Connecting cable with latch to Noggin

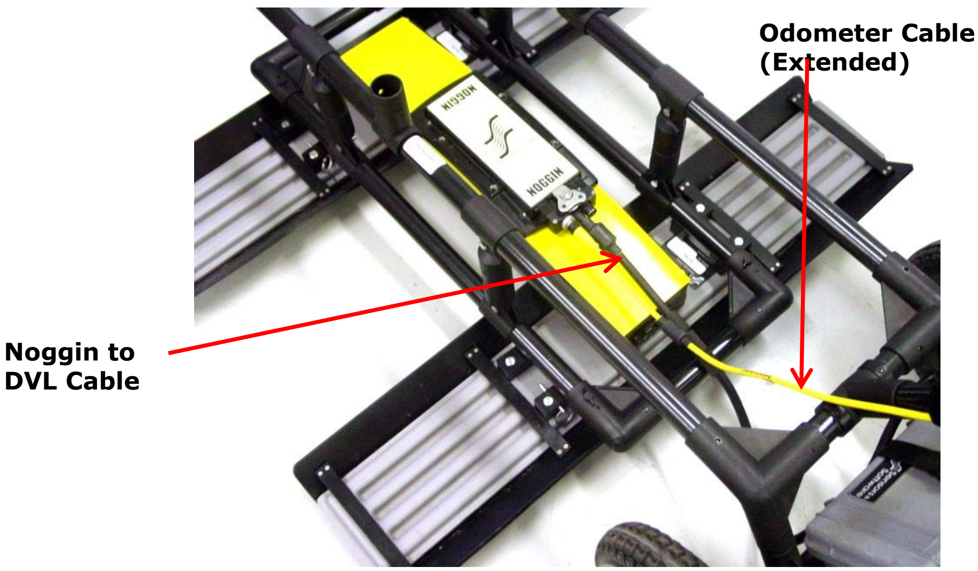


Figure 2-28: Connecting the Noggin-to-DVL cable to Noggin 100 electronics

2.3.7 Attaching the Digital Video Logger (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 (Figure 2-29).
3. The spring-loaded release pin with snap into place when secure. Do not let go of the DVL until you are sure that it is secure.

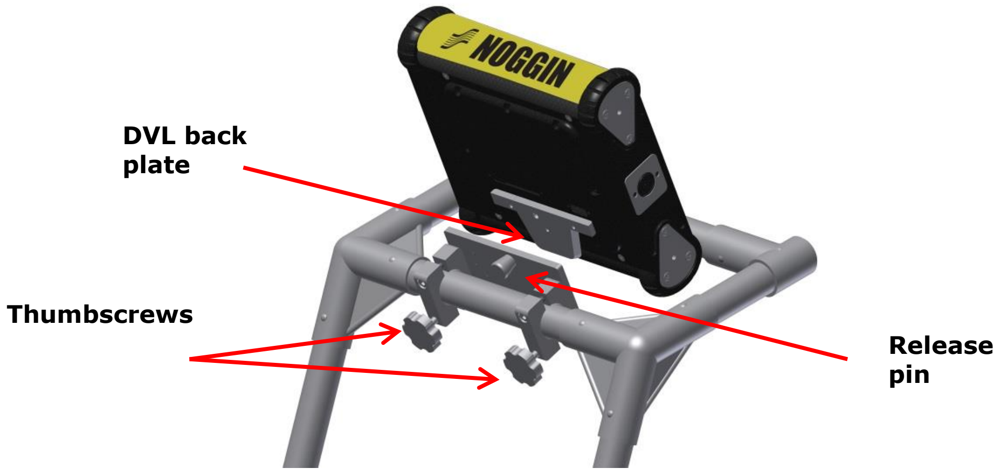


Figure 2-29: Attaching the digital video logger (DVL).

4. Wiggle the DVL to make sure it is firmly connected before letting go of the unit.
5. Pivot the DVL to adjust the view angle. If it is difficult to pivot the DVL, slightly loosen the thumbscrews on the bottom of the support shelf. Tighten to fix the viewing angle
6. To remove the DVL from the SmartCart, pull the cylindrical release pin outward and lift the DVL off the shelf.
7. Once the DVL is in place, attach the 37-socket female D-connector cable to the 37-pin receptacle on the back of the DVL. Secure the attachment with the latch (Figure 2-30).

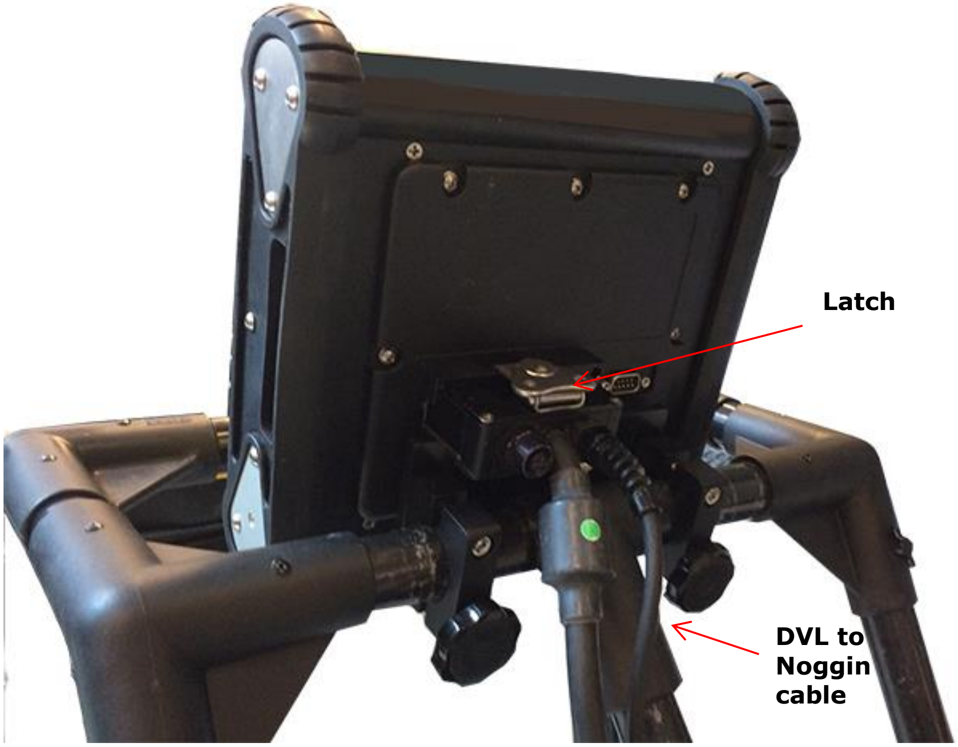


Figure 2-30: Connecting main cable to DVL

2.3.8 Attaching the Battery

The image in Figure 2-30 displays the SmartCart 9 Amp-hr. battery. Follow the steps for placing the battery in the SmartCart:

Figure 2-31: SmartCart battery

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

Figure 2-32: Attaching battery to SmartCart

2. Make sure 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. Tighten the straps.
5. Fasten the plastic buckle to lock the straps (Figure 2-32).

Note: The battery mass is part of the overall cart balance enabling you to raise the front wheels with little force. This allows you to change direction and ensure the rear wheels (especially the rear wheel in contact with the odometer wheel) are always in contact with the ground.

6. Connect the round four-pin battery cable to the receptacle (Figure 2-31) on the side of the battery.

2.3.9 Installing the GPS Mount (optional)

The optional SmartCart GPS mount is designed to mount a GPS receiver, which can log GPS information during data collection. It uses a 5/8-11 UNC-1A thread at the top of the pole. These are standard for Trimble, Topcon and other GPS units.

Identify all parts in the parts list (Figure 2-33):

Number	Quantity
1. GPS Mounting Post	1
2. Horizontal Support Bar	1
3. Vertical Support section	1
4. Tube clips	3
Hardware/pins (not shown)	

Figure 2-33: Components of the GPS mount

1. Open two **tube clips** (**4**) and push them over the separation bars; position them at the mid-point of the Noggin

2. Use two screws with lock washer and wing nut to fasten the U-shaped **Vertical Support Section** (**3**) onto the **tube clips** (**4**).

3. Clip the remaining **tube clip** (**4**) onto the **angular support bar** (**A**).
4. Use the screws with lock washer and wing nut to install the **horizontal support bar** (**2**) to the **angular support bar (A)**.
5. Secure the **horizontal support bar** (**2**) to the **vertical support section** (**3**) with a quick release pin.
6. Insert the **GPS mounting post** (**1**) and secure it with a quick release pin.
7. Adjust the assembly to make sure the **horizontal support post** (**2**) is completely horizontal and the **vertical support section** (**3**) is completely vertical.

> **Note**: There are 2 sizes for the horizontal support bars: one for the Noggin 250, one for the Noggin 500/1000. There is none for the Noggin 100 on a SmartCart.
>
> If you are using an external GPS with the Noggin 100 on a SmartCart, it is recommended to purchase the pulseEKKO GPS Mount, which doesn't require the horizontal support bar. In addition, you will need a longer GPS cable to run to the DVL.

The completed Noggin 250 & Noggin 100 SmartCarts are shown below (Figure 2-34).

Figure 2-34: Assembled Noggin 250 SmartCart (left) and Noggin 100 SmartCart (right)

2.4 Assembling the SmartTow

The SmartTow configuration enables you to drag Noggins (100, 250, 500, and 1000) across the surface to acquire data.

2.4.1 Noggin 100 SmartTow

The Noggin 100 tow frame is shipped disassembled and comes with four corner brackets for attaching the tow frame to the handle and odometer.

First, assemble the Noggin 100 electronics and antennas (see Assembling Noggin 100).

The image in Figure 2-35 displays the parts of the Noggin 100 SmartTow frame:

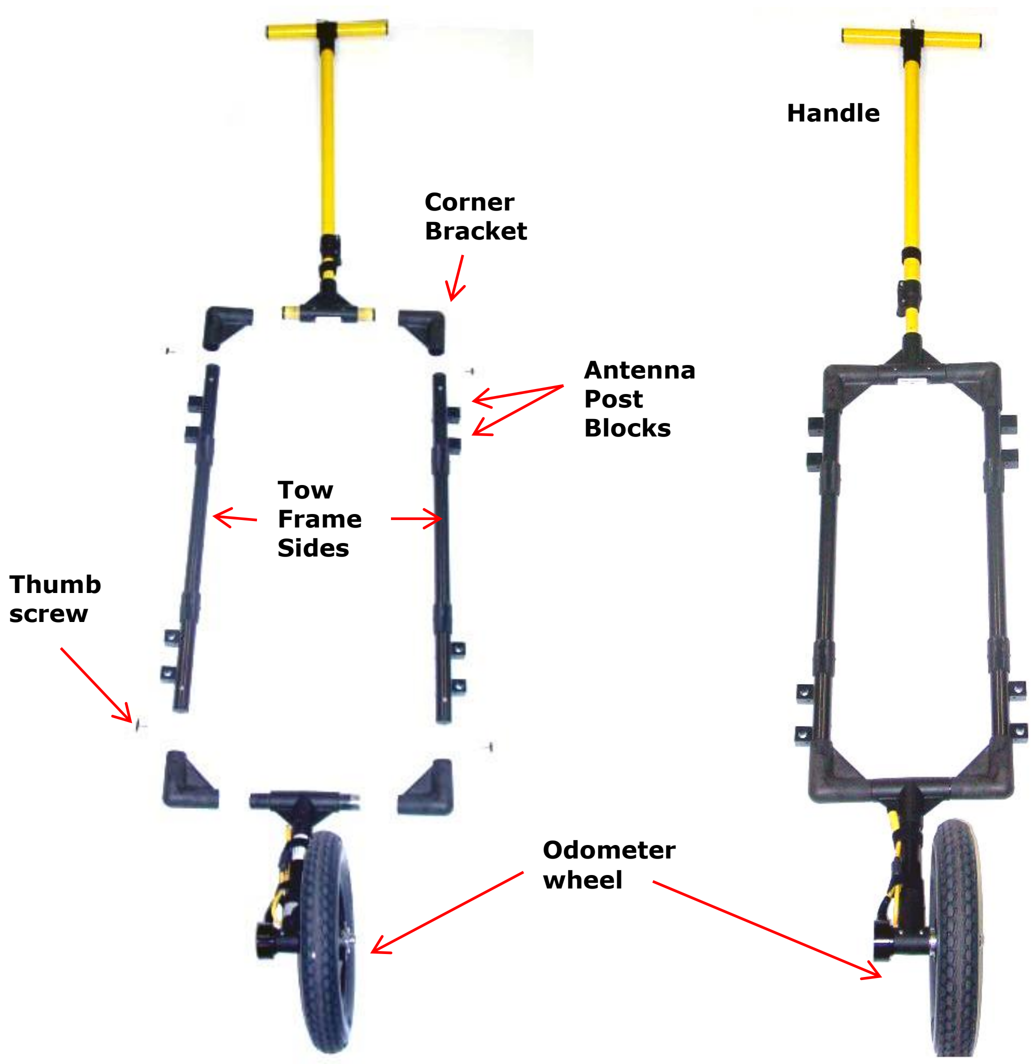


Figure 2-35: Noggin 100 SmartTow frame parts (left) and Assembled Noggin 100 frame (right)

The instructions below describe how to connect the antennas and electronics to the Tow Frame:

1. Make sure the antenna post blocks face outward before assembling.

2. Connect each piece using the four thumbscrews (Figure 2-36). Be careful not to strip the threads. The handle and odometer wheel are held in place with the corner brackets which are connected to the tow frame using the thumb screws.
3. Make sure you position the odometer wheel so the "This Side Up" sticker on the bar faces up.

Figure 2-36: Connecting thumbscrew

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

4. Align and then insert the eight antenna post blocks on the frame into the antenna mounting posts on the 100 MHz antennas. Make sure they go inside the skid plate cross braces, and not on top of them
5. Place the SmartTow frame over the Noggin 100 electronics. Ensure the end with the cable connector faces the odometer (Figure 2-37).
6. Press down on the Noggin 100 electronics until it is firmly connected to the antennas.

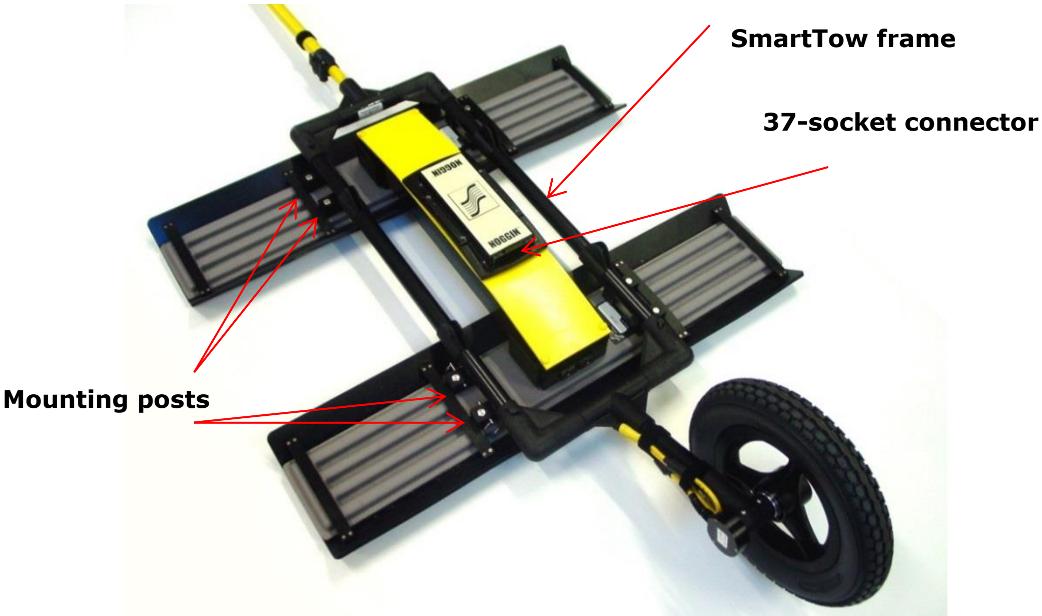


Figure 2-37: Attaching Noggin 100 electronics to antennas

7. To secure the SmartTow frame to the Noggin 100, insert the pins into the eight post blocks (Figure 2-38)

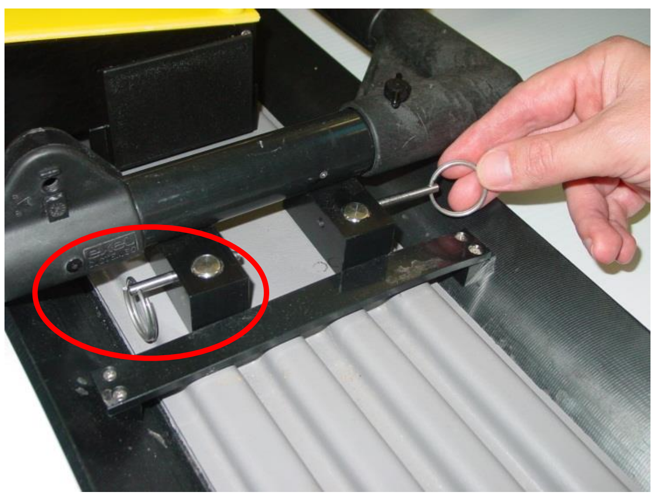


Figure 2-38: Securing SmartTow frame to Noggin 100 antennas

8. Latch the 37-pin end of the Noggin-to-DVL cable to the receptacle on the Noggin 100 electronics.

2-Person Operation

For issues of cable management, it is recommended to operate the Noggin 100 SmartTow configuration with two people: one person pulls the system forward, while the other person trails behind the system with the DVL and belt battery (Figure 2-39).

Figure 2-39: Two-person operation of the Noggin 100 and Noggin Ultra 100 SmartTow

For cable routing:

a) Route the Noggin-to-DVL cable straight back from the Noggin sensor to the DVL.
b) Secure the cable to the frame with Velcro straps.
c) Make sure that the cable does not sag and contact the antennas as this creates noise in the GPR data. The cable should have some slack to reduce any stress on the cable during data collection.
d) Connect the yellow odometer cable to the receptacle on the Noggin end of the Noggin-to-DVL cable.

1-Person Operation

If you will be using the system as a single operator, you will need to have the DVL and belt battery on the front end that is pulling the system. Because the Noggin-to-DVL cable will be coming out the back end of the Noggin sensor, care must be taken when routing the cable to minimize unwanted RF noise in the data.

For cable routing:

a) Route the Noggin-to-DVL cable on top of the Noggin sensor electronics towards the front. Make sure that the cable does not hover over or contact the antennas as this creates noise in the GPR data (Figure 2-40).
b) Route the cable up the handle and connect to the back of the DVL.
c) Secure the cable to the frame (near the handle end) and up the handle with Velcro straps.
d) Connect the yellow odometer cable to the receptacle on the Noggin end of the Noggin-to-DVL cable.

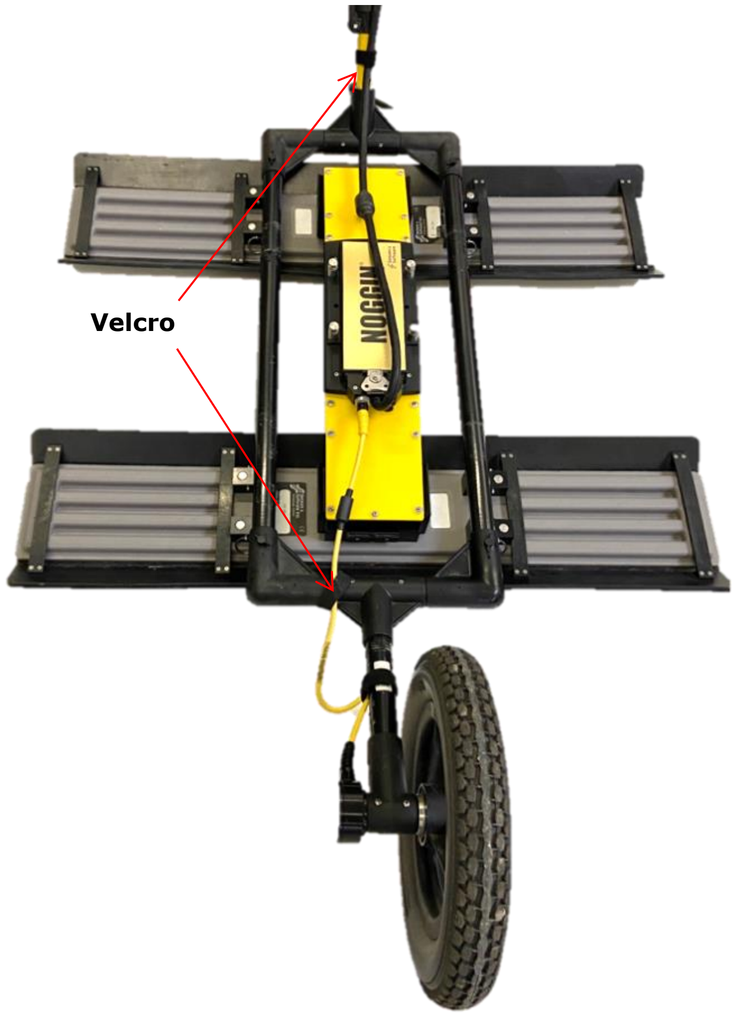


Figure 2-40: Connecting main cable and odometer cable. Secure to frame with Velcro straps provided.

Where possible, it is highly recommended to use the 2-person operation.

2.4.2 Noggin 250 SmartTow

The following image (Figure 2-41) displays the components needed to assemble the Noggin 250. Instructions are as follows:

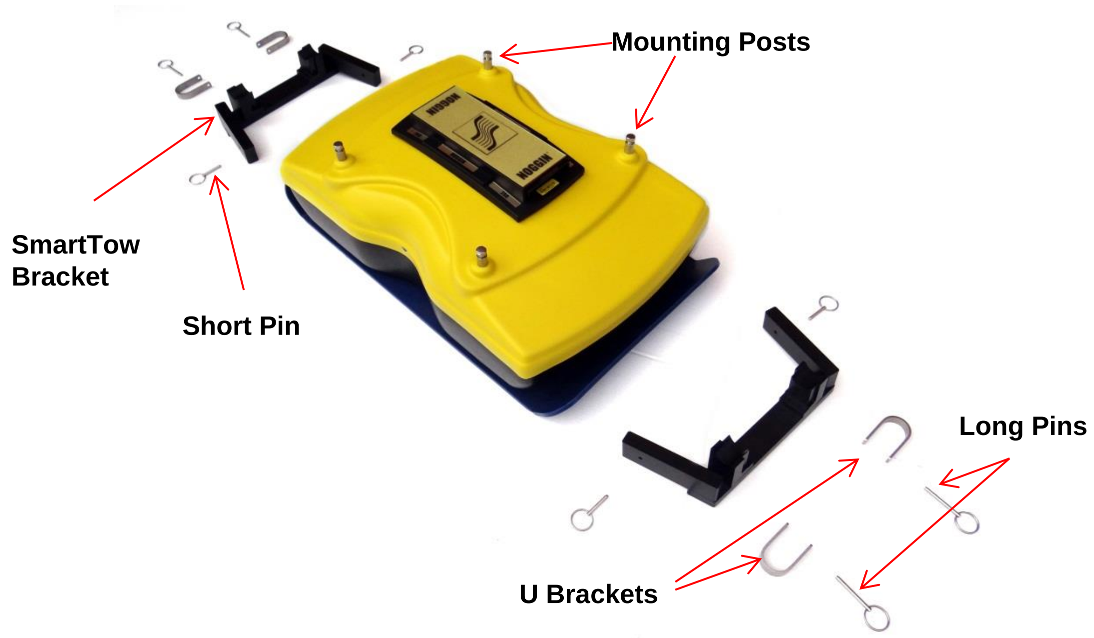


Figure 2-41: Components of the Noggin 250 SmartTow

1. Attach a **SmartTow Bracket** to the two front mounting posts on the Noggin.
2. Secure the attachment with pins.
3. Attach the second **SmartTow Bracket** to the two back mounting posts on the Noggin (Figure 2-42).
4. Secure the attachment with pins.

Figure 2-42: Connecting the SmartTow bracket

5. Connect the large black cable to the Noggin 37-pin female connector and close the latch (Figure 2-43).

Figure 2-43: Connecting main cable to Noggin 250

6. Make sure the cable lies on top of the SmartTow Bracket assembly (Figure 2-44).

Figure 2-44: Routing main cable

7. Attach the large odometer wheel to the rear SmartTow Bracket closest to the 37-pin Noggin connector.
8. Position the odometer so the "This Side Up" sticker on the T-bar faces up.

9. Secure the odometer T-bar with the U-brackets and pins (Figure 2-45).

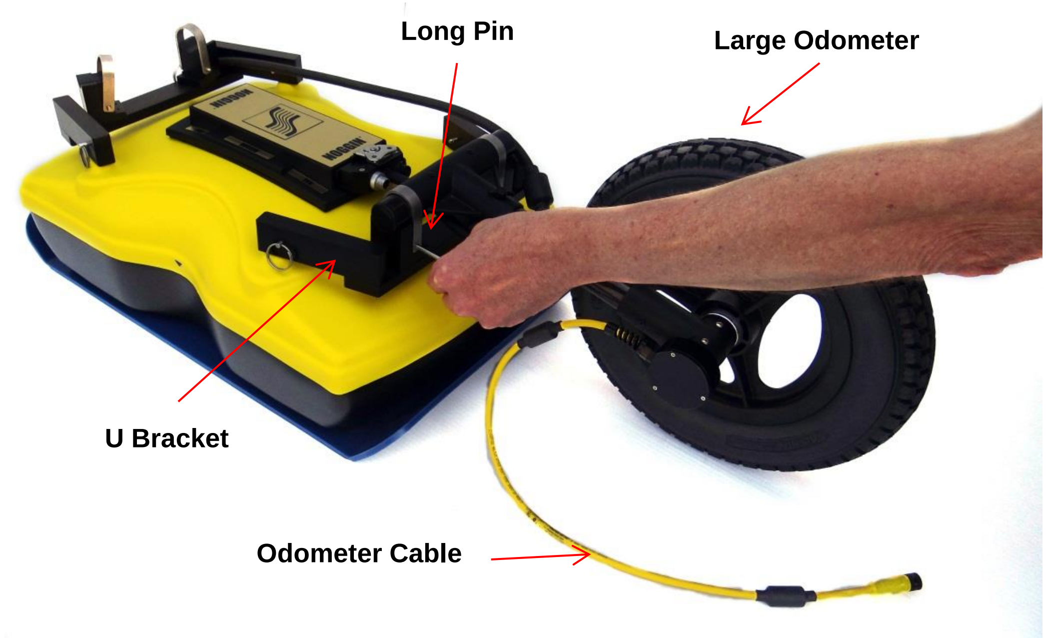


Figure 2-45: Attaching odometer wheel to one of the SmartTow brackets

10. Make sure the black cable is routed to the front of the Noggin so it does not interfere with the odometer wheel.
11. Connect the yellow odometer cable to the Noggin connector receptacle (Figure 2-46).

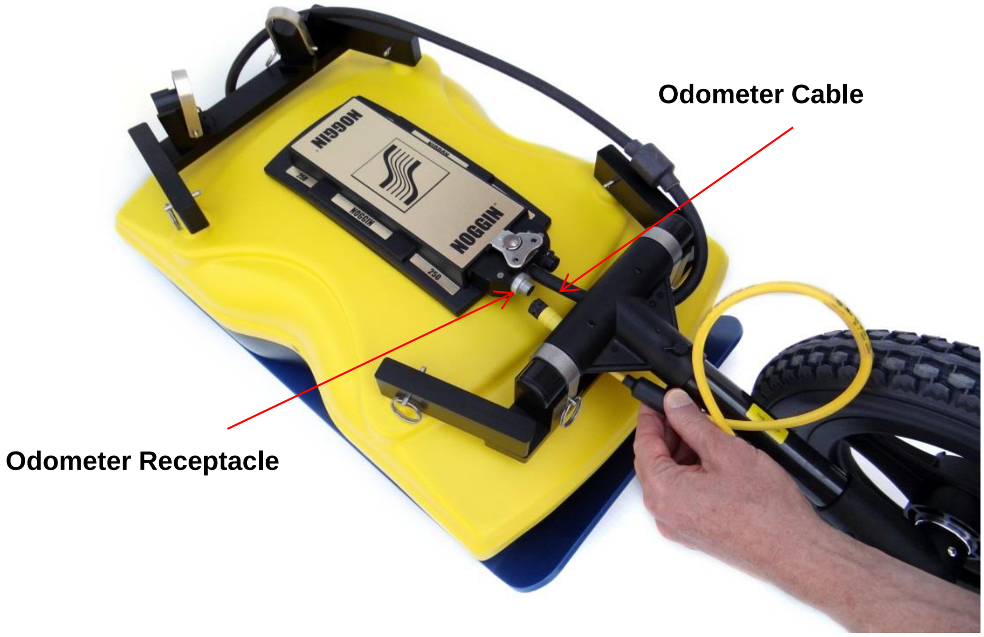


Figure 2-46: Connecting yellow odometer cable to odometer receptacle on main cable

12. Attach the handle to the front SmartTow Bracket assembly with the U-brackets and pins (Figure 2-47).

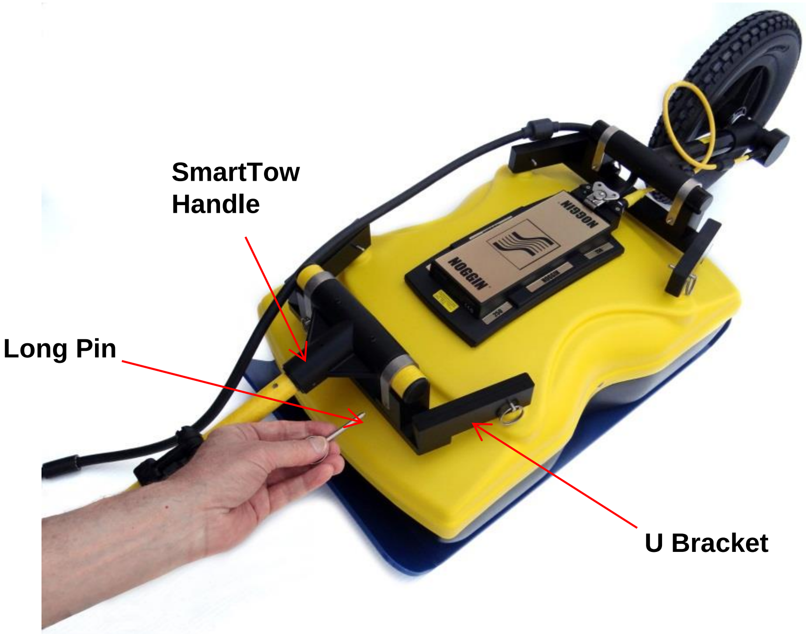


Figure 2-47: Securing handle to other SmartTow bracket

13. Secure the cable on the SmartTow brackets and along the side of the handle with Velcro straps (Figure 2-48).

Figure 2-48: Routing cable up the handle

2.4.3 Noggin 500 and 1000 SmartTow

The following image (Figure 2-49) displays the Noggin 500/1000 SmartTow brackets parts:

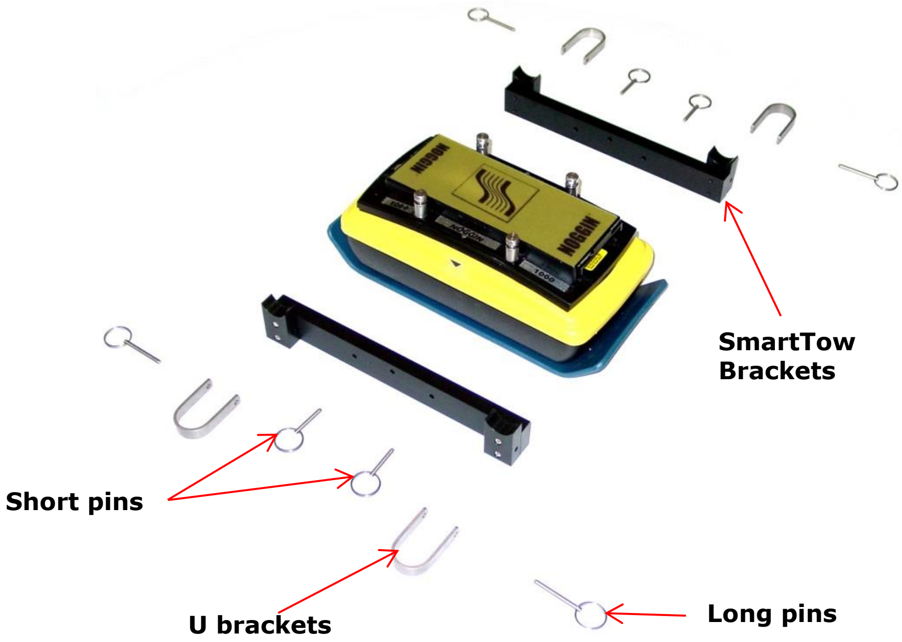


Figure 2-49: Components of the Noggin 500 SmartTow

1. Align the two holes on one of the SmartTow Brackets with the two mounting posts on one side of the Noggin.
2. Press down firmly.
3. Secure the connections with the short metal pins (Figure 2-50).
4. Attach the second SmartTow bracket to the other side of the Noggin and repeat

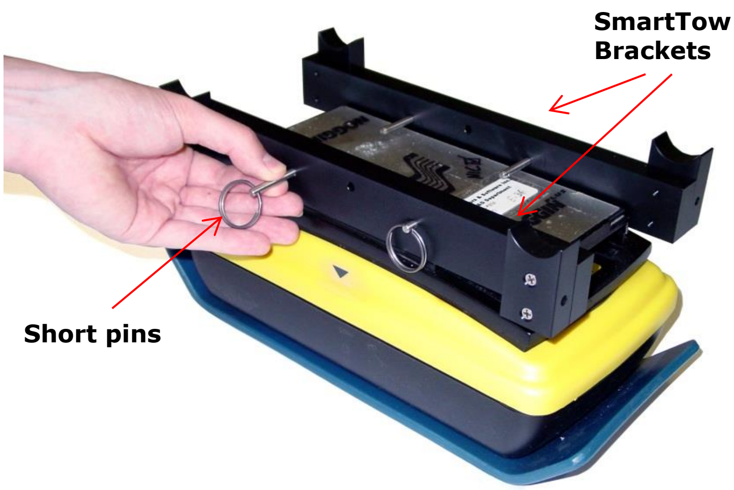


Figure 2-50: Securing SmartTow brackets to Noggin with pins

5. Attach the handle to the front of the SmartTow Brackets using the U-brackets and long pins (Figure 2-51). Make sure the handle is attached to the end of the Noggin opposite the 37-socket cable connection.

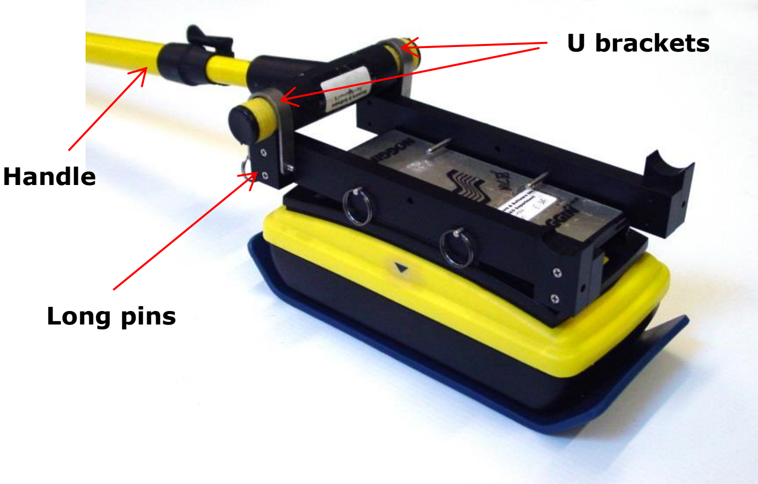


Figure 2-51: Attaching handle to one end of the brackets

6. Connect the large black Noggin-to-DVL cable to the 37-socket connector on the Noggin.
7. Close the latch.
8. Loop the cable to provide some slack.
9. Route the cable along the top of the SmartTow bracket and secure using Velcro straps.
10. Attach the large odometer wheel to the end of the Noggin with the 37-socket connector. Make sure the "This Side Up" sticker is facing up.
11. Secure the odometer T-bar to the SmartTow Brackets using the U-brackets and long pins (Figure 2-52).

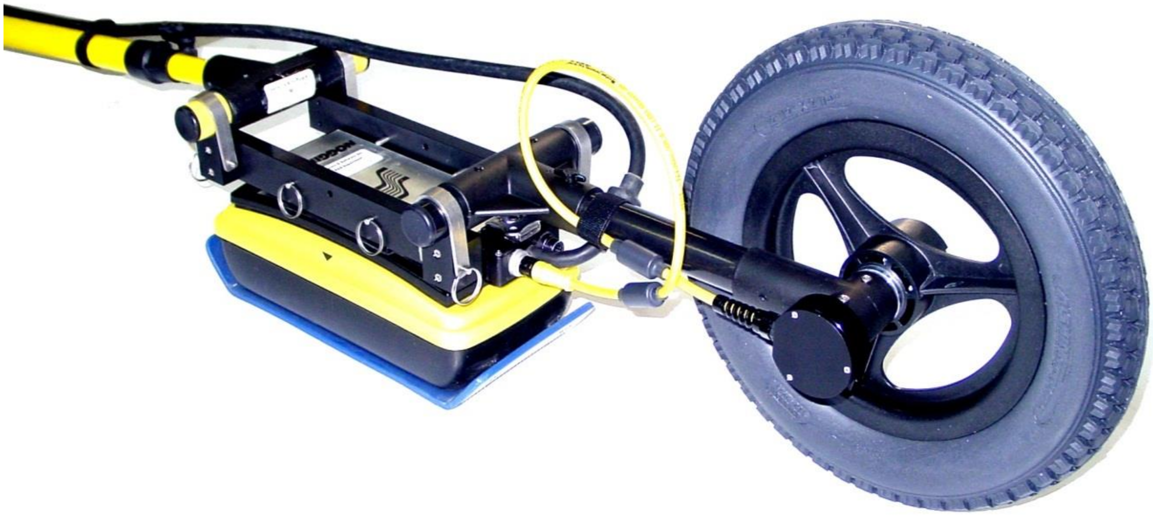


Figure 2-52: Attaching odometer wheel assembly to other bracket

12. Make sure the black Noggin-to-DVL cable faces the front of the Noggin so it does not interfere with the odometer wheel.
13. Connect the yellow odometer cable to the Noggin connector receptacle.
14. Loop the odometer cable so it does not interfere with the rotation of the odometer wheel.
15. Secure the cable to the T-bar with Velcro straps.
16. Secure the main cable along the side of the handle with Velcro straps.

The following image (Figure 2-53) displays a fully-assembled Noggin 500 in SmartTow configuration:

Figure 2-53: Assembled Noggin 500 SmartTow system

2.4.4 Connecting the Battery

In the majority of applications, a belt battery will be used to power the SmartTow configuration.

The main cable that connects to the back of the DVL has a shorter 4-pin connector to connect to a power supply. Connect this to the female connector on the belt battery, as shown in (Figure 2-54).

Figure 2-54: Connecting battery power

2.4.5 Using the Harness

The SmartTow system comes with a harness that connects to the DVL, so your hands are free to acquire data and tow the system. The clips on the harness connect to the ring loops in the four corners of the Display Unit (the ring loops may need to be installed, if they are not already). The longer straps go over the shoulders and the short straps go under the arms. Adjust the length of the straps for comfort (Figure 2-55).

Figure 2-55: Attaching harness clips to DVL (left), fully assembled harness with straps connected to DVL (right)

There is also an option of the Deluxe Harness which allows the operator to mount the DVL at a comfortable, fixed viewing angle for ease of operation. The harness resembles a vest which is pulled over the body and tightened with straps (Figure 2-56).

Figure 2-56: Deluxe Harness

2.5 Assembling the SmartHandle

Noggin 500 and 1000 systems can be operated in the SmartHandle configuration. The assembly images display how to setup the Noggin 500 SmartHandle system; the Noggin 1000 SmartHandle system is similar. The SmartHandle can be connected so that you can either push or pull the system.

1. Slide the Noggin odometer bracket over the four silver mounting posts (Figure 2-57)

Figure 2-57: Sliding Odometer bracket over Noggin 500

2. Connect the 37-pin connector on the Noggin-to-DVL cable to the 37-socket receptacle on the Noggin unit and tighten the latch (Figure 2-58)

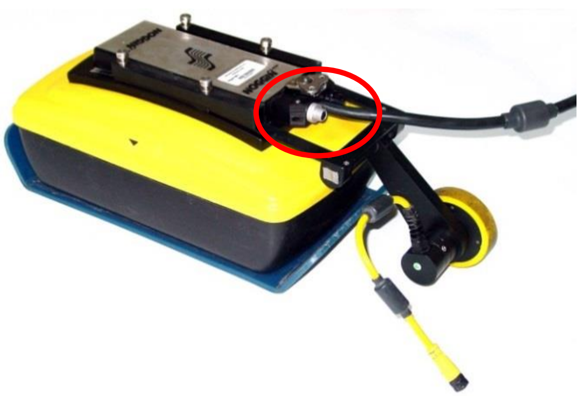


Figure 2-58: Connecting main cable to Noggin

3. Connect the yellow odometer cable to the round Noggin receptacle connector (Figure 2-59).

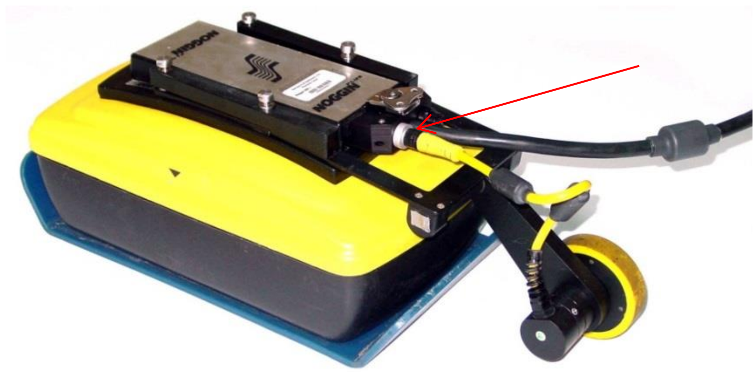


Figure 2-59: Connecting yellow odometer cable to main cable receptacle

4. Press the handle base down onto the four silver mounting posts.
5. Make sure the handle base is pushed all the way down onto the odometer bracket.
6. Insert the four quick-release pins to secure the handle (Figure 2-60).

Figure 2-60: Quick release pins (left), inserted to secure handle to Noggin

<u>Connecting to the DVL</u>

1. Plug the other end of the DVL to Sensor cable into the 37-pin connector on the back of the DVL.
2. To connect the power source, attach the SmartHandle cable 4-pin connector to a power supply, typically the belt battery (Figure 2-61).

Figure 2-61: Connecting belt battery

3. Run the DVL to Sensor Cable from the Noggin up the side of the SmartHandle.
4. Secure the cable to the SmartHandle with the Velcro straps.
5. Leave slack in the cable near the Noggin connection. It is important that there is no strain on the connection when the handle is pivoted up and down.

The completed SmartHandle will look like the picture in Figure 2-62:

Figure 2-62: Completed SmartHandle

If you want to pull the SmartHandle, rather than push it:

1. Remove the four quick-release pins that secure the handle to the Noggin.
2. Remove the handle bracket by pulling it straight up.
3. Rotate the handle so the handle is on the opposite end of the odometer wheel.
4. Press the handle base down onto the four silver mounting posts.
5. Make sure the handle base is pushed all the way down onto the odometer bracket.
6. Insert the four quick-release pins to secure the handle to the Noggin.
7. Completed SmartHandle for pulling is shown in Figure 2-63

Figure 2-63: Pulling the SmartHandle

2.5.1 Shortening the SmartHandle

To shorten the SmartHandle for collecting data in a confined space or on a wall, release the thumbscrews and remove the center handle section (Figure 2-64). Secure the cable to the SmartHandle using Velcro straps.

Make sure that there is excess cable near the Noggin connection to allow the SmartHandle to pivot up and down without straining the cable.

Figure 2-64: Shortened handle, by removing the middle section

2.5.2 Using the Harness

The SmartHandle system comes with a harness that connects to the DVL, so your hands are free to acquire data and tow the system. See Section 2.4.5 for information on using the Harness and the Deluxe Harness.

Below is a picture of the assembled SmartHandle and harness in use (Figure 2-65).

Figure 2-65: SmartHandle with harness on a site

2.6 Assembling the SmartChariot

The SmartChariot is a self-contained Ground Penetrating Radar (GPR) system used to deploy GPR sensors at low speeds (maximum 25 km/hr or 15 mph) from a tow vehicle (Figure 2-66). The SmartChariot can be used with the Noggin 250, 500 or 1000 sensors.

The SmartChariot can also deploy dual channel Noggin systems in-line: two Noggin 1000s or a Noggin 500 and a Noggin 1000 at the same time. This is achieved using the SPIDAR multi-channel platform, described in Section 2.8. The following image shows a fully assembled SmartChariot system with a Noggin 500 and GPS attached to a tow vehicle`:

Figure 2-66: Fully assembled Noggin 500 on a SmartChariot with GPS, connected to a tow vehicle

2.6.1 Attaching Swivel Adapters to Noggins

Before attaching the Noggin 250, 500, or 1000 to the SmartChariot, attach the four swivel adaptors (with attached pins) to the Noggin mounting posts as shown in Figure 2-67.

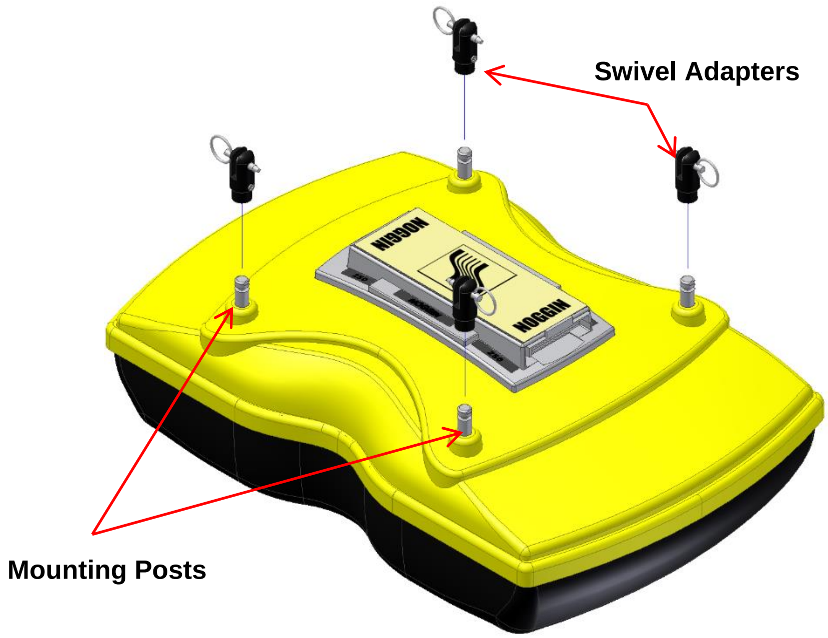


Figure 2-67: Connecting swivel adaptors to mounting posts

1. Place the swivel adapters on the mounting posts. To loosen the Allen (hexagonal) screw, use the 1/8" Allen (hexagonal) wrench provided with the assembly package so the swivel adaptor will slide down into the proper position. Tighten each screw, but do not over-tighten.

2.6.2 Hanger Kits

The Noggin attaches to the SmartChariot by a hanger kit. The Noggin hanger kit is first attached to the swivel adapters on the Noggin. Each hanger bar has six parallel mounting locations to attach the hanger kits to (Figure 2-68).

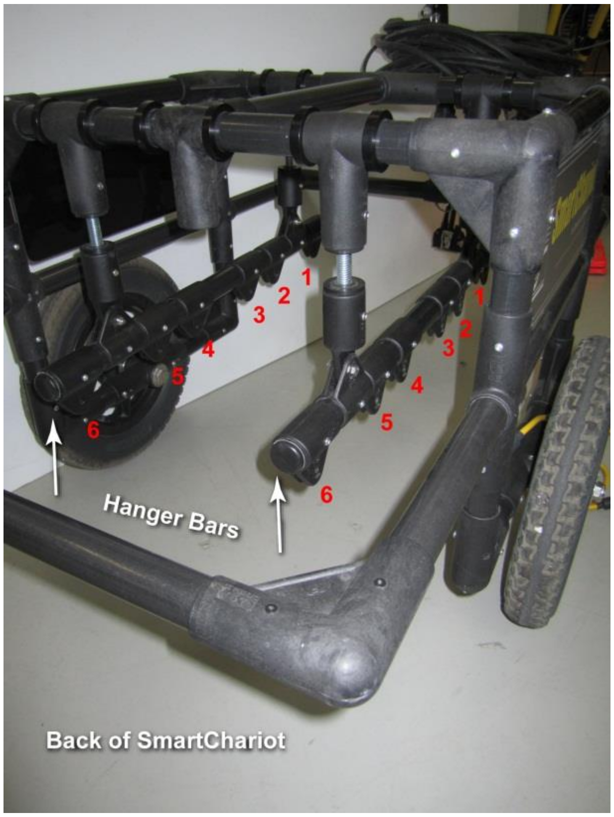


Figure 2-68: Hanger bars for mounting Noggins

To mount the GPR sensor hanger kit in the correct position on the hanger bars, refer to the following table:

Hanger Bar Mount	Single Channel GPR Sensor	Dual Channel GPR Sensors
1	N/A	Front of Noggin 500
2	Front of Noggin 250	N/A
3	Front of Noggin 500 or 1000	Rear of Noggin 500
4	Rear of Noggin 500 or 1000	Front of Noggin 1000
5	Rear of Noggin 250	N/A
6	N/A	Rear of Noggin 1000

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).

2.6.3 Connecting the Noggin 250

Connect the four Noggin 250 short hangers from the swivel adapters to Hanger Bar Mounts 2 and 5. Make sure the Noggin cable connection faces the back of the SmartChariot (Figure 2-69).

Figure 2-69: Noggin 250 attached to SmartChariot

2.6.4 Connecting the Noggin 500

The Noggin 500 hanger kit includes a crossbar that attaches to the swivel adapters. Connect the four short crossbar ends hangers to hanger bar Mounts 3 and 4. Make sure the Noggin cable connection faces the back of the SmartChariot (Figure 2-70).

Figure 2-70: Noggin 500 attached to SmartChariot

2.6.5 Connecting the Noggin 1000

The Noggin 1000 hanger kit includes a crossbar that attaches to the swivel adapters. Connect the four long crossbar end hangers to hanger bar mounts 3 and 4. Make sure the Noggin cable connection faces the back of the SmartChariot (Figure 2-71).

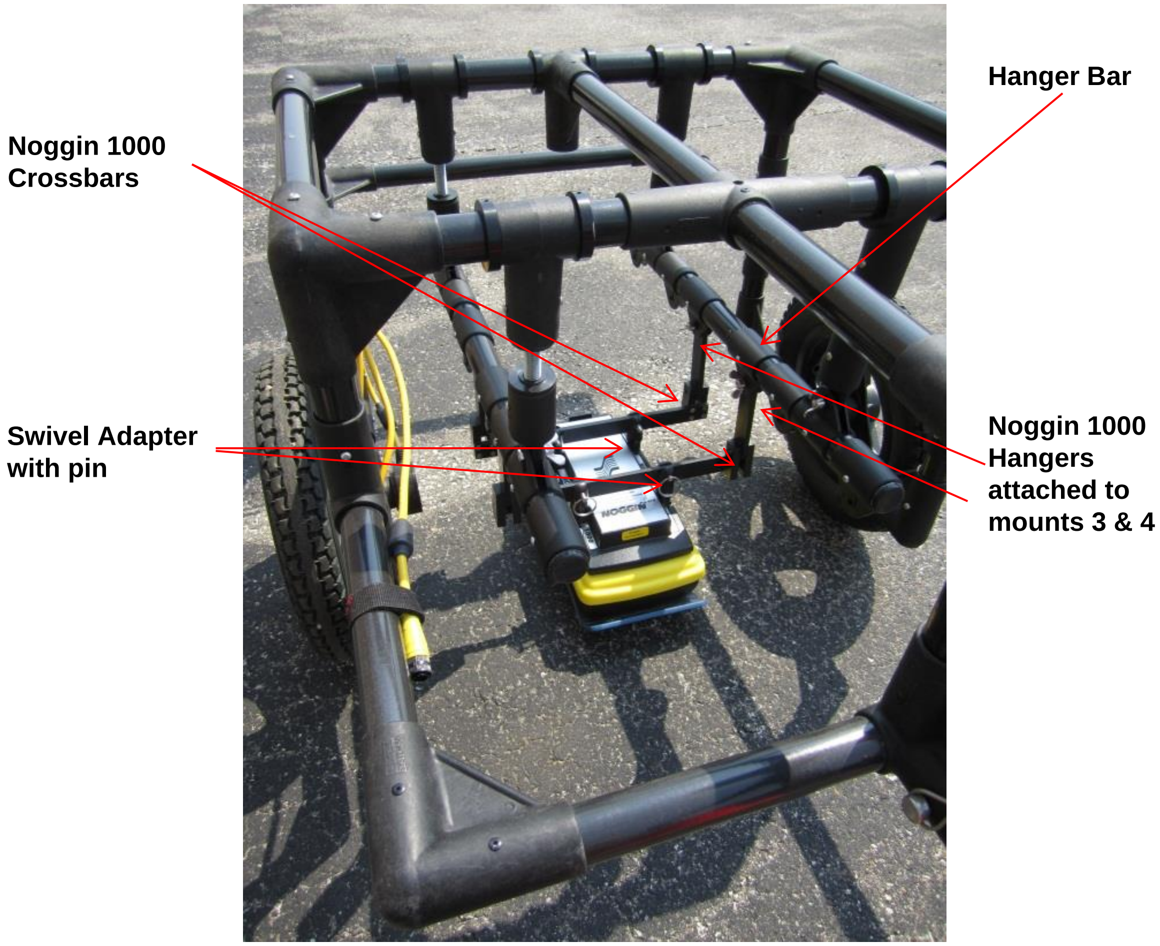


Figure 2-71: Noggin 1000 attached to SmartChariot

2.6.6 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 (Figure 2-72). Attach the handle assembly to the SmartChariot so the GPR sensor is as level as possible.

Low Handle Position

High Handle Position

Figure 2-72: Attaching handle to SmartChariot showing low position (top) and high position (bottom)

Attach the handle to the back of the SmartChariot using the two locking pins (Figure 2-73):

Figure 2-73: Securing handle to SmartChariot with locking pins

2.6.7 Attaching the Ball Hitch Receiver

The Ball Hitch Receiver is shipped detached from the handle assembly (Figure 2-74). It will connect to a hitch ball of size 1 7/8".

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.

Figure 2-74: Ball hitch receiver

4. Place the Ball Hitch Receiver on top, lining up the holes.
5. Insert the bolts, with washers (Figure 2-75).

Figure 2-75: Connecting and securing ball hitch receiver to handle

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

2.6.8 Adjusting the Noggin Height

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

If necessary, adjust the four SmartChariot Height Adjusters to attain the optimal Noggin height above the ground (Figure 2-76):

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

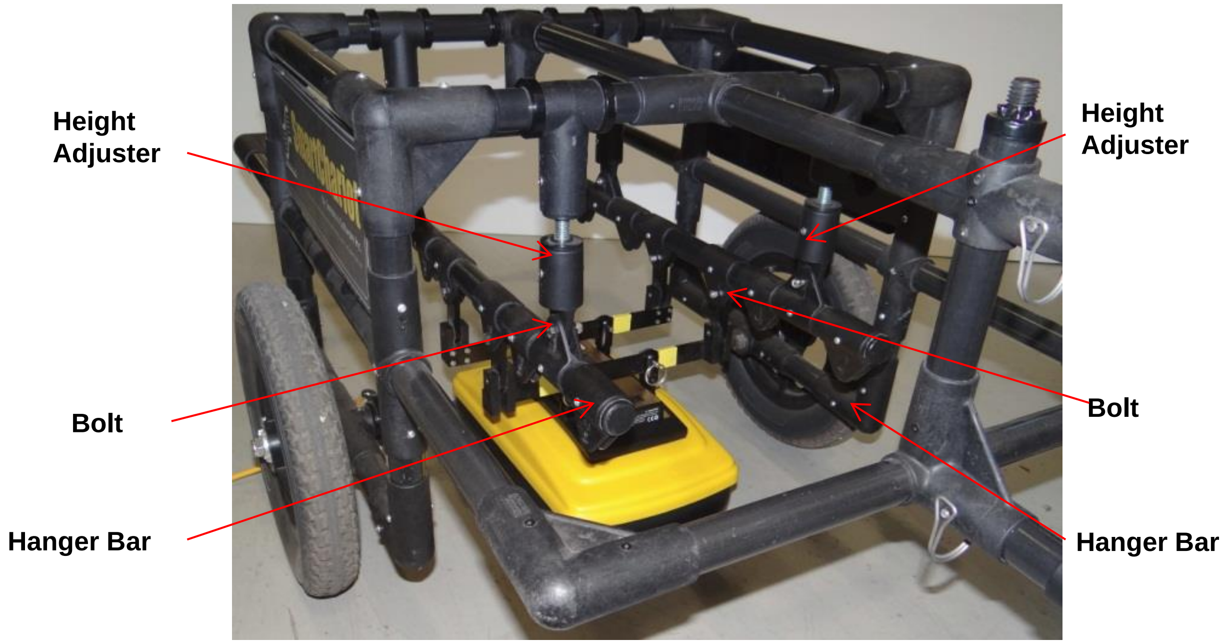


Figure 2-76: Adjusting height of Noggin

2. Turn the bottom of the height adjusters clockwise to raise the Noggin and counter-clockwise to lower the sensor height.
3. 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 (Figure 2-77).

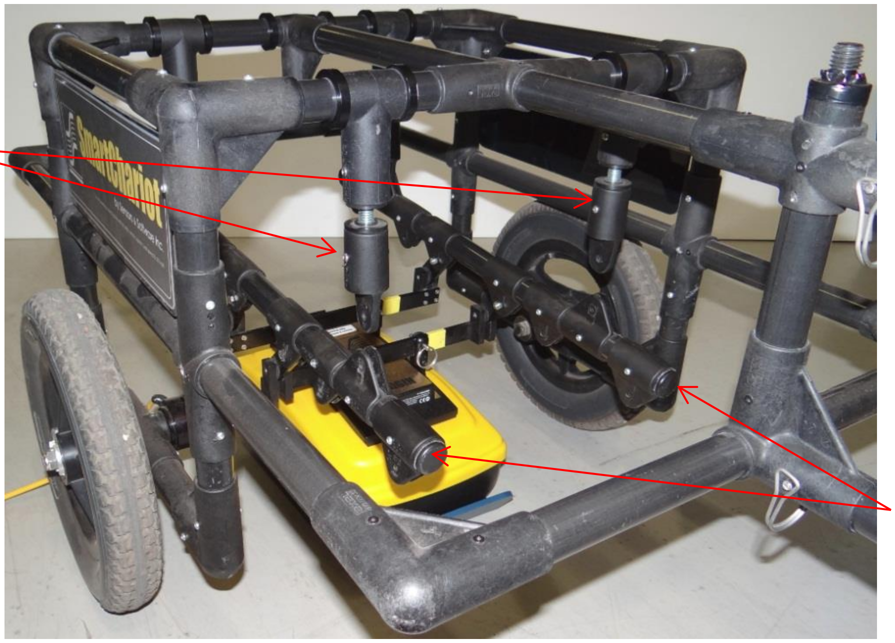


Figure 2-77: Tightening height adjusters

4. Reattach all the locknuts. Do not over-tighten the locknuts; the Noggin should be free to swing forward and backward.

During data collection with the SmartChariot on a flat road, the Noggin should not come in contact with the ground. It is normal to periodically hear the Noggin 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 on the bottom of the Noggin and, if excessive wear is seen, adjust the height if necessary; SmartChariot height generally only needs to be adjusted once.

2.6.9 Adding GPS

If an optional Global Positioning System (GPS) unit was shipped with your SmartChariot, attach it to the threads at the front of the SmartCart, near the point where the handle attaches (Figure 2-78).

Figure 2-78: GPS connected to SmartChariot

2.6.10 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 (Figure 2-79).

Noggin Cable

1. Use the black cable with a 37-pin connector to connect SmartChariot systems to the Noggin.
2. Secure the latch.
3. Route the cable(s) up the hanger brackets and along the SmartChariot frame on the same side as the odometer cable.
4. Route the cables to the top of the SmartChariot frame.
5. Run the cable along the SmartChariot handle and into the towing vehicle.
6. Secure the cable(s) to the SmartChariot frame with the Velcro straps provided.

Odometer Cable

7. Route the yellow odometer cable along the horizontal frame to the back and up to the top of the SmartChariot frame.
8. Route the cable down the Hanger.
9. Attach the cable to the Noggin.

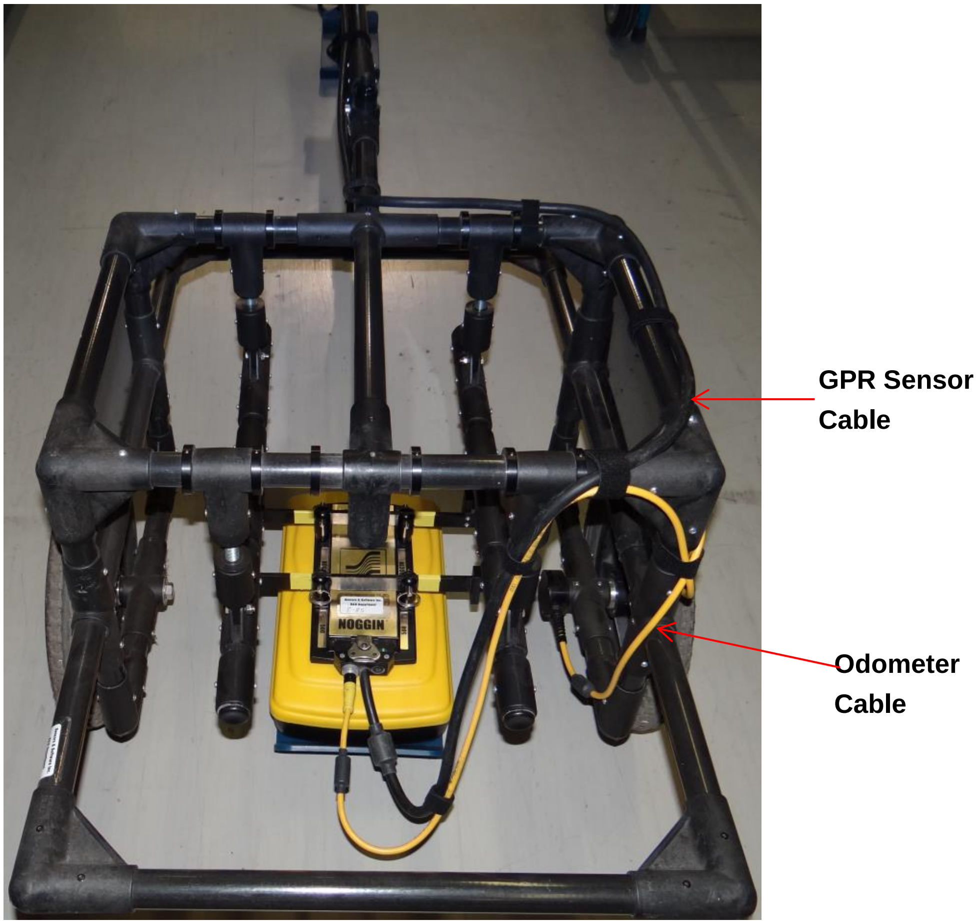


Figure 2-79: Back of SmartChariot showing cable routing

DVL Cable

Connect the other end of the black Noggin cable with the 37-pin connector to the back of the DVL in the tow vehicle:

GPS Cable

1. Route the GPS cable up to the top of the SmartChariot Handle Assembly (Figure 2-80).
2. Route the cable along the top of the SmartChariot handle and into the tow vehicle.

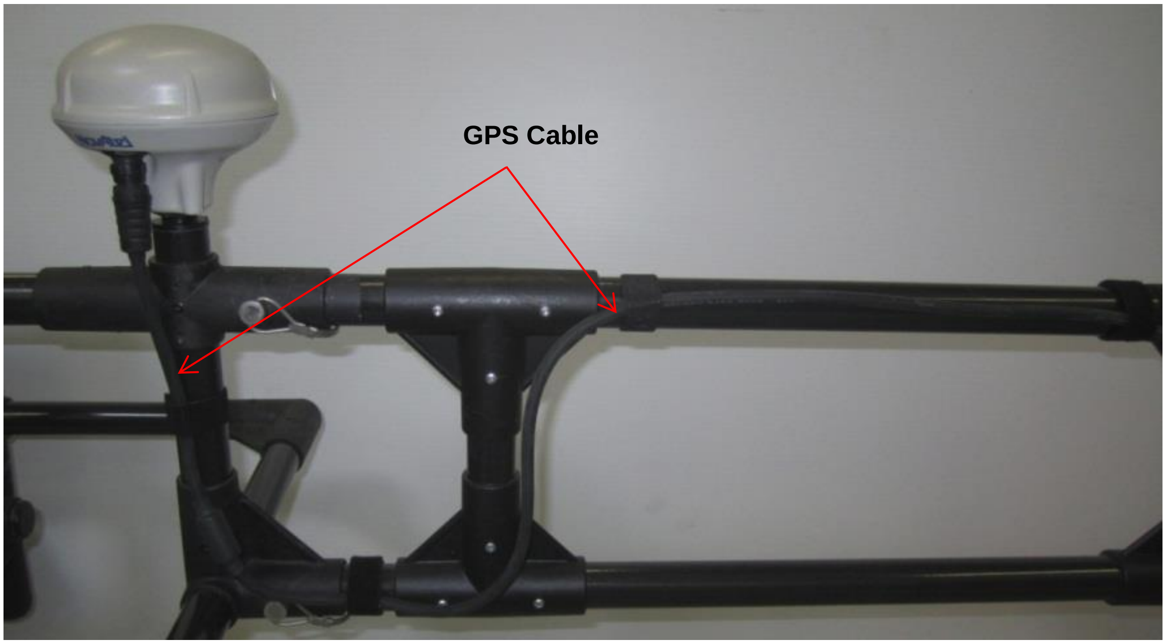


Figure 2-80: Routing GPS cable

3. Secure the odometer cable to the SmartChariot using the Velcro straps provided.

2.6.11 SmartChariot GPR system parameters

There are default settings for the SmartChariot configuration on the DVL, but you may still need to manually change these values. The following table lists suggested GPR parameters based on the maximum SmartChariot speed of 25 kph (15 mph). These can be set in System Configuration, Section 5.2.

Parameter	GPR Sensor (MHz)		
	250	**500**	**1000**
Depth (m)	3.0	1.5	0.75
Noggin	250	500	1000
Stacks	1	1	1
Trigger Method	Odometer		
Step Size (cm)	5 cm	5 cm	5 cm

2.6.12 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.

Noggin Mounting Pins

When installing the quick release pins to the Noggin Hanger and mounting posts, position the pins so they are facing opposite directions (Sections 2.6.3, 2.6.4 & 2.6.5, depending on Noggin unit). During normal operation the assembly vibrates and occasionally a pin can vibrate out. The odds of two pins vibrating out are reduced if the pins are installed in opposite directions.

Check the Noggin mounting pins after each survey session to ensure they are still properly installed, and the Noggin is secure.

Noggin Mounting Posts

Once the Noggin is installed on the SmartChariot, use the hex (Allen) key provided to tighten the four set screws in the Noggin Mounting Posts that attach the Noggin to the Hanger Kit. In SmartChariot applications, tighten the screws to prevent the mounting post from rotating which may cause the set screw to vibrate out. If a thread lock compound is applied, a semi-permanent type is recommended.

Check that the set screws are secure after every survey.

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, Section 6.8.1. This causes the screen to scroll more slowly, making the data image more visible.

Skipped Traces

The system will occasionally skip traces, especially when you are using a GPS. The point is that typically only a few traces will be skipped but thousands will be collected so it's not usually a major issue. For an explanation of skipped traces, see Show Skips under Line Options.

2.6.13 Dual Channel System on a SmartChariot

When running a SmartChariot with two Noggin systems (Noggin 500 and Noggin 1000), mount the Noggin 500 in front of the Noggin 1000 on the SmartChariot. Since Noggin 500 hangers are shorter than Noggin 1000 hangers, the Noggin 500 will not swing back and hit the Noggin 1000 during system operation (Figure 2-81). Mounting a Noggin 1000 in front of a Noggin 500 can result in the Noggin 1000 hitting the Noggin 500 while moving forwards, potentially damaging the unit.

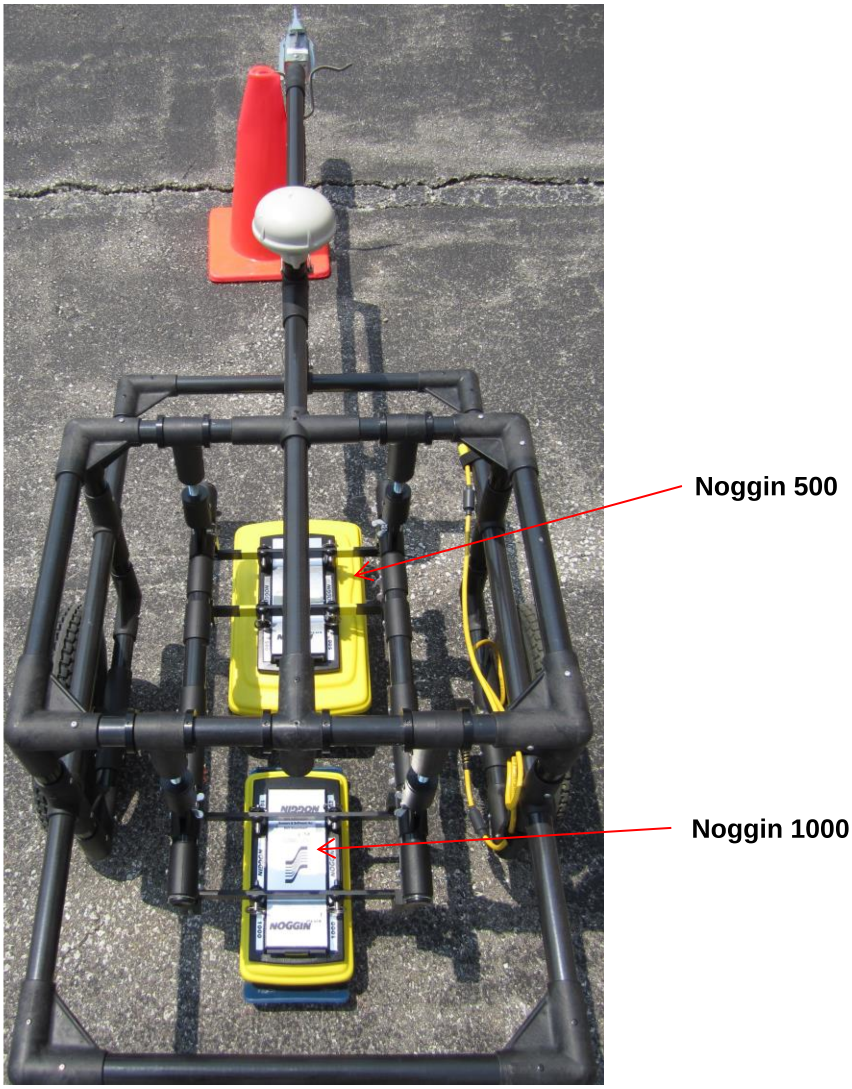


Figure 2-81: Dual channel setup, showing Noggin 500 and Noggin 1000

Odometer

Since the SmartChariot has only one odometer output, running dual Noggin systems means you must split the odometer to trigger both Noggins. Use a custom odometer splitting cable to split the odometer to trigger both systems.

2.7 Assembling the SmartSled

The SmartSled allows users to deploy their GPR systems in rough terrain environments where the other configurations may be not suitable. The SmartSled supports Noggin GPR sensors with the following antenna frequencies: 250, 500, 1000 MHz.

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
- Wheel odometer (optional)
- 1 m Odometer extension cable (optional)
- TopCon GPS receiver (optional)

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 2-82).

Figure 2-82: Remove locking pins

On the front of the sled, slide the tow bar into the slots as shown in Figure 2-83, then insert and close the locking pins that were previously removed in Figure 2-82.

Figure 2-83: 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 2-84).

Figure 2-84: Clam-style vehicle hitch

A fully assembled SmartSled is shown in Figure 2-85.

Figure 2-85 – Fully assembled SmartSled

To begin assembly, place the anti-skid mat in the center of the sled, as shown in . 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 2-86: Anti-skid mat

The details for connecting each of the Noggin GPR sensors are described below.

2.7.1 Noggin 250

Place the Noggin 250 on the anti-skid mat, centered in both directions, ensuring the cable connector is facing the front of the sled. Route the ratchet straps over the Noggin 250 as shown in Figure 2-87. Tighten the straps using the ratchet mechanism (use of ratchet straps are described in Section 2.7.6).

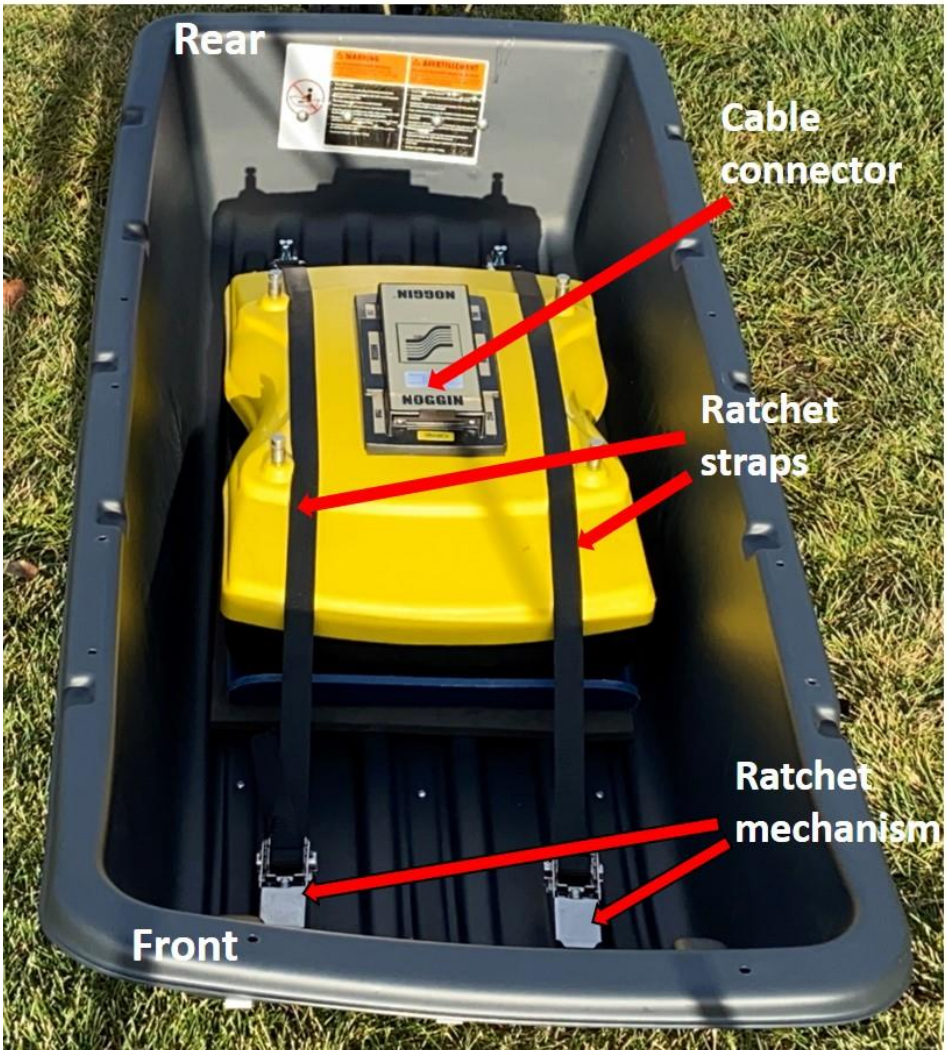


Figure 2-87: Noggin 250 secured with ratchet straps

Secure the mounting plate as shown in Figure 2-88. 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 2.7.4.

Insert the Noggin cable into the cable connector on the Noggin GPR. As illustrated in Figure 2-88, secure the Noggin cable to the mounting plate using the Velcro straps provided. The mounting plate has oval shaped cut-outs for the Velcro straps. Route the cable under the locking pin, as it makes it way towards the front of the sled. Cable management is described in detail Appendix G:.

If you are using the wheel odometer, connect the yellow odometer extension cable to the Noggin cable connector, as shown in Figure 2-88. Loop and secure any excess cable with the Velcro straps. The wheel odometer is described in Section 2.7.5.

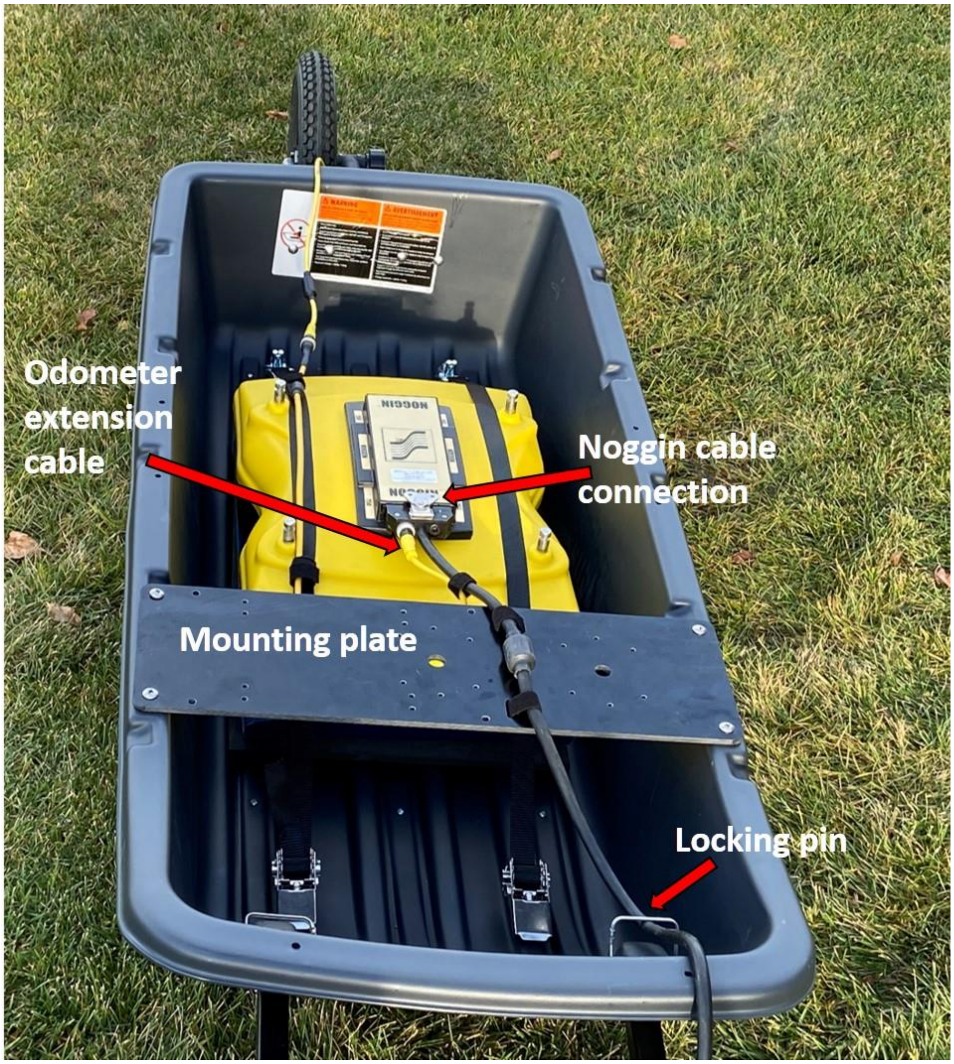


Figure 2-88: Inserting Noggin cable and routing towards the front of the sled

Proceed to Section 2.7.4 to continue with the remainder of the assembly.

2.7.2 Noggin 500

Place the Noggin 500 on the anti-skid mat, centered in both directions, ensuring the cable connector is facing the front of the sled. Route the ratchet straps over the Noggin 500 as shown in Figure 2-89. Tighten the straps using the ratchet mechanism (use of ratchet straps are described in Section 2.7.6).

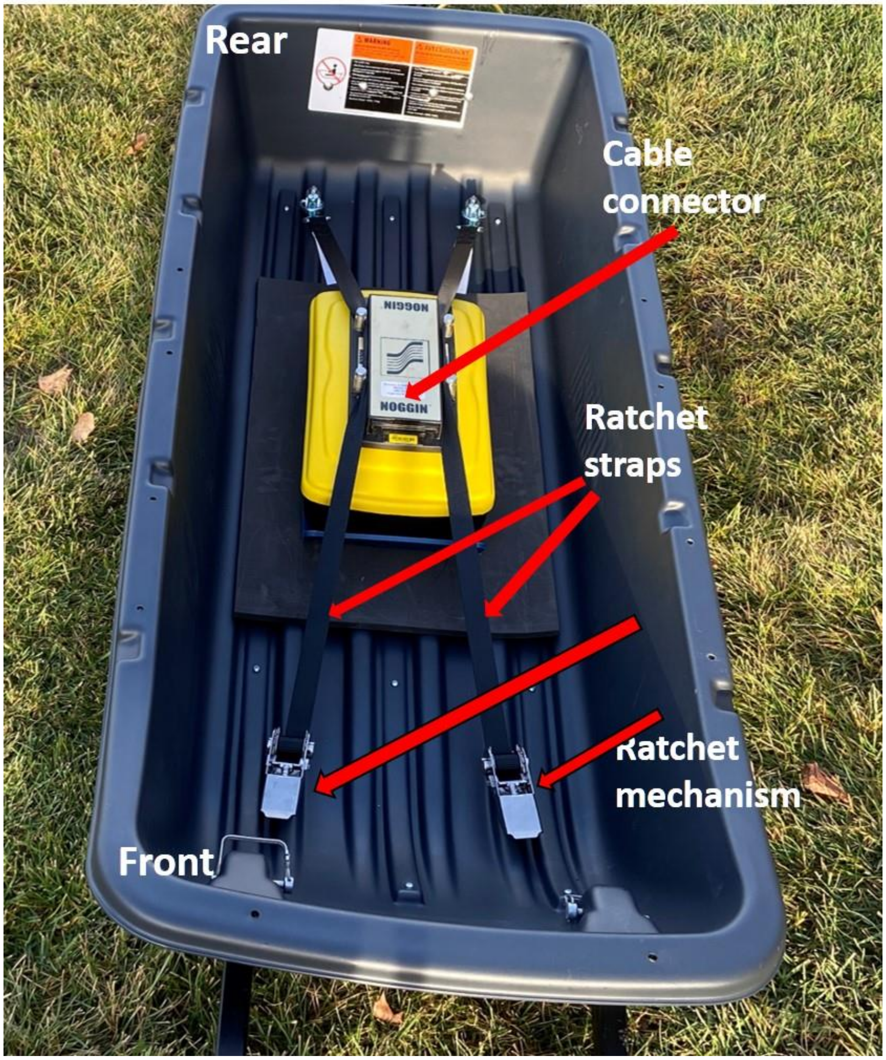


Figure 2-89: Noggin 500 sensor secured with ratchet straps

Secure the mounting plate as shown in Figure 2-90. 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 2.7.4.

Insert the Noggin cable into the cable connector on the Noggin GPR. As illustrated in Figure 2-90, secure the Noggin cable to the mounting plate using the Velcro straps provided. The mounting plate has oval shaped cut-outs for the Velcro straps. Route the cable under the locking pin, as it makes it way towards the front of the sled. Cable management is described in detail in Appendix G:.

If you are using the wheel odometer, connect the yellow odometer extension cable to the Noggin cable connector, as shown in Figure 2-90. Loop and secure any excess cable with the Velcro straps. The wheel odometer is described in Section 2.7.5

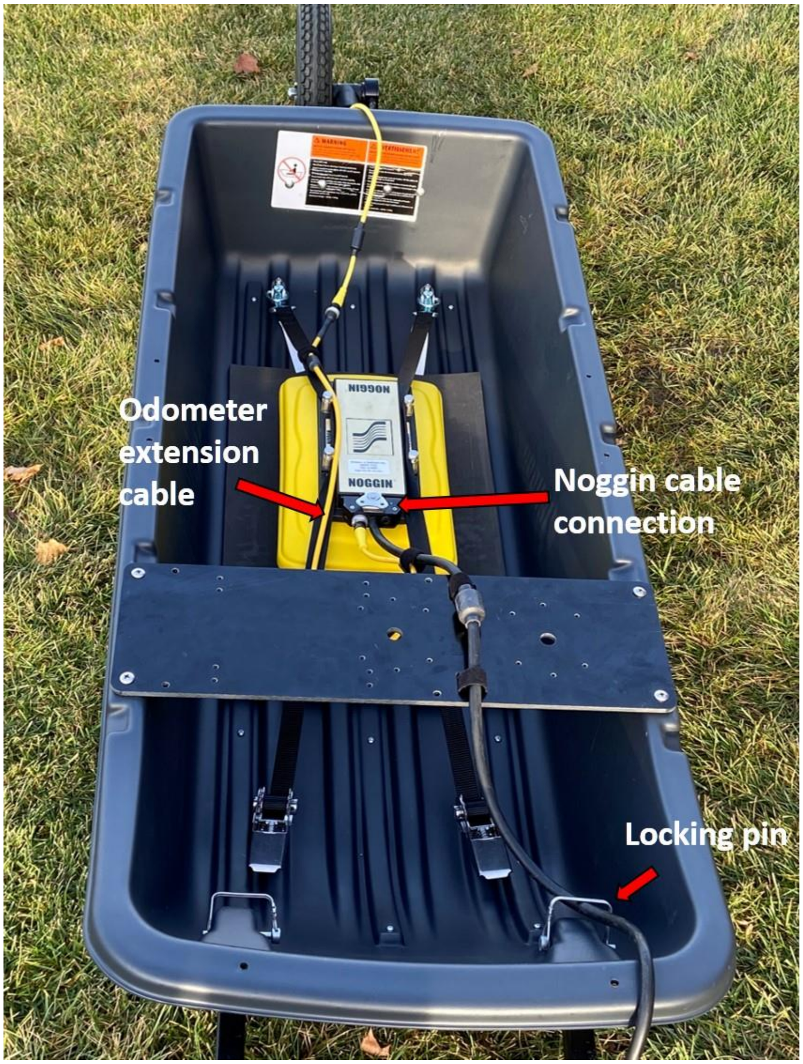


Figure 2-90: Inserting Noggin cable and routing towards the front of the sled

Proceed to Section 2.7.4 to continue with the remainder of the assembly.

2.7.3 Noggin 1000

Place the Noggin 1000 on the anti-skid mat, centered in both directions, ensuring the cable connector is facing the front of the sled. Route the ratchet straps over the Noggin 1000 as shown in Figure 2-91. Tighten the straps using the ratchet mechanism (use of ratchet straps are described in Section 2.7.6).

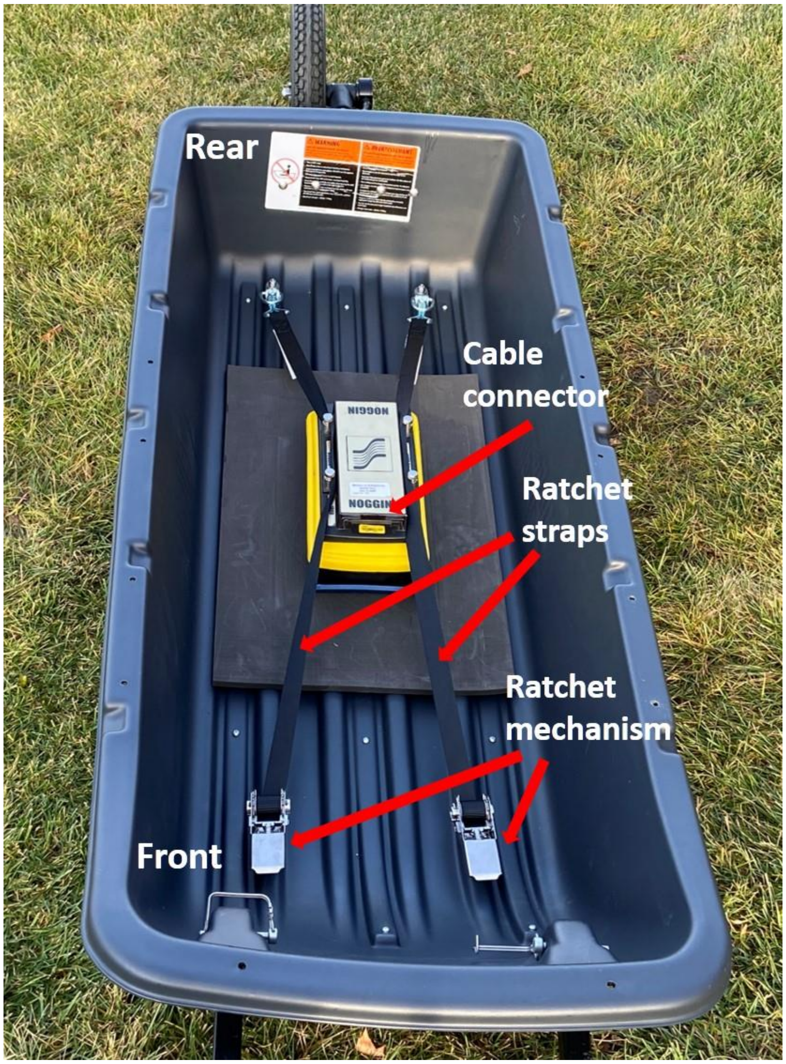


Figure 2-91: Noggin 1000 sensor secured with ratchet straps

Secure the mounting plate as shown in Figure 2-92. 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 2.7.4.

Insert the Noggin cable into the cable connector on the Noggin GPR. As illustrated in Figure 2-92, secure the Noggin cable to the mounting plate using the Velcro straps provided. The mounting plate has oval shaped cut-outs for the Velcro straps. Route the cable under the locking pin, as it makes it way towards the front of the sled. Cable management is described in detail in Appendix G:.

If you are using the wheel odometer, connect the yellow odometer extension cable to the Noggin cable connector, as shown in Figure 2-92. Loop and secure any excess cable with the Velcro straps. The wheel odometer is described in Section 2.7.5.

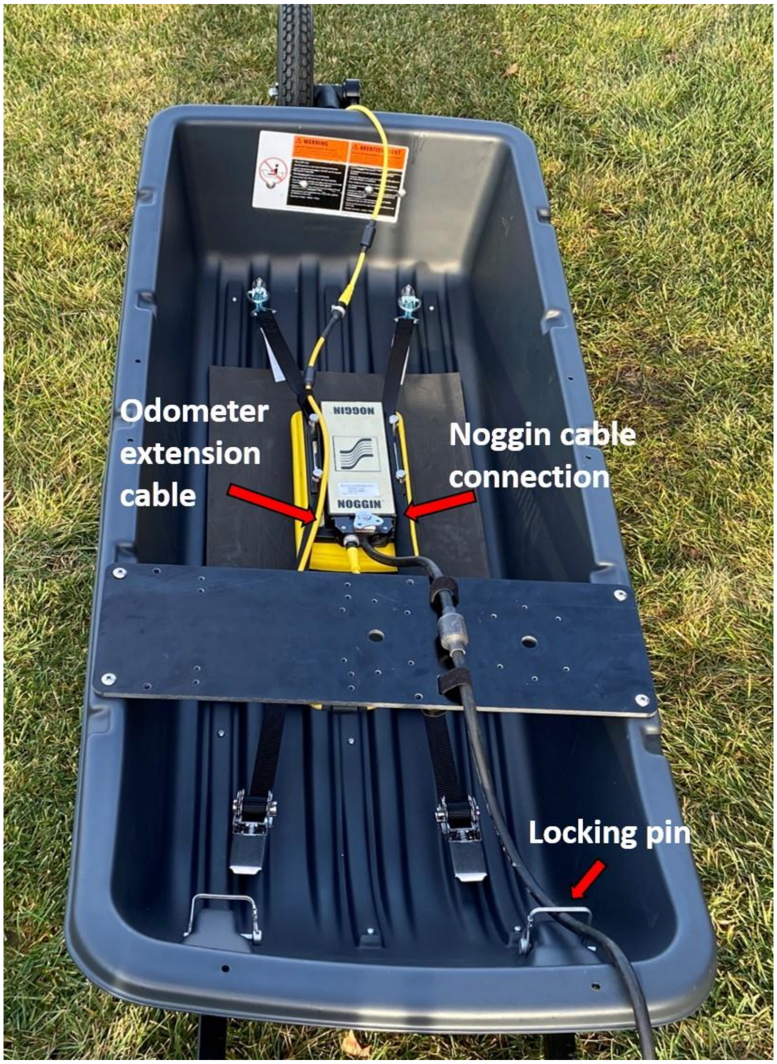


Figure 2-92: Inserting Noggin cable and routing towards the front of the sled

Proceed to Section 2.7.4 to continue with the remainder of the assembly.

2.7.4 Mounting Plate & GPS

The mounting plate (Figure 2-93) is used to hold a GPS and if required, a NIC-500.

Figure 2-93: 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.

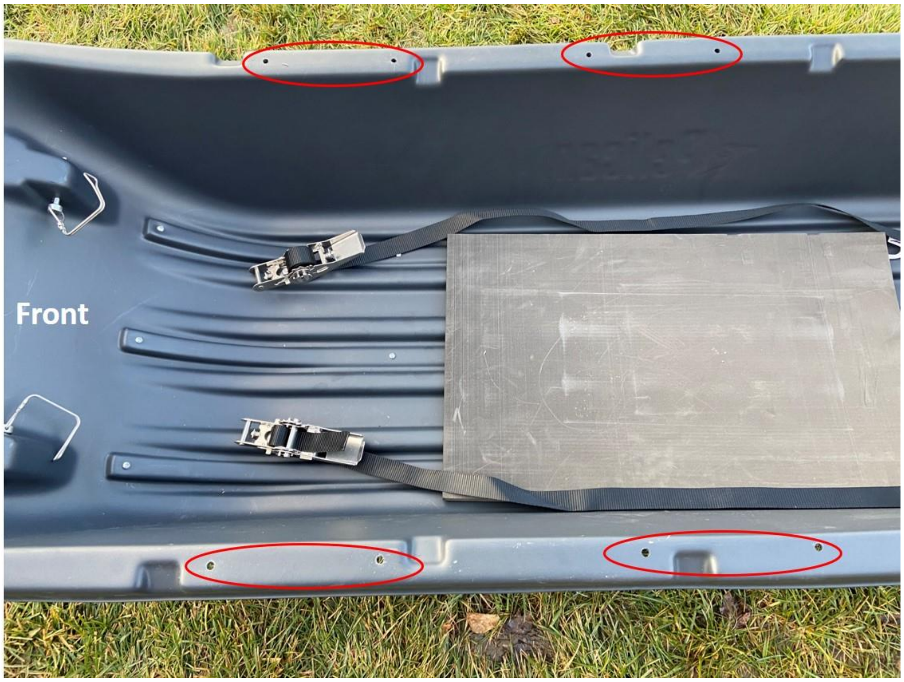


Figure 2-94: Two possible locations to attach the mounting plate

To attach the optional GPS supplied by Sensors & Software, line up the holes on the underside of the GPS (Figure 2-95) with the small pre-drilled holes in the mounting plate. Attach the GPS receiver to the mounting plate using the screws and washers. The completed setup in shown in Figure 2-96.

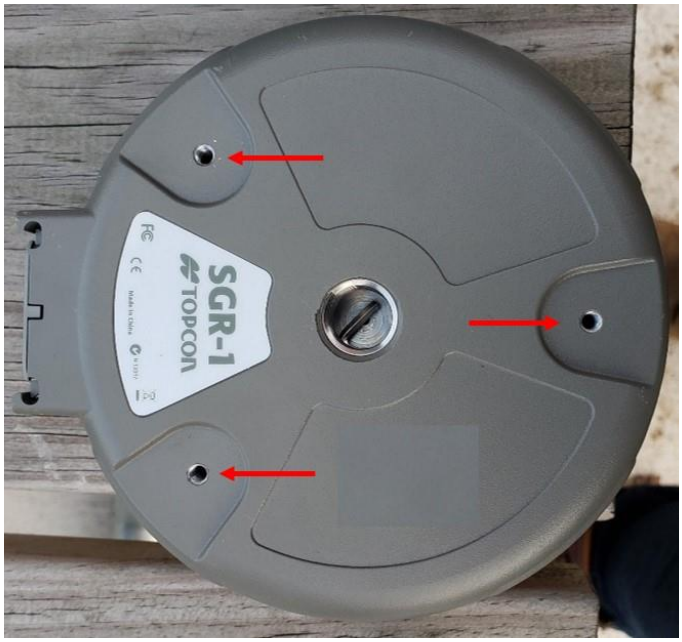


Figure 2-95: Underside of GPS showing the 3 holes for mounting

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 2-96: 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 2-97.

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. Cable management is described in detail in Appendix G:.

Figure 2-97: 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 2-98. For SPIDAR systems, contact Sensors & Software to discuss specific details about mounting and cable connections.

Figure 2-98: SPIDAR NIC and GPS connected to mounting plate

2.7.5 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 2-99, along with the 1 m long odometer extension cable.

Figure 2-99: 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 2-100. Insert pins from the top down, to minimize the chance of them becoming loose, due to vibration when surveying.

Figure 2-100: Attaching the wheel odometer assembly

The completed assembly is shown in Figure 2-101.

Figure 2-101: 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 on the Noggin cable connector (Figure 2-102). If there is excess cable, it should be secured with Velcro, to prevent unnecessary movement. Cable management is described in detail in Appendix G:

Figure 2-102: Yellow odometer extension cable is connected to the Noggin cable

2.7.6 Using the Ratchet Straps

Ratchet straps are a fastening method to secure various types of cargo (Figure 2-103). In SmartSled, ratchet straps are used to secure the GPR sensor so it does not shift while surveying.

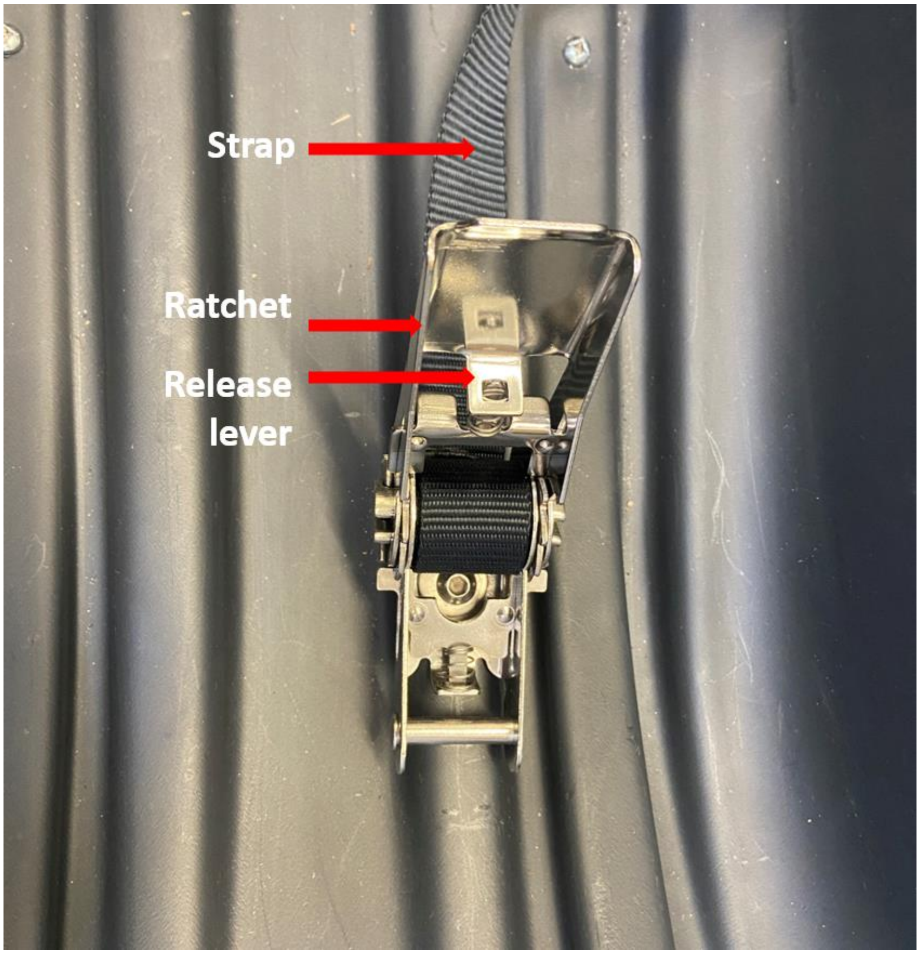


Figure 2-103: Parts of the ratchet mechanism

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, or the GPR. Once the GPR feels secure, stop ratcheting and close the ratchet (Figure 2-104) to ensure it doesn't loosen.

Figure 2-104: 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 2-105).

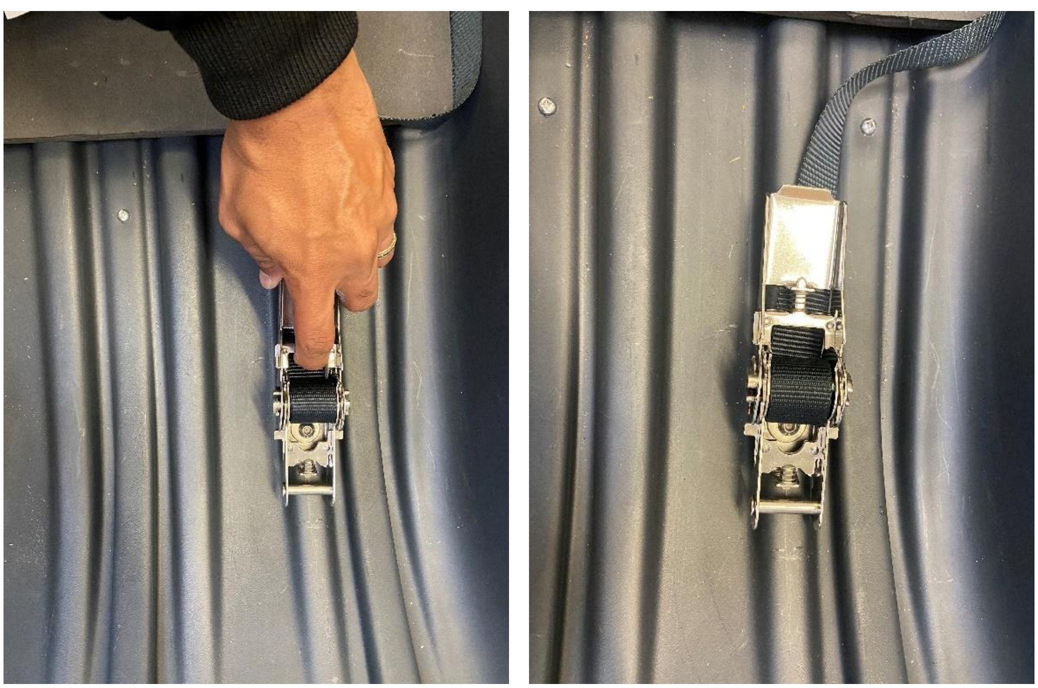


Figure 2-105: Pulling on the release lever (Left) and completely opening the ratchet (Right)

2.7.7 Operation & Tips

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

- If you are using the wheel odometer, on the DVL under Noggin setup, set the Trigger method to Odometer. Ensure SmartTow is selected as the odometer type. 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.
- 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.

2.8 Multi-Channel Applications

Multiple Noggin sensors can be connected together using the SPIDAR architecture. SPIDAR allows any number of Noggin sensors to be linked, enabling simultaneous data collection (Figure 2-106). A user might want to connect the same sensors side-by-side, in order to collect a wide swath of data. Or they may want to connect Noggin with different center frequencies in order to collect shallow and deep data in a single pass. For more information on SPIDAR, please contact Sensors & Software (www.sensoft.ca).

Figure 2-106: Multi-Channel SPIDAR system, with 3 x Noggin 250

2.9 Connecting an External GPS (optional)

If you have purchased the Trimble AG-200 GPS from Sensors & Software, this can be screwed onto the threads (5/8-11 UNC-1A thread) at the top of the GPS mount. Ensure that you use the cable labeled AG-200 that comes with the Trimble GPS; do not use any other cable, as the internal wiring is different and could damage the Trimble AG-200 GPS. Connect the 90º end of the GPS cable to the GPS receiver, and the other end to the serial port on the back of the display unit. This single cable powers the GPS and receives data from it. Ensure that the Display Unit is powered down when connecting or disconnecting the GPS cable.

The Trimble AG-200 GPS is pre-configured to communicate with the DVL, and no further changes are required. Should some of the settings change, the default settings are as follows:

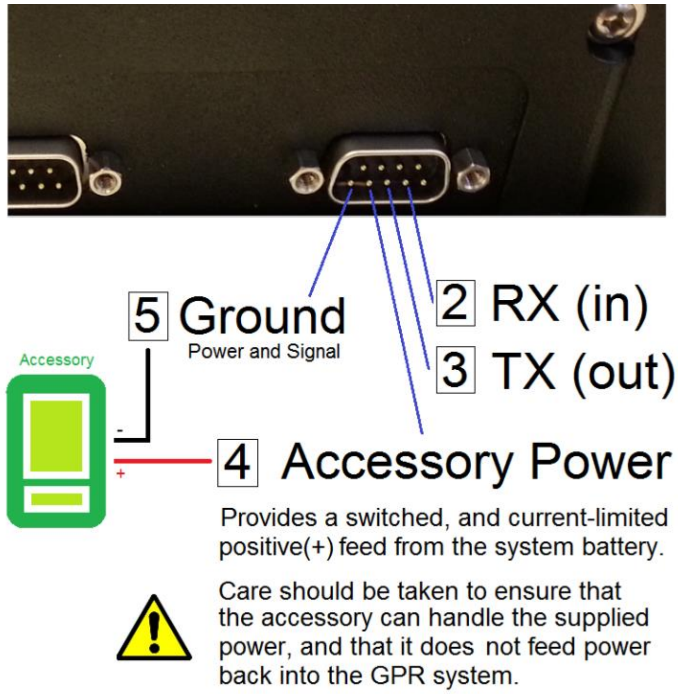
- Baud Rate = 19200
- Saved Strings = CGA only

To connect and utilize a 3rd party GPS with the Noggin 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.
- GPS must not expect any handshaking from the DVL

NOTE: Since the serial port of the Display Unit outputs power (current=1A, voltage=12V), it is the responsibility of the user to confirm with the GPS manufacturer that the serial cable does not provide power to the GPS or that the GPS will accept 12V power from our serial cable on the pins shown above. Sensors & Software is not responsible for damage caused to a GPS from using the serial port.

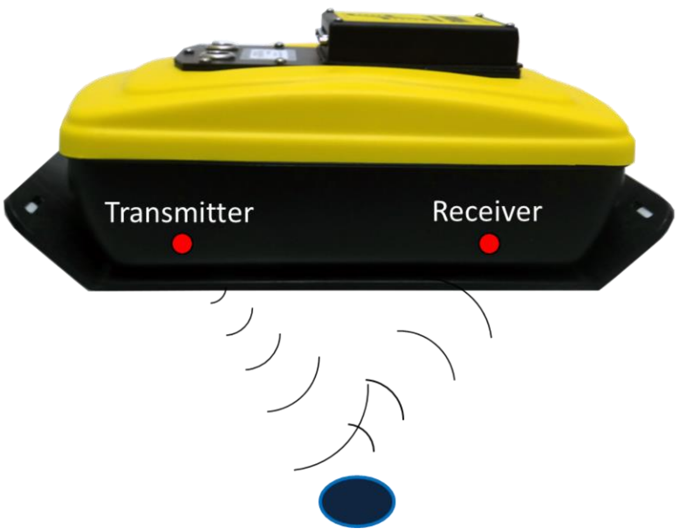
You can enable or disable power to the serial port, see Serial Port Power in 5.2.4.


5 Ground
Power and Signal
2 RX (in)
3 TX (out)
Accessory
-
+
4 Accessory Power
Provides a switched, and current-limited positive(+) feed from the system battery.
Care should be taken to ensure that the accessory can handle the supplied power, and that it does not feed power back into the GPR system.

3. GPR Concepts

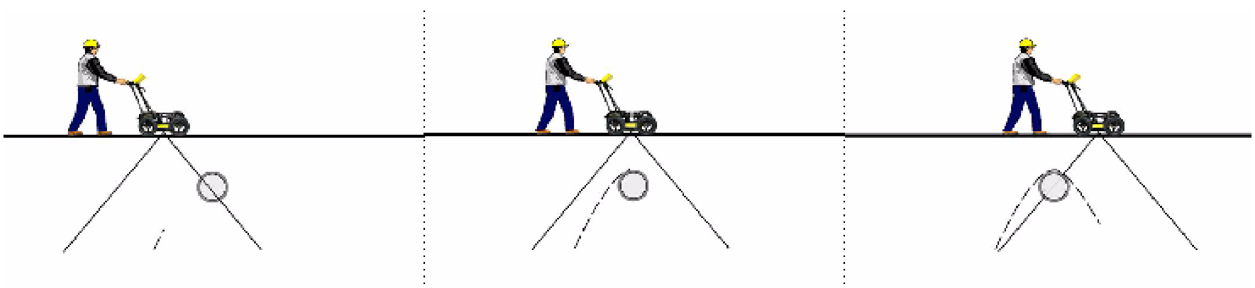
3.1 Theory

Ground penetrating radar (GPR) technology uses radio waves to image objects in the subsurface. The subsurface may consist of soil, rock, asphalt and other materials. GPR systems emit high frequency radio wave pulses and detect the echoes that return from objects within the subsurface. Echoes are produced when the target material is different from the host material (e.g. PVC pipe in gravel)

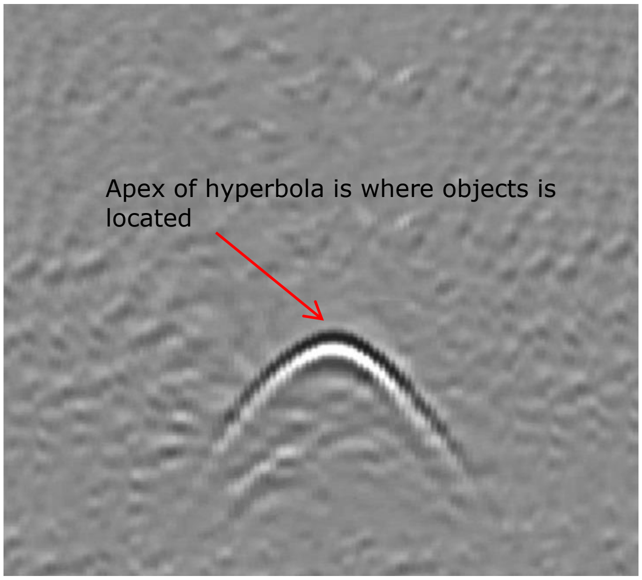


3.2 Hyperbolas

The GPR display shows signal amplitude versus depth (time) and sensor position along a line. This is called a "Line Scan". Since radar energy radiates in a 3D cone shape rather than a thin beam, a ***hyperbola*** (or inverted U) is the GPR response from a small point target or linear target (crossed perpendicularly) like a pipe, rock, or a tree root. The radar wave hits the object before and after going over it and forms a hyperbolic reflection that can appear on the record even though the object is not directly below the radar:



Hyperbolas are best viewed when subsurface targets are crossed perpendicularly (at a 90-degree angle). The actual position of the object is located at the apex of the hyperbola.



3.3 Calculating Depth

Ground penetrating radar records the time it takes a radio wave to travel to a target and back; it does not measure the depth to that target directly. Depth to target is calculated based on the velocity with which the wave travels to the target and back.

To calculate depth:

$$D = V\ x\ T/2$$

$$Where\ D\ is\ Depth$$

$$V\ is\ Velocity$$

$$T\ is\ the\ Two - way\ travel\ time$$

There are a few ways to determine an accurate velocity of the ground:

1. Hyperbola fitting – most often used to determine an accurate velocity of the ground. This requires the user to obtain a hyperbolic response, crossed at a 90-degree angle. Hyperbolas are explained above in Section 3.2.
2. Target at known depth – if you know, or can measure, the depth to a subsurface target, you can set the velocity such that the depth on the screen matches the measured depth. This is also known as "ground-truthing".
3. Soil media – if you don't have any hyperbolic responses, or targets at a known depth, you can estimate the water content of the soil and set soil Media. While not as accurate as the above two, it does get you an approximation. This is explained in Section 5.2.3.

3.4 Velocity values

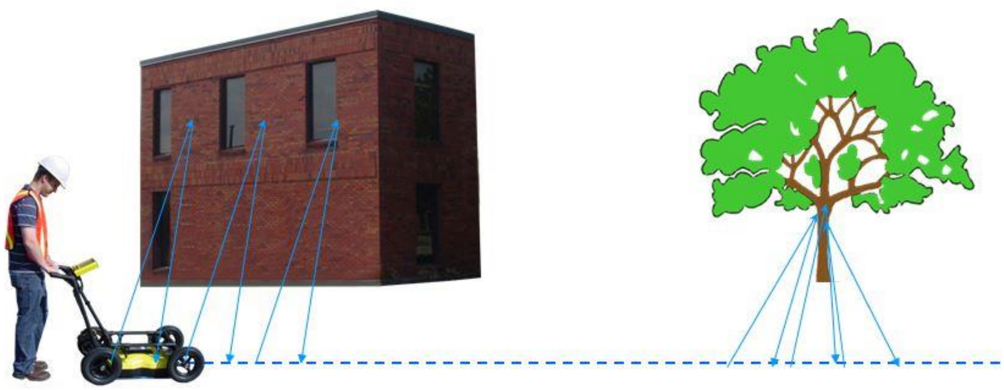
Below is a table of common subsurface materials and their corresponding velocity. This is only a guideline and there is some variation based on the fact that there can be a mixture of different materials in the subsurface. By far, the soil water content has the biggest influence on velocity values.

Material	**Velocity**
Air	300
Ice	160
Dry Soil	140
Dry Rock	120
Soil	100
Wet Rock	100
Concrete	100
Pavement	100
Wet Soil	65
Water	33

3.5 Air Waves

Some hyperbolas are caused by air wave reflections from objects above ground, such as posts, fences, overhead wires, and trees.

The following image displays how air wave reflections affect data:



An important part of understanding the data image is learning to recognize these unwanted "air" targets and distinguish them from the targets in the ground. Good field notes are indispensable for helping identify unwanted events on the data.

The best way to identify air reflections is the target hyperbola method. Hyperbolas from above ground objects are wider than objects in the ground and will have a velocity at, or close to, 0.300m/ns (0.984 ft/ns).

4. Getting Started

4.1 Powering up the Display Unit

Once all connections are made between the Noggin, the DVL, and any accessories (odometer, GPS), connect the system to a 12-volt power source; typically this is either the large battery or the belt battery, pictured in Figure 4-1.

Figure 4-1: Large battery (left) and Belt battery (right)

Connect the Noggin-to-DVL cable round four-pin battery cable to the receptacle on the side of the battery (Figure 4-2). When the battery is first plugged in, the LED goes green for 5 seconds then disappears.

Figure 4-2: Connecting to battery

To start the system, press the **red power button** on the display unit. The LED on the front panel will light up green during boot up (Figure 4-3).

Figure 4-3: Powering up the Display Unit

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

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

The first time you turn on the Display Unit, you will need to configure the system (Figure 4-3). A series of screen prompts will allow you to setup the language, units, date & time, and some other options. You will have to do this again anytime you update the embedded software (Section 14.6). Every subsequent time the system boots up, you will see the main screen (Figure 4-4).

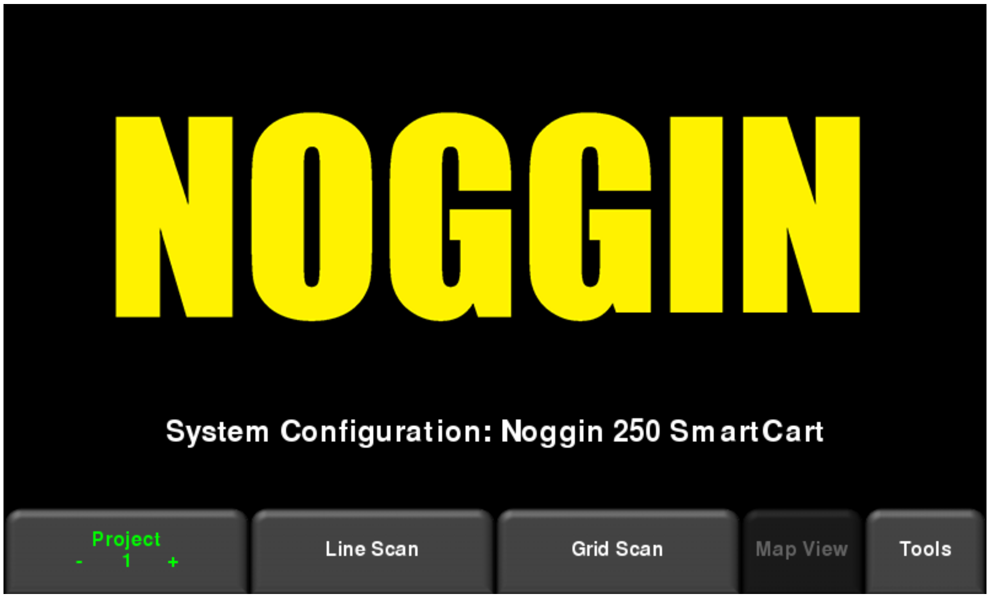


Figure 4-4: Main Screen on bootup

Menu operation is described in Section 5.

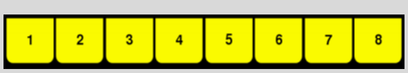
4.2 Shutting down

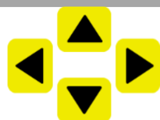
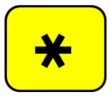
To power down, press the **red power button** on the display unit once. A confirmation message will appear, after which you can press **Yes** to proceed. If necessary, a hard shutdown can be done by pressing and holding the red power button until the unit shuts down.

4.3 Interacting with the Display Unit (DVL)

Data collection is controlled by the Display Unit. The Display Unit has embedded software to set survey parameters and collect, display and store data.
The Display Unit offers touch screen operation, as well as a water-resistant membrane 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 on the Display Unit:

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.

Item	Description
	
Camera 	Saves a screenshot of whatever is displayed on the screen
Asterisk / Special Function 	Used for adding Flags during data acquisition.

4.4 Swipe Down menu

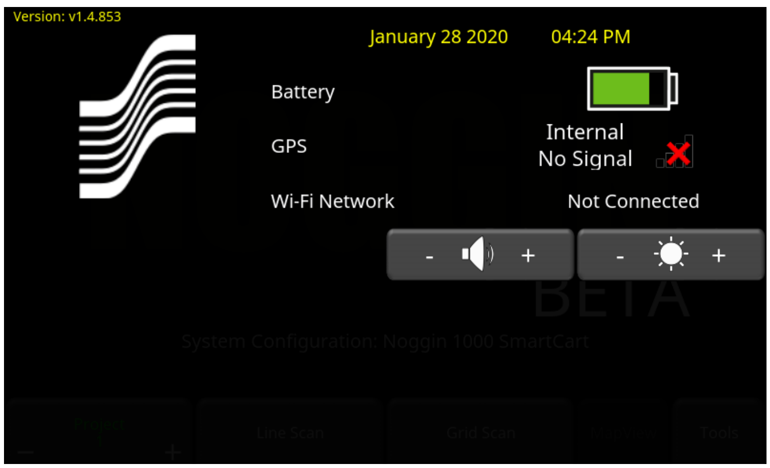


Figure 4-5: Swipe down menu

When the Display Unit is powered on, you can "swipe" your finger from the top of the screen towards the bottom, to display a Swipe-Down menu (Figure 4-5) with the following items:

Date and Time: The current date and time (12-hour clock). The time needs to be changed in areas that observe daylight-savings-time. (See Section 5.3.3 for more details)

Battery: The battery icon displays the amount of power remaining in the battery.

GPS: Shows which GPS is being used (Internal or External) and the signal strength. (refer to Section 5.2.4 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 5.3.6 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.

5. Tools and Setup

5.1 Main Screen

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

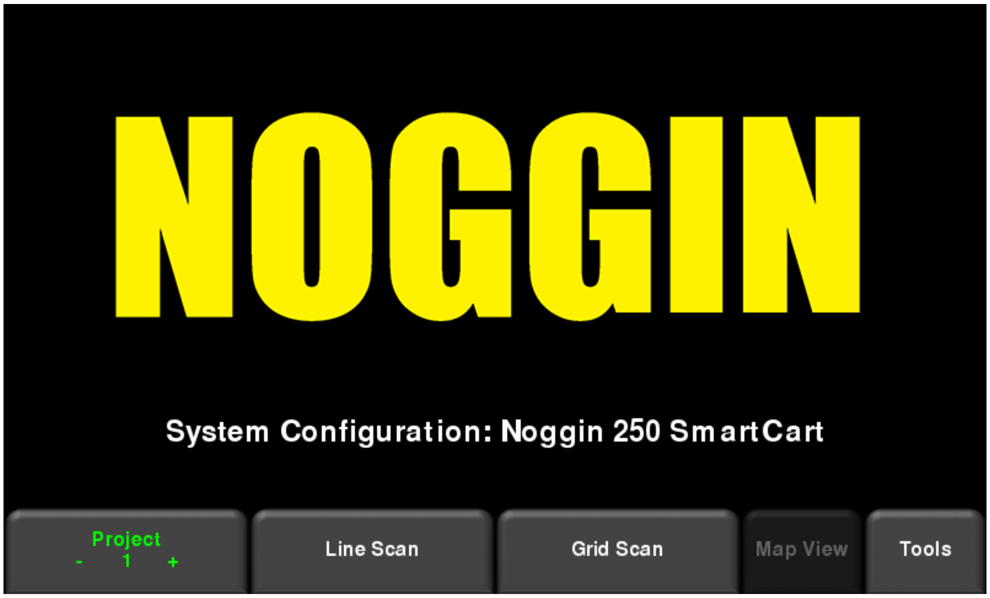


Figure 5-1: Noggin main screen

The main screen indicates the type of Noggin sensor (automatically detected) and the type of configuration (which is set in the Tools menu).

On the bottom menu, the left button indicates the current project number. A project will contain all data (lines, grids, interps, screenshots etc.), typically collected at the same site. Projects that contain data are in red color, whereas those with no data are in green.

Press the **–** and **+** buttons to change projects; there are 9 projects in total along with a special Demo project containing demo data (Lines & Grids). As you change projects, it will display the number of lines and grids collected in each project, under the Line Scan and Grid Scan buttons respectively. Line Scan, Grid Scan and MapView are described in later sections.

Press **Tools** to enter this sub-menu. You will see the screen shown in Figure 5-2. Here you can set preferences, adjust system settings, perform system tests and manage files.

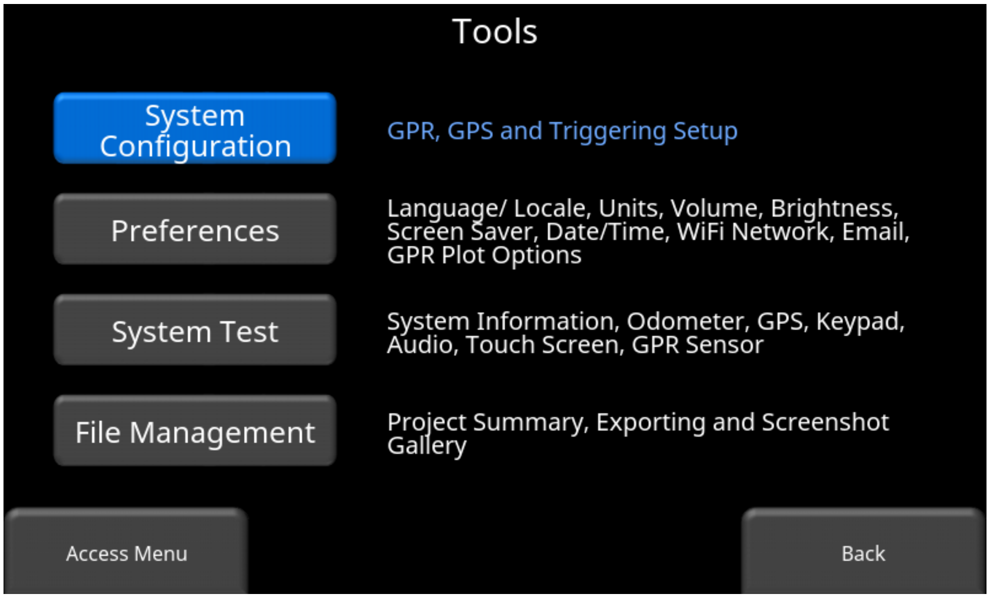


Figure 5-2: Tools menu

5.2 Systems Configuration

Press **System Configuration** to enter the menu shown in Figure 5-3.

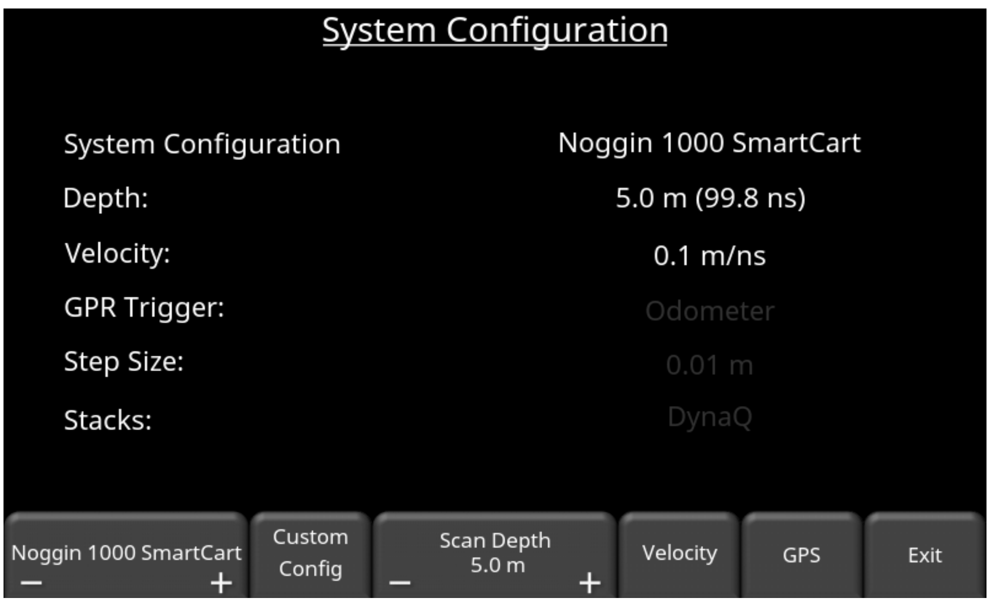


Figure 5-3: System Configuration menu

From here, the following settings can be changed:

5.2.1 System Configuration

The software will auto-detect which Noggin system is connected. This will be either the Noggin 1000, Noggin 500, Noggin 250, Noggin 100 or the Noggin Ultra 100. The Noggin Ultra 100 allows the user to acquire data thousands of times faster than the Noggin 100. This increased speed allows the user to stack up to 65,536 times, resulting in a reduction of the noise floor which can improve the depth of penetration in certain conditions. Stacks are explained in Section 5.2.7.

There are several configurations of a Noggin system, but this is not auto-detected. On the bottom of the screen, pressing the **+** and **–** buttons will cycle between the configurations described in Section 2 (SmartCart, SmartTow, SmartHandle, SmartChariot and Custom Configuration). This will set the appropriate odometer calibration value, since the odometers are different for each configuration.

Note that some systems/configuration combinations are not possible, and will not show up as options:

a) The SmartHandle configuration will only appear if a Noggin 500 or 1000 is detected

b) The SmartChariot will not appear if a Noggin 100 is detected

5.2.2 Scan Depth

Pressing the **+** and **–** buttons under Scan Depth will change the depth during data collection. This will apply to both Line Scan and Grid Scan modes. Note that setting a deeper depth value does not mean that you will necessarily see deeper; this just opens the recorded time window for that depth (which is displayed in brackets beside the depth setting). In general, you should set your scan depth for 1.5 – 2 times the expected depth of the deepest target.

The maximum depths that can be set are:

- Noggin Ultra 100 = 50m (150 feet)
- Noggin 100 = 50m (150 feet)
- Noggin 250 = 30m (100 feet)
- Noggin 500 = 20m (75 feet)
- Noggin 1000 = 10m (30 feet)

Higher depths can be set under Custom Configuration (Section 5.2.8).

Section 6.8.1 explains how you can zoom in on your depth during data collection in Line Scan mode. Note that when you export data, the Zoomed depth is used, rather than the depth set here. For example, the user sets a scan depth of 4m, but then zooms in to display 2m in Line Scan mode. The exported data will only have a depth of 2m.

5.2.3 Velocity

Pressing **Velocity** displays a screen (Figure 5-4) where you can set the GPR wave velocity.

- If you know the type of soil, you can press the pre-set velocity values on the main screen.
- If you know what the velocity should be, you can use the four left buttons on the bottom menu to change the velocity value manually.

- If you have an idea of the water content of the soil, you can press the **Media** button, which cycles between: water, wet soil, moist soil, dry soil, very dry soil and air.

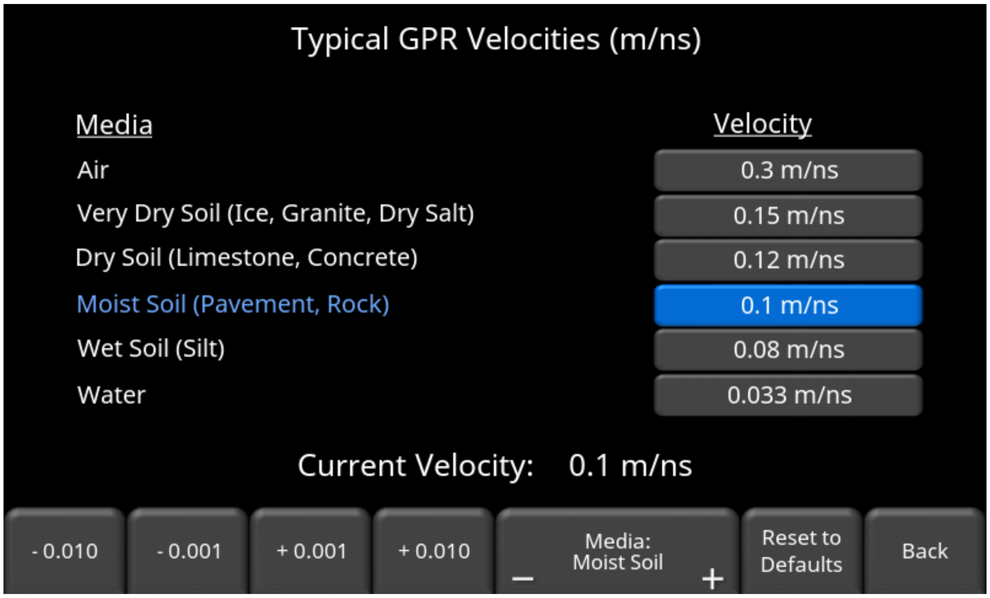


Figure 5-4: Table of approximate velocity values (units of metres shown)

5.2.4 GPS

The DVL contains an internal GPS, but you also have the option to purchase an external GPS receiver from Sensors & Software. Alternatively, you may have your own GPS that you want to connect to the Noggin system. Pressing **GPS** from the System Settings menu takes you to the GPS menu (Figure 5-5) where you can configure some options. The GPS mode option will determine what the main screen looks like:

- **GPS Mode** –you can select whether to use the internal GPS, external GPS, or no GPS at all (Off).
    - The Internal GPS is used to position Grid Scans and screenshots. **The Internal GPS cannot be used to position Line Scans.**
    - If you select the External GPS, you will see the additional options shown in Figure 5-5:

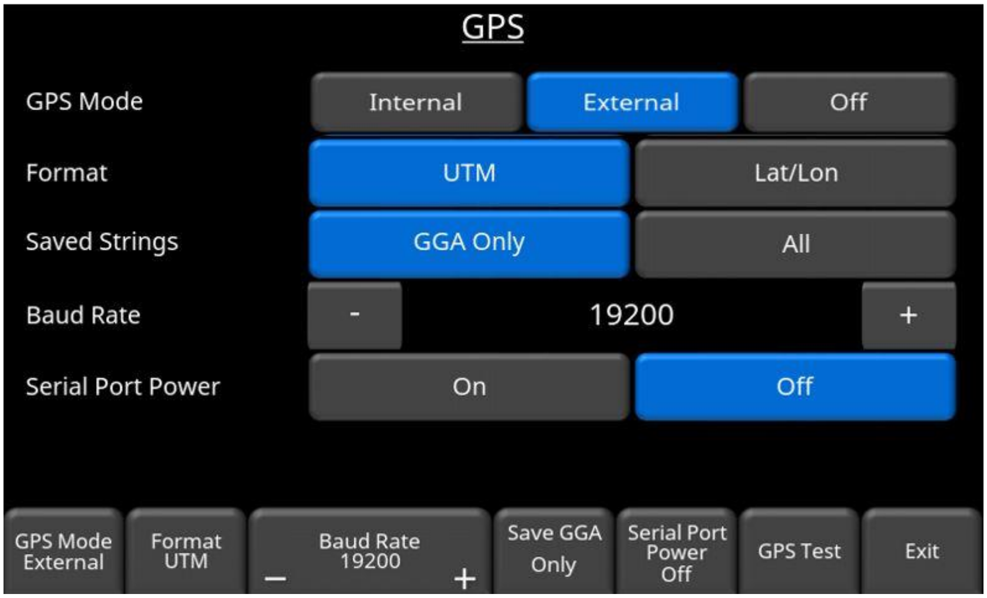
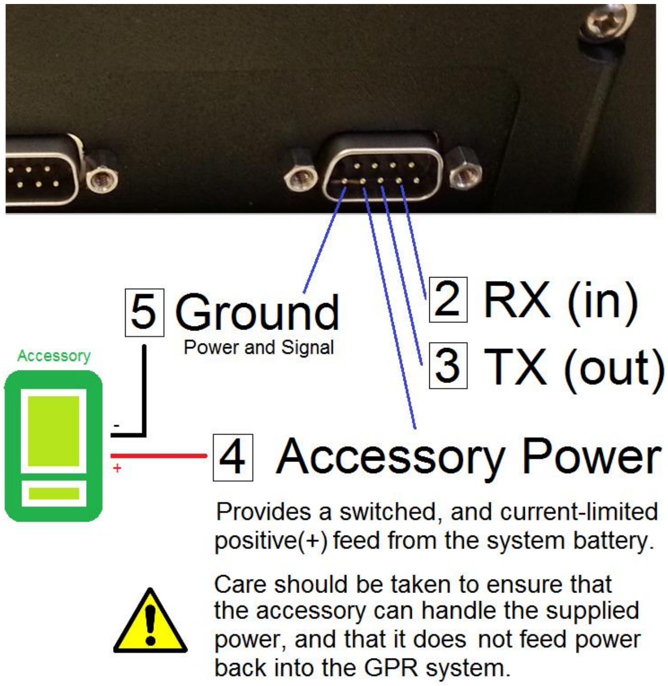


Figure 5-5: GPS Setup menu

- **Baud Rate –** set the baud rate for your GPS to communicate with the DVL.
- **Saved Strings –** the GPS 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 GPS 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 output power, thereby enabling a single cable to be used for the GPS (power and data). When you purchase the GPS from Sensors & Software, this is already configured. However, if you use a 3rd party GPS, you need to determine if it can accept power via the serial port.

Important: Since the serial port of the Display Unit outputs power (current=1A, voltage=12V), be very careful if connecting other GPS units to the serial port. Verify the pins on the drawing below.



Pressing the **Serial Port Power** button will turn power to the serial port on, but it will display a warning message first (Figure 5-6).

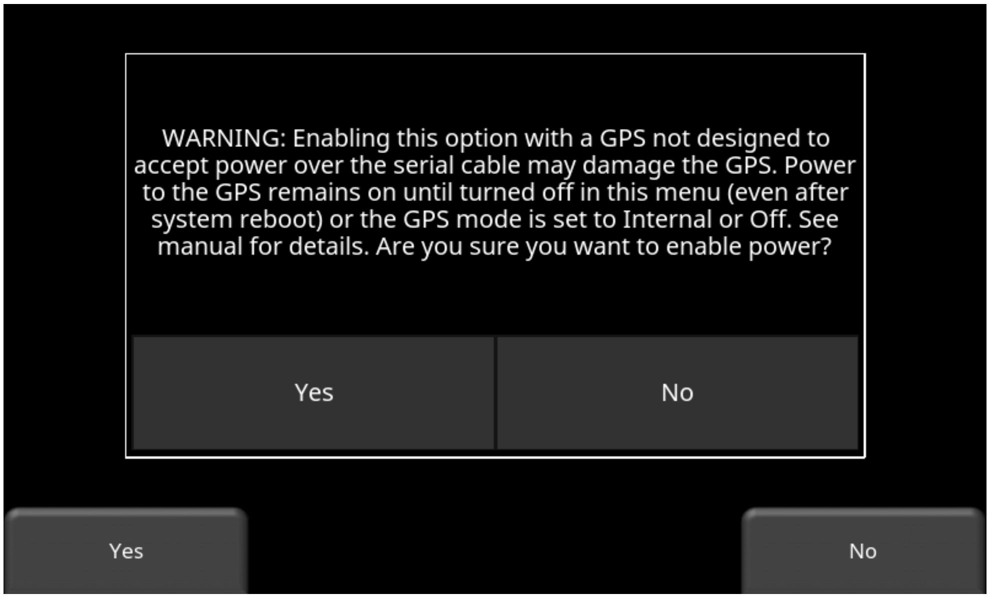


Figure 5-6: Warning message about enabling power to the serial port

- **Format** – GPS units can be either UTM (Universal Transverse Mercator) or Latitude/Longitude coordinates
- **GPS Test** – This test confirms proper operation of the GPS (see GPS in Section 5.2.4 for details)

5.2.5 Custom Configuration

There may be times when you need to override some of the common settings. You can customize some additional settings, which get saved under the newly created Custom configuration.

When the system is first used, and you are cycling through the different configurations there will not be a Custom option. However, if you press the **Custom Config** button, you will see the messages in Figure 5-7. These messages are only displayed the first time you create a Custom configuration. Press **OK** and you will now see the screen in Figure 5-8.

As you are cycling through the different configurations using the **+** and **-** buttons, you will now see Custom as an option. When Custom is selected, you can Edit these settings by pressing the **Edit** button.

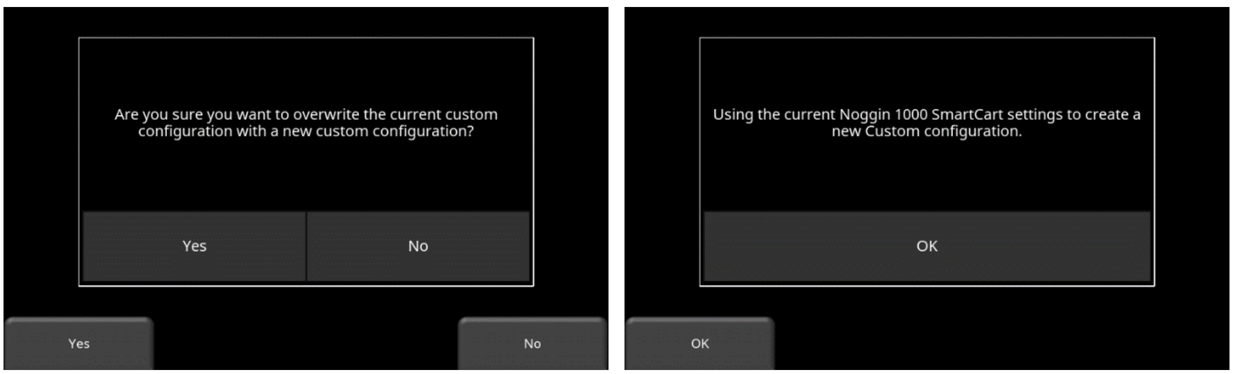


Figure 5-7: Messages displayed when initially creating a Custom configuration.

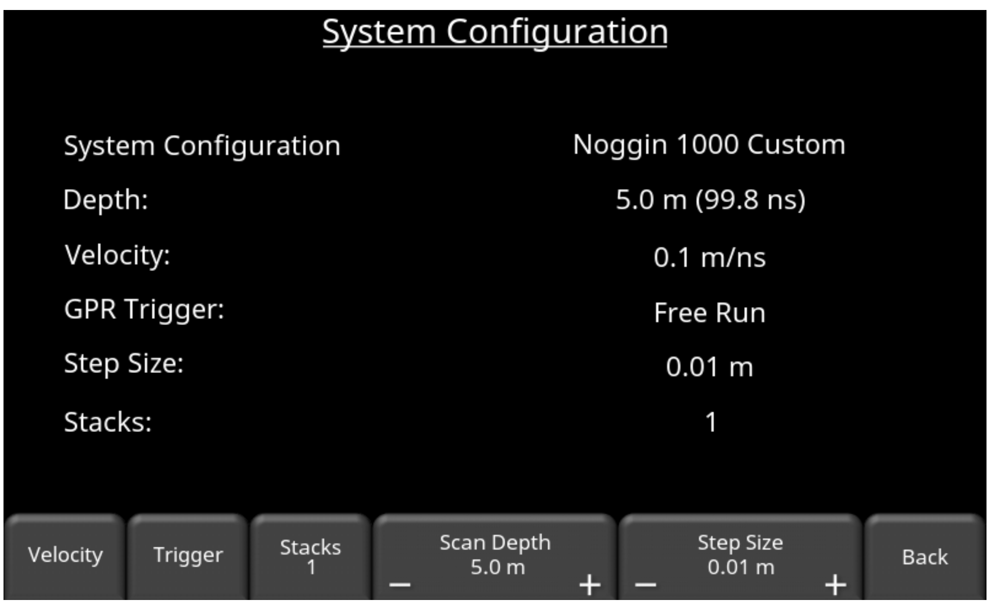


Figure 5-8: Custom Config menu

5.2.6 Trigger

Pressing this button takes you into the Trigger Method menu, Figure 5-9. This menu allows you to set various options that control the way the Noggin is pulsed. The system can be triggered to pulse the GPR in different ways. The most common is via the odometer, but there are other ways. Pressing the + and – buttons under Trigger changes the method, as well as the bottom menu options. Each is explained in detail below:

- **Free Run** – in some cases, collecting data with an odometer is not practical or even possible. Free run mode will allow the Noggin to pulse based on a specified trace interval or pulse continuously (zero delay, shown in Figure 5-9). The trace interval (time between trace collections) can be varied from a little as 0.01s up to 60s.

  The user has the option to control the trace interval or the travel *speed*, such that the programmed step size (*distance*) is maintained. For example, if step size is 0.01m, and the user sets a trace interval of 0.1s, they must collect data at 0.36 km/h, as illustrated in Figure 5-10. This time-speed pairing will also vary as stacks and scan depth are changed.

  > **Note**: If the trace interval and speed value are coloured in red, it means that it's too fast for the system to collect (Figure 5-11). When entering Line Scan mode, it will display a warning message that will only allow you to collect in continuous mode (Figure 5-12).

  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 towing speed usually varies. It is a best practice to have a secondary means of positioning the data, for example, a GPS or adding Flags at known positions along the survey line. Note that the user cannot collect a grid when free run mode is set.

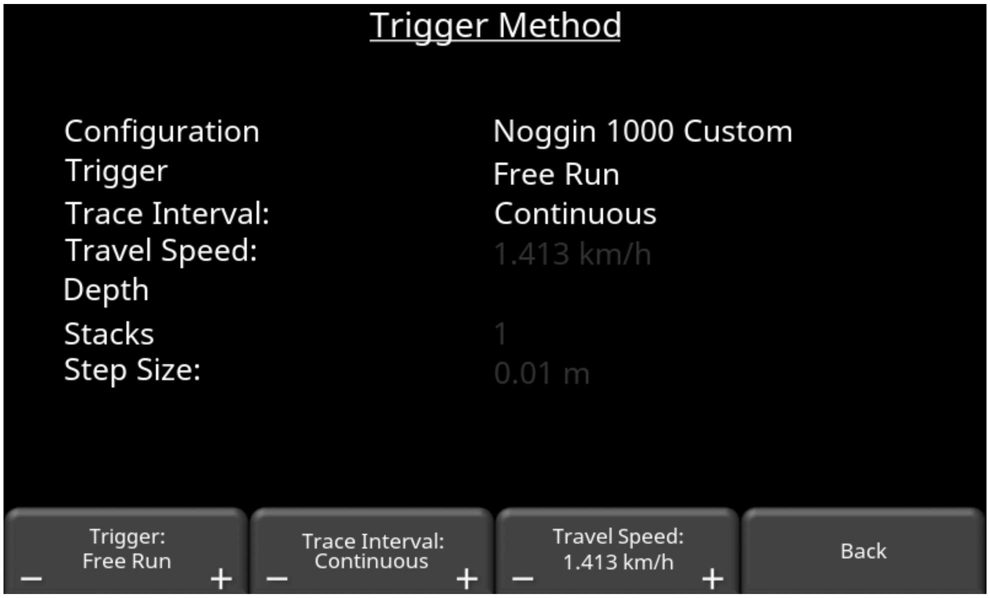


Figure 5-9: Triggering Method menu, currently set to Free Run continuous mode

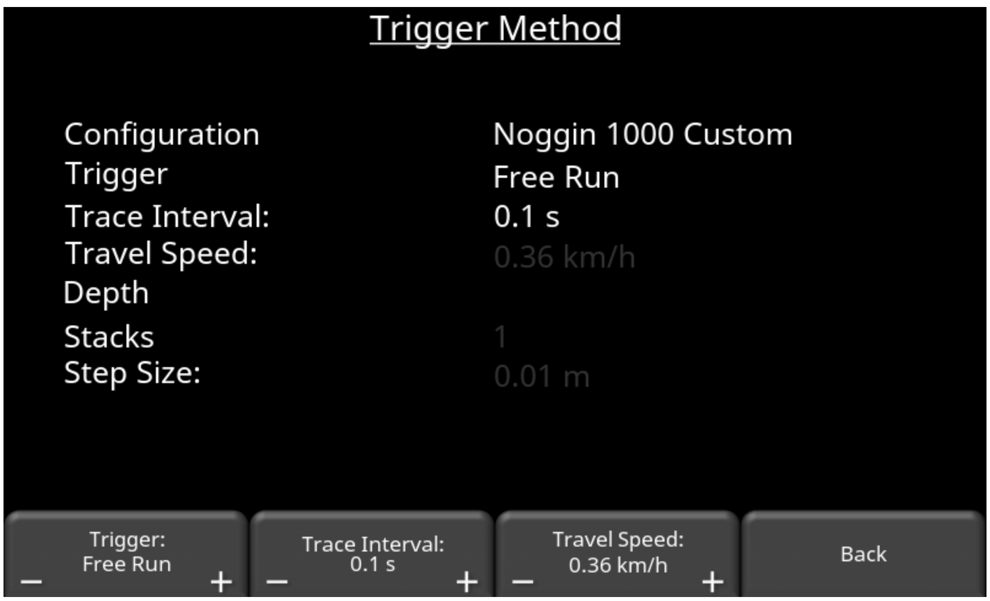


Figure 5-10: Free Run mode, with a trace interval of 0.1s

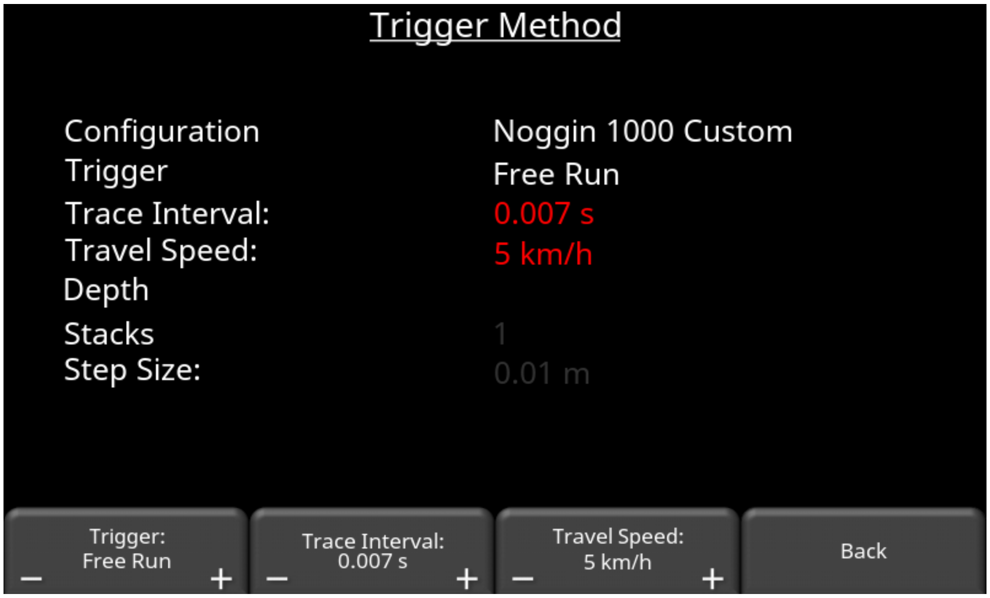


Figure 5-11: Trace interval and speed combination is not compatible, hence it's in red

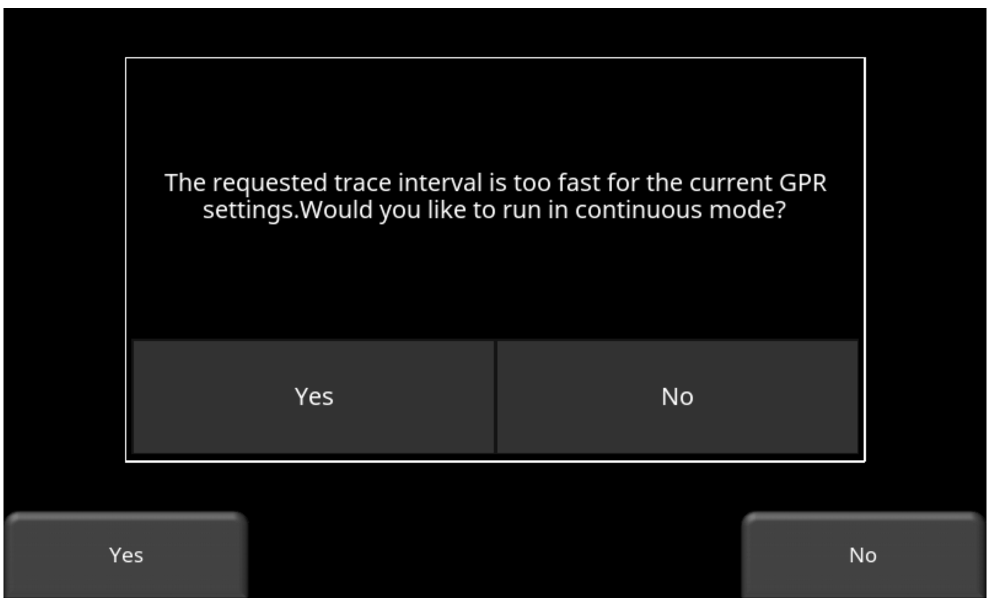


Figure 5-12: If previous interval/speed combination is not changed, warning message appears when entering Line Scan

- **Manual** – in this mode, you would press the up or down keypad button to pulse the Noggin during data collection (Figure 5-13). There are no settings in this screen

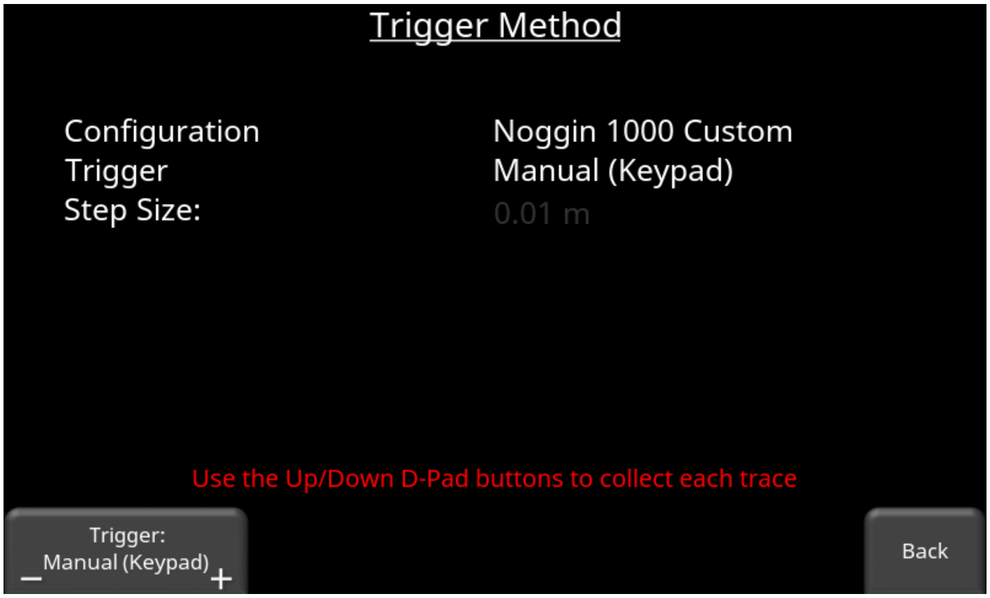


Figure 5-13: Trigger method set to Manual

- **Odometer –** this will pulse the Noggin based on distance travelled. The bottom menu will change as shown in Figure 5-14, displaying the following options:

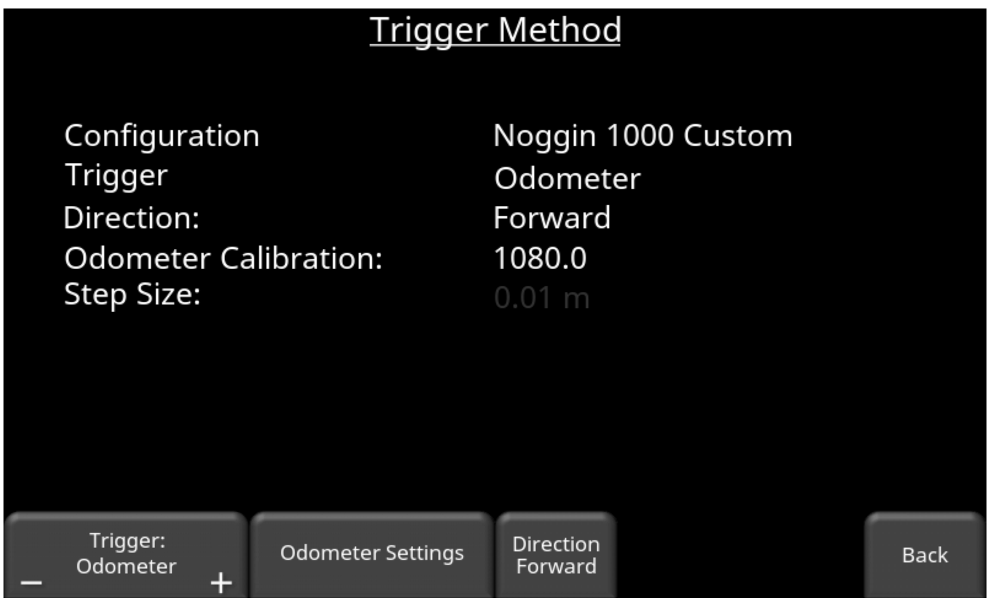


Figure 5-14: Trigger Method menu, showing odometer settings at bottom

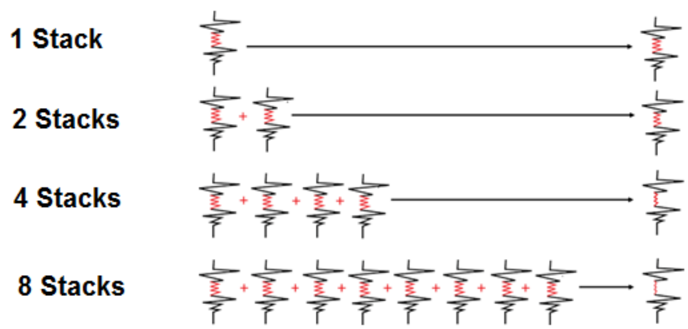
  - **Odometer Settings** – Pressing this will display the same options as Odometer under the System Test option, see Section 5.4.6.
  - **Direction** – allows you to use the odometer in the forward (push) or reverse (pull) direction. The majority of users will be pushing it forward. It is

recommended to do an odometer calibration when switching between forward and reverse.

- **Back** – Press this to return to the Custom Config menu (Figure 5-10)

5.2.7 Stacks

Stacking (sometimes called averaging) is used to improve data quality by maximizing the signal to noise ratio. Stacking involves pulsing the GPR multiples times at a given position. The return from these pulses are "stacked" or averaged to minimize the background noise, allowing you to potentially see deeper.



Pressing the **Stacks** button cycles between the number of stacks. The downside of increasing stacks is that you must move slower when acquiring data, or you will get skipped traces. The maximum stacks possible for the Noggin 1000, 500, 250 and 100 is 2048.

Things are a little different with the Noggin Ultra 100, which is designed to acquire data thousands of times faster than the Noggin 100. This means that higher numbers of stacking can occur for a given speed. As a result, if the Noggin Ultra 100 is connected, the stacks can be set from 256 up to 65,536.

Instead of selecting a fixed number of stacks, the user can select DynaQ. DynaQ's patented technology stacks automatically **when using an odometer**, resulting in the highest possible data quality for a given speed. 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. As the Line Scan data scrolls on the screen, the DynaQ Index Bar is displayed along the bottom of the screen. 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
8192-65536*	Dark Green

*Noggin Ultra 100 only

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 Noggin frequencies, however you will never get light or dark green colours on the DynaQ Index Bar unless a Noggin Ultra 100 is used.

5.2.8 Scan Depth

Being in Custom Config also allows you to extend the maximum depth range beyond what is normally available in the standard settings. This is typically used for extreme applications where conditions may allow a large depth setting (time window).

Press the **+** and **–** buttons under the Scan Depth button to change this.

If the **Noggin Ultra 100** is connected, there are some special conditions that must be adhered to:

a) If Stacks are set to DynaQ, the maximum time window must be less than 2000 ns.

b) If Stacks are manually set to a fixed number (instead of DynaQ), the maximum time window is 8000 ns.

The Noggin software allows the user to specify depth and velocity, and it then calculates the required time window (Section 3.3). Any combination of depth & velocity that exceeds the above values will result in an error message when you press **Back** and then **Exit** (Figure 5-15). If you Exit, the same warning message will appear again when you try and collect data.

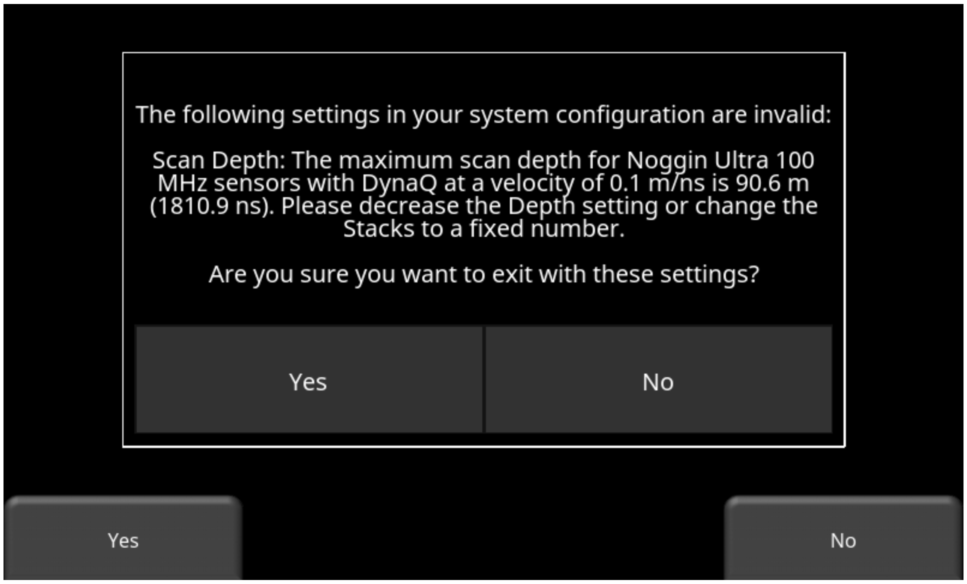


Figure 5-15: Error message if time window is exceeded with the Noggin Ultra 100

5.2.9 Step Size

Controls how often the GPR takes a reading based on distance travelled, provided the trigger method is set to odometer. The default value is based on what type of Noggin sensor is selected. You may want to set this higher is when you are travelling at faster speeds and don't want to skip traces, or possibly if you are collecting long lines and want to limit the file sizes of data collected. The default step sizes are:

- Noggin 100 = 0.10 meters (0.33 feet).
- Noggin 250 = 0.05 meters (0.17 feet).
- Noggin 500 = 0.02 meters (0.07 feet).
- Noggin 1000 = 0.01 meters (0.04 feet).

5.2.10 Back

Exits the Custom Config menu and return to the screen shown in Figure 5-9.

5.3 Preferences

Selecting the preferences option will take you to the sub-menu shown in Figure 5-16.

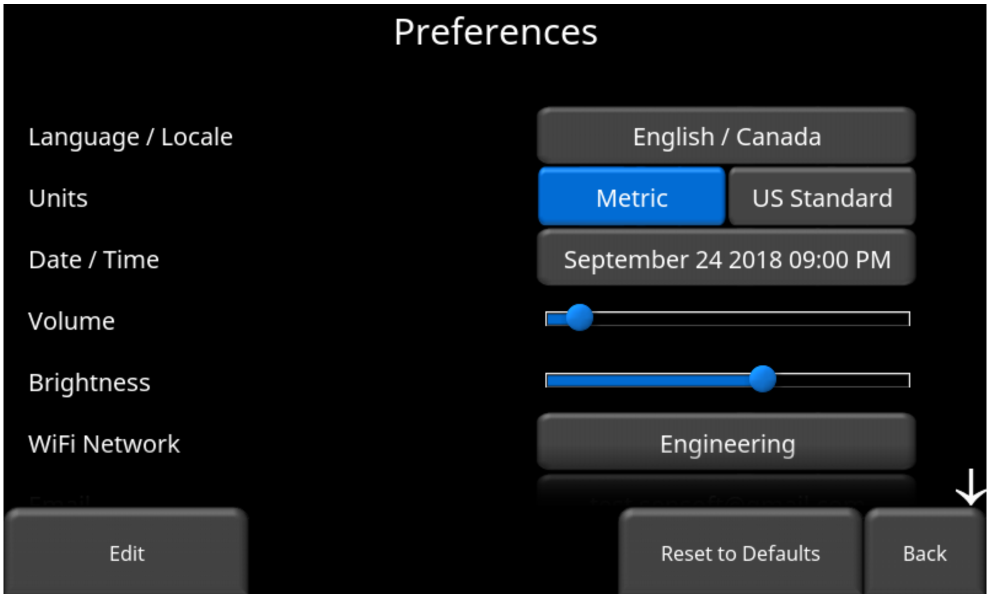


Figure 5-16: Preferences Menu

There are several parameters that can be modified. Touch the screen and swipe up or down to scroll and view additional parameters. To change a value, press the value on the right side of the screen. Alternatively, use the up and down arrows on the 4-way keypad to highlight the desired parameter, then press Edit. Each parameter is described in detail below.

5.3.1 Language/Locale

Pressing this button will take you to a screen shown in Figure 5-17. The current language is displayed; pressing the **+** and **–** buttons on either side of the language will change the languages currently available. Below that, the Country/Region is displayed. Press the **+** and **–** buttons on either side of the displayed Country/Region to alphabetically move to the next or previous country or region.

Alternatively, both Language and Country/Region can be changed by pressing the **+** and **–** buttons on the bottom of the screen. Press **Back** when you are done.

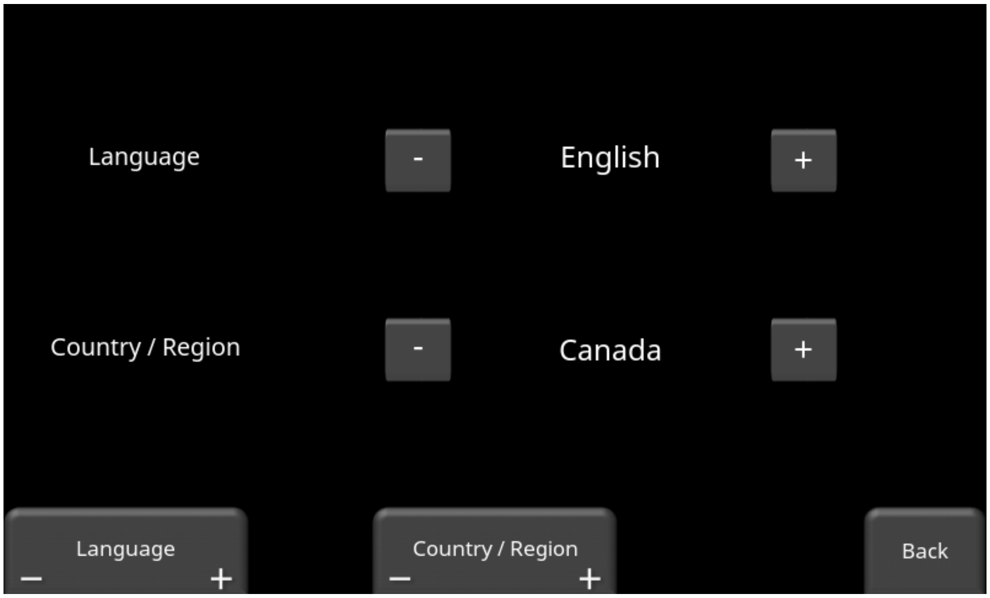


Figure 5-17: Setting the Language & Locale

5.3.2 Units

Select either US Standard or Metric Units.

5.3.3 Date / Time

Pressing this button takes you to a sub-menu where you can set the Date and Time (Figure 5-18). The time is manually set and will not automatically correct for daylight savings time.

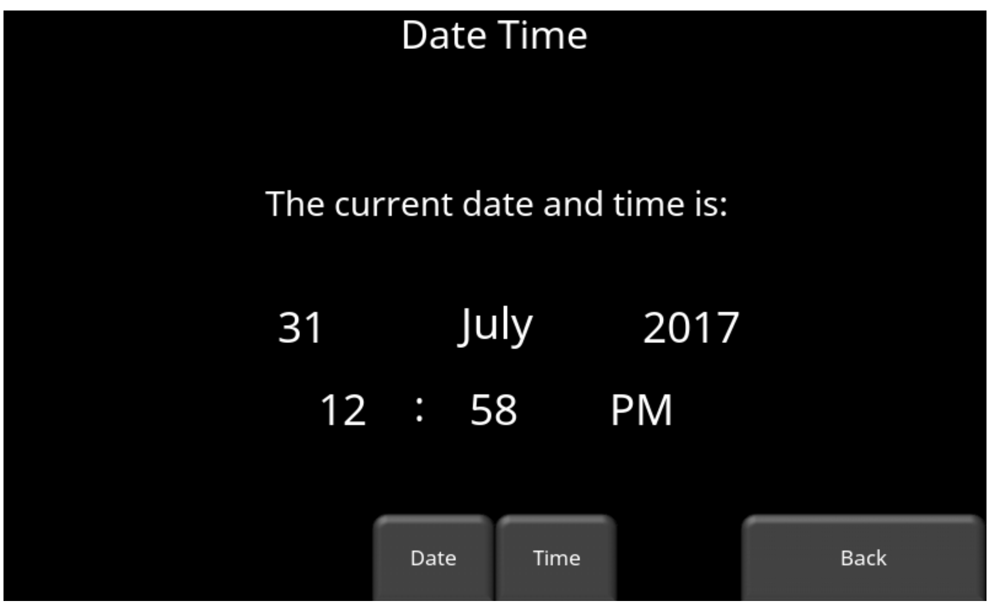


Figure 5-18: Setting the date and time

5.3.4 Volume

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

5.3.5 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 (Section 4.4) anytime the system is not collecting data.

5.3.6 Wi-Fi Settings

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. Pressing the **Wi-Fi Network** button at the bottom of the screen takes you to a sub-menu (Figure 5-19) to connect and configure Wi-Fi settings.

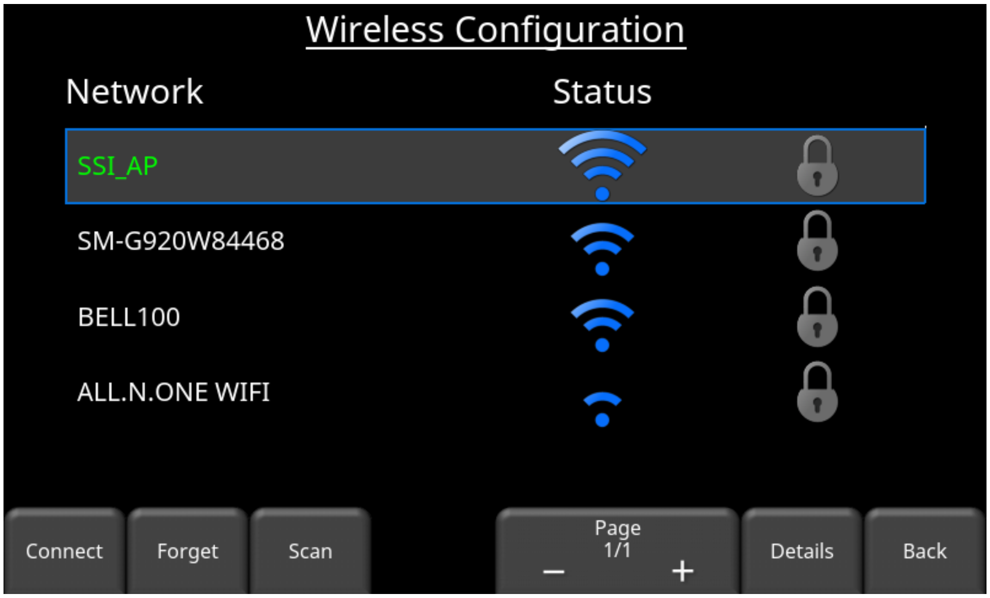


Figure 5-19: Options in the Wi-Fi Settings menu

The DVL automatically scans for available networks when you enter this menu. Use the 4-way directional arrows or touch screen to select the network. 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

You have the following options available:

- **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 it connects the Network Name will turn green.

- **Forget –** Use the Forget button to remove the password for 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 signal strength. You may need to press this button a second time if you don't see the network you are looking for.
- **Details –**Pressing this button displays the security settings related to the selected network.
- **Back -** Press this button to return to the System Settings screen

5.3.7 Email

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

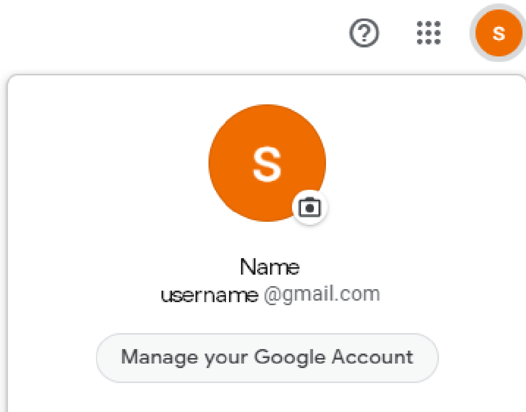
<u>Using GMAIL</u>

Using a Gmail address on the Display Unit 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.

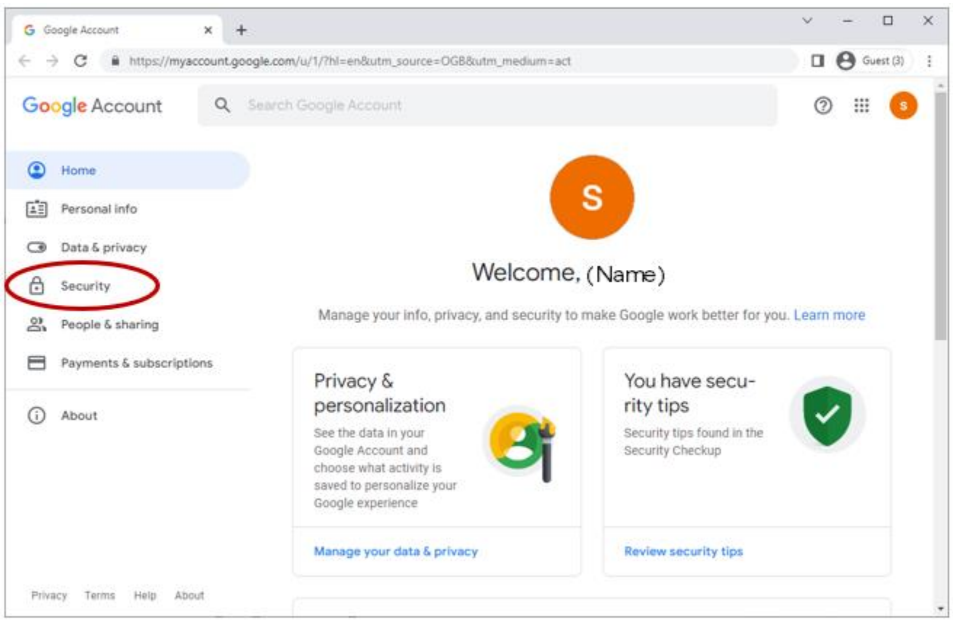
The following procedure details the steps required to enable and generate an app specific password:

1) Log into Google account on a desktop computer.

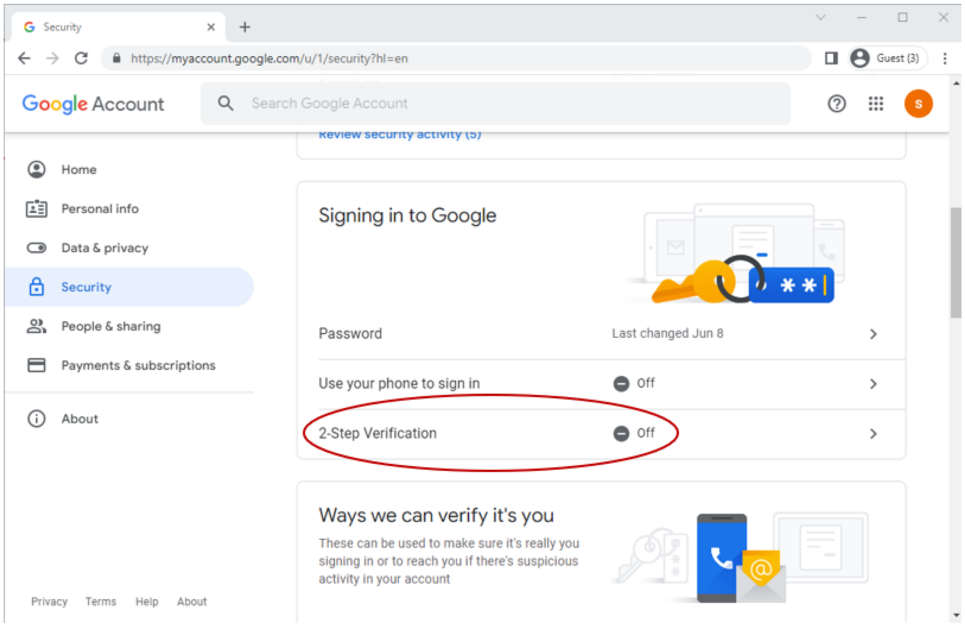
2) Click on the top right account icon and select **Manage your Google Account**



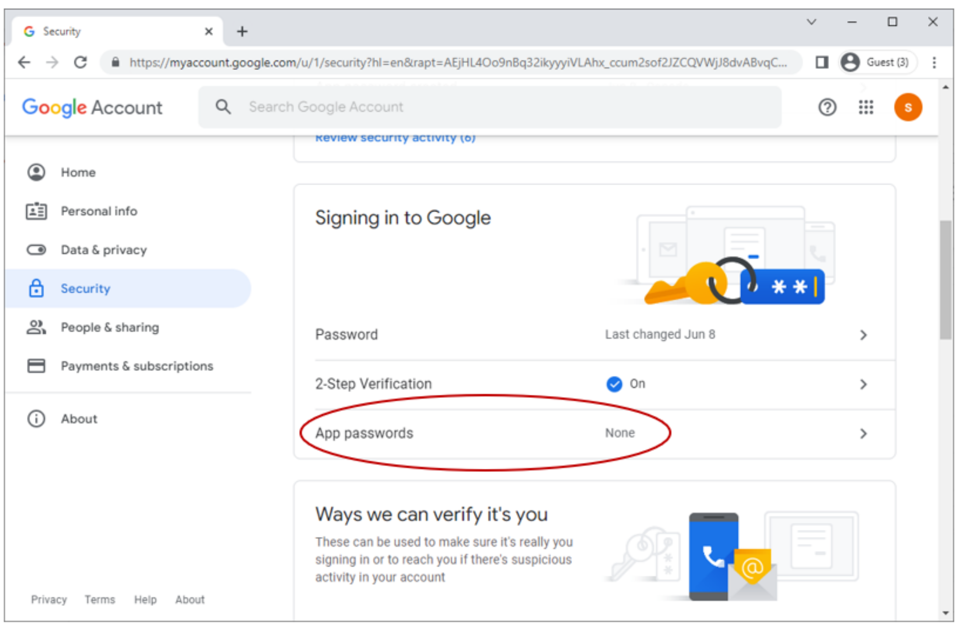
3) Select **Security** from the left menu



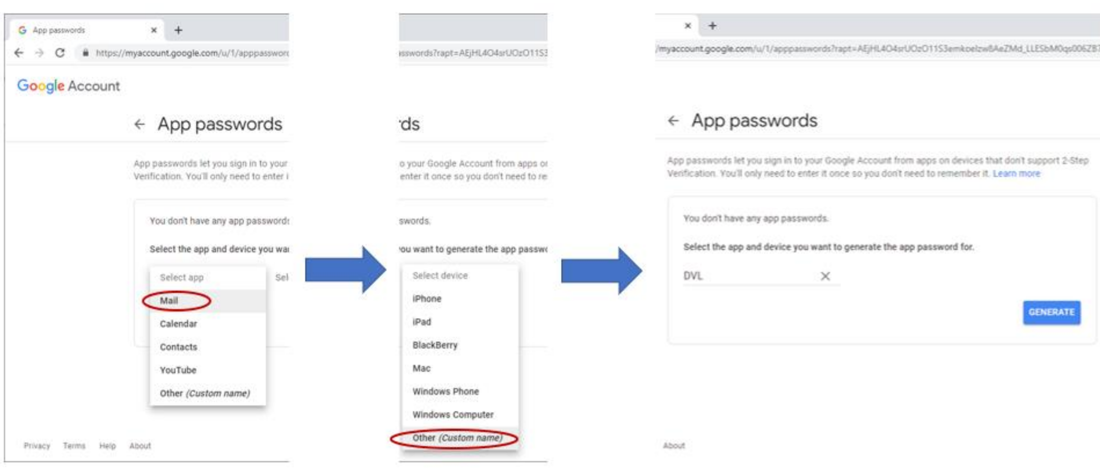
4) Scroll down to the **Signing into Google** section and turn on **2-Step Verification** (if it is not already enabled). Follow the onscreen instructions to add/verify your phone number



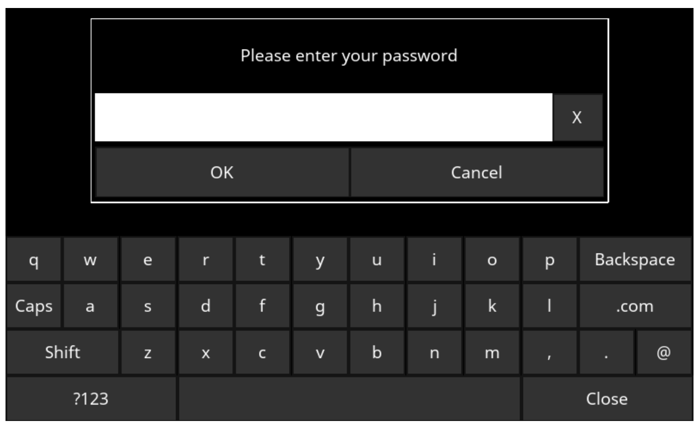
5) Return to the Security menu and you should now find the **App passwords** option under **Signing into Google**. Click on **App passwords**.



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 (without spaces) when configuring your Gmail account on the DVL:



Once you have made the changes in your Google account, continue below (Figure 5-20)

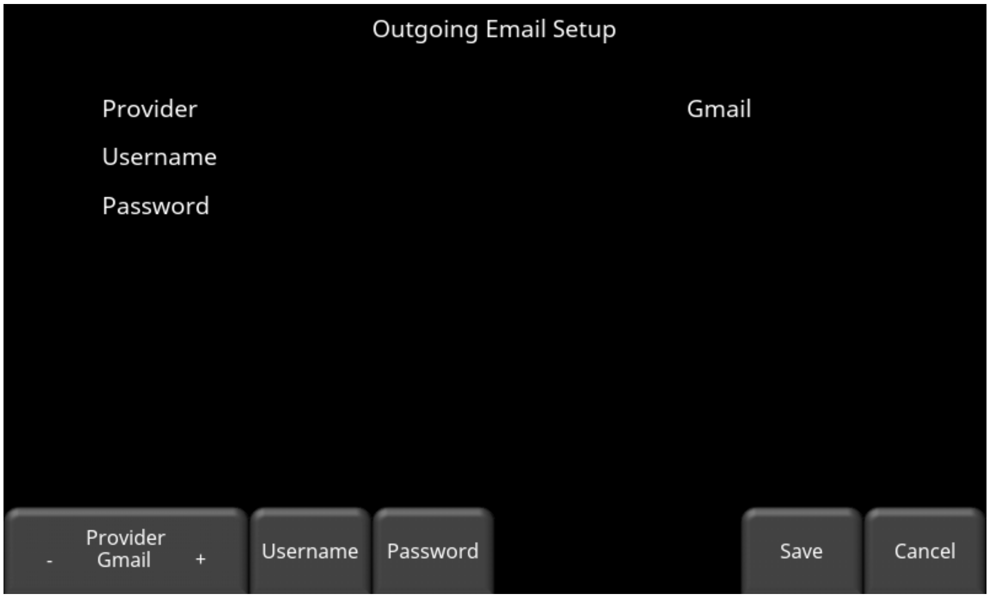


Figure 5-20: Using Gmail as provider

- Press **Username** to display a keyboard where you can enter your GMAIL user name only; you do **not** need to enter @gmail.com. Then press OK when done (Figure 5-21a).
- Press **Password** to display a keyboard where you can enter your GMAIL password. Then press OK when done (Figure 5-21b).
- Press **Save** when both the GMAIL Username and Password have been entered

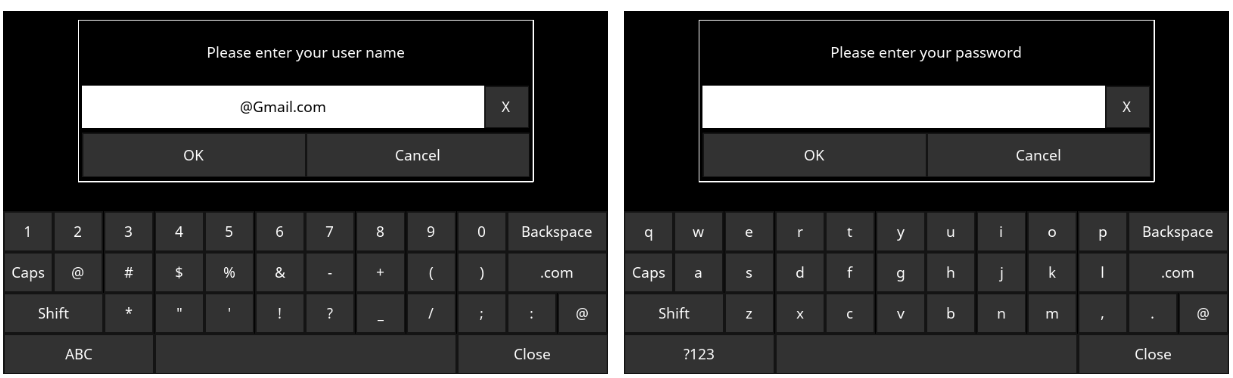


Figure 5-21: Entering e-mail address (a) and password (b) for GMAIL

If there are no warning messages, the e-mail address is setup properly and you are ready to e-mail 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 5-22 allowing you to setup and configure a different e-mail provider.

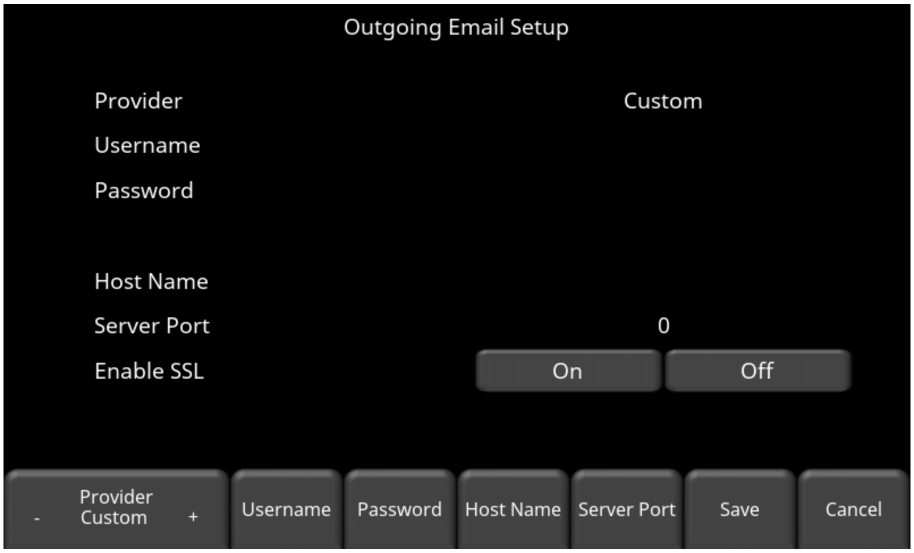


Figure 5-22: Setting up a custom email provider

- 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 address 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**
Yahoo	smtp.mail.yahoo.com	465	On
Hotmail/Outlook	smtp.live.com	587	Off
iCloud	smtp.mail.me.com	587	Off
163.com	smtp.163.com	465	On

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.

5.3.8 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.

5.3.9 GPR Plot Options

Pressing this takes you to a new screen that allows you to set a few options that deal with how lines are collected and displayed (Figure 5-23).

Figure 5-23: Line 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 GPS signal can be displayed on the screen. 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 5mx5m 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. During Line Scan mode, you can choose to display whether the skipped traces are shown on the screen or not, 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.

5.3.10 Reset to Defaults

This will reset all settings & preferences back to the default settings. Pressing **Reset Defaults** asks you to confirm the Reset to Defaults. After this screen, you will get another prompt asking if you want to clear all email and Wi-Fi settings (*Figure 5-24*).

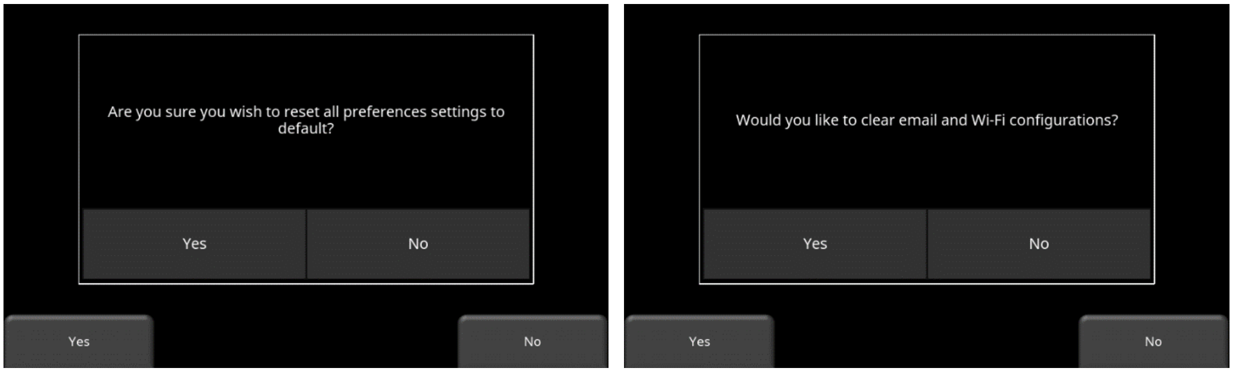


Figure 5-24: a) Image on left is the first confirmation screen for system settings & preferences. b) Image on the right is the second confirmation screen on the right asking about deleting e-mails and Wi-Fi settings.

5.3.11 Exit

Pressing **Exit** will return to the main Tools menu shown in Figure 5-2.

5.4 System Test

The system test sub-menu (Figure 5-25) allows the user to perform certain tests to ensure proper operation of the system. Select the component to test then press **Start**. After completing a test there is an indication of whether the system passed or failed the test. Each test is described below in more detail.

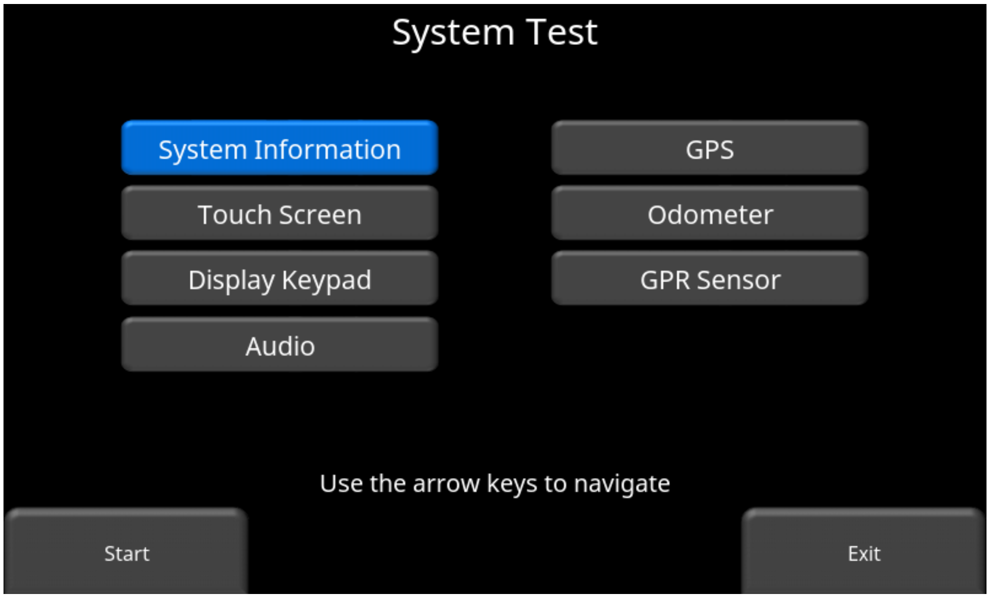


Figure 5-25: System Test menu

5.4.1 System Information

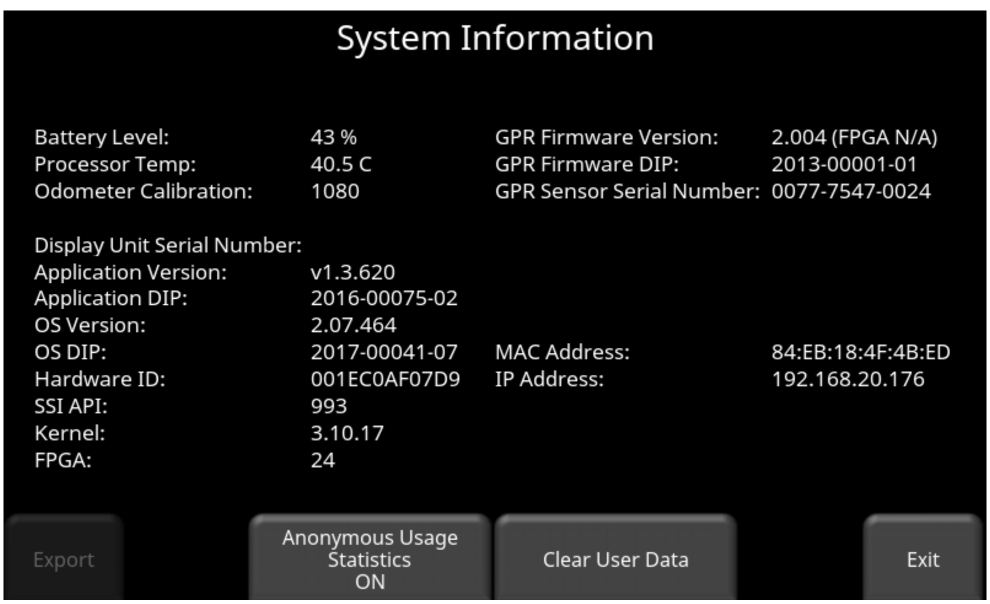


Figure 5-26: System Information screen

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 5-26). If a USB key is currently inserted, pressing **Export** will just export a System Summary Report with this information.

There is an option called Anonymous Usage Statistics. When this is set to **ON** and the user is connected to a wireless network, any system malfunctions will trigger an automatic notification to Sensors & Software. This is to help with gathering information about any system irregularities. As the name suggests, the notification is completely anonymous and no personal information is sent.

Pressing **Clear User Data** will delete all saved GPR data, e-mail addresses, system configurations and preference settings. A message window will pop up asking you to confirm deletion. Press **Yes** to proceed with deletions or **No** to cancel (Figure 5-27).

> **Note:** Clear User Data essentially wipes the system clean. Upon reboot, it will run the Setup Wizard, similar to when it's used the first time or after re-installing the firmware.

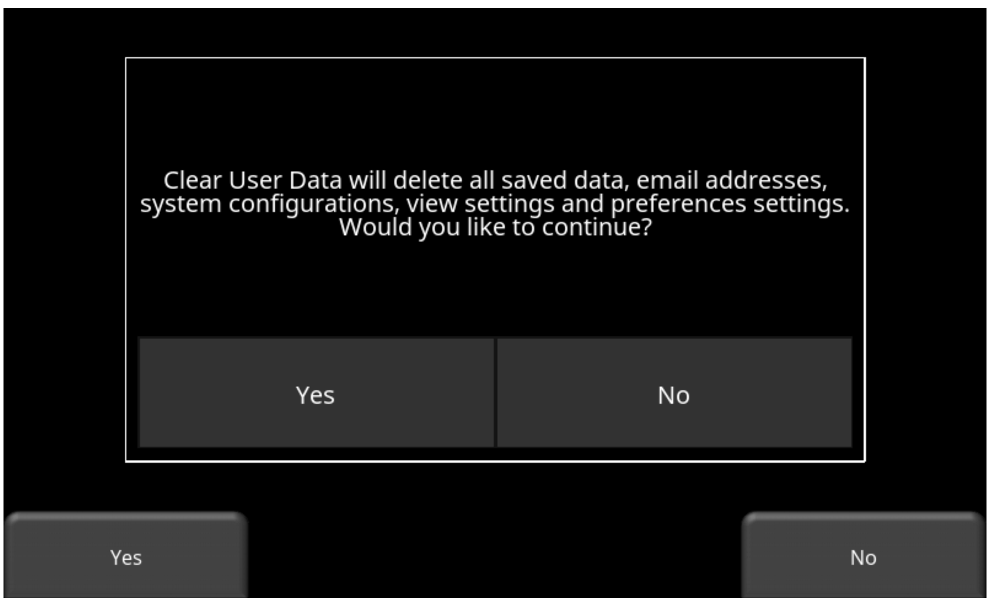


Figure 5-27: Warning message after pressing Clear User Data

5.4.2 Touch Screen

The test checks proper operation of the touch screen (Figure 5-28). It allows you to test the screen (by pressing **Test**) or perform a quick calibration followed by a test (by pressing **Calibrate**). Both involve touching targets on the screen as they appear.

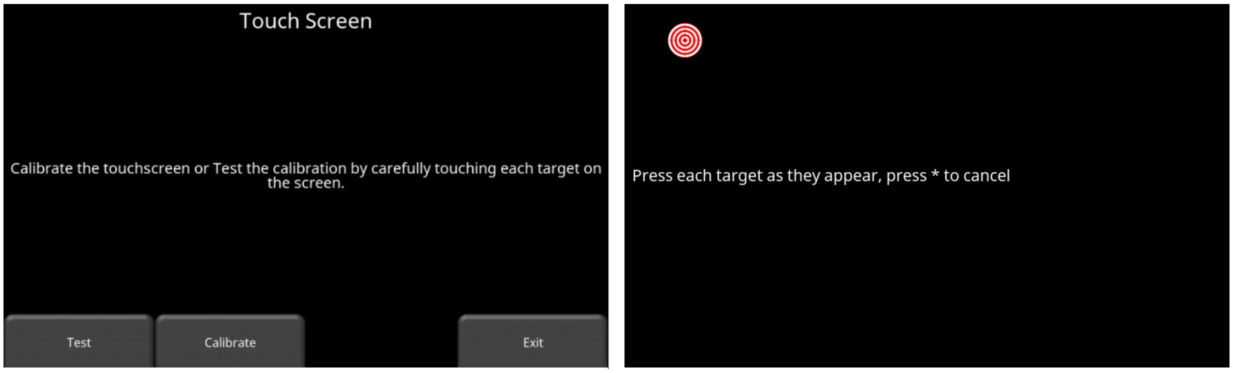


Figure 5-28: Touch Screen test

5.4.3 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 5-29).

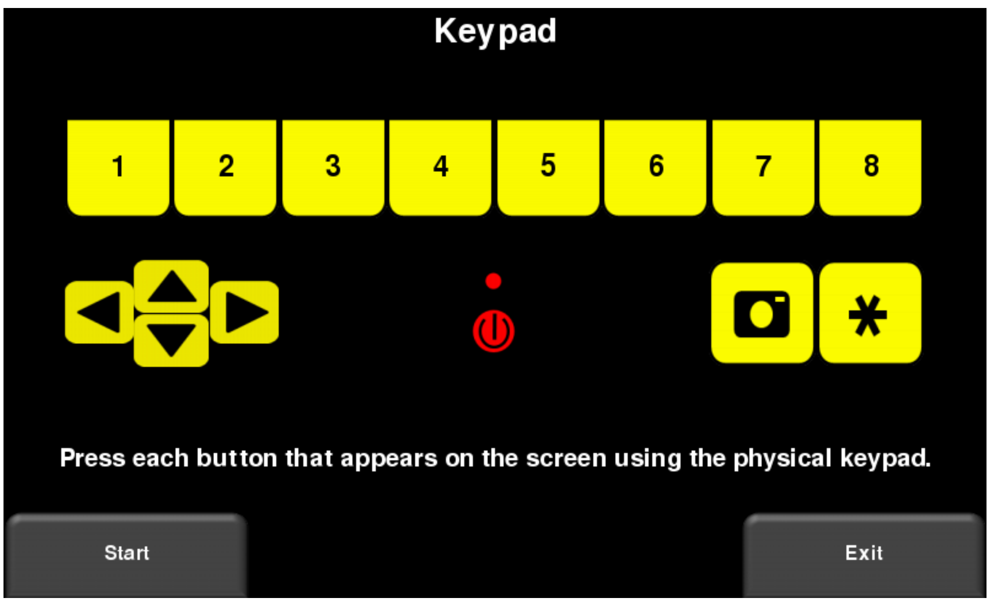


Figure 5-29: Keypad Test

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

5.4.4 Audio

This test ensures that the speaking is operating properly. After starting the test, you should hear a sound with an increasing pitch (Figure 5-30).

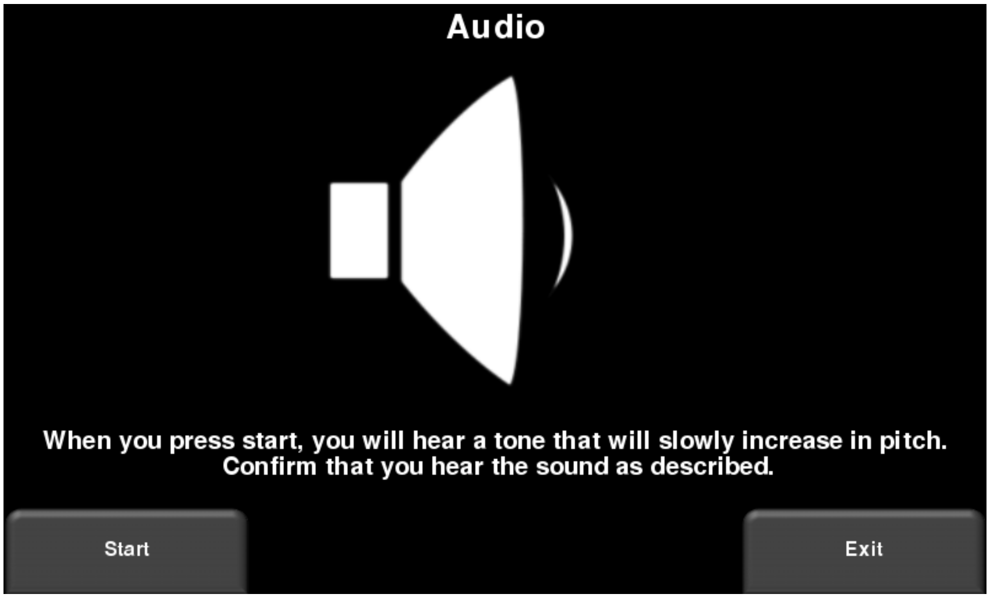


Figure 5-30: Audio Test

5.4.5 GPS

The Display Unit contains an internal GPS, but you also have the option to purchase an external GPS receiver from Sensors & Software. Alternatively, you may have your own GPS that you want to connect to the system. The GPS test will ensure that the system is communicating properly with the GPS and receiving data. It doesn't mean you are actually seeing satellites; the GPS test can still pass indoors with zero satellites visible. If the test fails, check the GPS cable is connected securely at both ends and the GPS is receiving power.

Whichever GPS mode is selected in the GPS Configuration (5.2.4) will be the one used for the test. Pressing **GPS** will show the screen in Figure 5-31.

Figure 5-31: GPS Test

The basic position and time information is displayed on the screen. On the screen, the Fix Type notes if there are any corrections being applied, such as DGPS. When first going outside, give it a few minutes to track, or lock onto satellites.

Pressing **Strings** will display the raw data strings that are outputted by the GPS (Figure 5-32) as they scroll down the screen. The user may select this option to verify the GPS is outputting the proper NMEA string format.

Pressing **GPS Setup** will take you the screen shown in Figure 5-32.

Figure 5-32: GPS Strings

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

5.4.6 Odometer

This option allows you to not just test the odometer, but also 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. The odometer calibration value is stored in the Display Unit. If the Display Unit is changed, or swapped out, you will need to run the Odometer Calibration test again. The image in Figure 5-33 is displayed when you enter this menu, the options are explained below:

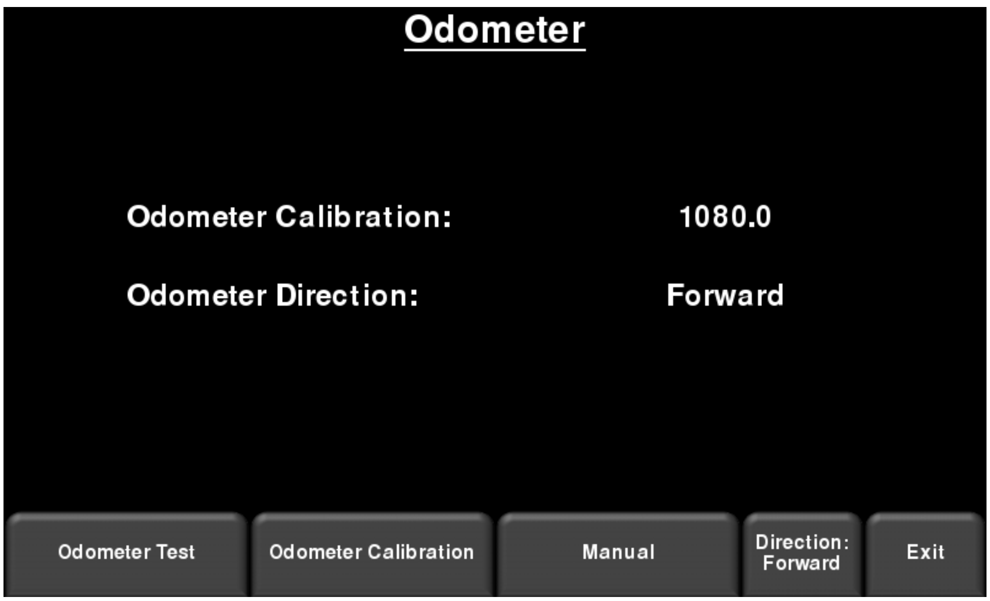


Figure 5-33: Odometer Calibration screen

- **Odometer Test** – This test verifies the odometer is calibrated properly (Figure 5-34). It involves moving the system a set distance (5m or 10', depending on units used), and comparing the value obtained to a known value. Press **Start** to begin and then press **Finish** when you've moved that distance. It will display a pass or fail, along with a percentage difference from the known value (Figure 5-35).

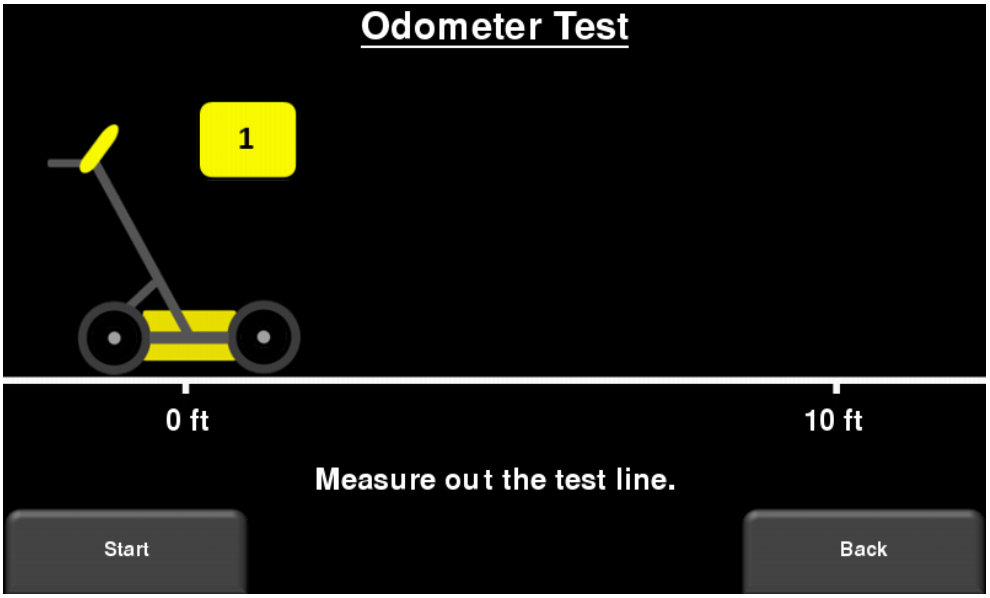


Figure 5-34: Ready to calibrate odometer a distance of 10 feet

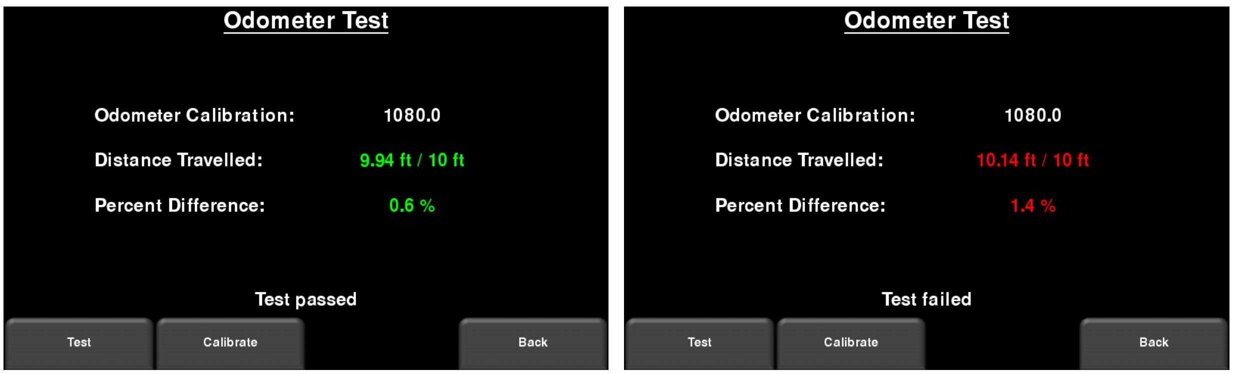


Figure 5-35: Odometer Test passed on left, failed on the right

- **Odometer Calibration –** This option actually calibrates the odometer. Choose a set distance from 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 5-36).

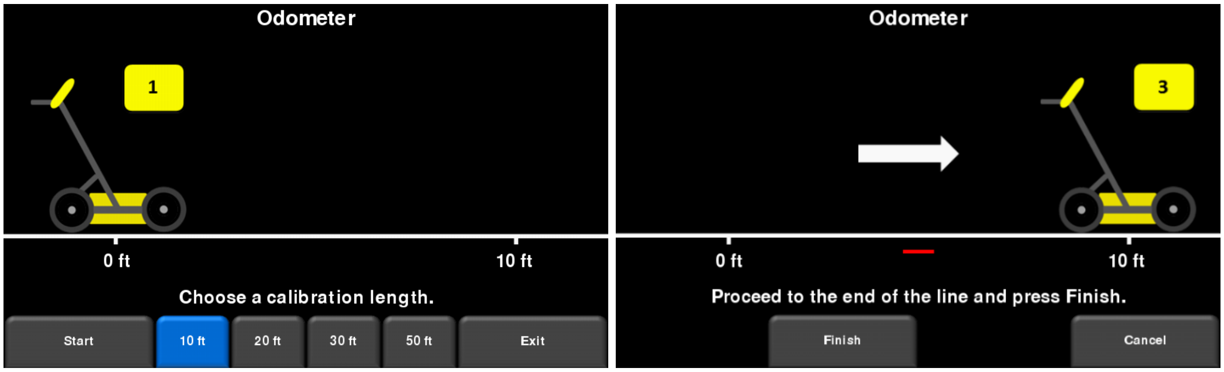


Figure 5-36: Odometer Test. Image on the left shows the screen where the user must select a distance. The image on the right instructs you to move that distance then press Finish.

Upon completion, it will display one of the screens shown in Figure 5-37. 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 accepted 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.

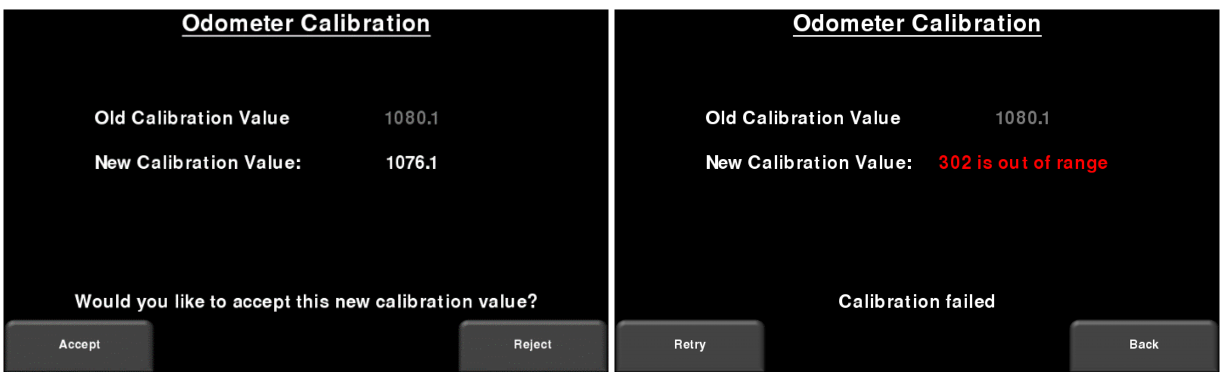


Figure 5-37: Results of Odometer Calibration. Image on right shows a failure, as calibration is way out of range

- **Manual –** If you want to manually insert a value, it can be done using the buttons on the bottom of the screen to increment of decrement the calibration value (Figure 5-38).

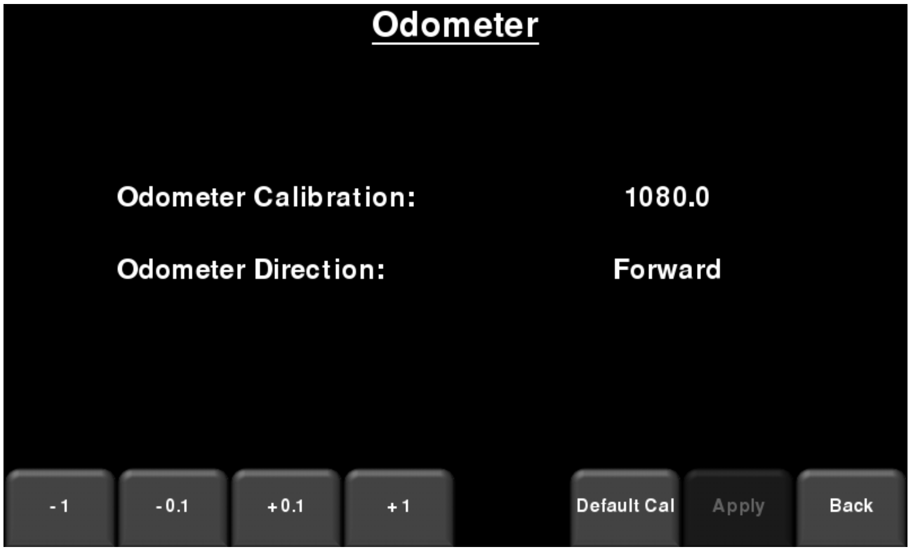


Figure 5-38: Manually setting odometer calibration value

- **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.

5.4.7 GPR Sensor

This test checks proper operation of the GPR sensor, including the amplitude of the pulse. Once the cart is tipped backwards and start is pressed, it will conduct the test (Figure 5-39). If there are any irregularities, the test will indicate failure. However, if the test passes, it doesn't mean the system is working perfectly. A test line should be setup as a baseline, and results compared to the test line to validate proper performance and operation (Section 13.5).

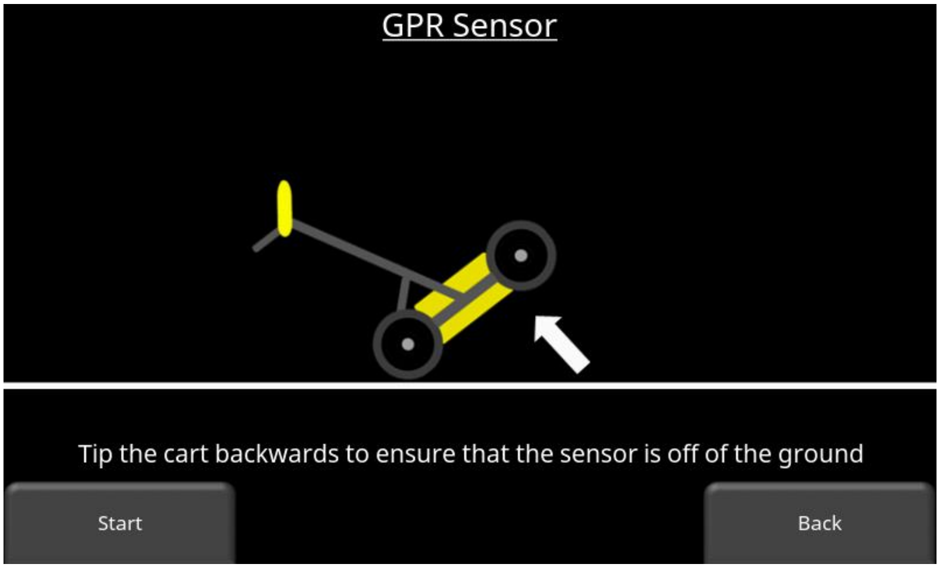


Figure 5-39: Sensor Test

5.5 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, export data and delete projects (Figure 5-40).

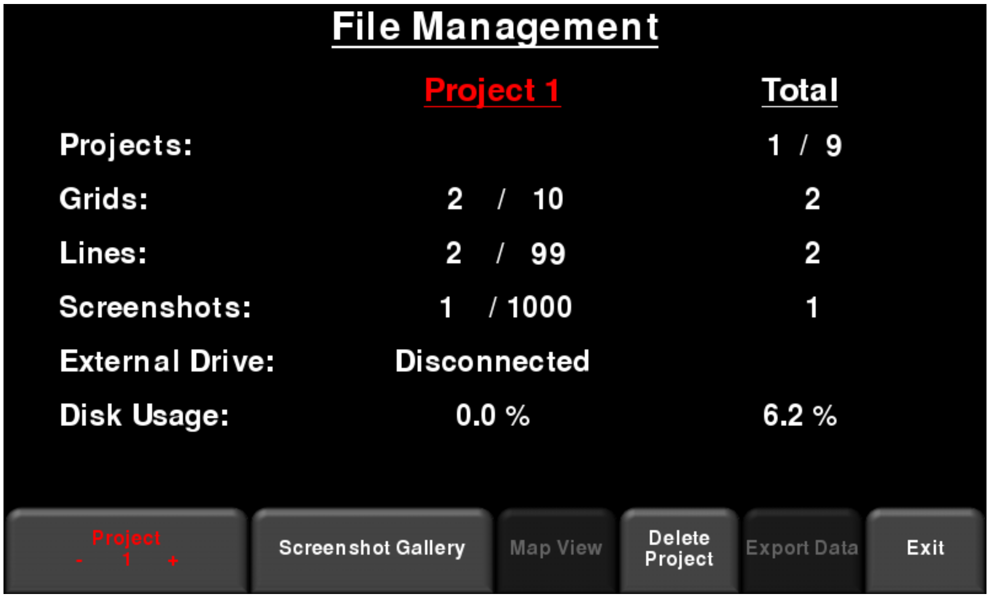


Figure 5-40: Main screen in File Management

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 combined total saved on the whole system.

The current disk space is shown, expressed as a percentage of used disk space. 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:

5.5.1 Project

Pressing the **+** and **–** buttons cycles between Projects 1 – 9, along with the Demo project (which contains demo data). The values in the middle column change as the project number is changed. Projects that contain some data are in red, whereas Projects that are in green have completely no data.

5.5.2 Screenshot Gallery

This allows the user to view all screenshots that were saved by pressing the Camera button (this is explained in Section 11.1). The display will show a Tile View of four screenshots per page (Figure 5-41). 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

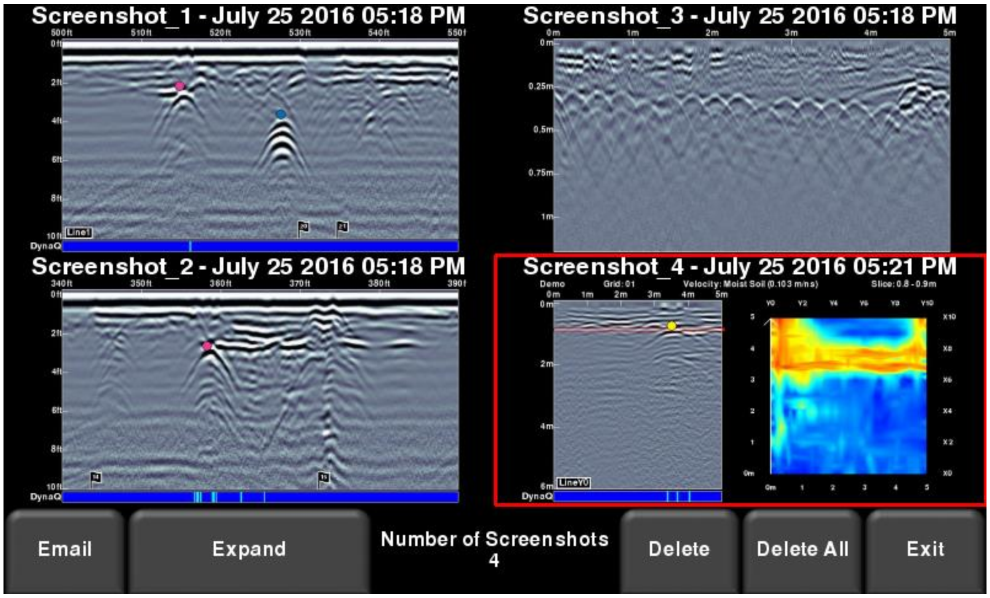


Figure 5-41: Tile View in Screenshot Gallery

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

- **E-mail** – pressing this button will e-mail the selected screenshot (provided you are connected to a wireless network and have setup a Gmail account to send from, refer to Setup an e-mail address). You will be prompted to enter an e-mail address, or you may use the most recent one which will be listed by default. Pressing the "**…**" button to the left of the e-mail address displays the last 5 e-mail addresses used, allowing the user to easily 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. On the subsequent screen, press **Tile View** to return to the screen displaying four screenshots per page.

- **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.

5.5.3 MapView

Pressing this will display a MapView for all the data (lines & grids) in a given Project (Figure 5-42). For collected grids, MapView is enabled if a GPS (internal or external) was on during data collection. However, for lines, MapView will only be enabled if an external GPS was used. MapView shows the survey path travelled, as well as any flags or interpretations added to the data. MapView is fully explained in Section 9.

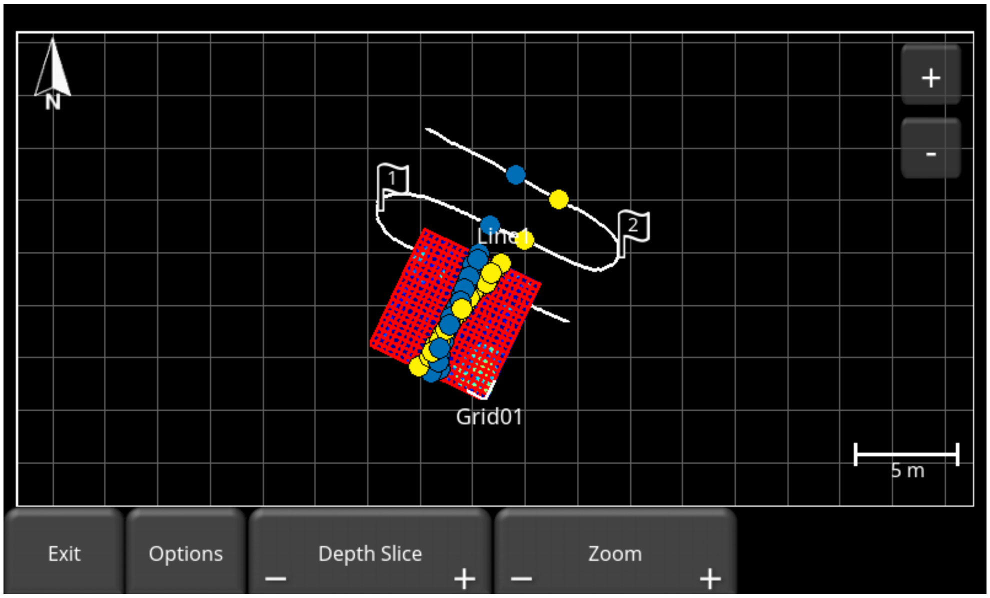


Figure 5-42: MapView showing two grids and a long line with interpretations.

5.5.4 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.

5.5.5 Export Data

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

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.

6. Line Scan

Line Scan mode allows the operator to acquire data along a straight line and examine it as a cross-section image. The operator can locate a feature and easily back-up and mark the location of that object on the ground. Line Scan mode can be used to identify the alignment of subsurface features, check for linearity and acquire accurate depth measurements.

From the main screen, ensure 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 6-1.

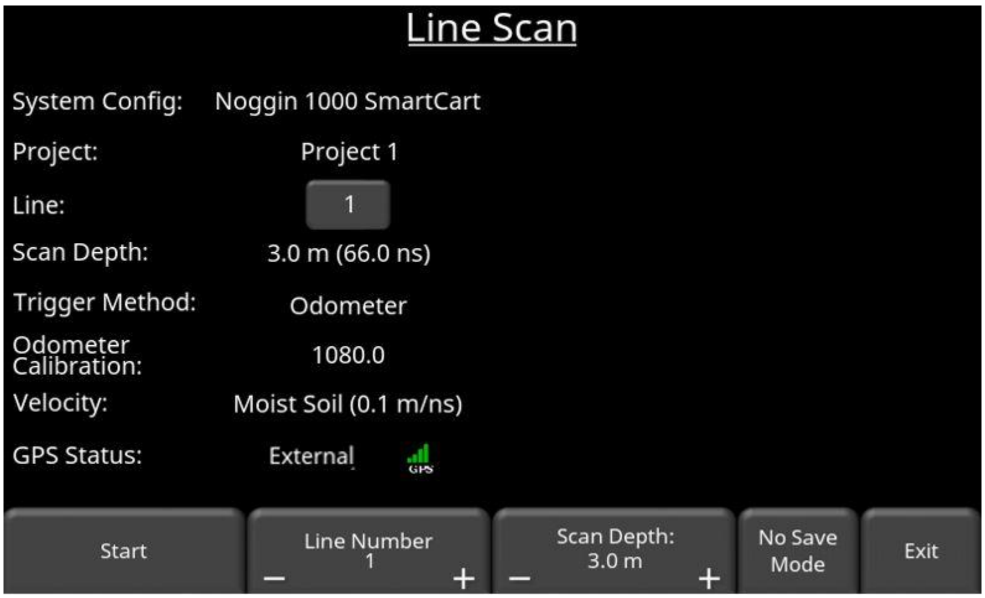


Figure 6-1: Preparing to Line Scan

The line number is displayed, along with some information pertaining to the line that is about to be collected.

The GPS Status indicates which GPS is currently selected, as well as the quality of the GPS signal, which is based on the number of satellites that it sees. The chart below explains what the colours 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+

6.1 Selecting a line

To select the desired line, press the **+** and **-** buttons under **Line Number** on the bottom of the screen. If the line number is white, then that line is empty; if the line number is red, that line already contains data.

In situations where there are many lines in a project, the user may want to go directly to a line, without continually pressing the **+** and **–** buttons. To do this, press the button containing the line number. You will see the screen in Figure 6-2, where you can enter a line number directly and the press **OK**. This can also be done when reviewing lines.

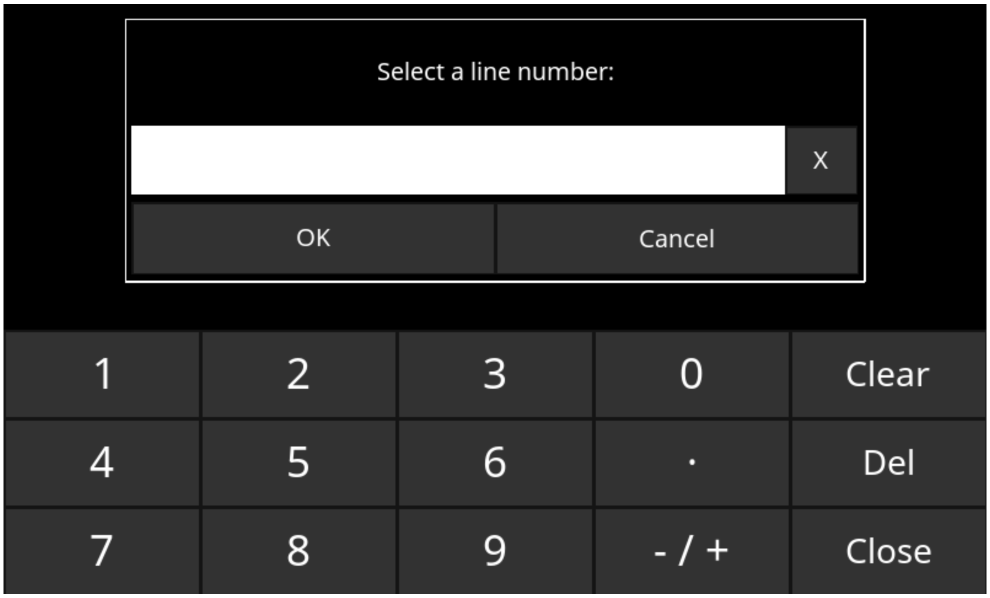


Figure 6-2: Directly entering a line number

To collect data without saving it, press **No Save Mode**. Any data collected will NOT be saved, but screen shots can still be taken with the **Camera** button. These screen shots get placed in the currently selected project. Two features that are only available in No Save Mode (the Pause button and the ability to draw arrows) are described in Sections 6.8.7 and 6.8.8 respectively.

If the line number is white (Figure 6-1), Press **Start** to enter data acquisition. All data collected will be saved under this line number.

If the line number is shown in red (Figure 6-3), you will see the data preview on the right side of the screen. If it's a long line, only the last part of the data will be shown. From this screen, you will have the following options available:

- **View** – press this button to review the previously collected line. See Section 6.8 on Line Scan menu options
- **Delete** – pressing this will delete the line. It will prompt you to confirm before deleting.

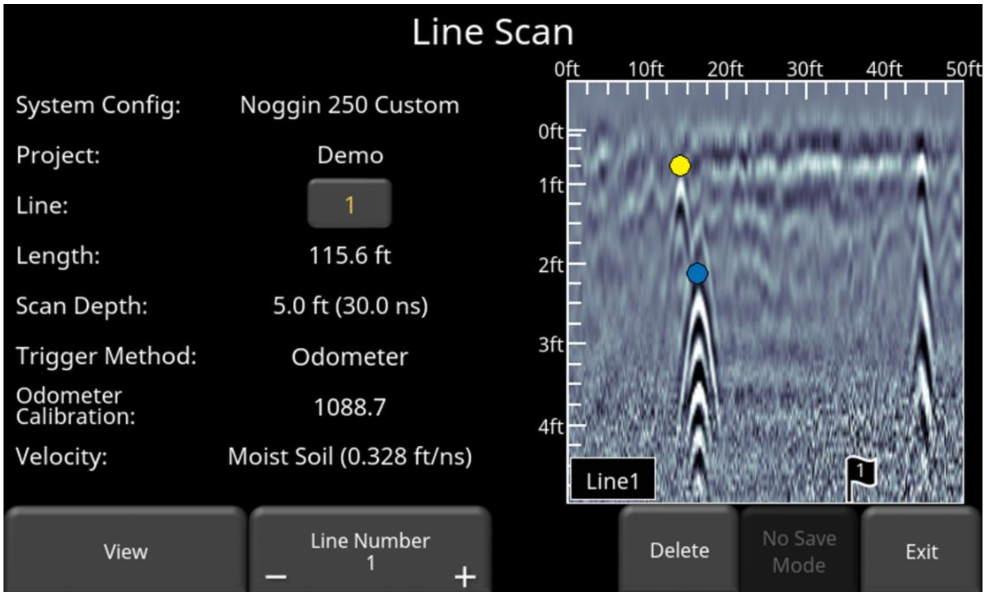


Figure 6-3: Viewing a line that was already collected

6.2 Acquiring Data

In the data acquisition screen, the parameters for the data collection are displayed in the left of the window (Figure 6-4). Press **Start** to begin collecting data.

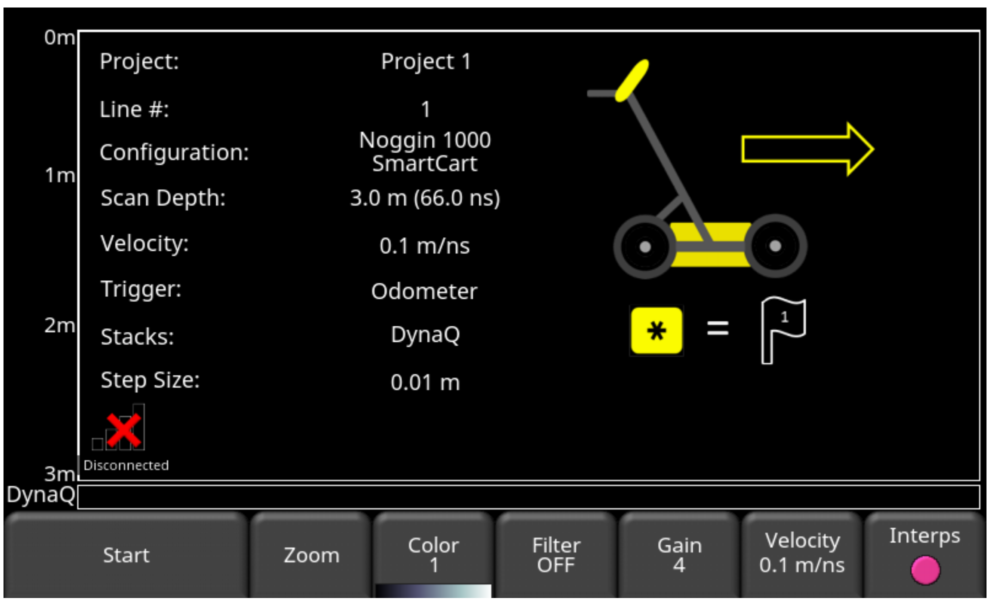


Figure 6-4: Beginning of data acquisition

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 6-5).The depth scale along the side of the

GPR Line image and the position scale along the top of the image are set to Metric or US Standard units based on the setting in the Section 5.3.2.

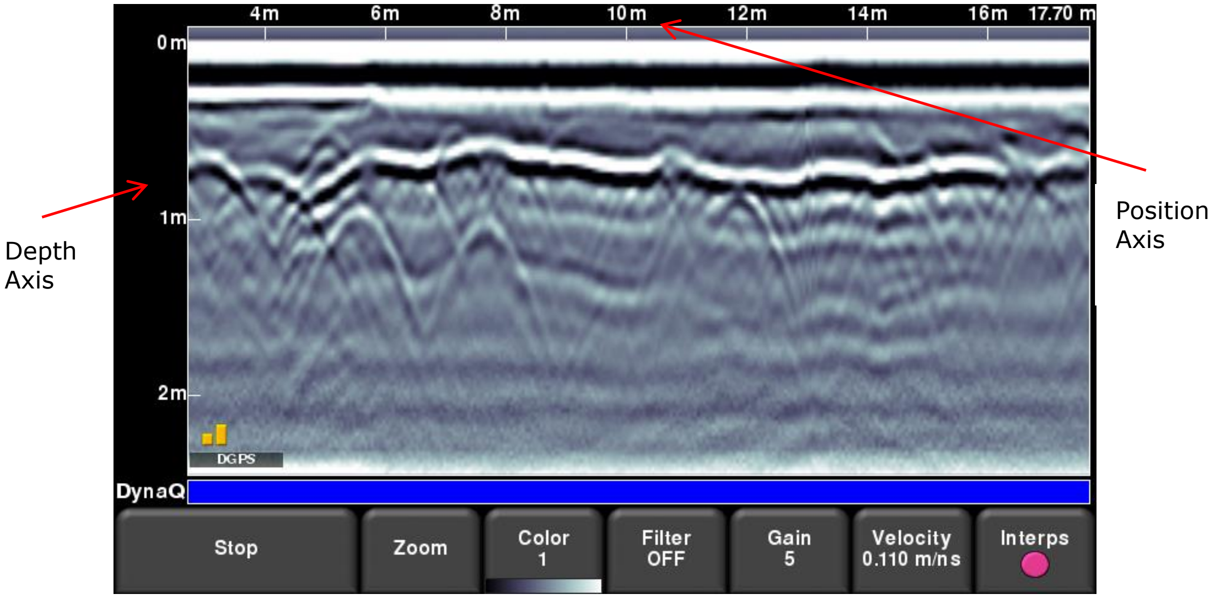


Figure 6-5: Line Scan acquisition mode, showing collected data and axis labels. DynaQ indicator is shown at the bottom above the menu options.

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 is collecting 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 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 will be small red indications at the bottom of the data (Figure 6-6). If the total number of skipped traces is greater than 10% of the total number of traces, a warning message will appear (Figure 6-7).

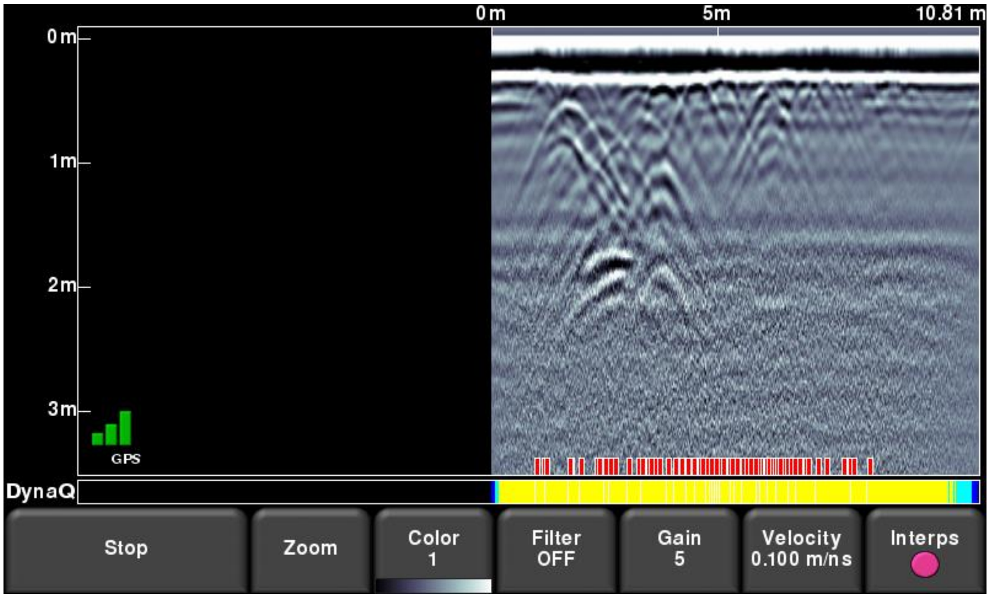


Figure 6-6: Skipped traces shown in red at bottom of screen

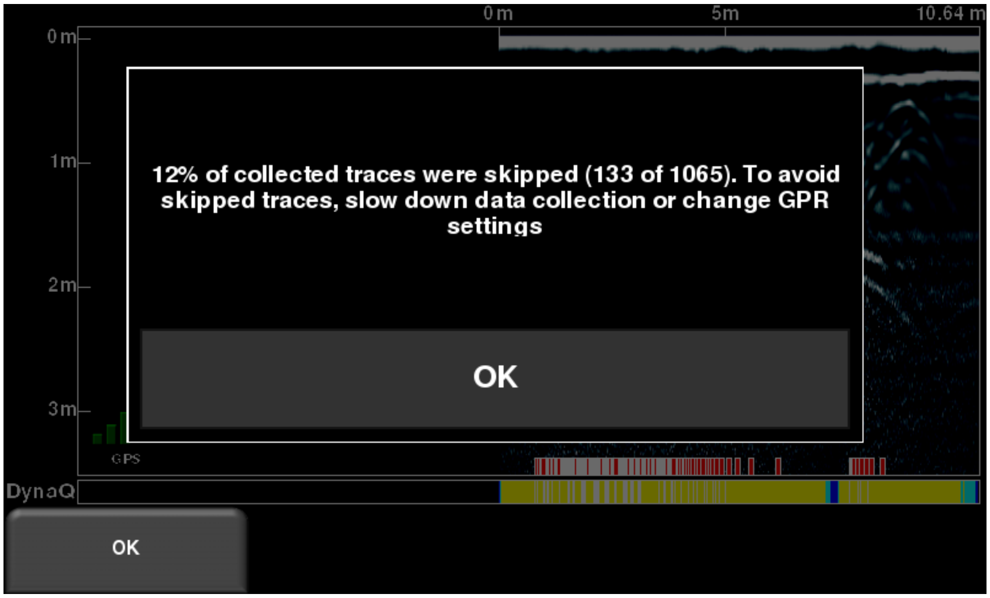


Figure 6-7: Warning message when more than 10% of traces are skipped

6.3 DynaQ

DynaQ is an advanced patented technology that adjusts data quality as the 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.

DynaQ is only available if the Trigger is set to Odometer. By default this is enabled, but the user can override this (Section 5.2.7) by specifying a specific number of stacks.

As the Line Scan data scrolls on the screen, the DynaQ Index Bar is displayed along the bottom of the screen (Figure 6-3). 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
8192-65536*	Dark Green

*Noggin Ultra 100 only

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 Noggin frequencies, however you will never get light or dark green colours on the DynaQ Index Bar unless a Noggin Ultra 100 is used.

6.4 Back-up Indicator

Only available if trigger is set to odometer, Line Scan mode incorporates a back-up feature to enable you to accurately locate targets and mark them on the ground. After acquiring some data on the screen, move the system backwards (Figure 6-8). 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 cart 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.

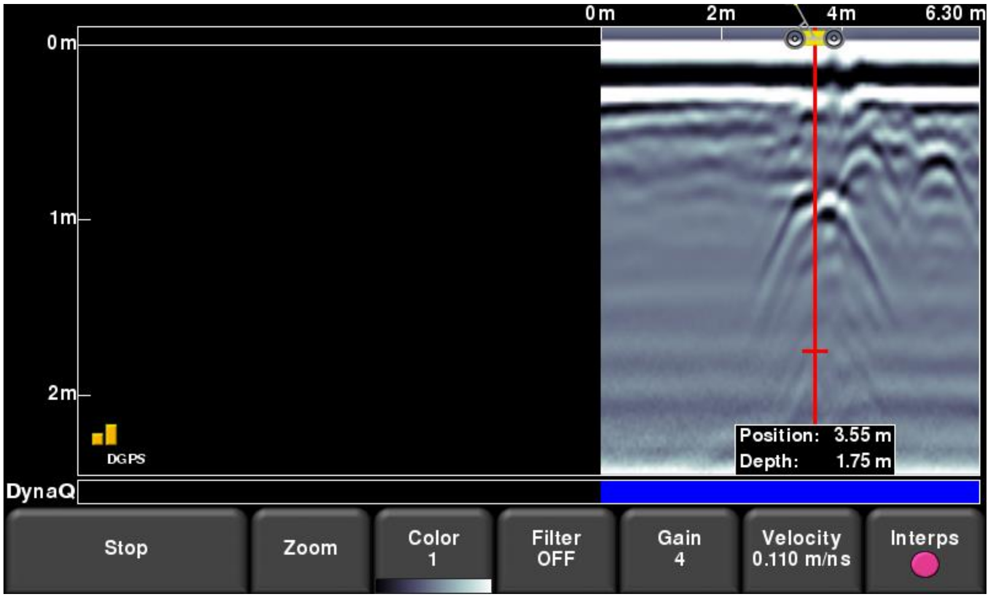


Figure 6-8: Back-up Indicator and Depth Indicator shown

- **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 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 (6.8.5).

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 surface and continue data collection. Once you reach the point where you initially started backing-up, the system will continue acquiring new data.

6.5 Stopping the Line

Pressing **Stop** ends the line. This line is saved internally on the system and cannot be added to. Use the **Left** and **Right** directional arrow buttons to scroll and view data not currently displayed on the screen. The maximum line length that can be collected is 10km or 1 million traces, whichever comes first. Traces are explained under Show Skips.

If you are in free run mode, and press **stop**, you have the option to resume collecting data or exit Line Scan mode (which will save the line), as shown in Figure 6-9.

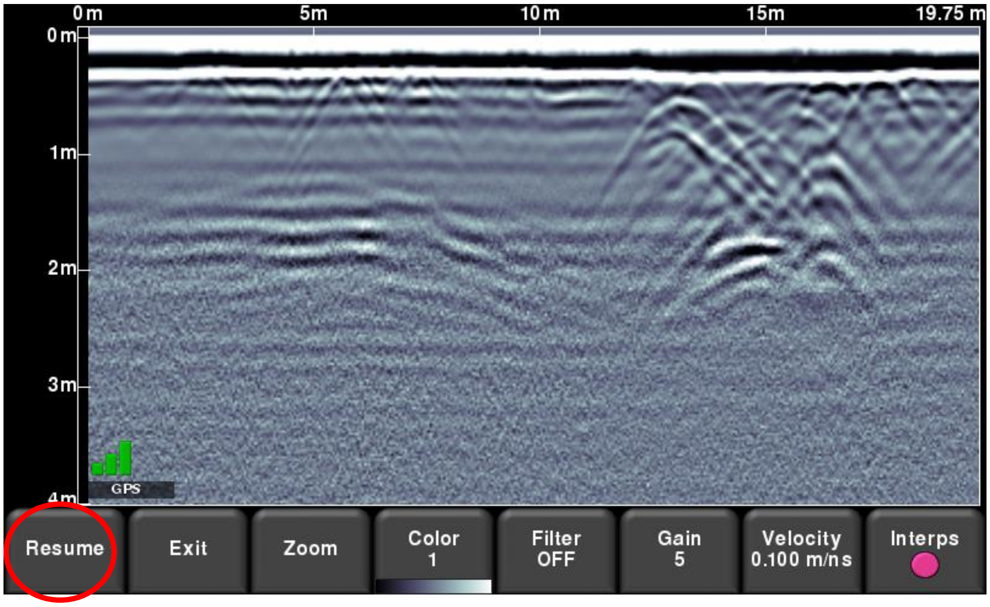


Figure 6-9: Resume button in Free Run mode.

6.6 Dialog Box

You can obtain depth and position information anywhere on the Line Scan by touching the screen and holding for a second. A cross-hair appears where you touched the screen, with a box displaying the position and depth (Figure 6-10). To get the position and depth information about a different point on the screen, simply touch and drag the box or cross-hair to the desired position. This is available regardless of what trigger is selected.

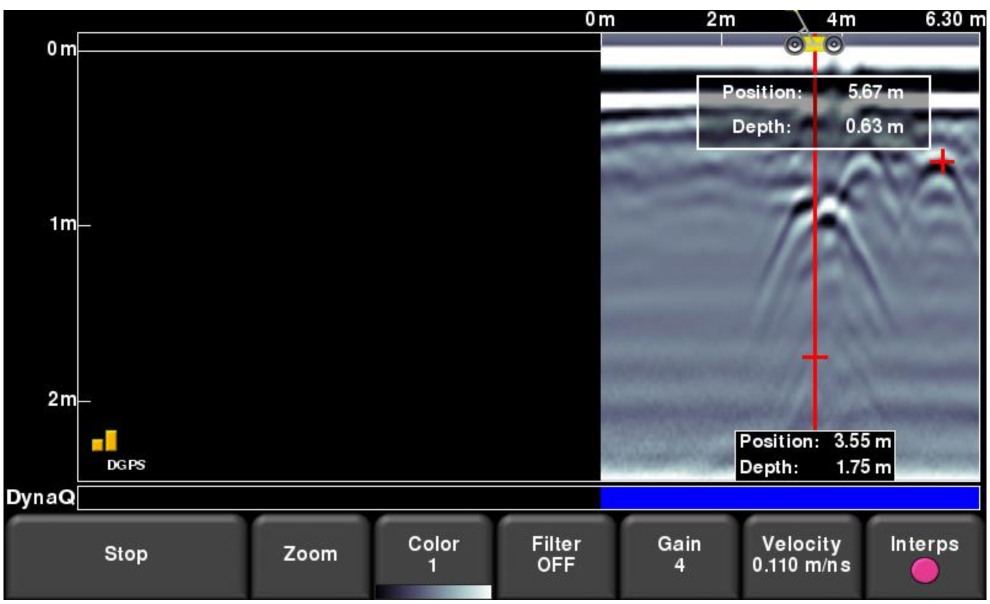


Figure 6-10: Touch the screen to get depth and horizontal position at any point

6.7 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

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 6-11).

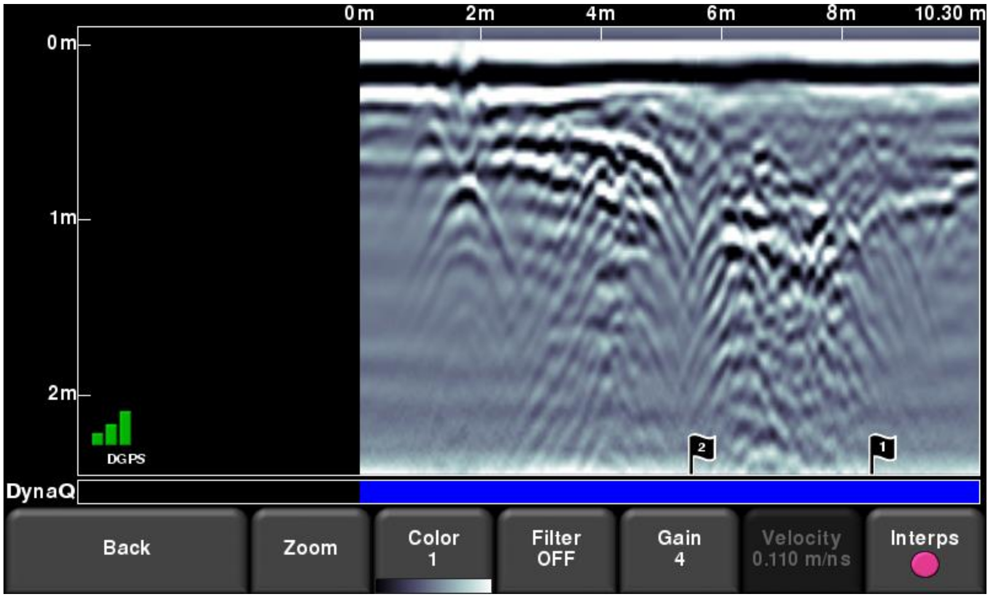


Figure 6-11: Inserting Flags

6.8 Line Scan menu options

All the settings described below change the way the data is viewed on the screen. They do not alter the saved data in any way. These settings can be changed while you are still collecting data, after pressing Stop, or when viewing a previously saved line.

6.8.1 Zoom

This button controls the horizontal and vertical scaling of the displayed GPR data. Pressing the **Zoom** button changes the buttons on the bottom menu, which are explained below:

- **Depth** – Pressing **+** and **-** under the **Depth** button allows you to change the displayed depth, up to the value set under Scan Depth in the System Configuration menu (Section 5.2.2). This is commonly referred to as the depth window. Note that when the data is exported, the depth set in this zoom menu will be used. For example, the Scan Depth is set to 4m in System Configuration, but the user zooms into 2m here. When exporting, the data will have a maximum depth of 2m.

The following are the maximum depths available for each system:

- Noggin 100 Ultra = 50m (150 feet)
- Noggin 100 = 50m (150 feet)
- Noggin 250 = 30m (100 feet)
- Noggin 500 = 20m (75 feet)
- Noggin 1000 = 10m (30 feet)

Higher depths can be set under Custom Configuration (Section 5.2.8).

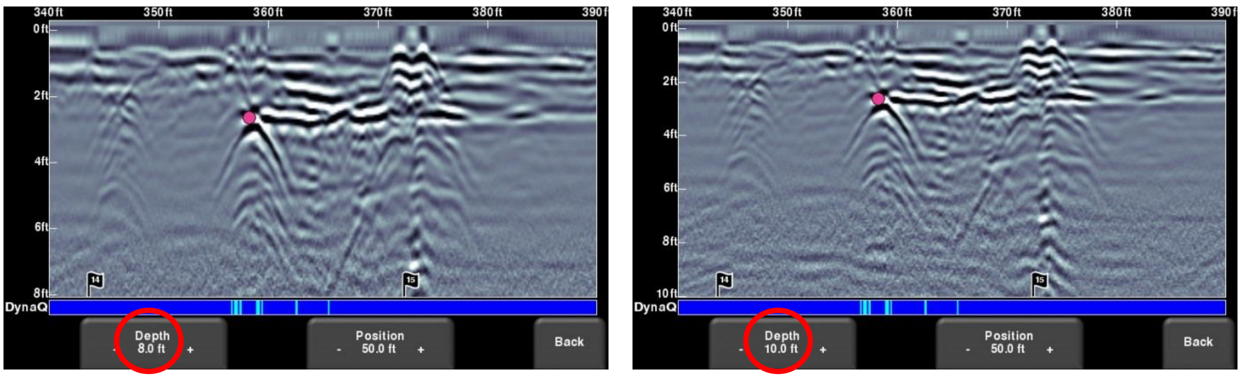
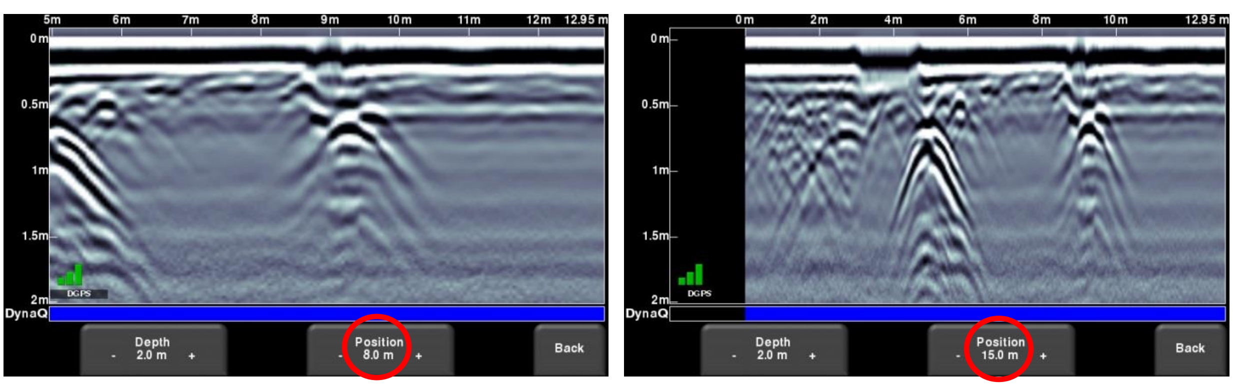


Figure 6-12: Changing the displayed depth

- **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 (Figure 6-13) One reason for setting this higher would be to fit more data on the screen and look for consistency among hyperbolas that were crossed.
  The maximum amount of data that can be displayed on a screen for each system is:
  - Noggin 100 = 100m (300 feet)
  - Noggin 250 = 75m (150 feet)
  - Noggin 500 = 50m (100 feet)
  - Noggin 1000 = 20m (50 feet)



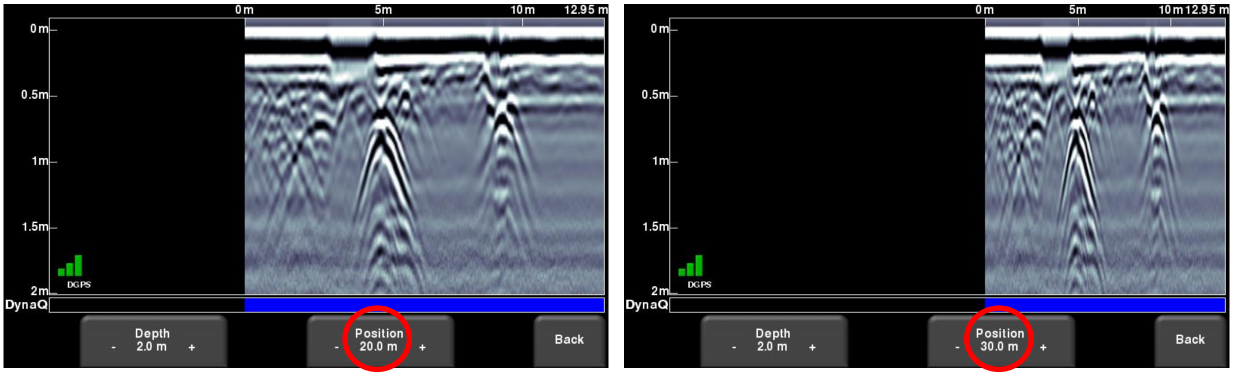


Figure 6-13: Varying position, or horizontal scaling

6.8.2 Color

Pressing **Color** changes the color palette for the GPR Lines. 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 6-14.

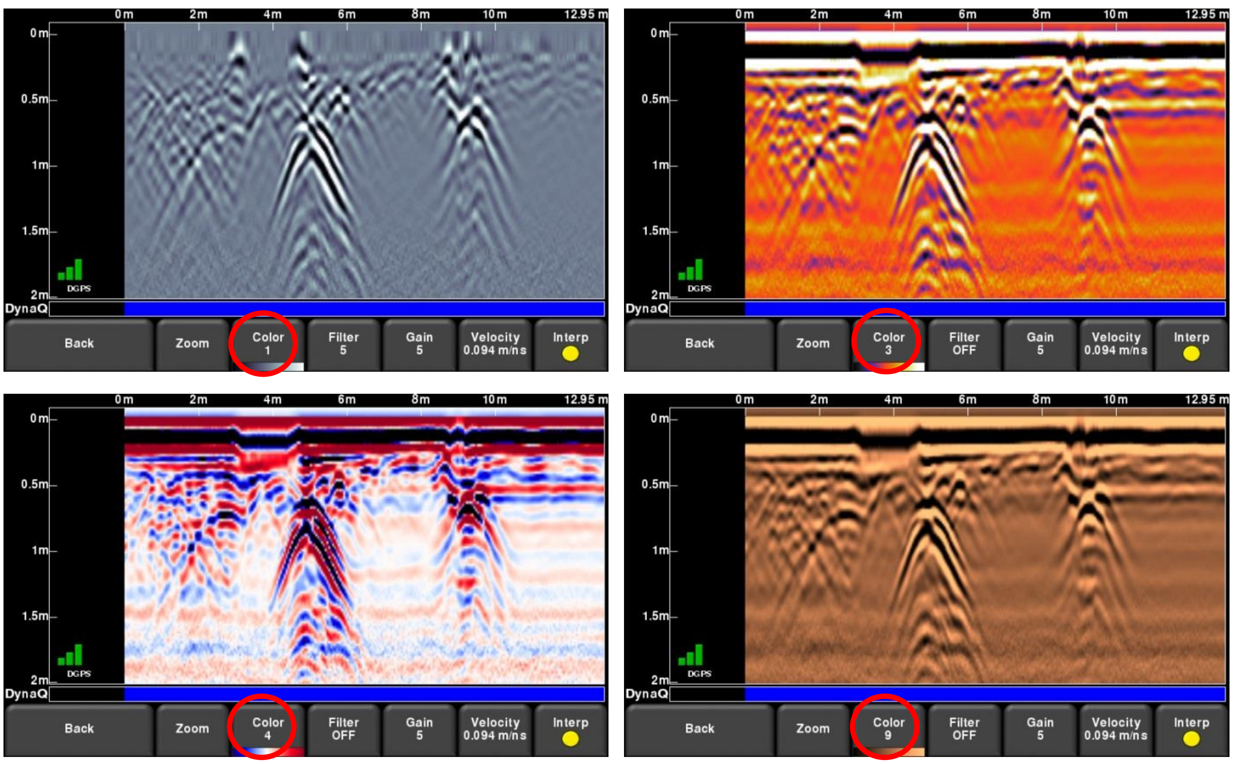


Figure 6-14: Changing colour palettes

6.8.3 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 this 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 6-15).

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.

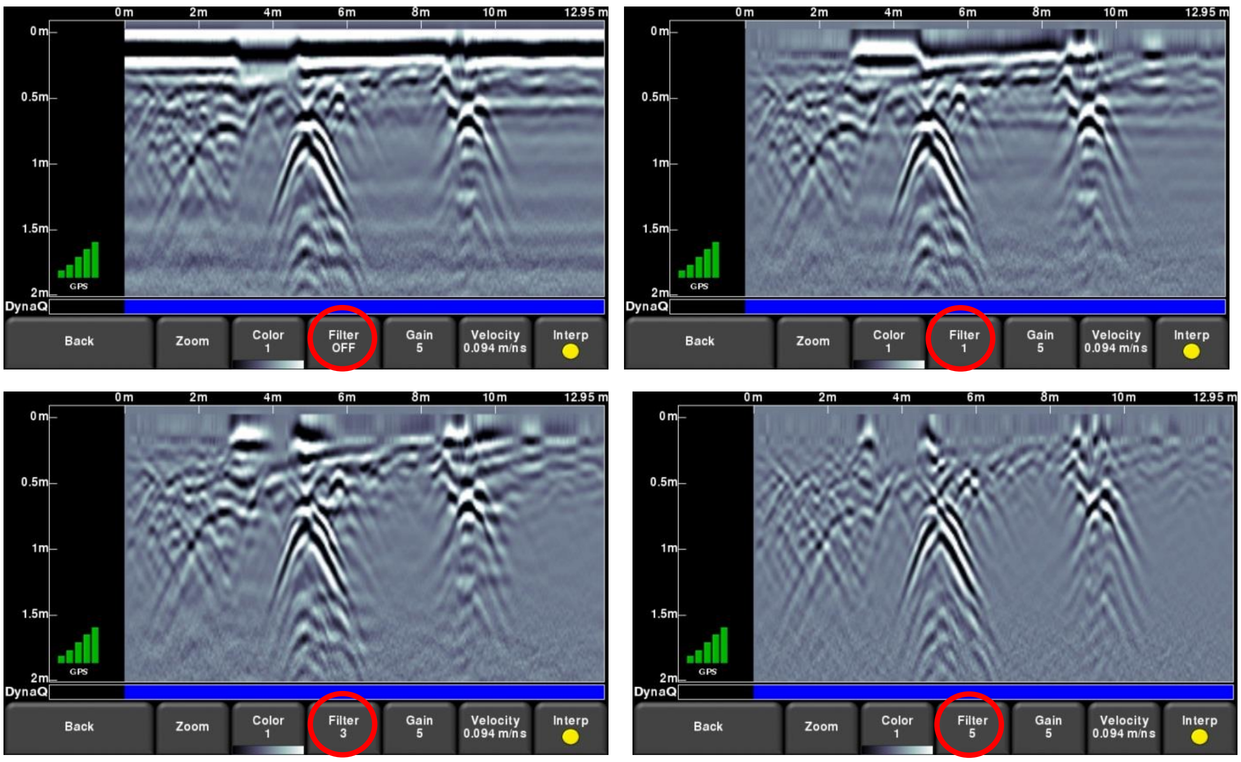


Figure 6-15: Showing variable filter lengths and Filter Off.

6.8.4 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 6-16). 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).

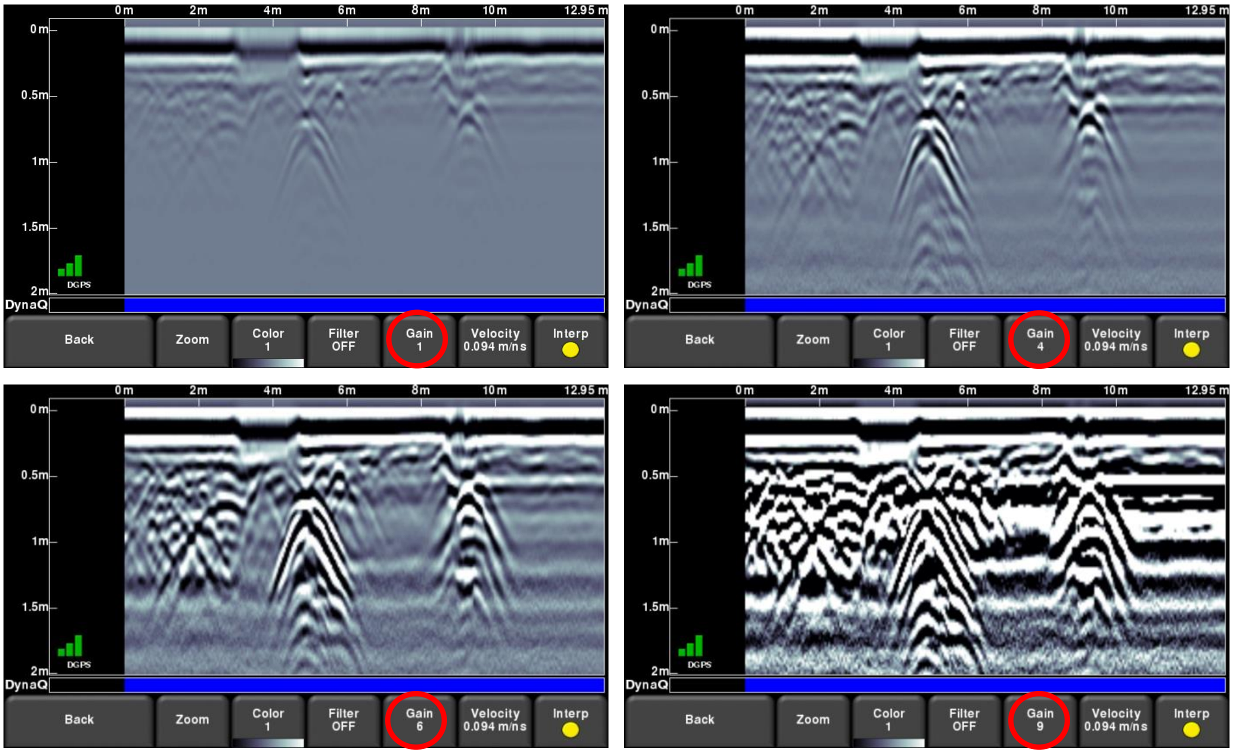


Figure 6-16: Varying the Gain

6.8.5 Velocity

The Velocity is a parameter used to ensure that measured depths are accurate. The best way to ensure this is by using the hyperbola-fitting method, since it is based on data collected in the area. The current value is displayed on that button beneath the word Velocity.

Crossing linear targets like pipes or cables at a 90-degree angle produces a hyperbola suitable for velocity calibration. The value obtained will be 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 90 degrees.

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 6-17), 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 **+** and **–** buttons to vary between the following mediums: water, wet soil, moist soil, dry soil, very dry soil and air.

- **Velocity** – allows you to use hyperbola-fitting to determine a more accurate velocity. The options are slightly different, depending on 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 & down keypad arrows such that it lines up with the top of the hyperbola in question (Figure 6-17).

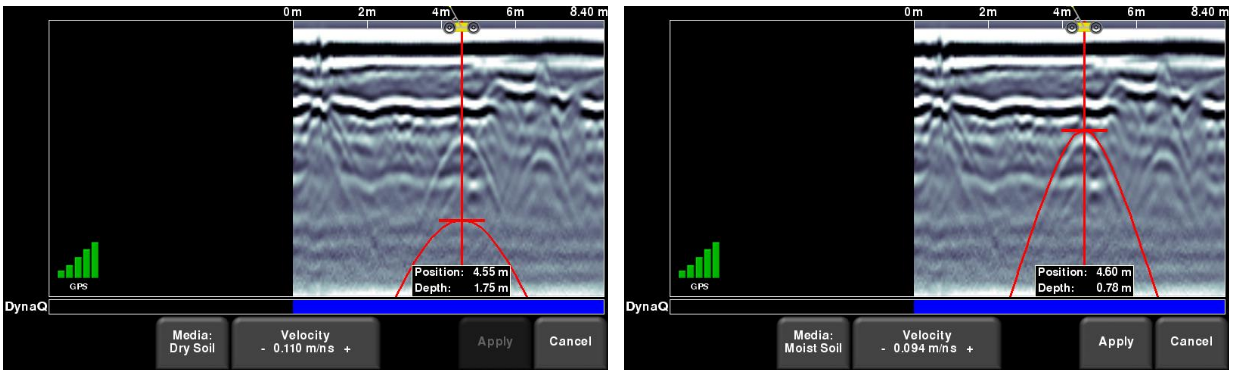


Figure 6-17: Adjusting Velocity while in backup mode. Image on left shows initial hyperbola that appears, while the one on the right has the correct hyperbola fit

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. Drag the hyperbola such that it lies over a real hyperbola from the ground (Figure 6-18). You can use the 4-way keypad arrows to fine tune the movements.

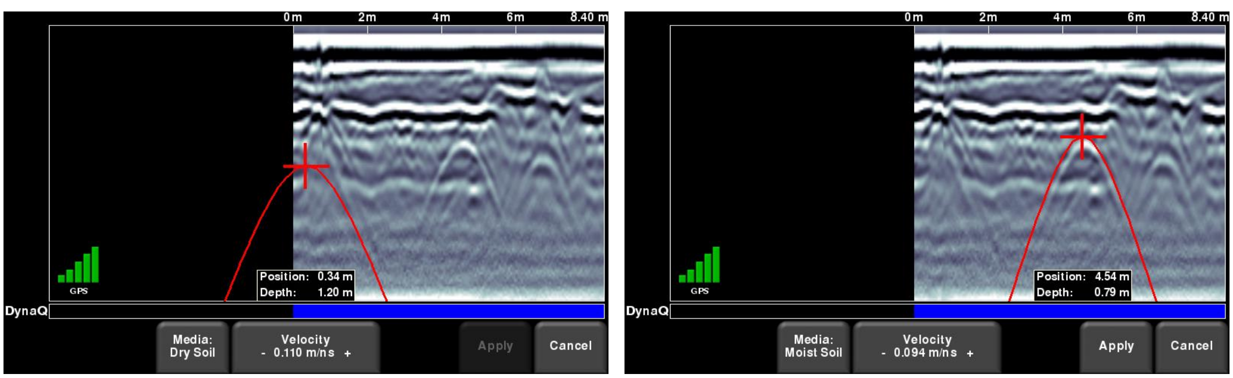


Figure 6-18: Adjusting Velocity, without backing up. Image on left shows initial hyperbola that appears, while the one on the right has the correct hyperbola fit

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 6-17 and Figure 6-18), 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 (Section 3.5), and you should calibrate to a different hyperbolic response.

6.8.6 Interp

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

Either during collection, back-up or when reviewing a collected line, you can simply touch anywhere on the screen to add an Interpretation (Figure 6-19). This appears as a dot of whatever colour is selected. To change the color, press the **Interp** button to see a selection of colours and to select a new one (Figure 6-20). Note, Interps cannot be added in No Save Mode.

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 MapView or in Google Earth™), but only if the more accurate external GPS is used.

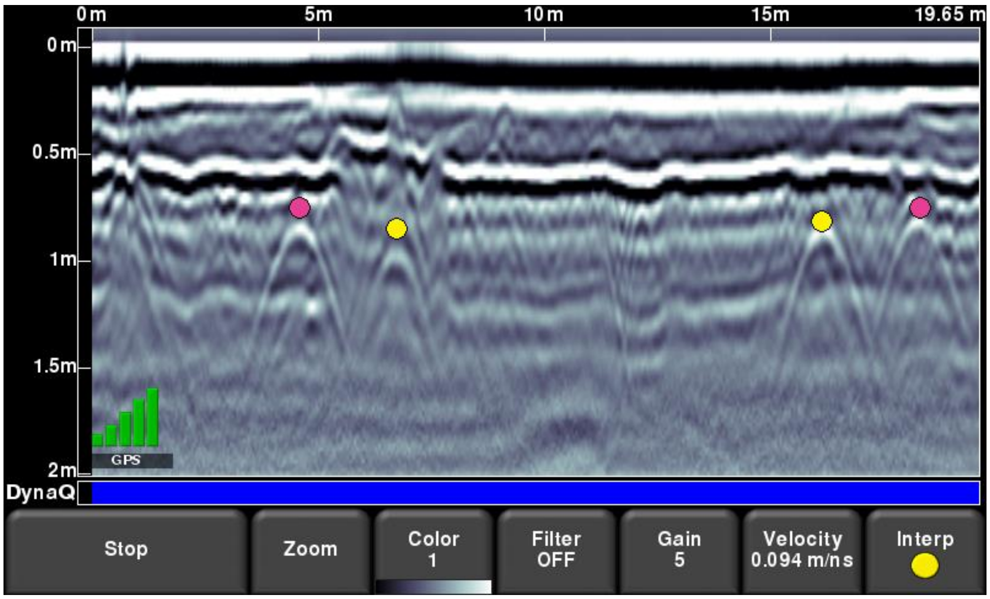


Figure 6-19: Touching the screen to put Interps

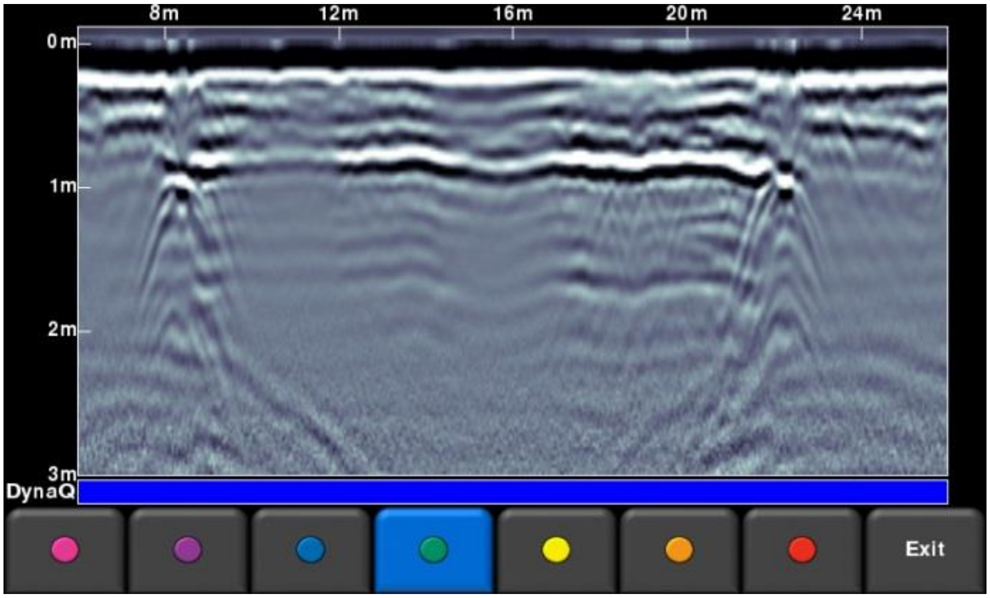


Figure 6-20: Available colors for Interps

6.8.7 Pause button (only available in No Save Mode)

The Pause button allows you to temporarily stop data collection and resume, without clearing the data from the screen. This might be useful if you want to collect a series of parallel lines over a target and show all the passes on the screen for comparison.

Once you collect some data, press **Pause.** You can now move the system without data scrolling on the screen. When you are ready to resume collecting data, press **Resume**. You will see a thick, red vertical line, corresponding to when you hit the Pause button and then restarted (Figure 6-21).

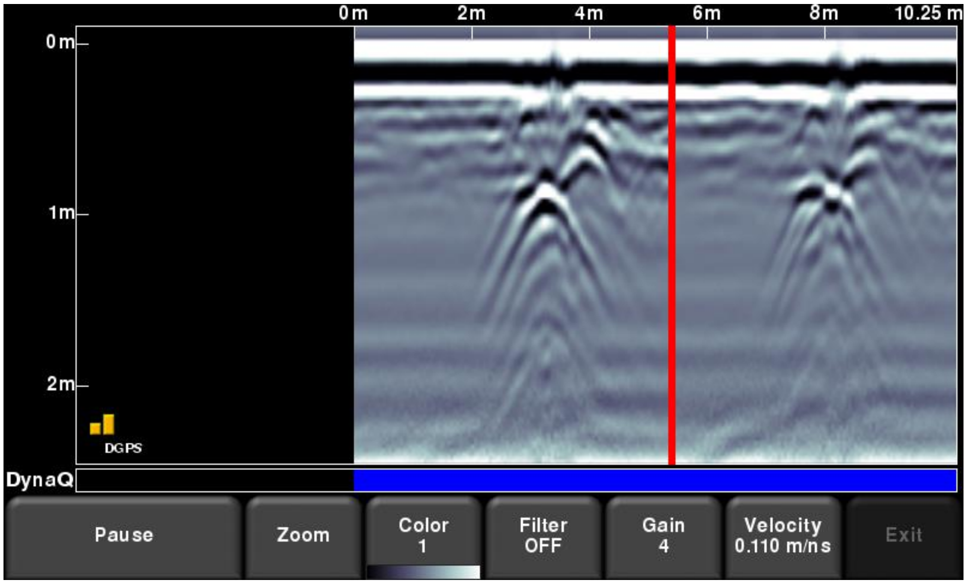


Figure 6-21: Pressing Pause and resuming data collection

6.8.8 Drawing arrows (only available in No Save Mode)

There is no option for Interps in this mode, as the data is not being saved. However, you do have the ability to draw arrows on the screen (Figure 6-22).

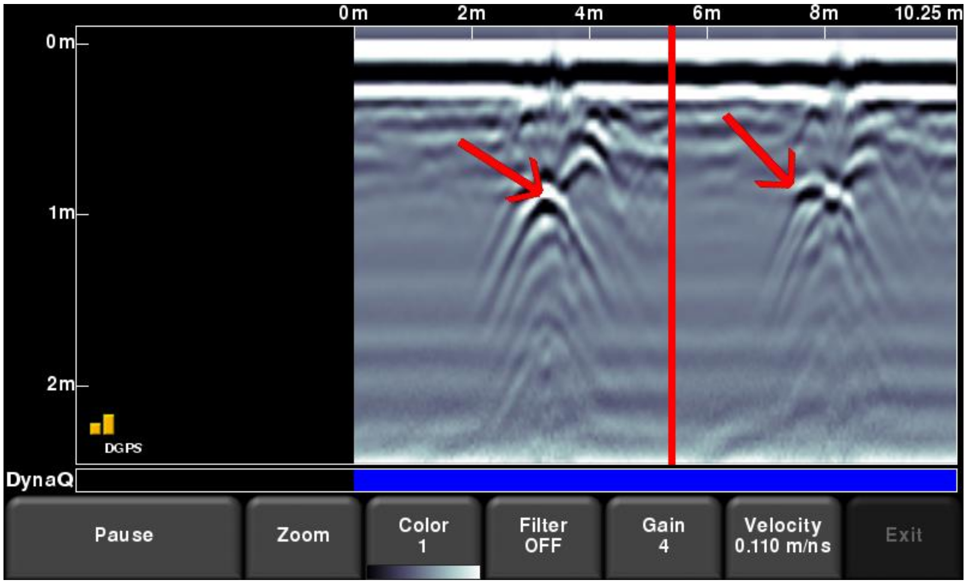


Figure 6-22: Drawing arrows on the screen to highlight targets and features

Touch the screen where you want the head of the arrow to appear, and then swipe away in the direction of the shaft. In the example in Figure 6-18, the user touched near the hyperbola, then swept their finger towards the top left to create the arrow. Just like Interps, any number of arrows can be drawn on this screen. Touch any arrow to remove it.

Remember that pressing the **Camera** button will take a screenshot and save it in the currently selected project.

7. 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 known and unknown 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.

7.1 Grid Setup

The setup screen in Figure 7-1 will allow you to set parameters of the grid, before data acquisition begins. Information about the grid (grid number, spacing, depth, size etc.) is displayed on the left side of the screen, including whether the depth slices are processed. 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 or hypotenuse measurement of a right-angle triangle; this is valuable when you are measuring out your grid to ensure complete accuracy.

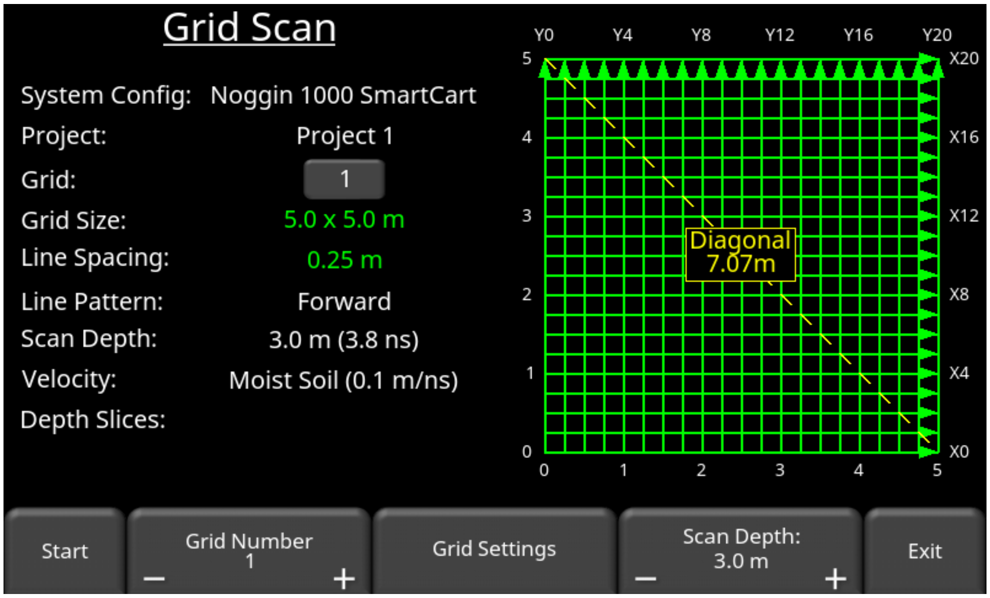


Figure 7-1: Grid Scan setup

Grid Number - To select a grid number, press the **+** and **-** buttons under **Grid Number** at the bottom of the screen. Grids that contain no data will have some text and grid lines shown in green, whereas grids containing data will have the text and grid lines shown in red. Grids that are partially complete will show the uncollected lines in green on the right side. To jump directly to a grid number, press the button containing the grid number on the screen. This will display a keypad where you can enter the grid number directly, rather than continually pressing the **+** and **–** buttons (similar to the Line Scan menu).

Scan Depth – Press the **+** and **–** buttons to set how deep the scan should be. Note that the deeper you go, the more depth slices will be generated in SliceView mode.

If a grid is completely or partially collected, you will have a different menu at the bottom of the screen (Figure 7-2).

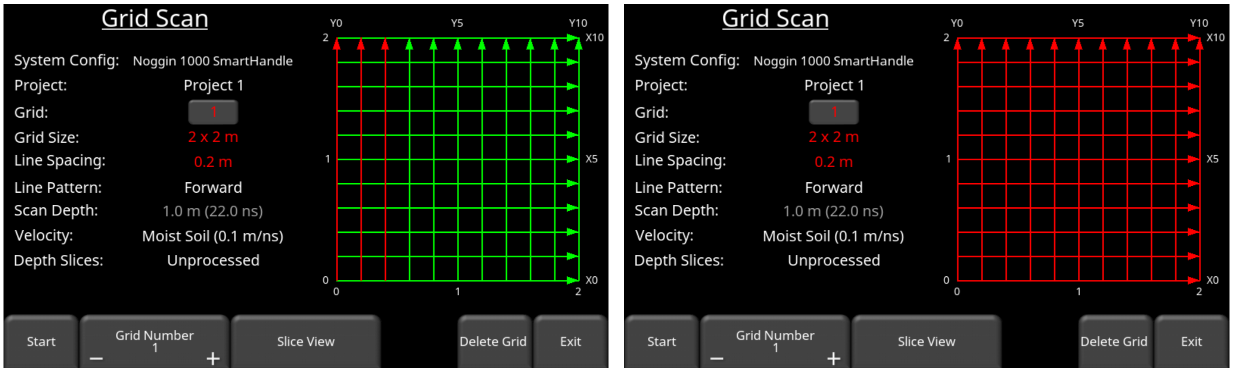


Figure 7-2: Partially collected grid (left) and fully collected grid (right)

SliceView – If a minimum of 3 lines are collected, the SliceView option will be enabled. Press this to create depth slices for the gridded area.

Delete Grid – press this to delete all data in this grid. It will ask you to confirm before deleting.

7.1.1 Grid Settings

Before starting Grid Scan, pressing this button will change the bottom menu, allowing you to set specific parameters for your grid (Figure 7-3). 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.

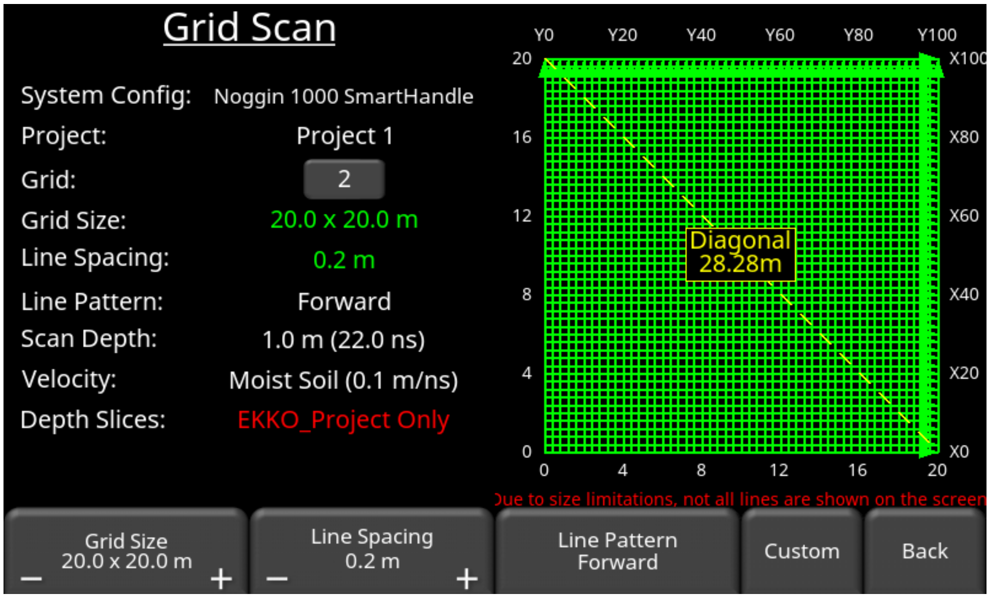


Figure 7-3: Grid settings. This example shows a large area grid where the depth slices will only be processed in EKKO_Project PC software

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 a message in red will say "EKKO_Project Only". This means that the grid must be exported from the DVL and opened in the EKKO_Project software to generate depth slices (Figure 7-3).

Line Spacing - Press the **+** and **-** buttons to vary the line spacing. The following are the recommended spacing for different frequencies:

- Noggin 100: 1m or 3' apart
- Noggin 250: 0.25m or 1' apart
- Noggin 500: 0.20m or 0.5' apart
- Noggin 1000: 0.10m or 0.5' apart

> **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. As well, these rules may have to be bent 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 7-4). Collect lines in forward mode when possible. Press this button to toggle between modes.

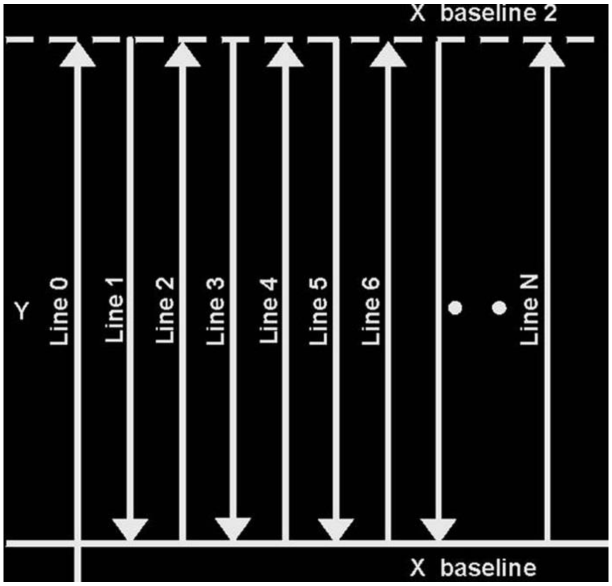


Figure 7-4: Forward/Reverse grid line collection

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

7.1.2 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 7-5)

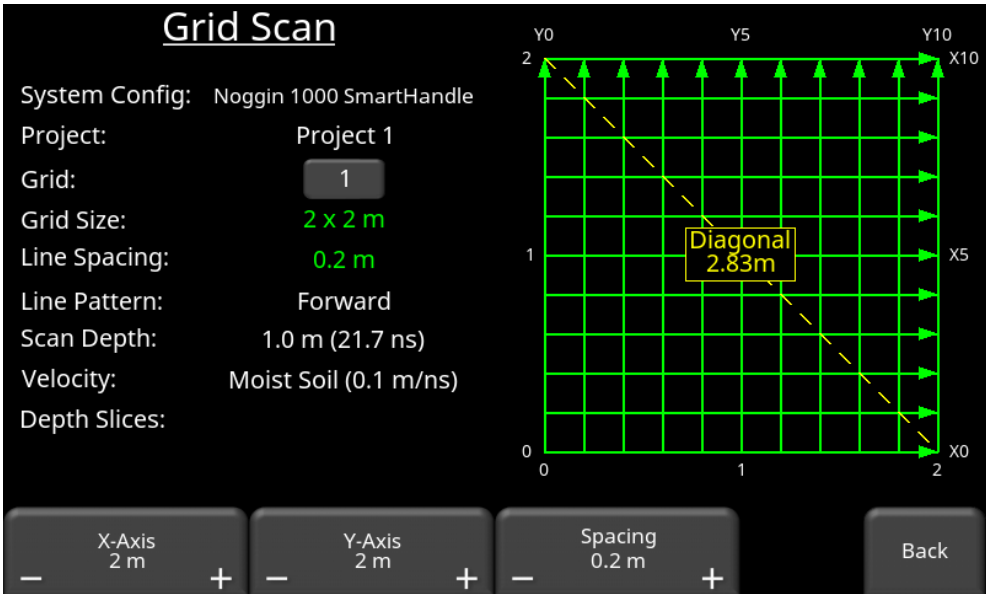


Figure 7-5: Custom grid setup, can vary dimensions of X & Y axes, as well as line spacing

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 set 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 set 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.

7.1.3 Starting (or resuming) data collection

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

> **Note**: You cannot collect a grid in Free Run mode. If you attempt to start a grid with Trigger set to Free Run, you will get the error shown in Figure 7-6.

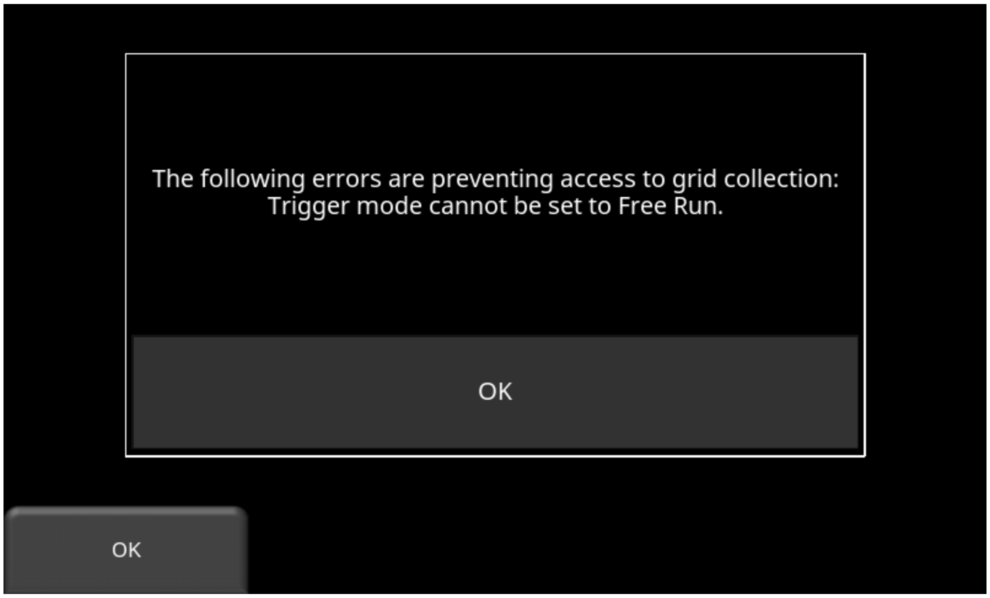


Figure 7-6: Error message when trying to start Grid collection with Trigger set to Free Run

The start button will be disabled if the line spacing is equal to the grid dimension, resulting in just 2 lines in either direction. An example of this would be creating a 1m x 1m grid, with line spacing of 1m.

If you are on a partially collected grid, pressing **Start** will take you into that grid and data collection resumes where you left off.

7.2 Laying out the grid

Positional accuracy of each line is vital to locating targets of interest once data has been processed. Follow the steps below to layout the grid.

Step 1 – Define the axis- Lines parallel to the Y-Axis are called Y-Lines. Similarly, lines parallel to the X-Axis are called X-Lines (Figure 7-7). Pick the origin of the grid such that it is the furthest corner away from any obstacles. This way, all the lines start properly, but they can be ended early if there is an obstruction.

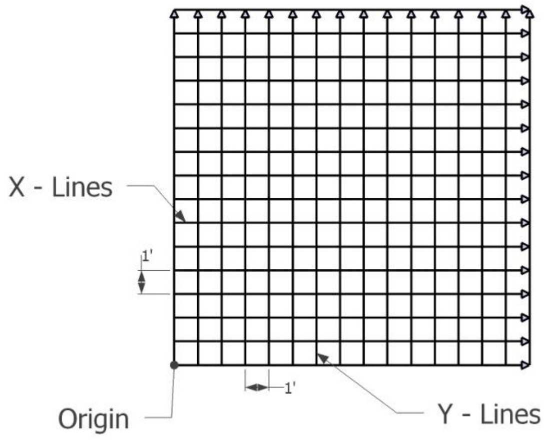


Figure 7-7: X-Lines and Y-Lines relative to the Origin.

Step 2 – Layout the Grid – for maximum accuracy, it's very important to establish a right-angle triangle (Figure 7-8). The easiest way is to use a single tape measure and refer to the diagram below. Start at the origin, walk out the desired distance for x-axis (A) and mark that point. Then then turn 90 degrees and walk out the desired distance for the y-axis (B) and mark that point. Determine the hypotenuse side (C) from the screen (Figure 7-8), then close in the triangle (C - hypotenuse side) back to the origin, making sure you meet the origin at the distance for C. If not, move that last point in tandem with the origin, such that both sides of the tape measure are taut.

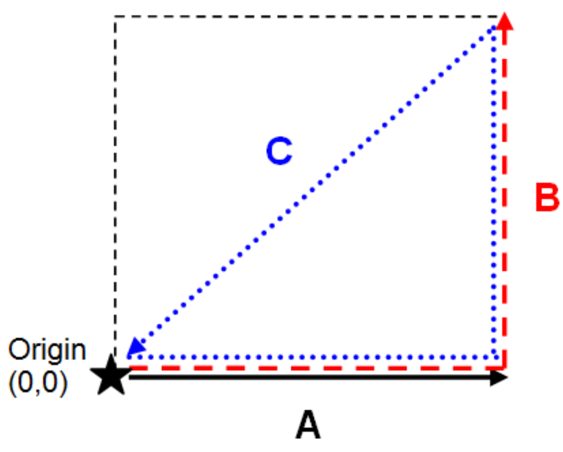


Figure 7-8: Forming a right-angle triangle

Step 3 – Mark the Line Start Positions – with the tape measure still on the ground, mark the line start positions based on the line spacings (Figure 7-9). Usually flags or paint work for grass, and chalk or paint on concrete. It is also recommended to paint a distance measurement every so often, in case you forget which line you're on.

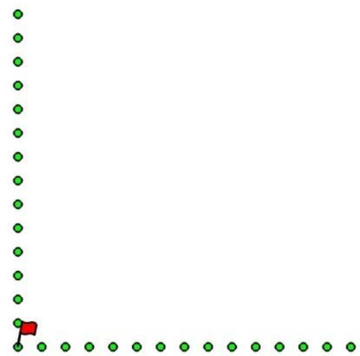


Figure 7-9: Marking the line spacing and starting positions for every line

Step 4 – Mark the End Positions – if you are doing a forward only grid, it is recommended to mark the end positions (Figure 7-10). You will need to aim for something to make sure your line is straight.

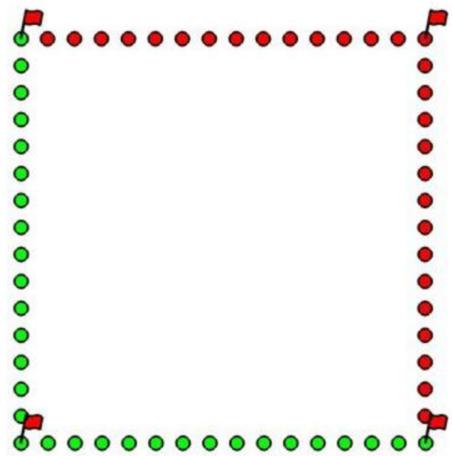


Figure 7-10: Marking ending positions

An example grid layout is shown in Figure 7-11.

Figure 7-11: Example of a grid survey. The red lines are superimposed just to illustrate the concept.

7.3 Data Collection

7.3.1 Physical Data collection

It is critical that the starting position is consistent on every line. Line up the middle of the unit with the starting line, and then push the system straight towards the end of the line (Figure 7-12). It is helpful to have a marker at the end so you have something to aim for.

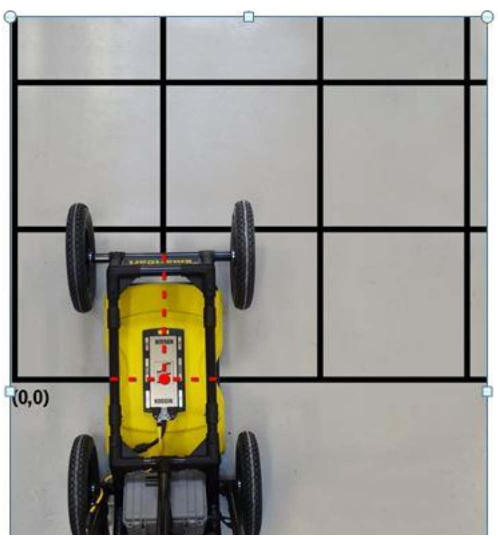


Figure 7-12: Lining up SmartCart properly on the lines

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 7.3.5.

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

7.3.2 Data collection on the DVL

The data collection screen is shown in Figure 7-13. 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 will initially display some parameters related to the grid.

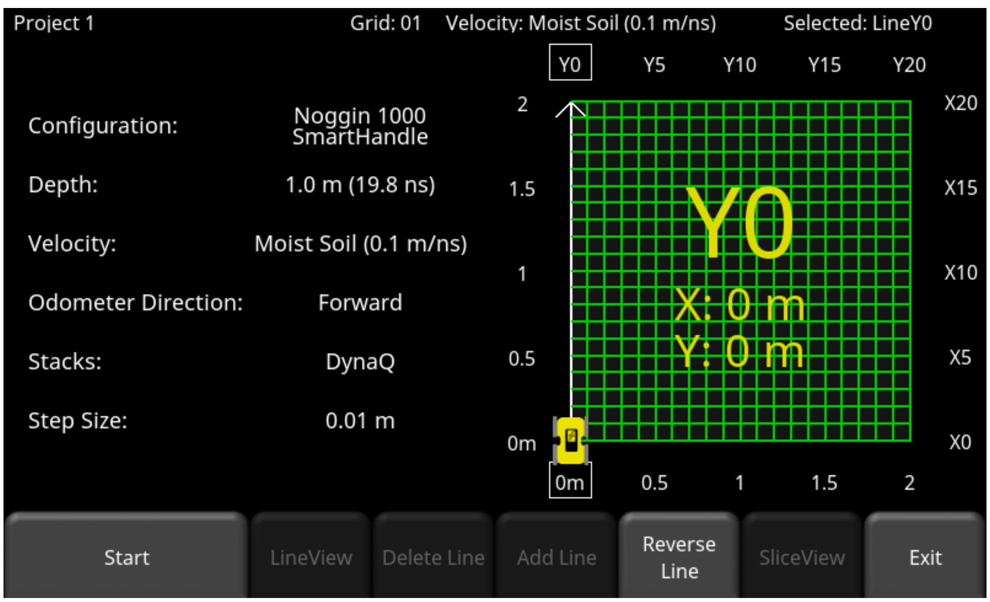


Figure 7-13: Grid collection screen prior to any data collection

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. Your current position (or distance travelled) is displayed in real time immediately below the DynaQ status bar (Figure 7-14). If Grid Line Stop is set to Auto, the system will automatically stop acquisition once that distance has been covered. If it 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 and make you re-collect that line.

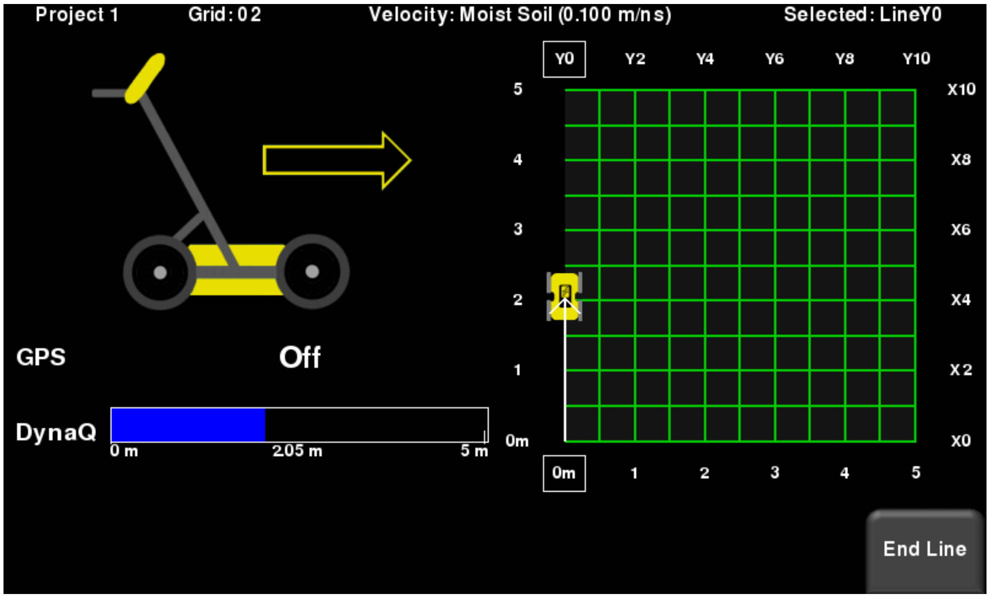


Figure 7-14: Collecting a line in the grid

Once data is collected, the Grid Line will turn red and the system will beep twice. The current line will now advance to the next one and is shown in white. The remaining lines to be collected are shown in green (Figure 7-15).

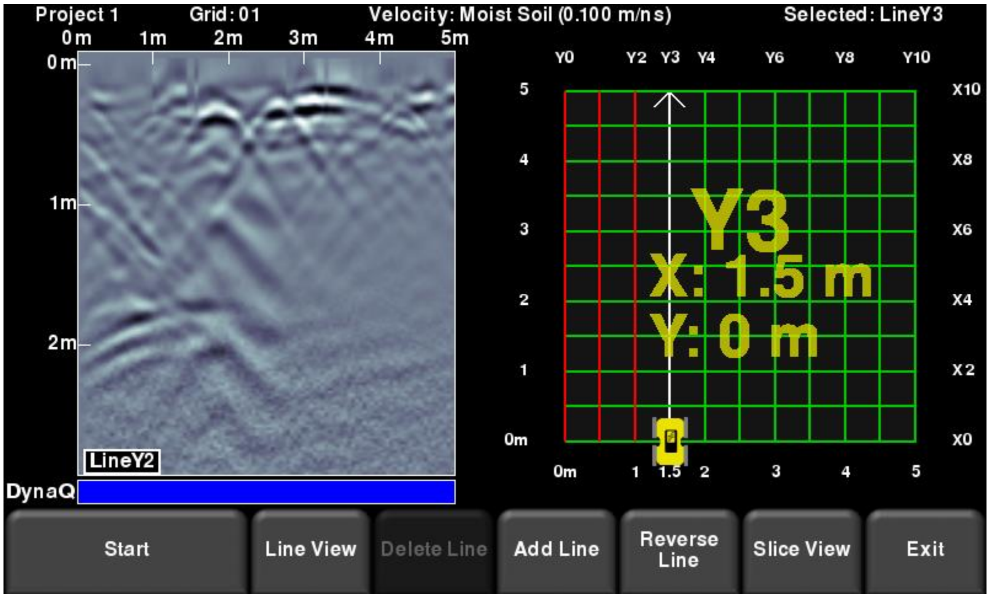


Figure 7-15: After a few lines have been collected

Move to the start of the next line and repeat the process. The grid image will always display the line number (e.g. Y3) 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.

> **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.

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 once all the lines in that direction are complete. For example, in Figure 7-16, Line Y0 was incomplete. Once all the remaining Y lines were collected, the system brings you back to Y0 in the reverse direction, labelled as Y0R. If you do not wish to collect this line, use the arrows on the directional keypad to move to the desired line.
Collecting around obstructions is described in Section 7.3.5.

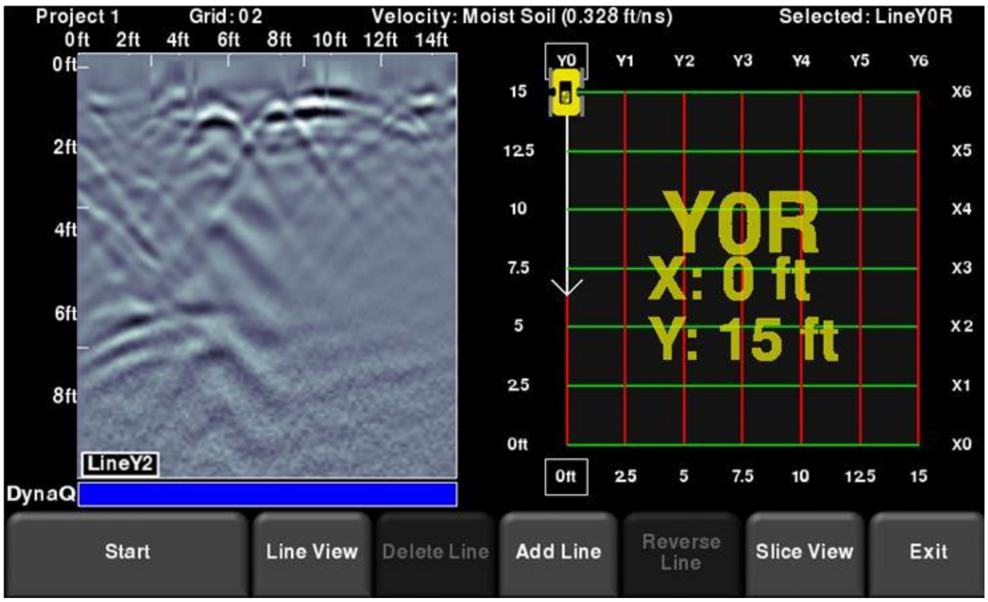


Figure 7-16: Option to add a reverse line when a collected line is incomplete

Flags can be added during grid collection by pressing the star button when you want to insert a flag at your current position.

7.3.3 Viewing & recollecting lines

Use the **4-way** directional keypad to highlight different X and Y lines. The selected line will always be in white. Collected lines will be in red and lines remaining to be collected will be in green. You may want to recollect a line if you make a mistake, or maybe just view a line.
To recollect a line, press **Start**. You will be prompted with a message asking if you want to overwrite that line (Figure 7-17). Press **Yes** to proceed.

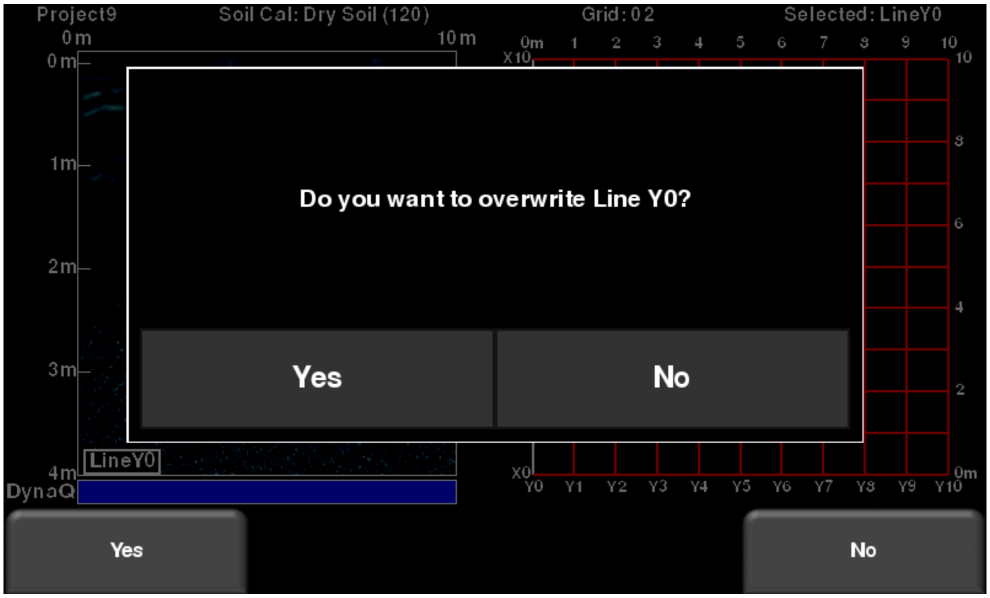


Figure 7-17: Overwriting a line

To change the way a line is viewed/displayed, press **Line View**. This will basically display the selected line in the Line Scan screen (Figure 7-18). 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.

Use the **left** and **right** arrows on the directional keypad to scroll through line data not visible on the screen.

It is also possible to display 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 changed, the depth slices will be reprocessed.

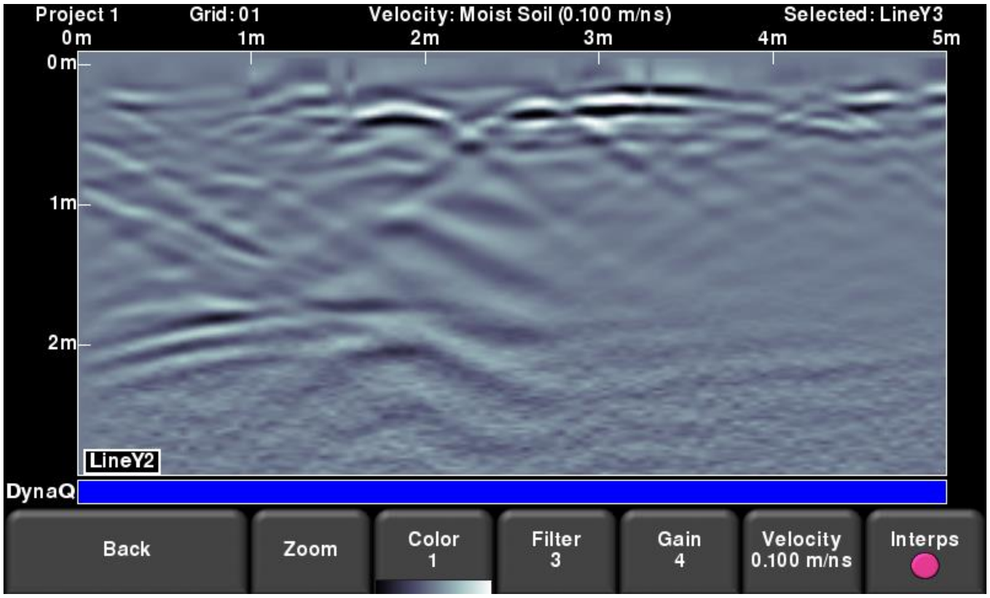


Figure 7-18: Viewing a grid line in full screen, with the Line Scan menu options at bottom

7.3.4 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 will take you to a screen shown in Figure 7-19.

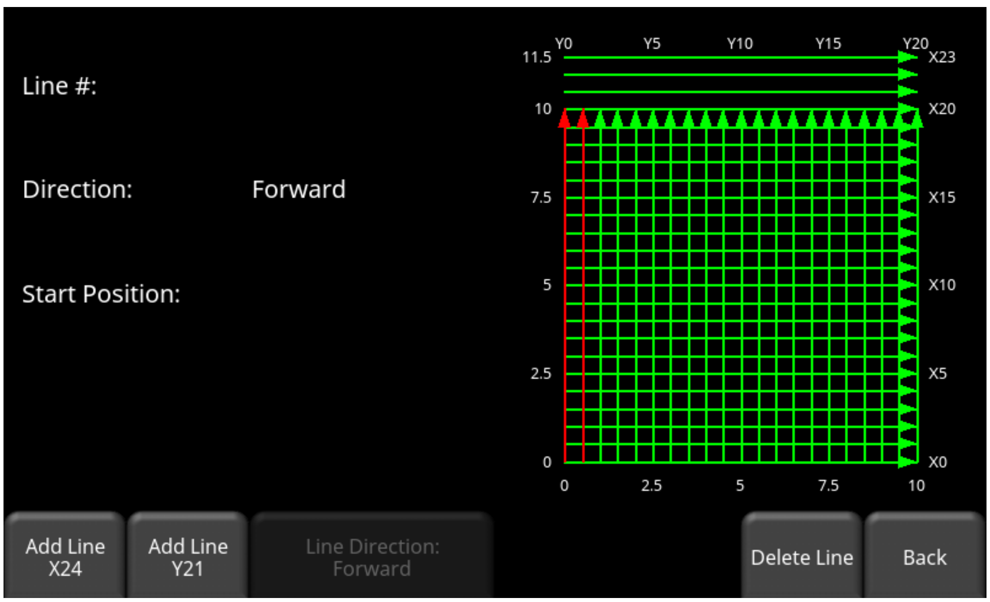


Figure 7-19: Addling lines to a pre-defined grid

Pressing **Add X Line** or **Add Y Line** will add a respective line in X or Y directions at the end of the grid. Press the same button repeatedly to add multiple lines. The number of the next line to be added is displayed on the button.

There is also the option of specifying if you want the newly added line to be in the forward or reverse direction by pressing the Line Direction button, which will toggle between forward and reverse.

Note that any added lines will not be included when the depth slices are created. Depth slices are restricted to the originally defined grid size.

7.3.5 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**. The system will advance you to the next line, but if you cycle back to the line using the **4 way** directional keypad, it will return to the same line, but in the reverse direction. The name of the line will now contain an R at the end (Figure 7-20).

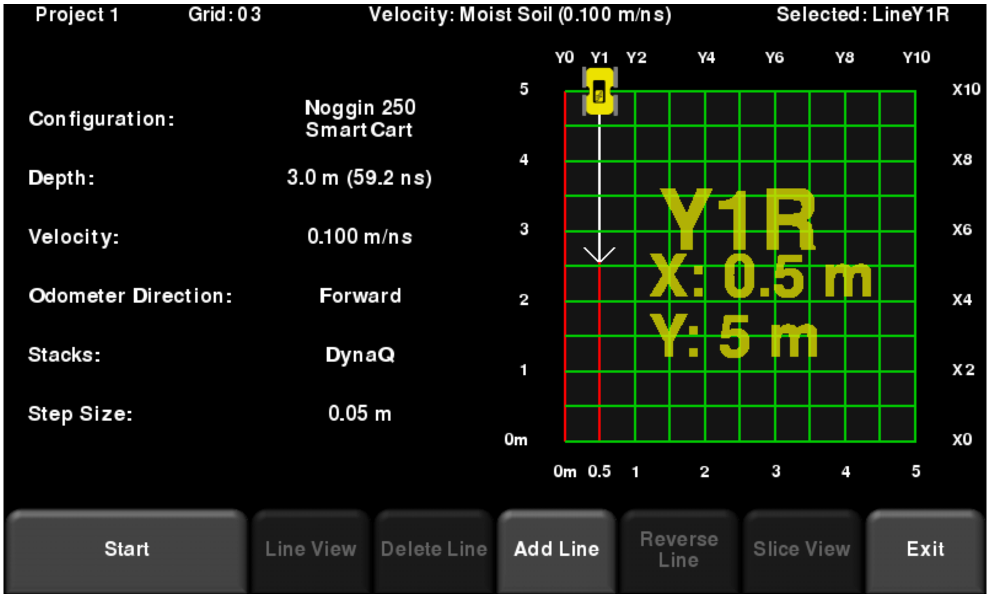


Figure 7-20: Collecting a reverse line around an obstruction

In the example above, Line Y1 was partially collected due to an obstruction. To collect from the other direction, the left arrow button on the 4-way directional keypad. This new line will now be labelled Y1R.

7.3.6 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

7.4 Processing Data

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

A message will display advising the velocity value that will be used (Figure 7-21). If you have adjusted this already for the ground you are on, you can press **OK** to proceed and create the depth slices.

If not, then it is recommended to press **Cancel** and adjust the velocity by using a good hyperbola on one of the collected lines (Section 7.3.3). Then return and press **SliceView** and press **OK** to proceed and create the depth slices.

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

See the next section on using SliceView.

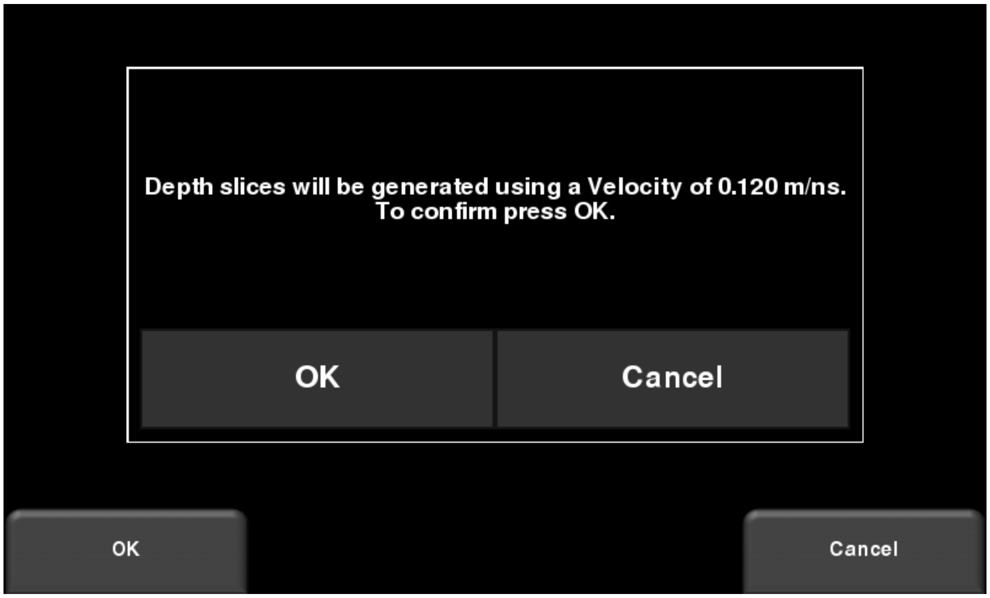


Figure 7-21: Processing depth slices with the correct velocity value

8. SliceView

SliceView 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.

Upon entering SliceView, the screen will be displayed as shown in Figure 8-1.

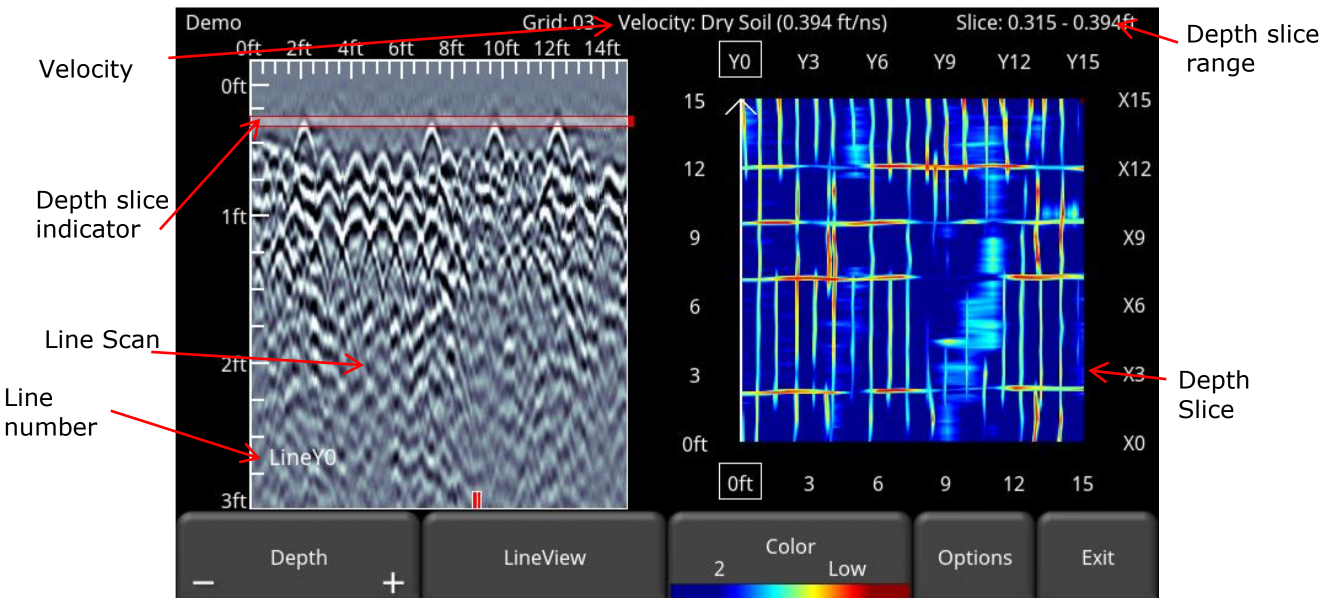


Figure 8-1: SliceView screen

The right half of the screen shows one of the depth slices. The top and right sides of this image show the 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 (Line Y0 in Figure 8-1). To move to another grid line, use the **4-way** directional keypad on the Display Unit; the highlighted line will be in 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 and slice thickness range. The slice thicknesses are automatically set, depending on the sensor used:

- Noggin 1000 = 2.5cm (1")
- Noggin 500 = 5cm (2")
- Noggin 250 = 10cm (4")
- Noggin 100 = 25 cm (10")

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 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.

8.2 Line View

Pressing this 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). The line number is overlaid on the lower left side of this image. Use the **4-way** directional keypad to change to a different line.

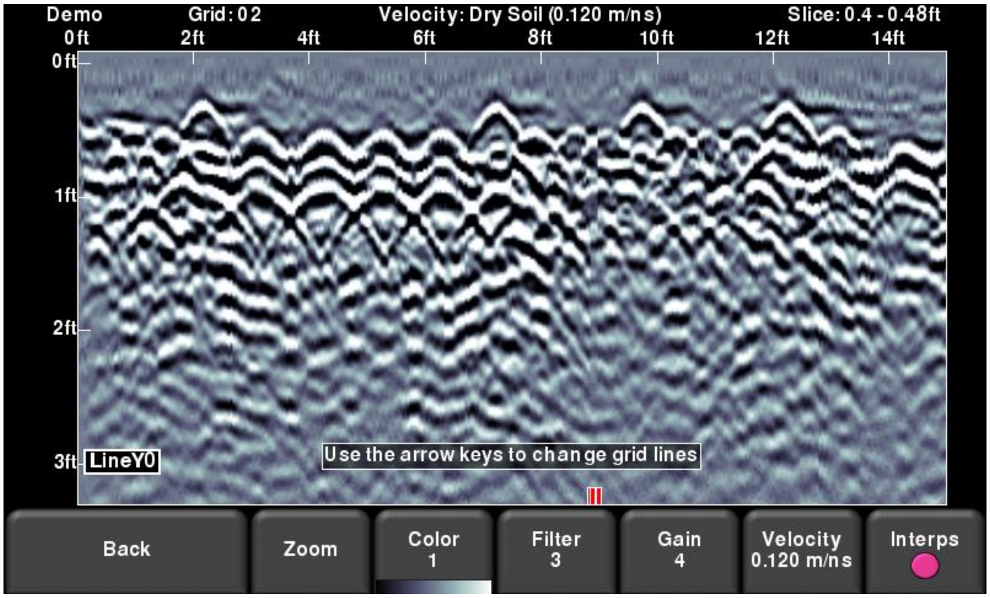


Figure 8-2: Changing Line View settings from within SliceView

Press **Back** to return to SliceView. Any changes made will be reflected on the GPR line in SliceView mode. If you change the velocity or depth, this will cause the depth slices to be re-processed.

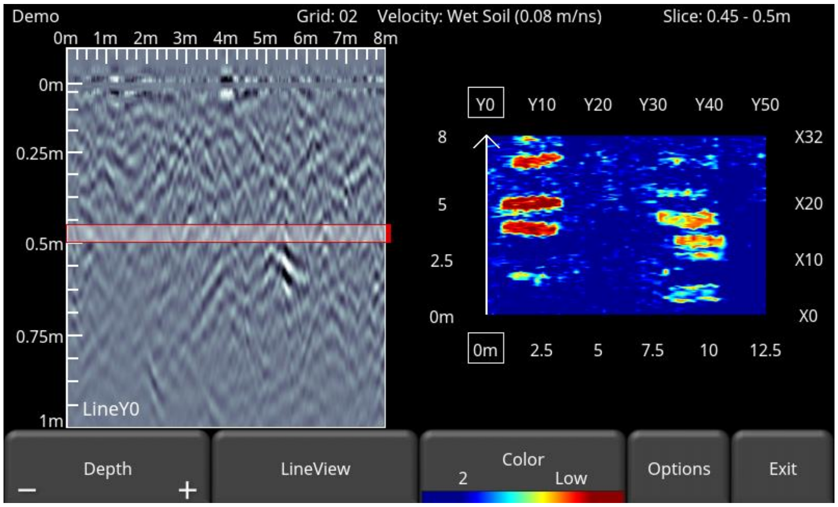
Users may want to change these display settings to make it easier to correlate line scan data with depth slices.

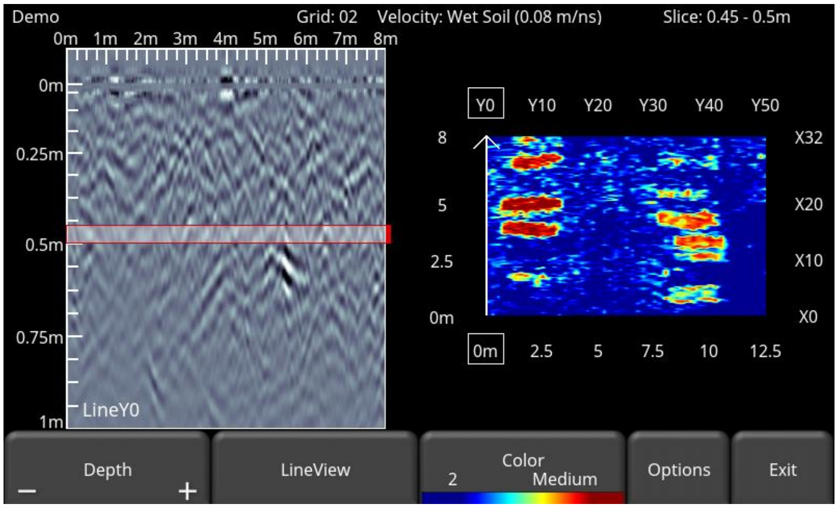
8.3 Color

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) **Color Sensitivity** - cycles between **LOW**, **MEDIUM** and **HIGH**. This is a function of how much signal data is displayed. A setting of HIGH is useful for revealing weaker targets which can sometimes 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.





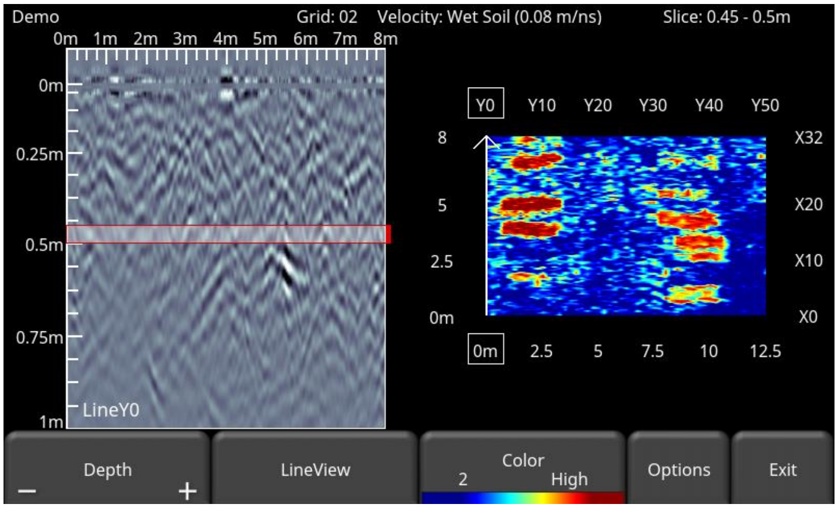


Figure 8-3: Varying the sensitivity, from top to bottom: Low, Medium and High settings. High shows more subtle targets but may sometimes appear cluttered while the Low setting only displays the strongest targets so be cautious when using it.

8.4 Options

Pressing **Options** changes the menu at the bottom of the screen, allowing the user to control the overlay of Grid Lines, Flags and Interps on the depth slice image. These are explained below:

8.4.1 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.

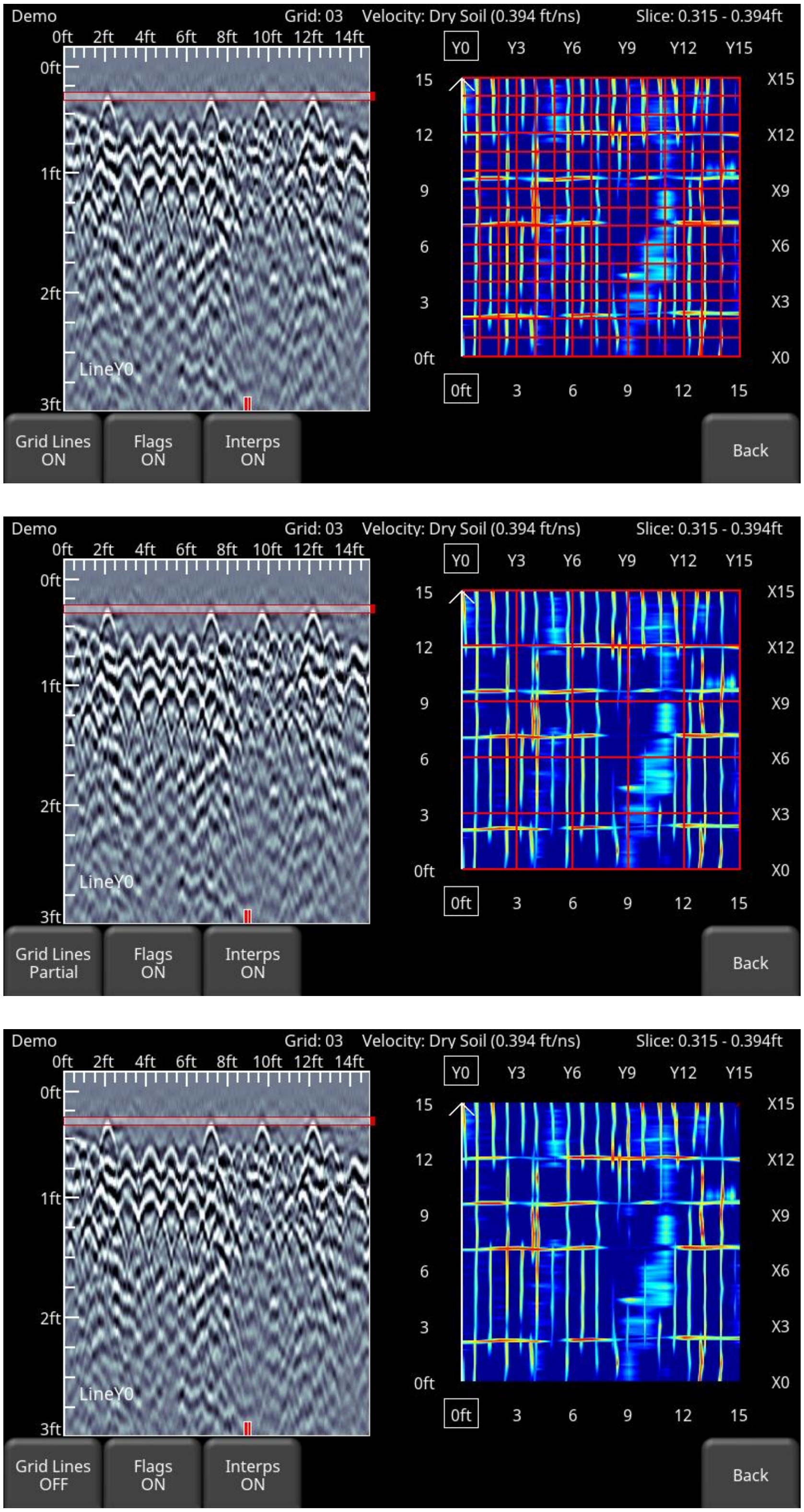


Figure 8-4: Varying the Grid Lines, from top to bottom: ON, PARTIAL and OFF settings

8.4.2 Flags

Pressing this button toggles on and off between displaying flags on the line scan data and the depth slice.

8.4.3 Interps

Pressing this button toggles on and off between displaying Interps on the line scan data and the depth slice

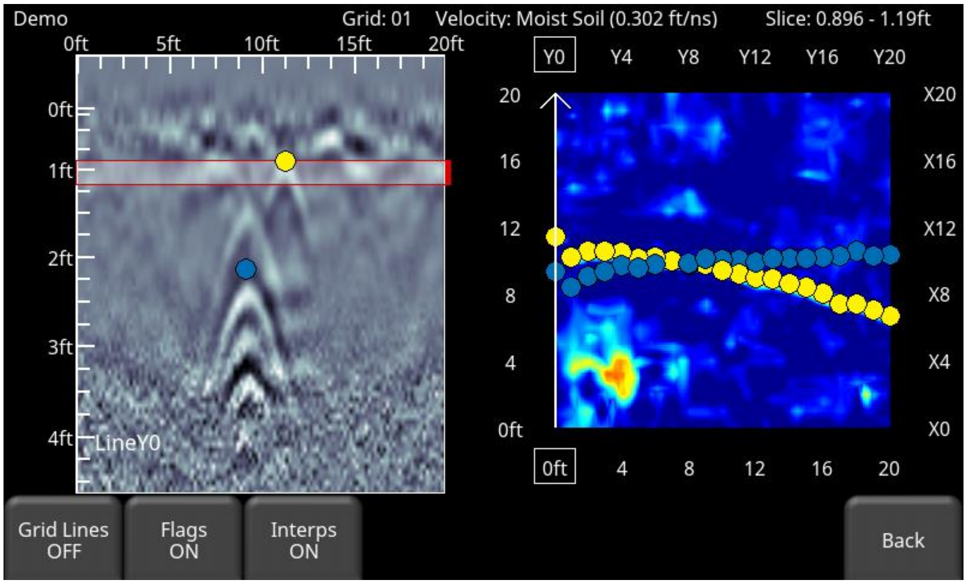


Figure 8-5: With Interps turned on, field interpretations are shown on the Line Scan data and the Depth Slice.

8.5 Recollecting lines

After looking at the grid data in SliceView you may discover that one or more grid lines need to be recollected (for example, maybe the starting position was offset). If so, you will need to enter the Grid Scan 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 **SliceView** button to re-process the grid data.

9. MapView

MapView is a unique feature that allows the user to graphically view the path travelled by the system, and any flags or interpretations made. This is helpful in determining the linearity and consistency of buried objects. It will also display a view showing the lines collected as part of a grid.

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, all the interpretations will line up when viewed in MapView.

MapView only works if GPS data is collected with the GPR data. This is what allows the lines and/or grids to be positioned correctly (with the right orientation).

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

9.1 Accessing MapView

MapView is project based and will display all grids and lines collected in a project. Remember that Projects typically contain data from a given site.

MapView can be accessed either from the main screen or from the File Management menu (Figure 9-1). The **MapView** button will only be available if data exists in the project AND it was collected with the GPS enabled; otherwise it will be greyed out.

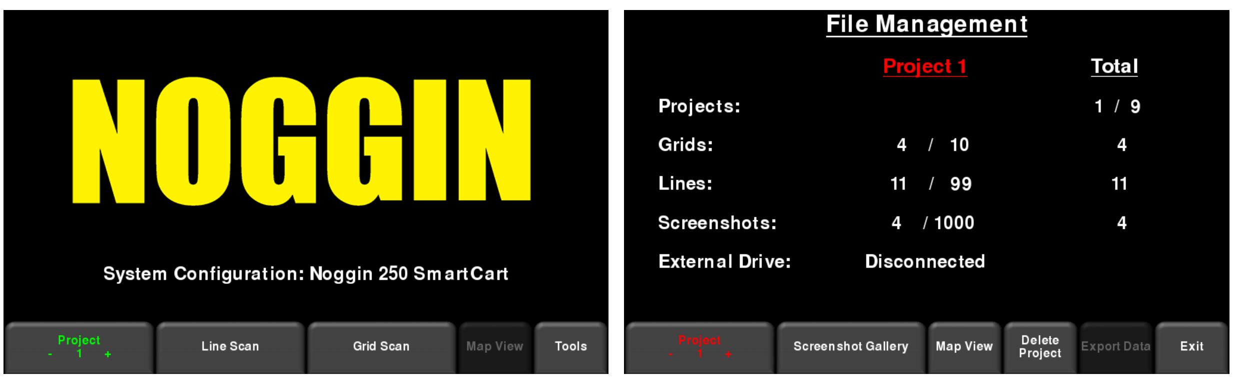


Figure 9-1: Accessing MapView either from the Main screen (left) or File Management menu (right)

9.2 MapView screen

Irrespective of how you get there, entering **MapView** will show an image like the one in Figure 9-2. Moving your finger around the screen will move the entire image around and can be used for centering the image. The scale is shown in the bottom right corner. The available options on this screen are described below:

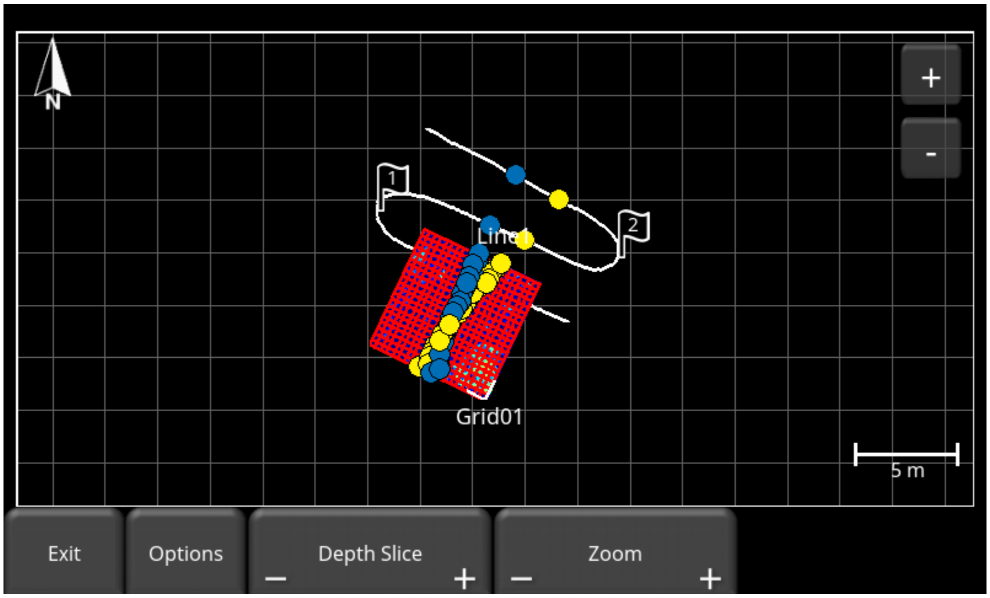


Figure 9-2: MapView showing the position of a line and grid

- If a grid is collected and depth slices have been processed, the Depth Slice button is available (otherwise it is greyed out). Pressing the **+/-** buttons under Depth Slice will increase or decrease the depth of the depth slice currently displayed
- Pressing the **+/-** buttons under **Zoom** will resize the image accordingly. Alternatively, you can also press the **+/-** buttons in the top right of the screen. To reposition the image in the middle of the screen, simply swipe the screen until the image is positioned properly.
- Pressing Options will display the screen shown in Figure 9-3 allowing you to customize the layer view. This is explained in the section below.

9.2.1 Options (Layer views)

Pressing the **Options** button will allow you to customize what is shown in the MapView display. The screen will be split between the Layer options on the left and the MapView display on the right (Figure 9-3).

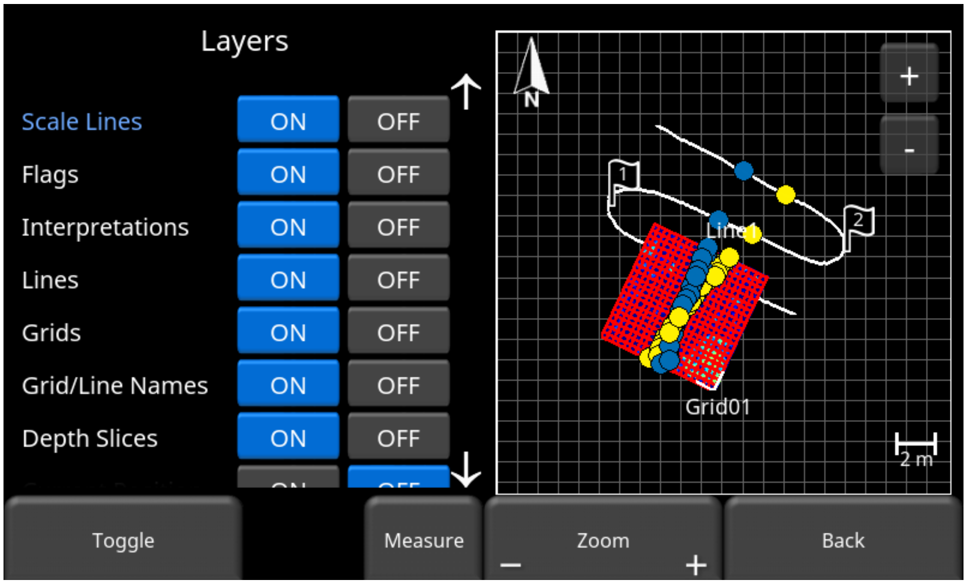


Figure 9-3: Setting layer options in MapView

Press the **ON** or **OFF** button beside each option to show or hide that particular feature on the display on the right. Alternatively use the Up and Down arrows on the 4-way directional keypad to select the desired feature, then press the **Toggle** button on the bottom of the screen to turn that feature on or off. The image in Figure 9-3 shows them all turned ON.

Each layer feature is described below:

- **Scale Lines** – controls the display of the background grid lines (Figure 9-4). These are used as scale reference.

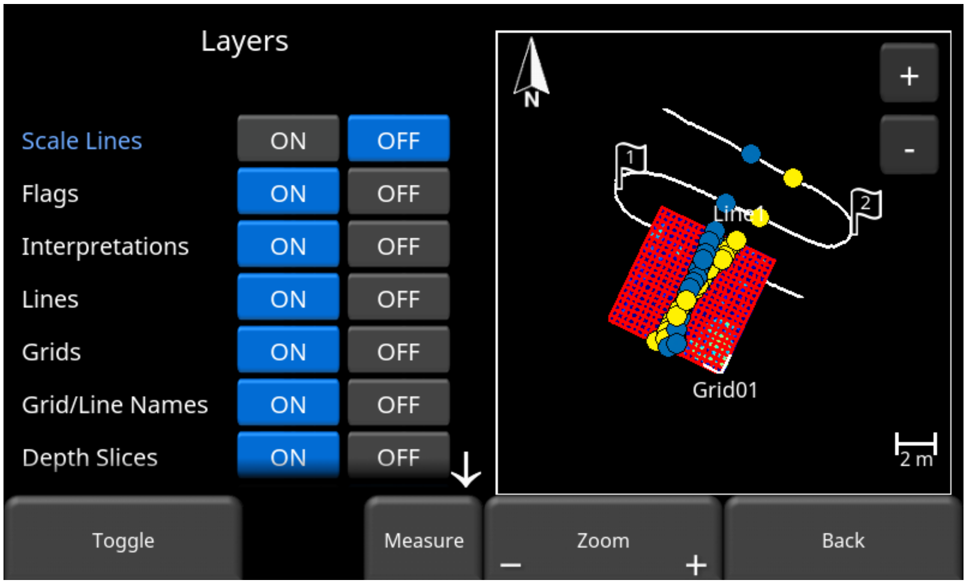


Figure 9-4: Scale Lines turned off

- **Flags** – controls the display of flags (Figure 9-5)

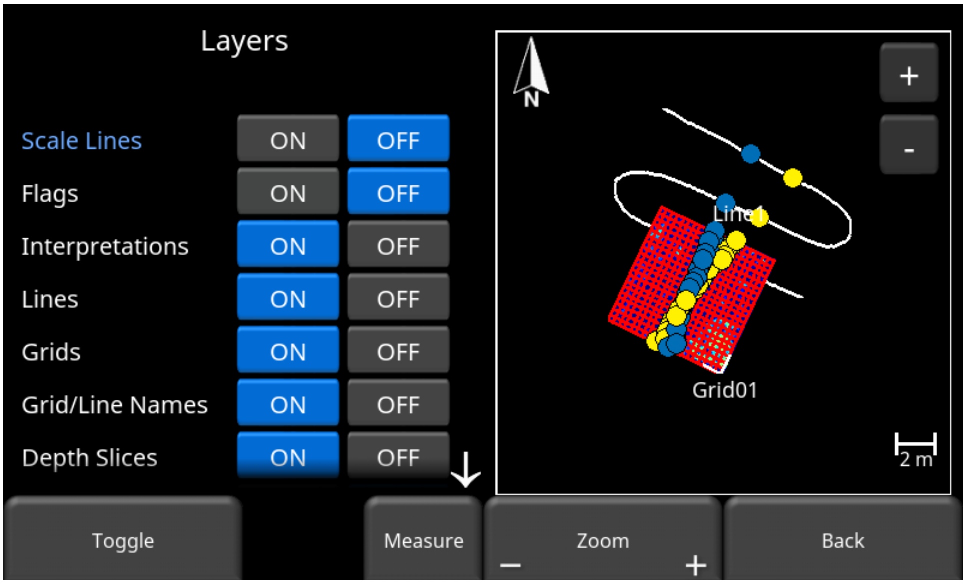


Figure 9-5: Flags turned off

- **Interpretations** – controls the display of all interpretations (Figure 9-6)

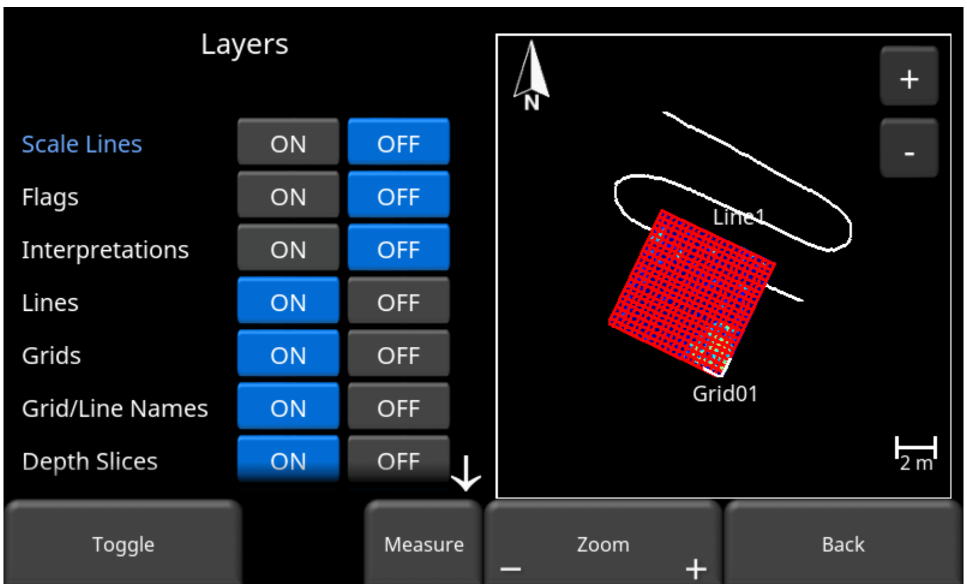


Figure 9-6: Interpretations turned off

- **Lines** – turning this off will remove all collected lines from the display (white lines turned off in Figure 9-7). It will also remove the line name.

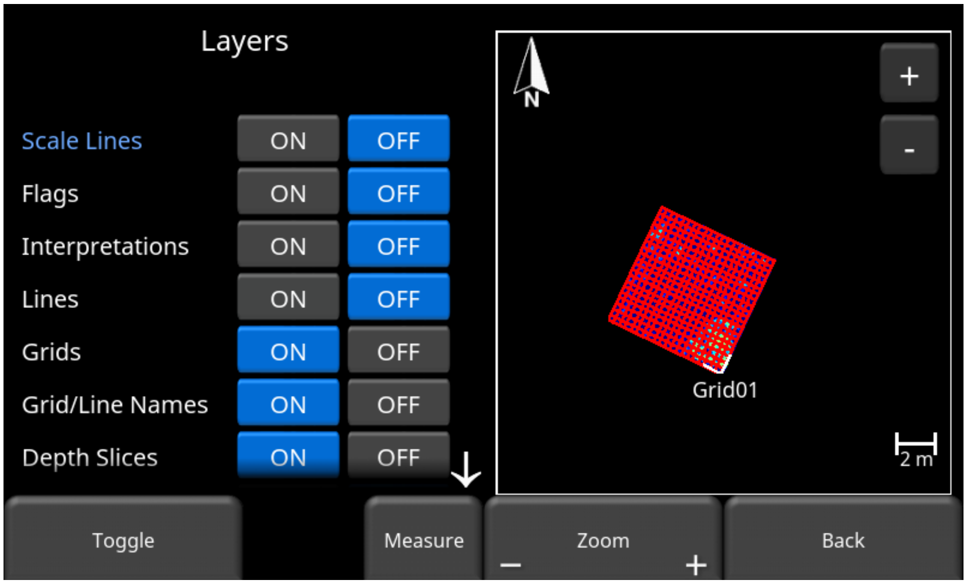


Figure 9-7: Lines turned off

- **Grids** – turning this off will remove all grids displayed (red grid turned off in Figure 9-8). It will also remove the grid name.

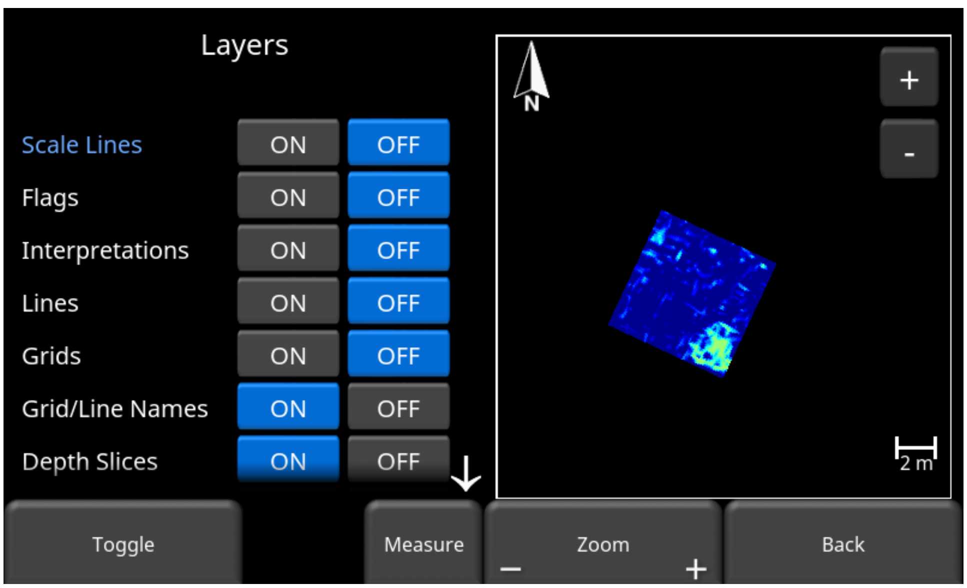


Figure 9-8: Grid lines turned off

- **Grid/Line Names** - the name of each line and grid is shown beside it. Turning this off will remove the displayed name. Note that the lines and grids must be shown for the name display only to be turned off (Figure 9-9).

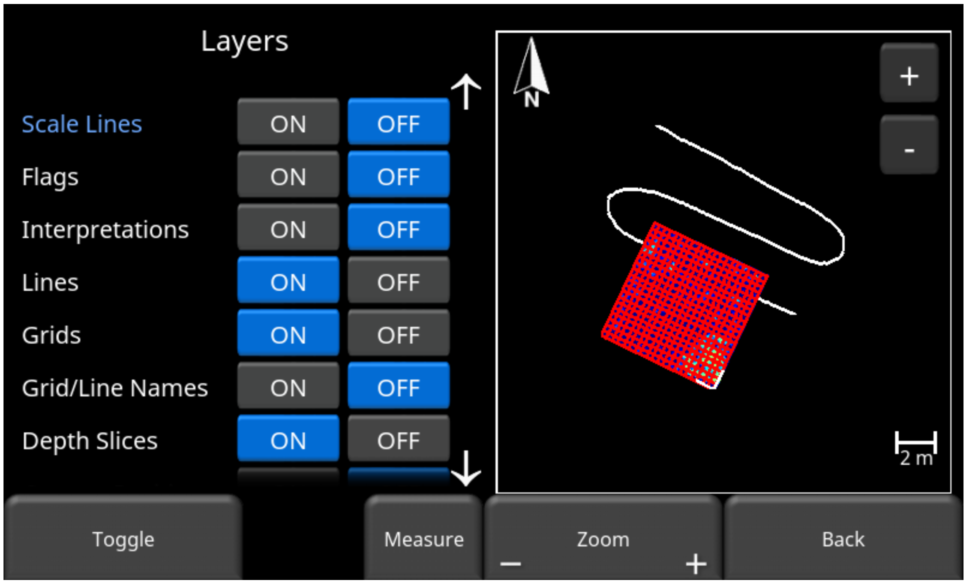


Figure 9-9: Names of grids and lines turned off

- **Depth Slices** – when set to ON, the depth slice will be displayed in the MapView window (Figure 9-8). The depth slice can be set by exiting the Options menu. Press OFF to hide the current position.
- **Current Position** – when set to ON, and provided the external GPS is enabled, the current position is indicated on the screen by a blue dot with a green circle (Figure 9-10). Press OFF to hide the current position.

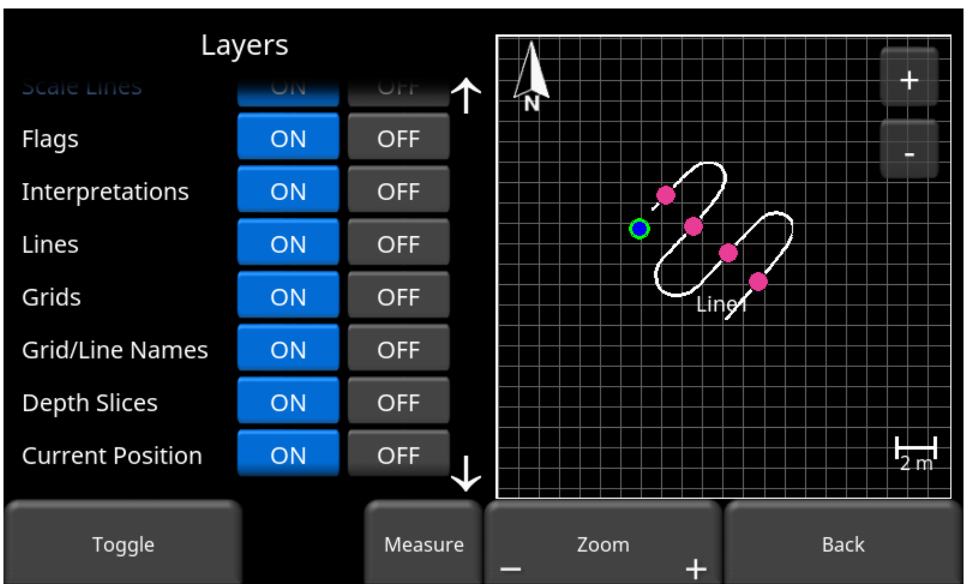


Figure 9-10: Blue dot showing the current position

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 the distance drawn (yellow line in Figure 9-11). The distance value is displayed in the lower right corner of the MapView display. Pressing the Measure button again exits from Measure mode and removes the yellow measured line and the measured value.

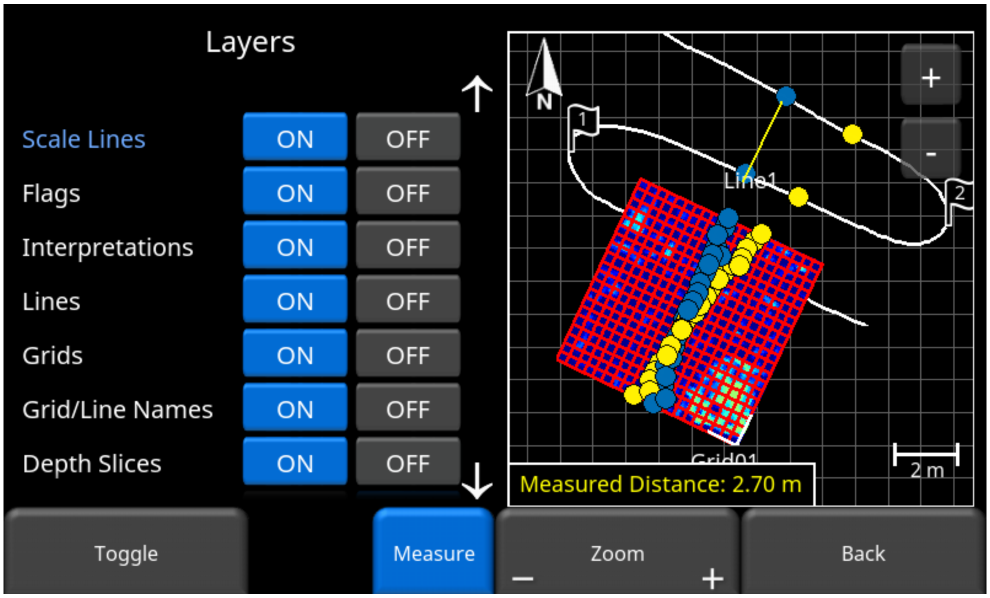


Figure 9-11: Using the Measure tool to draw a line on the screen

Where there are multiple lines and grids, the MapView could look like the example in Figure 9-12.

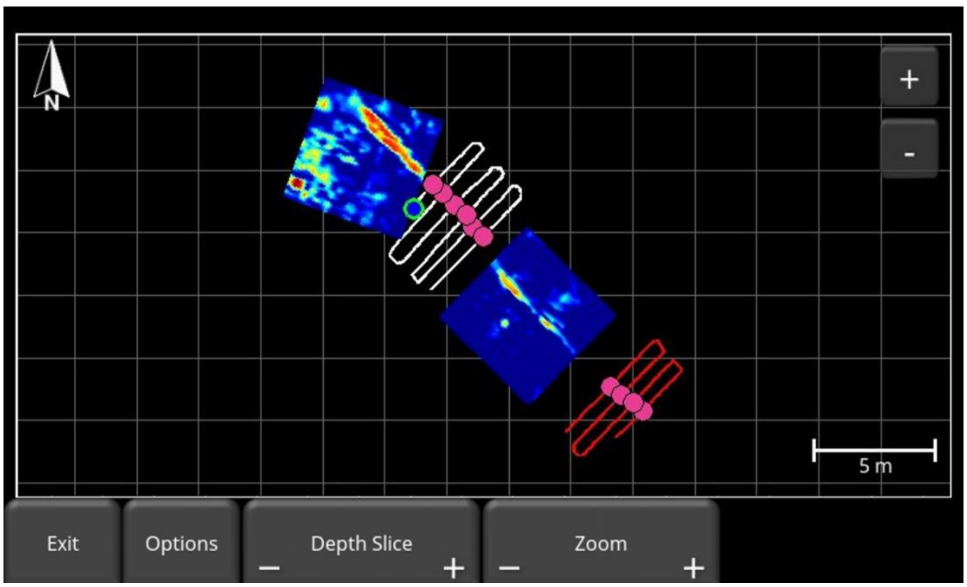


Figure 9-12: MapView showing multiple grids and lines

However, if lines/grids in a project are collected far apart, MapView will only display them if they are collected within a 2.5 km radius of the currently selected line. In this case, the data shown in the MapView display will follow the rules in the order below:

- Centre around the currently selected line <u>or</u>

- Centre around the highest line number collected with GPS <u>or</u>
- Centre around the highest grid number collected with GPS

If data exists outside the 2.5km radius, it will display the error message shown in Figure 9-13

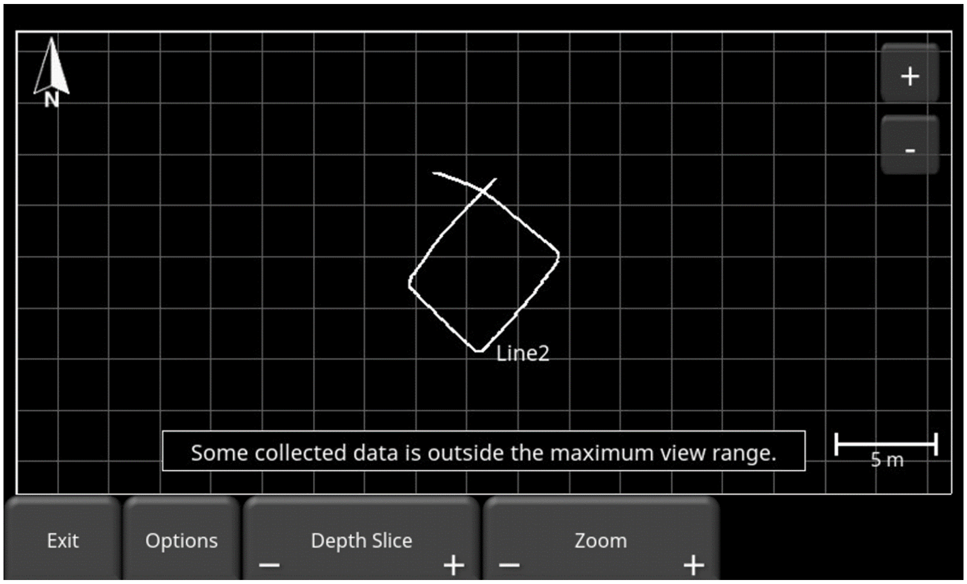


Figure 9-13: Warning message that some data is outside the MapView display range

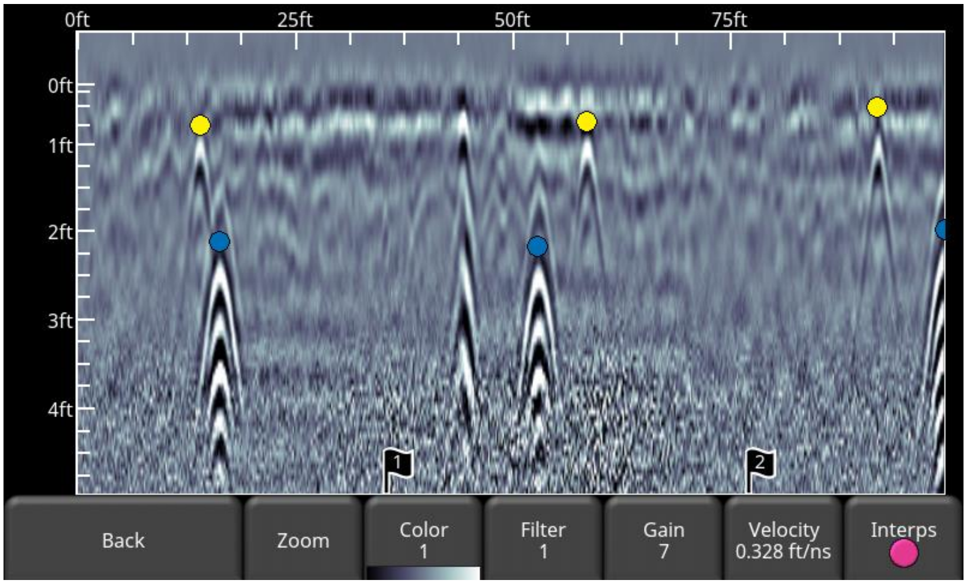
10. Demonstration Data

Demo Data is pre-loaded on all Noggin systems, and is found in the Demo project folder (from the main screen, press the minus button when you are in Project 1). The Demo project is used to illustrate various application examples and data collected with different Noggin systems. The Demo project folder contains 3 lines and 4 grids.

From a learning point of view, it is recommended go through each line and see the affect of changing display parameters (zoom, depth, calibrating velocity). For the grids, it is useful to move down through all the depth slices to see how features come into focus, then disappear. As well, correlating hyperbolas on the line scans and seeing how they appear on the depth slice images helps to build confidence in what you are seeing.

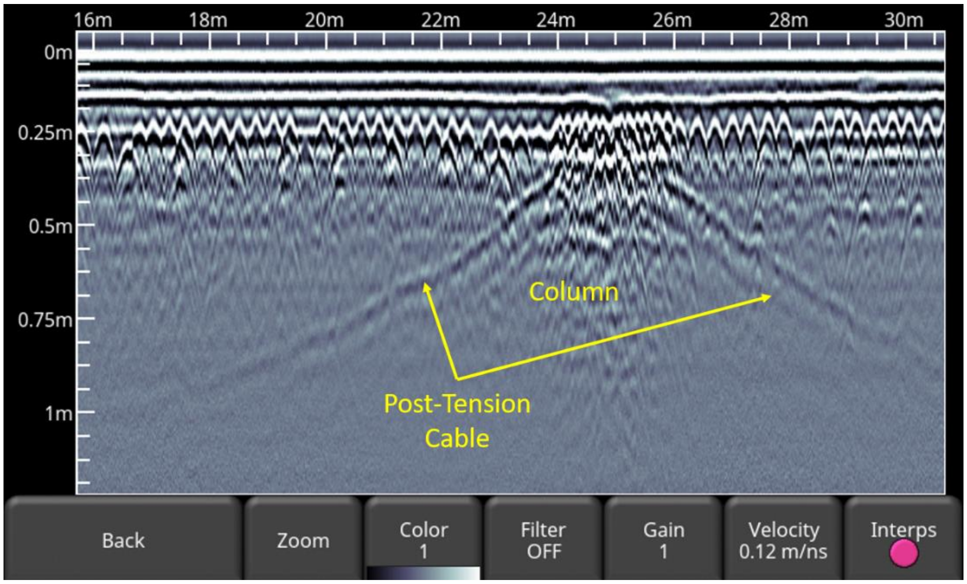
The following is a brief description of each of the lines and grids:

Line 1 – collected with a Noggin 250 SmartCart.
The data shows two utilities that were crossed three times by collecting data in a zig-zag pattern. Interpretations were used to mark the utilities; yellow for the shallower one and blue for the deeper one. Flags (visible at the bottom of the screen) are used to indicate where the user turned the SmartCart around. Crossing utilities this way and using Interpretations is a great way to check the linearity of targets in MapView on the DVL or in Google Earth^{TM} (once the data has been downloaded to a PC).

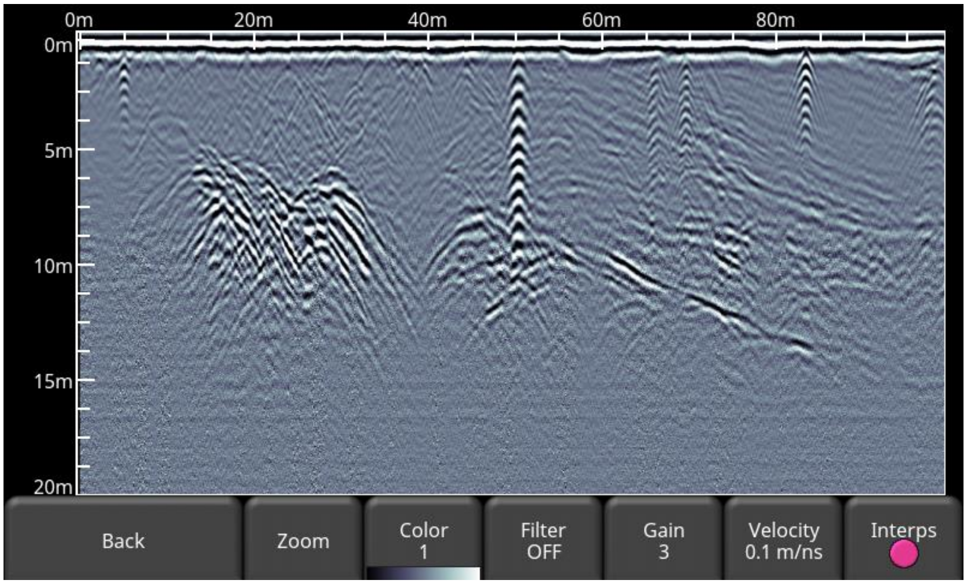


Line 2 – collected with a Noggin 1000 SmartCart.
The data was collected on a suspended concrete bridge deck that supported vehicular traffic. There is a thin asphalt layer over the concrete, seen as a flat line around 15cm deep. The concrete contains rebar at the top (mostly) and some at the bottom. This data is collected in one direction only, showing rebar running perpendicular to the direction of movement; there would very likely be rebar running in the other direction as well. The sloping feature below the

rebar is a post-tension (PT) cable, as data was collected parallel along it. PT cables tend to drape (or change depth) in between columns. In this example, the PT cable gets shallower near the column and starts to get deeper when moving away from the column. The column underneath the bridge deck is more heavily reinforced, which is evidenced by the closely-spaced and amount of rebar.

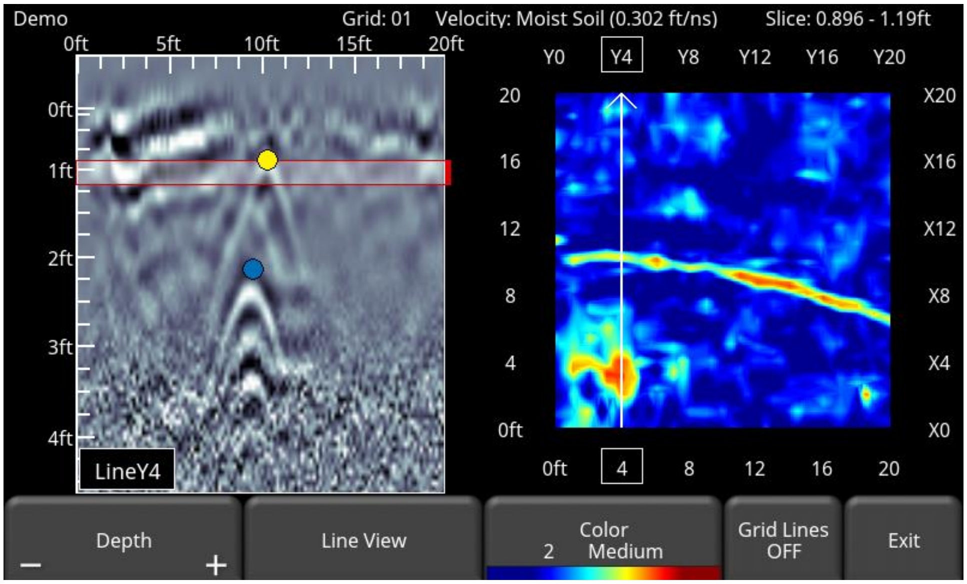


Line 3 - collected with a Noggin 100 SmartCart.
Data was collected at a limestone quarry. Around the 15-30m positions, there are caves visible at 5-6m deep. There is a strong, shallow metal reflector at 50m position (likely some debris) and just to the right of that is a bedding plane visible starting at 8m deep, sloping down to about 14m deep.



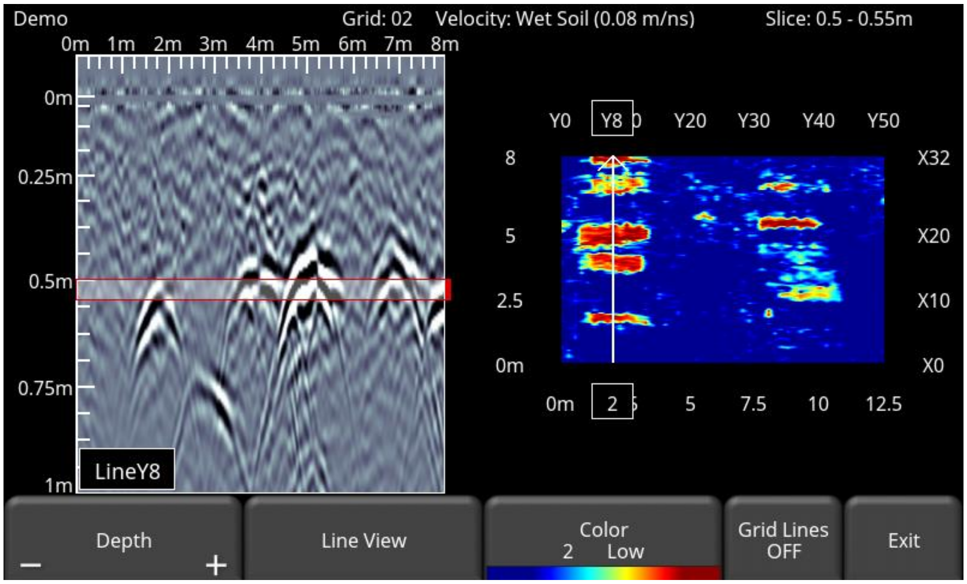
Grid 01 – collected with a Noggin 250 SmartCart.

Below is a collected grid with dimensions of 20' x 20', and lines spaced 1' apart. Two buried utilities are observed, one at 1' deep (shown in the image below), and the other at 2' deep (not seen here). The utilities cross each other, though they are at different depths. Having a tight line spacing provides good resolution and allows the user to clearly see the direction the pipe curves in the ground.

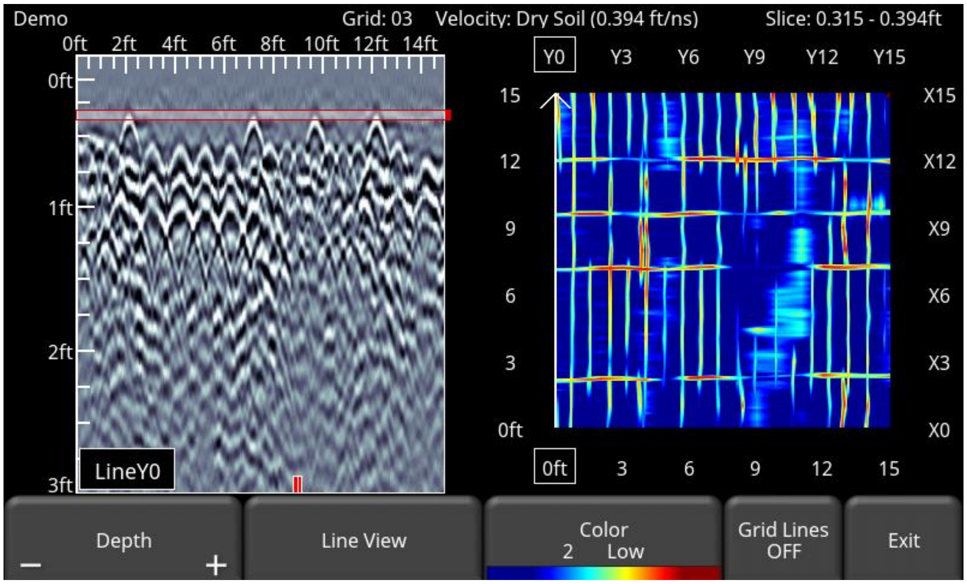


Grid 02 –collected with a Noggin 500 SmartCart.

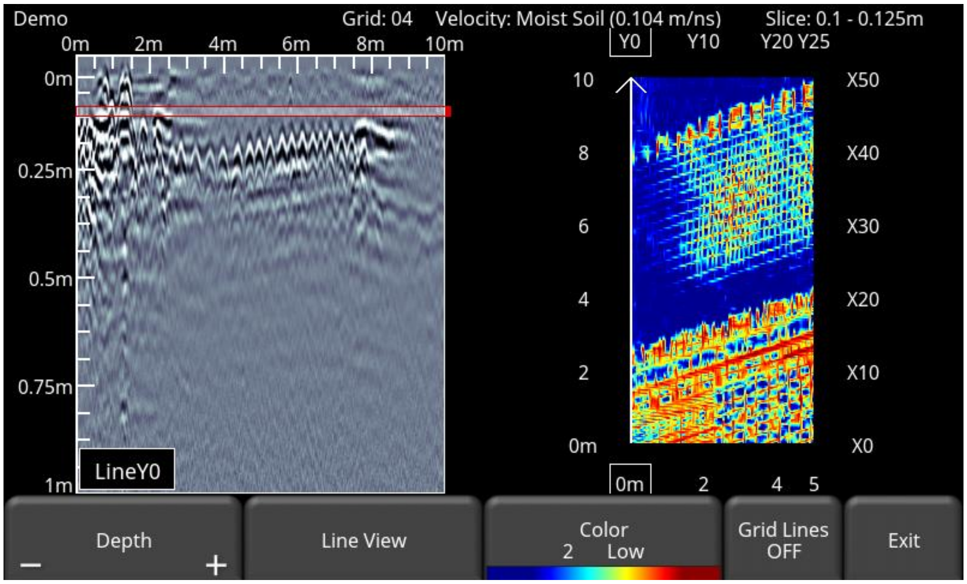
Below is a collected grid with dimensions of 8m x 12.5m, and lines spaced 0.25m apart. Data was collected at a cemetery showing burials. Since the orientation of the burials was known, based on the grave markers, this data was collected in one direction only to cross the burials perpendicularly. Targets start at various depths from 30cm to 50cm deep.



Grid 03 – collected with a Noggin 1000 on a SmartCart.
Below is a collected grid with dimensions of 15' x 15', and lines spaced 1' apart. This was collected on a concrete floor in an industrial warehouse. Data show rebar running in both directions, approximately 0.3' – 0.4' deep. However, the bars are not continuous everywhere as there are gaps in a few places.



Grid 04 – collected with a Noggin 1000 SmartCart
Below is a collected grid with dimensions 5m x 10m, and lines spaced 0.2m apart. Data was collected on a highway bridge approach slab. There are many structural elements in this image (such as rebar, dowel bars and tie bars) associated with bridge construction.



11. Capturing Screens & E-mailing Mini-Reports

11.1 Screenshots

If you would like to save an image of the current screen, press the **Camera** button on the Display Unit. This saves the screen as a Screenshot image (.JPG), which can be viewed in any third-party viewing software. If any GPS is enabled, the screenshot image for depth slices will contain also a geo-tagged reference.

If you are not connected to a Wi-Fi network, a message appears confirming the filename of the saved image (Figure 11-1).

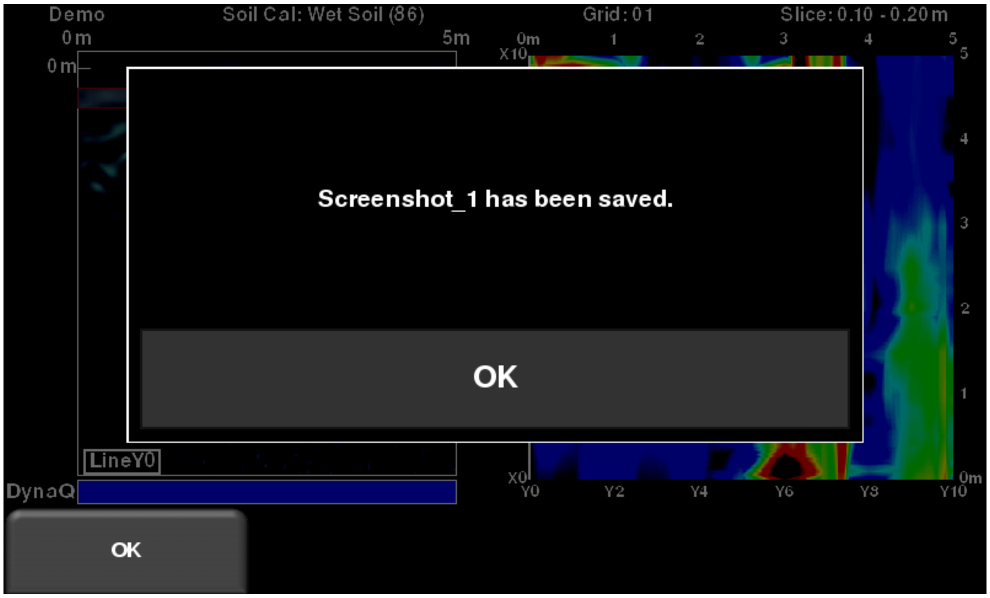


Figure 11-1: Message displayed after pressing the camera button on the DVL to capture the screen (no Wi-Fi present).

If you are connected to a wireless network and have a sending e-mail address configured, the user will see the message in Figure 11-2, 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 and allows you to enter a new email address. Pressing the "**…**" button to the left of the e-mail address displays the last 5 e-mail addresses used, allowing the user to easily select a recent email address, rather than re-entering it.

Screenshots can always be e-mailed at a later time from the Screenshot Gallery.

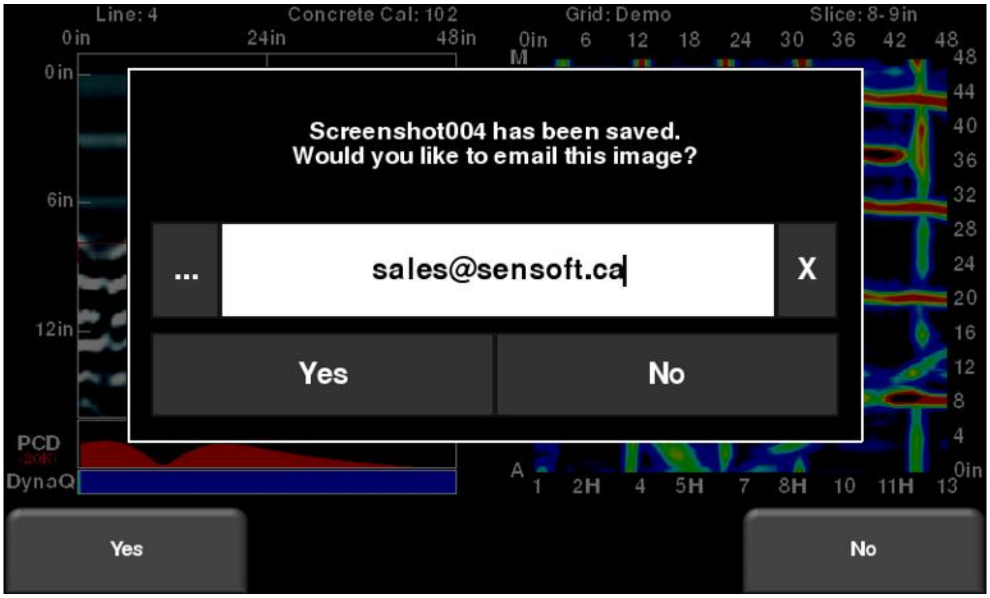


Figure 11-2: Message after pressing the Camera button on the Display Unit to capture the screen with Wi-Fi enabled and a connection to a wireless network. The user can enter an email address to send the mini-report to.

11.2 Using the Hotspot on your Smartphone

If a Wi-Fi signal is unavailable, you may be able to use your Smartphone as a Wi-Fi access point, by creating a Personal Hotspot. If you are experiencing difficulty connecting to a cell phone Personal Hotspot, ensure that the phone is in discovery mode while connecting. On iPhone (iOS 13), for example, this involves going to **Settings - Personal Hotspot** (Figure 11-3). 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 Display Unit, the cell phone can resume normal use.

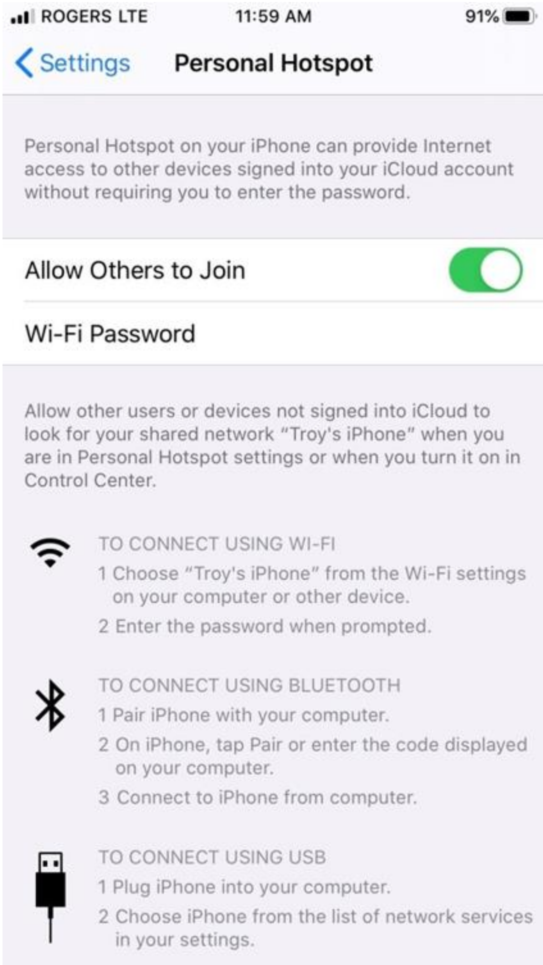


Figure 11-3: Setting up a Hotspot on an iPhone

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.

11.3 Mini-Reports

When a screenshot is e-mailed, 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 11-4).

NOGGIN Mini Report

Project	Demo
System Configuration	Noggin 100 Custom
Screen Capture Number	1
Screen Name	Grid Scan
Date Collected	February 4 2020 3:49 PM
Mode	SliceView
Grid	Grid02
Grid Size	12 x 8 m
Grid Spacing	0.25 m
Velocity	Wet Soil (0.08 m/ns)
Slice Depth	0.45 - 0.5m
Slice Color Palette (Gain)	2 (Low)
Grid Line Visibility	OFF
Selected Line	LineY7
Depth	1.00 m
Line Color Palette	1
Filter	ON (OFF)
Gain Level	4
DynaT	All

Sensors & Software

Your screen capture is attached to this email.

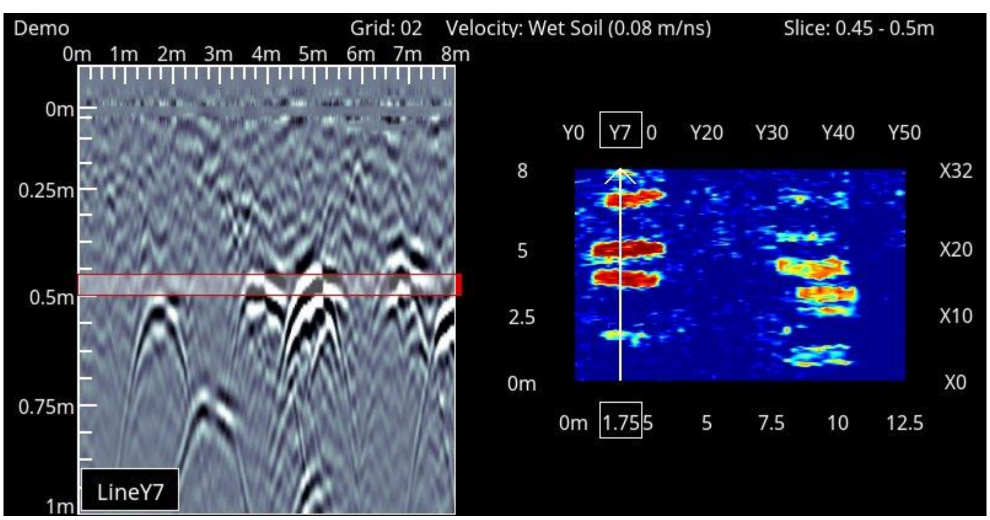


Figure 11-4: Example of a Mini-Report

12. Transferring Data to a PC

Data can be exported to a PC by inserting a USB drive into the USB port (Figure 12-1).

Figure 12-1: Insert a USB memory stick into the USB port on the Display Unit to export data.

Once the USB drive is recognized, a message will appear telling you that a drive has been inserted and if you wish to export your data to it (Figure 12-2). Click **Yes** if you wish to proceed.

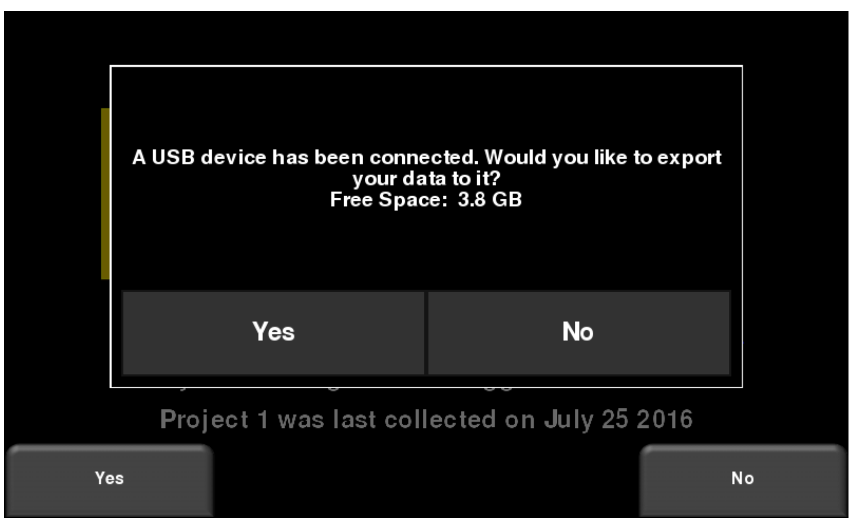


Figure 12-2: When a USB drive is connected to the Display Unit, a message opens asking if you would like to export all your data to it. Select Yes to transfer immediately. If you select No, you can export the data later by going to the ***Setup > File Management*** *menu option.*

If there are grids that were collected, but not processed, it will alert you after you select **Yes** to exporting the data (Figure 12-3). This is important, as unprocessed grids will not automatically show up in EKKO_Project as depth slices (you will need an additional module to view them) – see Section 12.6.

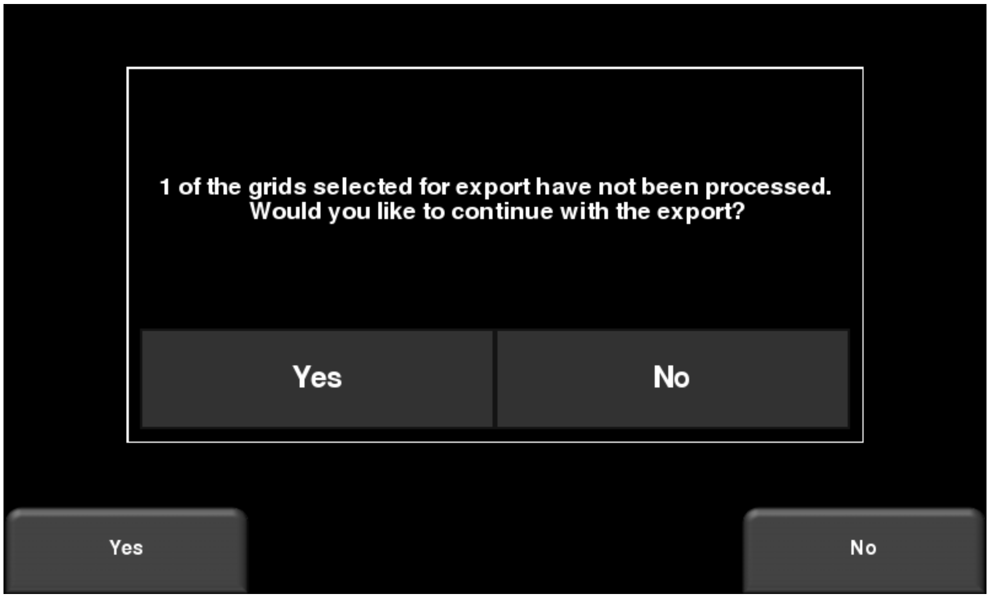


Figure 12-3: Insert a USB memory stick into the USB port on the Display Unit to export data.

Alternatively, if you want to export the data later, you can select **No** for the time being. Later on, when you are ready to export your data, go into **Tools > File Management** and press **Export Data** (Section 5.5.5). From there, you can export selected projects, rather than all the projects currently on the system.

12.1 Formatting USB Sticks

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

12.2 Directory Structure

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

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

Each successive export of data will create a new directory called ExportXX, where XX is incremented by 1 from the previous directory. 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 a GPS, a .KMZ file is generated, which can be opened in Google Earth™. This file will contain the following information:

- If Internal GPS is selected, any saved screenshots are geo-tagged and their approximate location is displayed in Google Earth™. In addition, if a grid is collected, a layout of the grid lines is displayed in Google Earth™.
- If External GPS is selected, the above will still apply. As well, the path of any line data collected will be displayed in Google Earth™, along with any flags and interpretations.

If any Field Interpretations were added during data collection, 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 an APP.LOG file and a System Summary diagnostic report. The APP.LOG file contains important information about system operation and may be requested by Sensors & Software to help troubleshoot any issues.
Some of the output files are described and shown below.

12.3 Field Interpretations file

If any interpretations are made a Field Interp Report file is created. This file is a CSV (Comma separated values) format, most 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 GPS positions (if a GPS was connected). A sample output for this file is shown in Figure 12-4.

	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											

Figure 12-4: Contents of a sample Field Interp Report file

12.4 Google Earth™

Anytime a GPS is used, a .KMZ file is included as part of the exported data. If the internal GPS was used, you will only see screenshots and a layout of the grid (if a grid was collected). Clicking on the yellow camera icon in Google Earth™ will display the screenshot image (Figure 12-5)

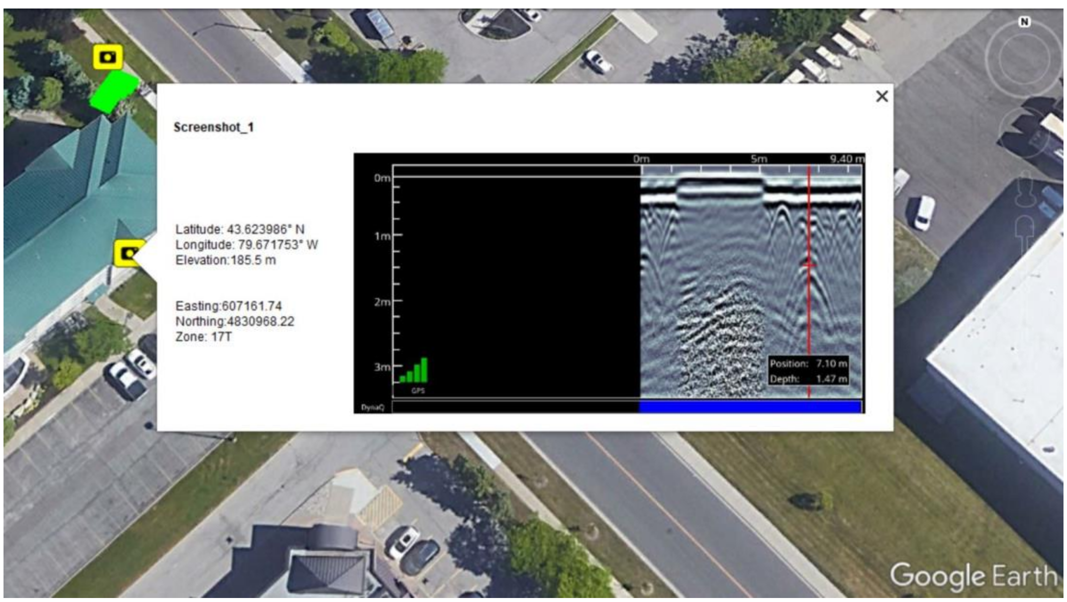


Figure 12-5: Google Earth™ image, showing a layout of the grid and some screenshots taken

Data collected with an external GPS will also show the path walked for any line scan data as well as any Interpretations and Flags (Figure 12-6).

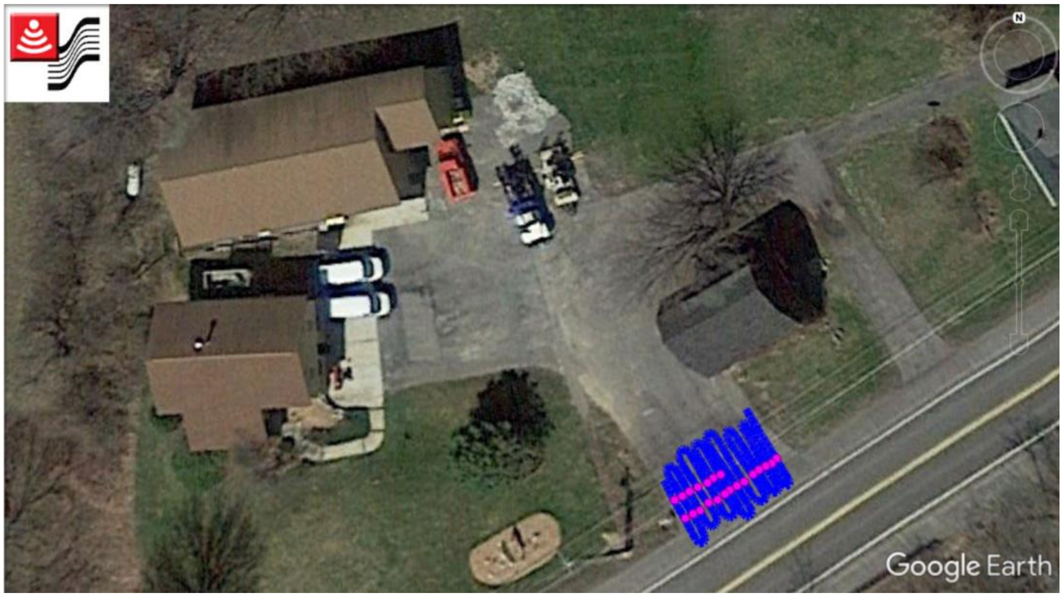


Figure 12-6: Path travelled with Interpretations, collected using an External GPS

Opening the data in EKKO_Project (Section 12.6) and creating depth slices, will allow you to export those slices to Google Earth™ (Figure 12-7).

Figure 12-7: Depth slice displayed in Google Earth™

12.5 System Summary Report

The System Summary report is a PDF file, which lists system usage information, serial numbers and when system tests were done and their pass/fail status. An example file is shown below:

Sensors & Software NOGGIN

System Summary

System Information

Display Unit (DVL) Serial Number	
GPR Sensor Serial Number	0101-0000-0001
Application Version	v1.4.854 (2016-00075-03)
OS Version	2.10.566 (2017-00041-10)
GPR Firmware Version	2.0 (2019-00147-00)
Hardware ID	001EC0AF51D5

Usage Statistics

Data Exports	14
Grids Collected	0
Average Grid Area	0.0 m² / 0.0 ft²
Average Grid Collection Time	
Total Grid Area	0.0 m² / 0.0 ft²
Total Grid Line Distance	0.0 m / 0.0 ft
Lines Collected	41
Average Line Length	153.4 m / 503.3 ft
Average Line Collection Time	2 minutes 32 seconds
Total Line Collected	6289.1 m / 20633.7 ft
Screenshots Saved	12
WiFi Reports Sent	0
System Power Cycles	61
Operation Time	8 hours 48 minutes
Total Distance Collected	6289.1 m / 20633.7 ft

System Tests

GPS Test	30 January 2020	Failed - External
Touch Screen Test	---	---
Odometer Test	30 January 2020	Passed - 1049.0 t/m
Display Keypad Test	---	---
GPR Sensor Test	---	---
Audio Test	---	---

12.6 EKKO_Project

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

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

From the main screen (Figure 12-8), 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).

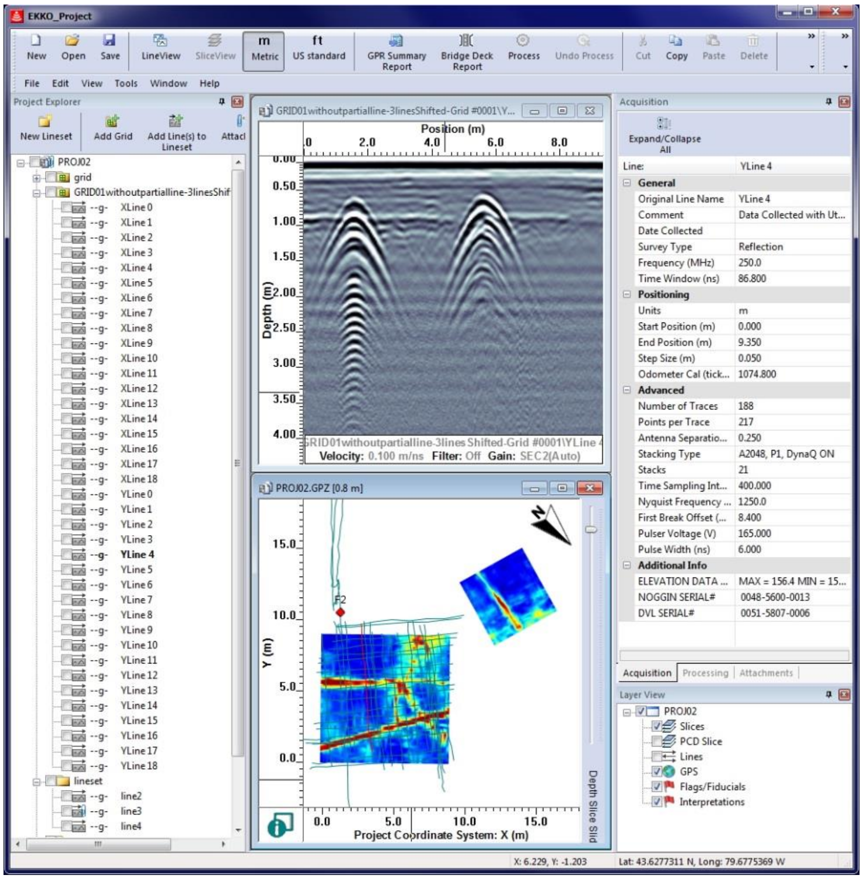


Figure 12-8: Main screen of EKKO_Project

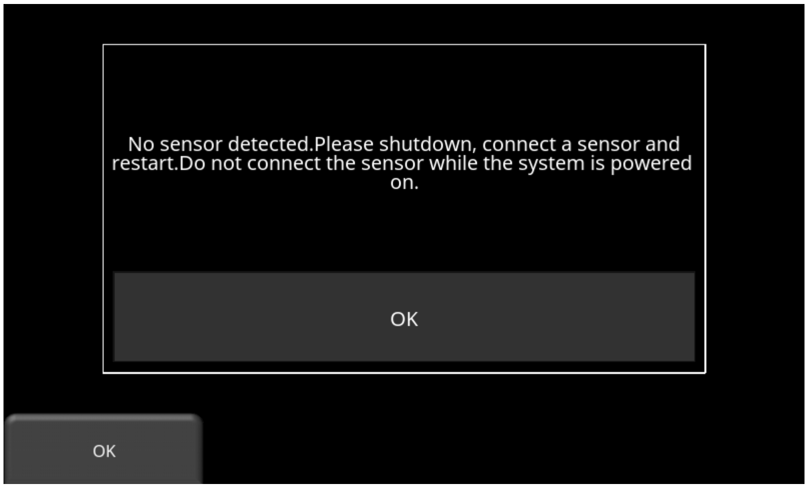
13. Troubleshooting

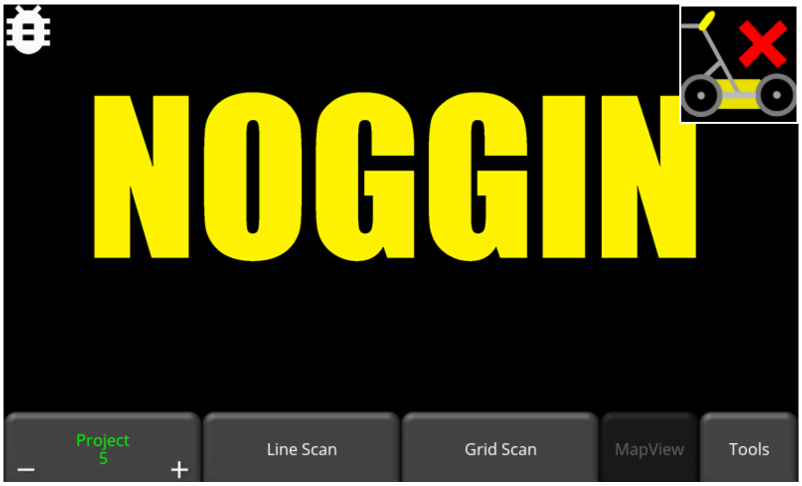
The Noggin system is designed to minimize user problems; however, all electronic devices are subject to possible failure. In some cases, doing the System Tests will help isolate the problem to a certain component. The following are also troubleshooting hints which can be referred to if your system fails to operate.

13.1 Noggin Does Not Power Up or Sensor Not Detected

If you have connected the cables to the Noggin Sensor, Display Unit, and the battery, pressed the **Power** button on the Display Unit and:

- The Display Unit does not power up, or
- The Noggin Sensor is not detected, and you get the following messages:





1) Wait at least 1-minute and see if the Display Unit starts up. Sometimes the Power LED on the Display Unit fails but the Display Unit is otherwise OK. If the application starts but the LED on the Display Unit does not turn on, test the operation of the LED using the **System Test > Keypad** test under **Tools.**

2) Test the battery

a) 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.

b) 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.

3) Test the Battery Cable

Insert the battery cable into the battery and test the battery cable. Use a multimeter to measure the battery voltage at the connector at the end of the battery cable. 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 cable.

4) Check the Noggin Sensor and Display Unit Connectors
Turn off the Noggin and disconnect the battery before disconnecting the cable that connects the Display Unit to the Noggin Sensor.

a) On the back of the Display Unit, check that none of the 37 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 Noggin system again.

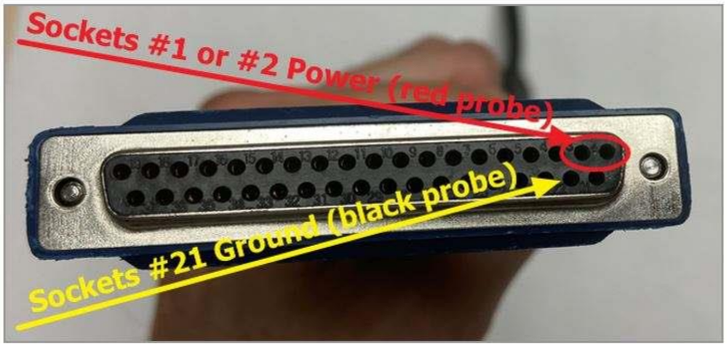
b) Check all 37 sockets at the Noggin connector, ensuring that none are blocked with debris. If so, clean out the debris, reconnect the cable and try powering the system again.

5) Replace the Cable
If you have a spare cable, replace the current cable. If the system does not power on or if the Noggin Sensor is not detected with either cable, please contact your GPR supplier for further assistance.

6) Test the Cable
a) On the end of the cable that connects to the Noggin Sensor, check that none of the 37 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. Connect the cable to the Noggin Sensor and try powering the Noggin system again.

b) Disconnect the end of the cable that connects to the back of the Display Unit.
c) Check all 37 sockets at the end of the cable, ensuring that none are blocked with debris. If so, clean out the debris, reconnect the cable and try powering the Display Unit again.

d) With the cable connected to the Noggin Sensor and the battery connected to the system, check the power from the battery is reaching the Display Unit through the cable by using a multimeter to measure the voltage between socket #21 (ground, using the black probe) and sockets #1 or #2 (power, using the red probe) on the end of the cable. If the voltage is zero, there may be a problem with the cable. If the voltage is at least 10.5 volts, the problem may be the Display Unit. Please contact your GPR supplier for further assistance.



Display Unit Screen turns White After Powering Up
If the Display Unit 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

13.2 System Communications

If the battery is OK and the Display Unit turns on but the GPR sensor does not scan, there may be a communication failure between the DVL and the GPR sensor. If an error occurs, an error message will appear. Power Off the system and disconnect the battery.

Make sure the display cable is not damaged, 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.

If the Battery, Battery Cable and Display Cable are OK, the problem is either a failure of the Display Unit or the GPR sensor. These units have no user-serviceable parts so they will have to be returned to the vendor for inspection and repair.

13.3 System Overheating

The GPR 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.

The temperature can be checked from the System Information screen, located under System Tests. If you suspect that the GPR sensor 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 GPR sensor.

13.4 Display Unit Problem

If the Display Unit does not power up, check the battery power and all cable connection. If that doesn't work, contact your vendor.

13.5 Creating a Test Line for Data Quality

After receiving the system and getting comfortable with its operation, one of the best ways of detecting any problems in the future 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 at a later date, this test line could be collected and compared with earlier tests. When comparing data, take into account weather and environmental conditions, which could skew the comparisons slightly.

13.6 Contacting the Vendor for Service

When returning the system to the Vendor, 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) Include photos and/or videos to document the occurrence of error messages.
4) APP.LOG file – these are downloaded to your computer during data export.

14. Care and Maintenance

14.1 Battery Care

The Noggin system may either come with a large battery or a belt battery, depending on the configuration. Either way, both are 9 Amp-hour, 12-Volt sealed lead acid batteries. It is fused with a 10 Amp fuse to protect it from short circuit damage.

The battery unit should run the Noggin continuously for 4-6 hours before recharging is necessary. If long days of data surveying are typical, a second battery unit may be useful.

If batteries are maintained in a charged condition, they will give long life and reliable service. Improper use and lack of maintenance will greatly reduce their life.

Sealed lead acid batteries should **NEVER** be left in a discharged condition for any period of time. Charge the batteries as soon as possible after use.

Charge the battery at room temperature whenever possible.

The Noggin has a voltage monitoring circuit that will turn off the unit when the input voltage drops below 10.5 volts.

If a battery has been deeply discharged or left in a discharged condition for some period of time it may not accept charge immediately when it is connected to the charger (the fast charge light will not illuminate). If the fast charge light does not come on within 6 hours the battery should be considered damaged and should be 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 12-14 hours.

Ensure that the batteries are fully charged before storing. If practical, store the batteries in a cool place, 10ºC, but make sure the temperature is not likely to drop below -30ºC or the electrolyte may freeze and possibly split the case.

14.2 Cable Care

With the use of this product in rough, dusty and outdoor environments, users can minimize potential downtime if they care for cables and treat connectors with respect.

1) The cable connectors as well as the connectors on the GPR Sensor and Display Unit 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.

2) 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.

3) 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.

4) Cables and connectors are not designed to suspend or tow or otherwise carry the weight of systems. They are part of the electronic circuit and should be treated accordingly. When not in use they should be placed in their storage box.

14.3 Skid Pads

The bottom of the Noggin Sensors (250, 500 and 1000) are covered with one large wear-resistant skid pad. The skid pad is designed to take the majority of the abrasive wear. If the pad wears down enough, the less-resistant plastic housing may start to wear. If this occurs, it is best to replace the skid pad. It is easily removed with a #2 Philips screwdriver and a new one can be purchased from the vendor. See Section 15.1 for list of replacement skid pads.

The Noggin 100 antennas can be fitted with skid plates, one for each antenna.

14.4 Odometer

The odometer should be periodically calibrated to ensure accuracy.

14.5 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.

14.6 Upgrading Embedded Software on Display Unit

From time to time, Sensors & Software may release new software for the Display Unit. The instructions below describe how to update this software. Please note that this procedure will **erase all GPR data** from the system, so export any valuable data before continuing.

1 Download

the zip file provided by Sensors & Software into a folder on your PC.

2 Insert

a clean USB stick into your PC.

3 Unzip

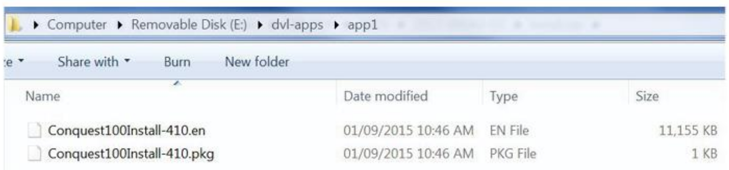
the file by double clicking the file in Windows Explorer.

4 Copy

the unzipped folder to the root of the USB key. The resulting folder structure on the USB key should be:

```
dvl-apps
    app1
        PACKAGE_NAME.en
        PACKAGE_NAME.pkg
```

where PACKAGE_NAME is the name of the item to be installed.
An example of the Conquest 100 installation files are shown below:



Computer ▸ Removable Disk (E:) ▸ dvl-apps ▸ app1

Share with ▾ Burn New folder

Name	Date modified	Type	Size
Conquest100Install-410.en	01/09/2015 10:46 AM	EN File	11,155 KB
Conquest100Install-410.pkg	01/09/2015 10:46 AM	PKG File	1 KB

5 Turn off

the Display Unit. Remove the USB stick from your PC and insert it into the USB port on the side of the Display Unit.

6 Turn On

the Display Unit. You will see a list on the screen showing all software installations. The USB key may hold one or more packages which are displayed as numbered items:

```
Select app to run:
    1. PACKAGE_NAME
```

7 Select

the package to run by pressing the associated numbered key on the Display Unit. The selected software will now be installed. The process may require multiple reboot cycles initiated by the system. When complete, the system will shut down, and the red light on the front of the Display Unit will turn off.

8 Remove

the USB stick from the Display Unit.

9 Turn On

the Display Unit and access the System Info screen to verify the newly installed version number.

15. Parts List & Accessories

15.1 Spare Parts

The following is a list of spare parts available for purchase:

Part Number	Description
122-10-1201	SmartCart Tee Screw Know
100-53-0020	Mounting Post Kit (x4)
126-71-0160	Odometer Cable Assembly
122-10-0032	Quick Release Hitch Pin
122-10-1200	DVL-500 Thumbscrew Knob
103-01-0014	Battery (only)
122-10-0078	Velcro Strap (32" long)
100-54-0084	Noggin 250 Molded Skid Plate Kit
100-54-0085	Noggin 500 Molded Skid Plate Kit
100-54-0086	Noggin 1000 Molded Skid Plate Kit
100-54-0127	Noggin 100 MHz Skid Plate Assembly (Single)

15.2 Accessories

The following accessories are available for purchase:

Part Number	Description
100-55-0012	Belt Power Supply with Case
100-55-0027	Power Source Charger
100-55-0021	Battery Assembly
103-01-0014	Battery (only)
100-53-0096	DVL-500 Harness
100-53-0113	Deluxe DVL-500 Harness
100-60-0066	DVL-500 Carrying Case
100-60-0063	SmartCart ATA Shipping Case (with DVL Bag)
125-30-0006	TopCon GPS Antenna
100-52-0120	TopCon GPS Cable (1.1m)
100-52-0124	TopCon GPS Cable (2.75m)
100-52-0125	TopCon GPS Cable (13m)

Part Number	Description
100-53-0102	GPS Mount (for Noggin SmartCart only)
100-52-0051	Noggin SmartHandle Cable (2.5m)
100-52-0049	Noggin SmartHandle Cable (5m)
100-52-0053	Noggin SmartHandle Cable (7m)
100-52-0050	DVL to Noggin Vehicle Cable (10m)
100-52-0062	Noggin SmartHandle Cable (30m)
100-52-0048	DVL to Noggin SmartCart Cable

16. Technical Specifications

16.1 Noggin Specifications

Specifications	Noggin Ultra 100 and Noggin 100	Noggin 250	Noggin 500	Noggin 1000
Size	91 x 76 x 17 cm (36 x 30 x 6.5 in)	63 x 41 x 23 cm (25 x 16 x 9 in)	38 x 23 x 15 cm (15 x 9 x 6 in)	30 x 15 x 11 cm (12 x 6 x 4.5 in)
Weight	9.5 kg (21 lbs)	7.3 kg (12.5 lbs)	3 kg (6.5 lbs)	2.3 kg (5 lbs)
Center Frequency -3dB Bandwidth	100 MHz 50 – 150 MHz	250 MHz 125 – 375 MHz	500 MHz 250 – 750 MHz	1000 MHz 500 – 1500 MHz
Shielding Front to Back	Ground coupled focusing	>20dB	>20dB	>20dB
Maximum Time Window*	4,000 ns @ 0.8 ns/pt 8,000 ns @ 0.5 ns/pt (**Noggin Ultra**)	2,000 ns @ 0.4 ns/pt	1,000 ns @ 0.2 ns/pt	500 ns @ 0.1 ns/pt
Data Bits	16-bit 32-bit (**Noggin Ultra**)	16-bit	16-bit	16-bit
Maximum Depth Setting*	200m (656 ft)	100m (328 ft)	50m (164 ft)	25m (82 ft)
Operating Temperature	-40 to 50°C	-40 to 50°C	-40 to 50°C	-40 to 50°C

* based on velocity of 0.1 m/ns, include some time before time-zero

16.2 DVL Specifications

Specifications	Values
Length	24 cm (9.5 in)
Width	24 cm (9.5 in)
Depth	6.8 cm (2.7 in)
Weight	2.83 kg (6.24 lbs)
DVL screen	8.0" high-visibility, sunlight-readable diagonal LCD display Resistive touch screen (can be used with or without gloves) Adjustable backlighting 800 x 480 VGA 1500 NIT and 800:1 contrast ratio
Input Power	11-18V, 4A maximum
Operating Power	12-16W (1-1.3A @ 12V) - varies with DVL settings
Wireless	Integrated modules: Wi-Fi (IEEE 802.11 b,g,n) GPS/GLONASS
Audio	Built-in speaker - 85dBA speaker w/volume control
Integrated GNSS (Global Navigation Satellite System)	Receives GPS/GLONASS signal (+/- 10m)
Storage	8 GB Internal

CPU Speed	Quad Core, 800 MHz
Temperature & Environmental 	Ruggedized, environmentally sealed unit and connections. Ingress protection (IP) rating: IP65 under IEC 60529 Relative Humidity operation (non-condensing): 10 – 90% Operating temperature range: -30 to 50°C
Regulatory Specifications	EMC-FCC, CE, IC, ACA, RSM Safety-TUV, CE

16.3 Battery Specifications

Specifications	**Values**
Battery	Type: 12 V Lead acid gel cell Battery Life: 4-6 hours Battery Capacity:9.0 Ah Weight: 3.6 kg (7.9 lbs)
Charger	Built-in charger with status indicator Universal AC mains charger input: 100-240V ∼, 1.5A, 50/60Hz Output: 12 Volts @ 3 Amps
Temperature	Use battery charger between 0 and 30°C.

Appendix A: 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 at the end of this Appendix.

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.

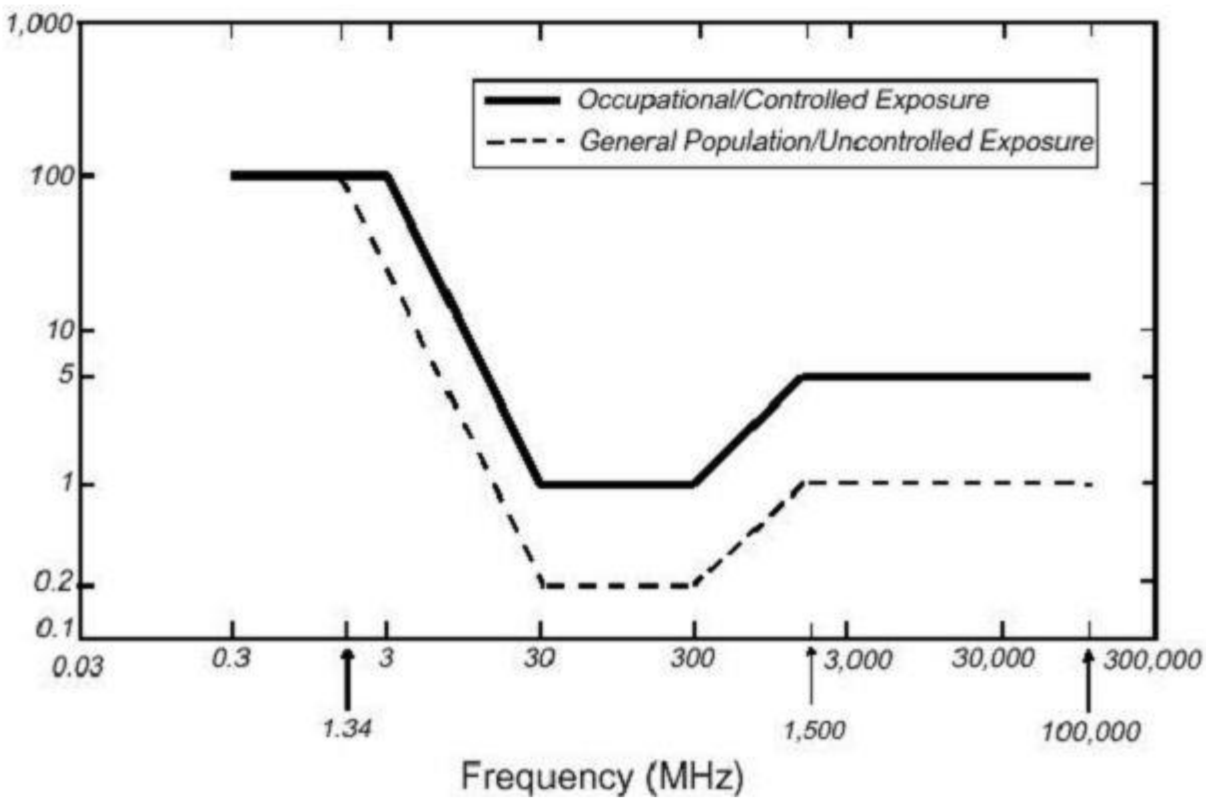


Figure A-16-1: FCC limits for maximum permissible exposure (MPE) plane-wave equivalent power density mW/cm^2.

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 B: 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 tests 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.

B-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-NG1000 (use appropriate one depending on Noggin sensor frequency)
EQUIPMENT NOMENCLATURE: NOGGIN 1000

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

B-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

B-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.

B-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 C: 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 D: 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 E: 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 F: 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.

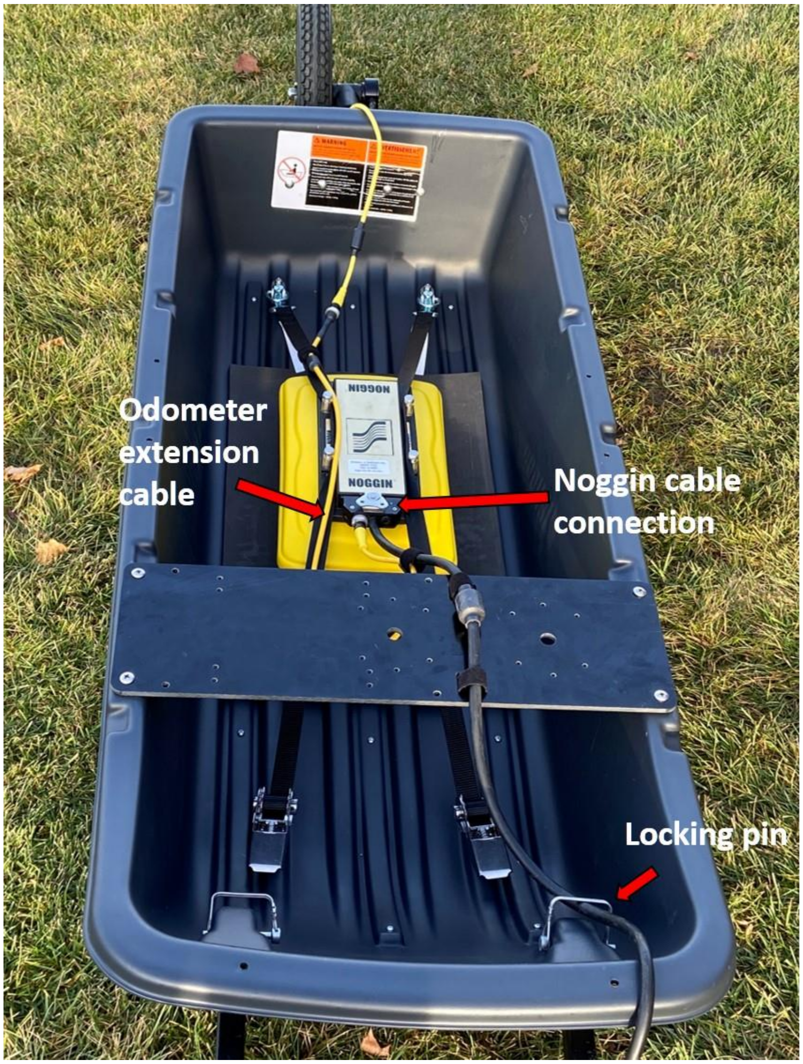
Appendix G: Cable Management

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.

See figures below as an example of how to route cables in the SmartSled and along the tow bar.



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SPX

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2016-00098-05