



## User's Guide

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# 1 General Overview

Noggins are completely self-contained Ground Penetrating Radar (GPR) systems. Once the unit has been assembled into its deployment configuration and powered up you can be carrying out a GPR survey in less than a minute. There are several different Noggin configurations available: Base, SmartCart, SmartHandle, SmartTow and the Rock Noggin.

This manual describes the assembly of each Noggin configuration, how to set survey parameters and how to run the system to collect data in lines or grids.

Each Smart System's Digital Video Logger (DVL) comes with the embedded software to acquire data and replay data files. Data management software allows the data to be transferred to an external computer for further processing and/or plotting.



*Figure: 1-1 Noggin configurations*

## 2 Noggin Components

The Noggin family of GPR systems consists of the Noggin 100, 250, 500 and 1000. The name reflects the center frequency of the GPR signals in MHz.

The basic configuration and key components of the Noggin 250, 500 and 1000 are shown in **Figure 2-1** and **Figure 2-2**. The key components of the Noggin 100 are shown in **Figure 2-3**.

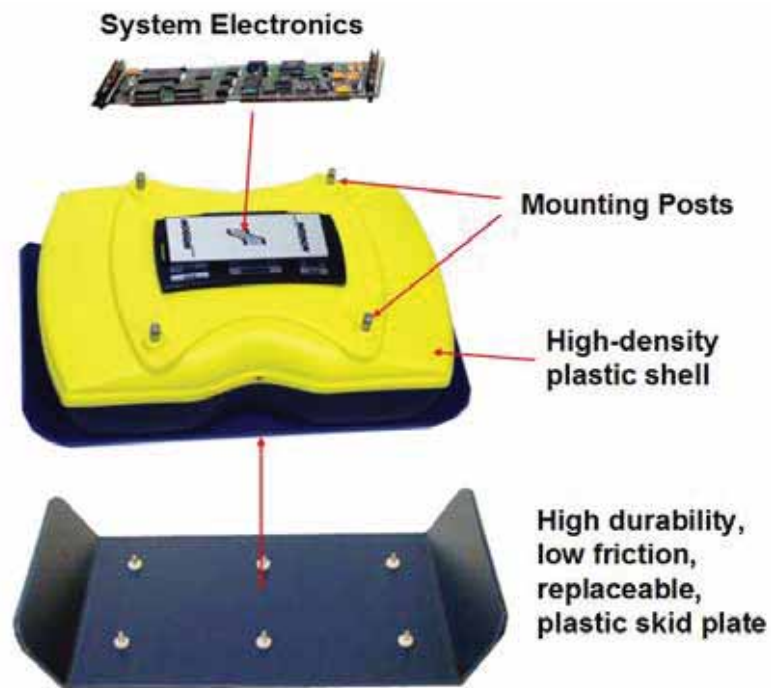


Figure: 2-1 Noggin components

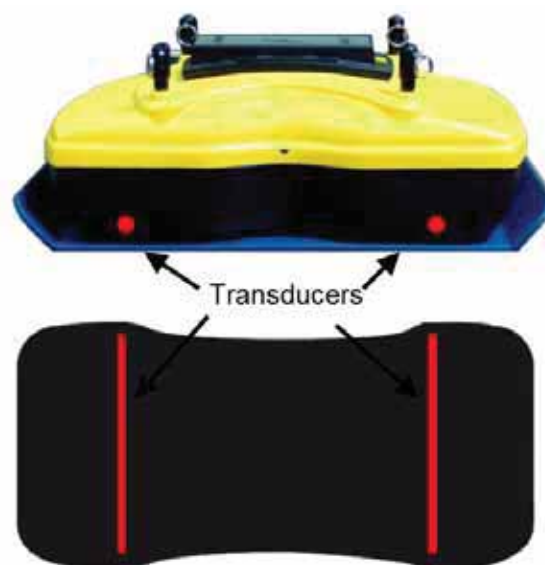


Figure: 2-2 Location of the Noggin transducers



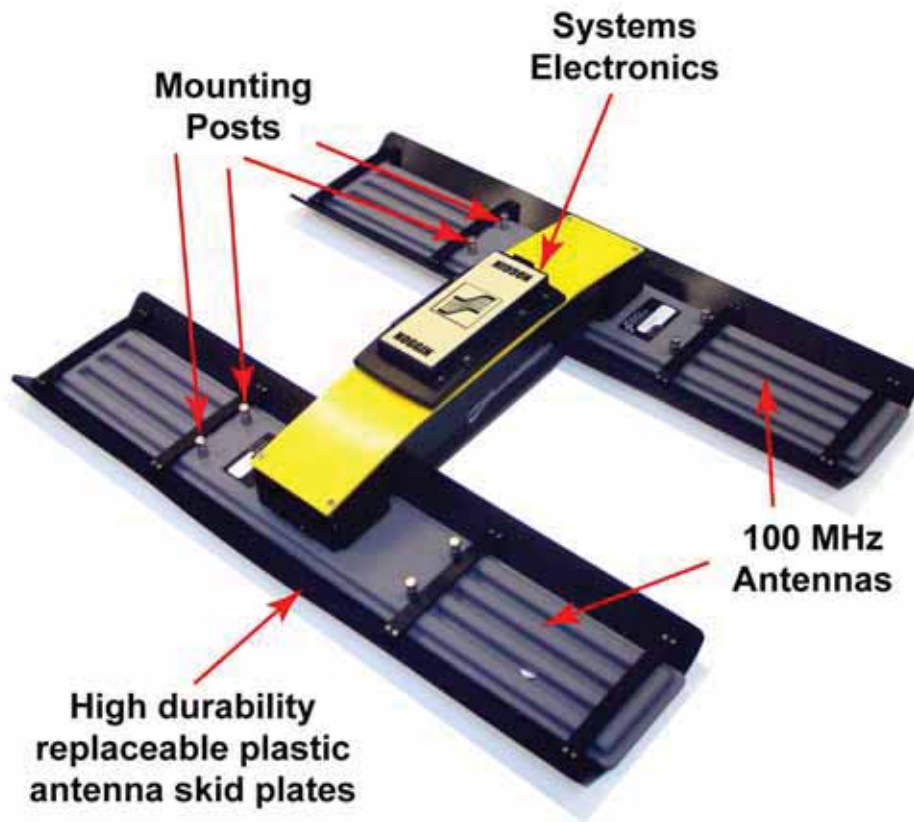


Figure: 2-3 Noggin 100 components

### 3 Noggin 100 Assembly

Unlike the higher frequency Noggins (250, 500 and 1000 MHz), the Noggin 100 comes with the antennas and electronics as separate units that need to be assembled.

To assemble, space the 100 MHz antennas about 0.5 meters apart with the mounting blocks facing up.

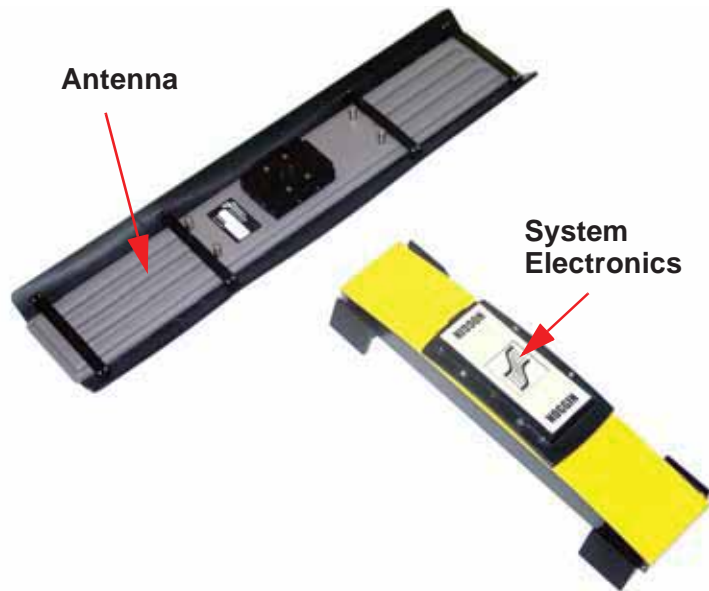


Figure: 3-1 Noggin 100 assembly of electronics to antenna.

Place one end of the Noggin 100 electronics module over one of the antennas and press downward until it is seated.

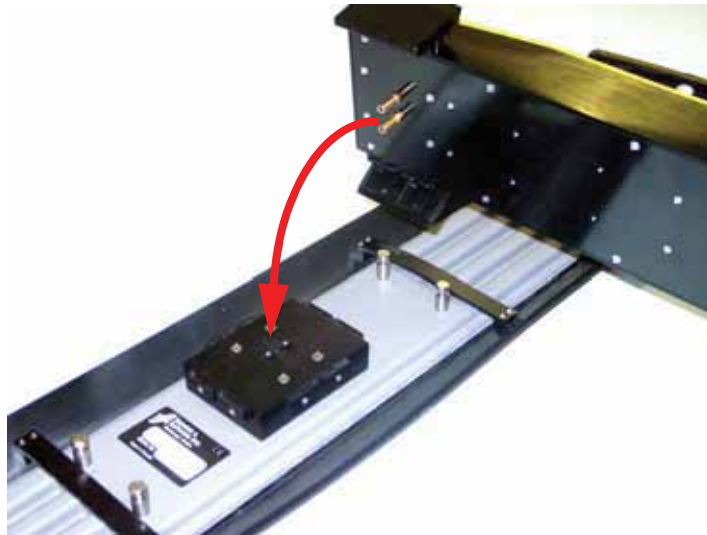


Figure: 3-2 Connecting the electronics to the 100 MHz antenna. The 2 brass sockets in the bottom of the electronics mate with the 2 brass pins in the antenna mounting block.

Secure using the electronics to the antenna using the 2 plastic latches.



*Figure: 3-3 Latching the electronics to the antenna.*

Do the same to connect the electronics to the second antenna.

See the complete assembly of the Noggin 100 in **Figure 2-3**.

## 4 Base Configuration Assembly

The Base Noggin Configuration consists of the parts shown in **Figure 4-1** (a Noggin 500 is shown but any Noggin (100, 250, 500 or 1000) could be included). The assembled system is shown in **Figure 4-2**. Follow the directions below to assemble the configuration.

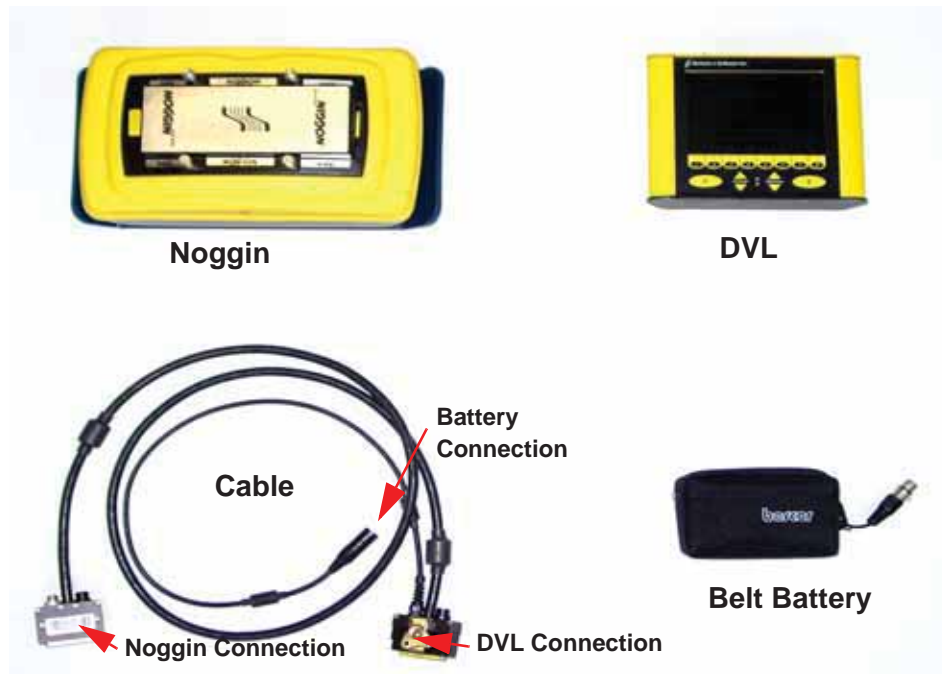


Figure: 4-1 Base Noggin 500 system components.



Figure: 4-2 Base Noggin system assembled.



The DVL-to-Noggin cable is a Y-shaped cable with 3 connections; one to the Noggin sensor, one to the DVL and one to the battery or the AC power supply.

**Noggin Connection:** Connect the 37-pin D-connector on the black cable to the 37-socket D-connector on the Noggin. Use the latch to secure this connection.



**DVL Connection:** Attach the end of the DVL-to-Noggin cable with the 37-socket D-connector to the 37-pin receptacle on the back of the DVL. This attachment can be secured by tightening the latch underneath.



**Power Connection:** The third connection on the SmartHandle cable attaches to a power supply. The round, 4-pin connector attaches to the belt battery.



The base configuration has all the components necessary for data acquisition in Free Run or Button modes (**13.3.2.2: p.98**). This configuration is appropriate for:

- 1) special or unusual GPR applications that require a customized data acquisition platform fabricated by the customer or a third-party.
- 2) time-lapse data collection to monitor changes in the subsurface at one location over time.

The base configuration is often augmented with handles and odometer wheels to make data acquisition easier.

## 5 SmartCart Configuration Assembly

The SmartCart can be configured for operation with all Noggins (100, 250, 500 and 1000).

The fully-assembled Noggin 250 in the SmartCart configuration is shown in **Figure 5-1**. The system is shown in field operation in **Figure 5-2**. Follow the directions below to assemble the configuration.



Figure: 5-1 Fully assembled SmartCart with a Noggin 250.



Figure: 5-2 Noggin 250 SmartCart (left) and Noggin 100 SmartCart (right) in operation.

## 5.1 Unfold the Handle

The Noggin SmartCart comes folded for transportation and storage (**Figure 5-3**).



Figure: 5-3 SmartCart in collapsed position.

To unfold the SmartCart, refer to **Figure 5-4**. Pull the ring to remove the handle Clevis pin from the handle support arm. Raise the handle support arm and then the handle and place the open end of the T-shaped tube on the handle onto the end of the support arm (Step 1). Then lock the handle into position by lining up the hole in the support arm with the hole in the T-shaped tube and inserting the handle Clevis pin (Step 2). When folding the SmartCart back up always ensure the handle folds down before the handle support arm.



Figure: 5-4 SmartCart set up.



## 5.2 Attach Wheels

The SmartCart may have been shipped without the wheels attached or they may have been removed for storage. If this is the case, find the axle for each wheel, press the button on the end of the axle, and insert the axle through the wheel and into the SmartCart frame (**Figure 5-5**).

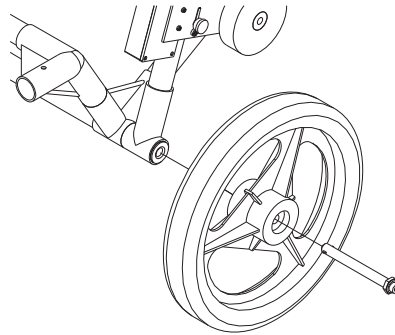


Figure: 5-5 Attaching the wheel.

With the system unfolded, make sure the small odometer wheel makes good contact with the side of the cart wheel.

If the odometer contact with the wheel is too loose, the odometer wheel may slip, resulting in erroneous position measurements. If the odometer wheel seems loose, use a  $\frac{1}{4}$  inch Allen (hexagonal) wrench to loosen the screws on the side of the odometer and pivot the entire odometer unit until the small odometer wheel makes good contact with the side of the cart wheel (**Figure 5-6**). Then tighten the screws to lock the odometer wheel in this position.

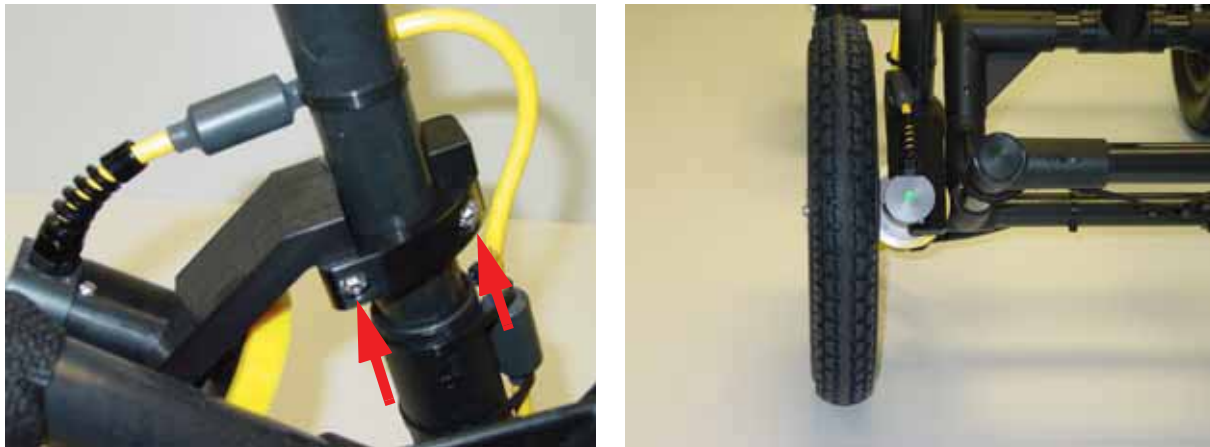


Figure: 5-6 If the odometer wheel does not make good contact with the wheel, use a hexagonal wrench to loosen the 2 screws (left) and pivot the odometer outward so when the wheel is attached the odometer rolls continuously (right).

After this has been done, it will be necessary to re-calibrate the odometer (**13.5.2: p.120**).

## 5.3 Attaching Separation Bars to the SmartCart

The Noggin SmartCart can be configured to carry a Noggin 100, 250, 500 or 1000 system. Each system has a unique set of separation bars used to attach the Noggin to the SmartCart and suspend it over the surface (**Figure 5-7**).

The separation bars are attached to the SmartCart by four thumb screws.

**Changing the support arms should only be done after the DVL and battery have been detached from the SmartCart, otherwise the back half of the cart may fall to the ground and be damaged.**

**Aligning the thumb screws and the support arm is very important. If the hole and insert are not perfectly aligned, the thumb screw will bind after only half a turn and will damage the insert by cross-threading it. As well, if the thumb screw is forced to turn it will also be damaged. If this occurs, the only way to correct this problem is to then run a 10-32 tap through the insert to re-tap the hole.**



*Figure: 5-7 The separation bars are attached to the SmartCart to carry the Noggin. Each Noggin system (100, 250, 500 and 1000) has a unique set of separation bars; the Noggin 250 separation bars are shown on the left and Noggin 100 separation bars on the right.*

### 5.3.1 Separation Bar Assembly

The Noggin 100 requires the separation bars be assembled before attaching them to the SmartCart. For details, see the separate document “Assembling SmartTow Frame and SmartCart Separation Bars”.

## 5.4 Attaching the Swivel Adapters (Noggin 250, 500 & 1000)

Before the Noggin 250, 500 or 1000 can be attached to the SmartCart, the 4 swivel adapters (with attached Clevis pins) must be attached to the mounting posts on the Noggin (see **Figure 2-1**). The swivel adapters may have been attached to the Noggin at the factory. If not, follow the instructions below.

Set the swivel adapter down on the post. It may be necessary to loosen the Allen (hexagonal) screw before the swivel adapter will slide down into the proper position. This can be done using the 1/8" Allen (hexagonal) wrench provided. Now, tighten each screw and then loosen ¼ turn so that the swivel adapters are firmly attached to the post but can still rotate. **DO NOT OVERTIGHTEN!**

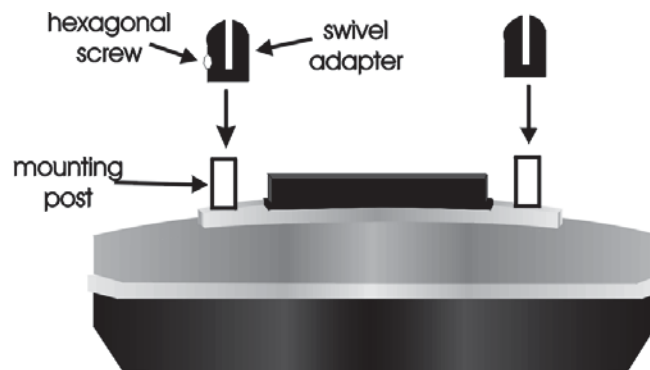


Figure: 5-8 Attaching the swivel adapters to the Noggin.

## 5.5 Attaching the Noggin to the SmartCart

The Noggin is attached to the cart with the long axis of the Noggin unit parallel to the wheels on the cart (see **Figure 5-9** and **Figure 5-10**). Ensure the 37 socket female electrical receptacle on the Noggin faces the back of the cart so that the cable on the cart will reach the receptacle.

### 5.5.1 Noggin 250

Remove the Clevis pins from the swivel adapters. Now, on the bottom of the cart, locate the 4 oval, moveable hangers suspended from the frame of the cart (see **Figure 5-9**). Notice that each hanger has a hole in it. To attach the Noggin 250 to the cart, place each hanger into the slot on the top of the swivel adapters, line up the holes and insert the Clevis pin.

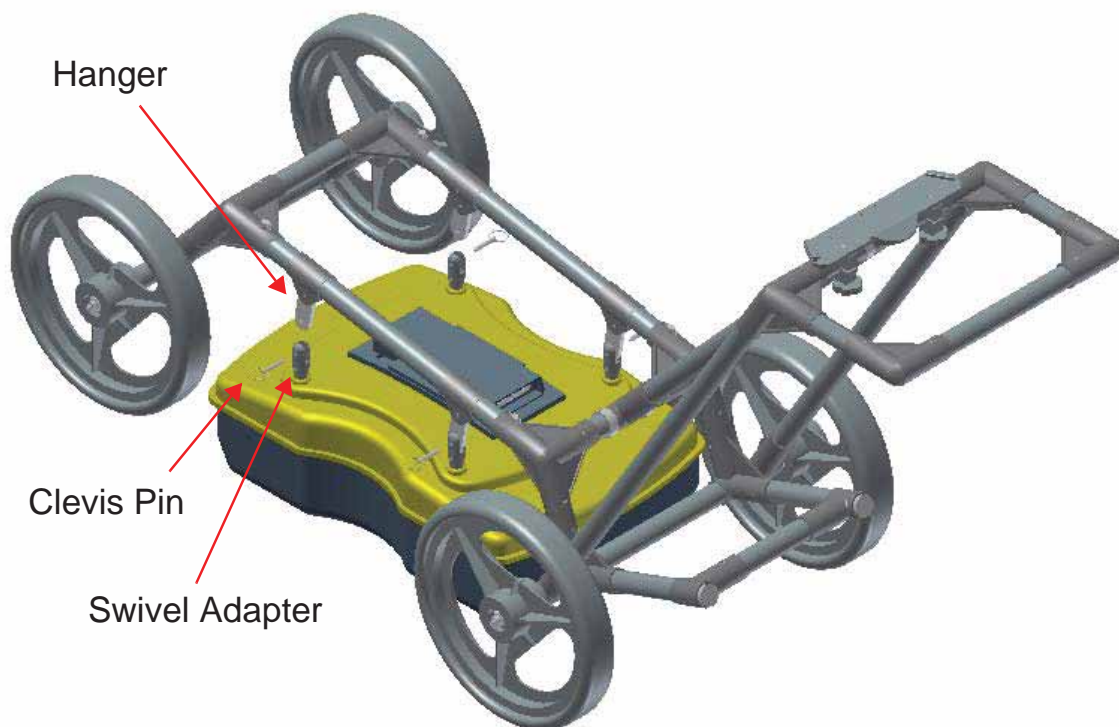


Figure: 5-9 Attaching the Noggin 250 to the SmartCart.

## 5.5.2 Noggin 500 & Noggin 1000

Remove the Clevis pins from the swivel adapters. Now, on the bottom of the cart, locate the two, flat, moveable crossbars suspended from the separation bars.

Notice that each crossbar has 2 holes, one on each side. To attach the Noggin 500 to the cart, place the crossbars into the slots on the top of the swivel adapters, line up the holes and insert the Clevis pins (**Figure 5-10**).

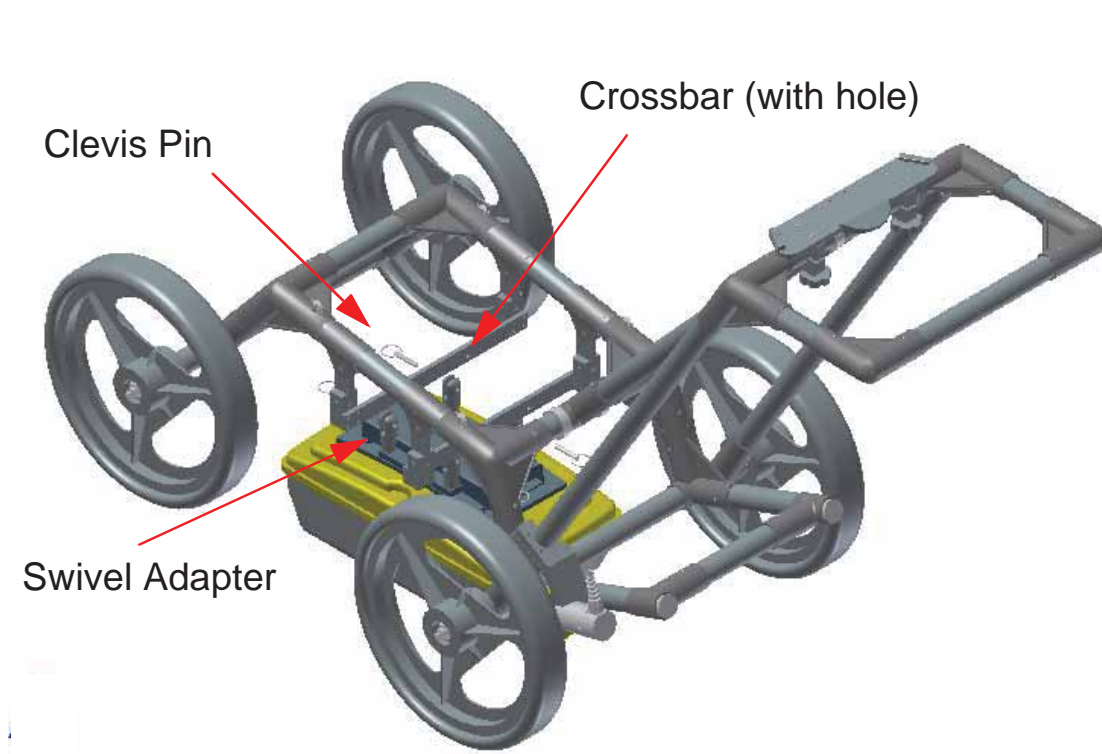


Figure: 5-10 Attaching the Noggin 500 and Noggin 1000 to the cart.

### 5.5.3 Noggin 100

Unlike the higher frequency Noggins, the Noggin 100 comes with the antennas and electronics as separate units that need to be assembled. Assemble the Noggin 100 electronics and antennas (**3: p.4**).

The Noggin 100 separation bars need to be assembled before attaching them to the SmartCart (**Figure 5-7**, right). For details, see the separate document “Noggin SmartCart Separation Bar Assembly”.

Place the SmartCart over the Noggin 100, aligning the antenna post blocks on the frame with the antenna mounting posts on the 100 MHz antennas. Ensure the 37 socket cable connection on the Noggin 100 electronics faces the back (handle end) of the SmartCart.



*Figure: 5-11 After attaching the separation bars, place the SmartCart over the Noggin 100 system with the 8 antenna mounting posts inserted in the post blocks. The 37 socket receptacle on the Noggin 100 electronics must face the back of the SmartCart for the cable to connect properly.*



*Figure: 5-12 Secure the SmartCart Separation Bars to the Noggin 100 by inserting the pins into each of the 8 post blocks.*

## 5.6 Noggin Cable Connection

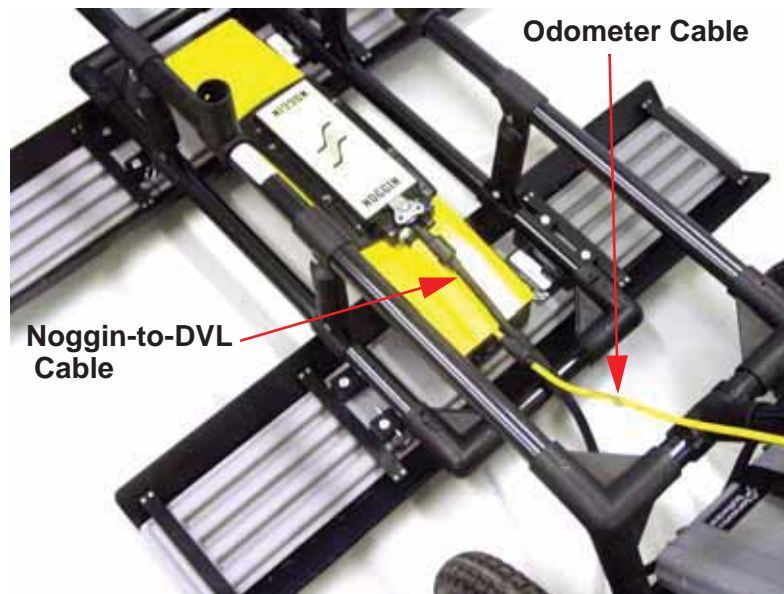
Connect the 37 pin end of the Noggin-to-DVL cable to the receptacle on the Noggin and secure this attachment with the latch.

The cable should have a little slack to reduce any stresses on the cable during data collection.

For the Noggin 100, ensure that the cable does not sag and contact the electronics or antennas as this will cause noise in the data.

If it is not already attached, connect the yellow odometer cable to the receptacle on the Noggin end of the Noggin-to-DVL cable.

For the Noggin 100, this connection requires use of a short odometer extension cable. Use the velcro straps to route the cable along the frame, keeping it away from the electronics and the antennas.



*Figure: 5-13 Connecting the Noggin-to-DVL cable to the Noggin 100 electronics. After this connection is made, connect the yellow odometer cable to the round receptacle on the connector at the Noggin end.*

## 5.7 Attach the Digital Video Logger (DVL)

The bottom of the Digital Video Logger is designed to slide onto the support shelf attached to the SmartCart (**Figure 5-14**). Line up the bottom of the DVL with the shelf and slide it back onto the shelf. Push the DVL back far enough so that the flexible clip on the front of the shelf catches and holds the DVL firmly in place. Wiggle the DVL to make sure it is firmly snapped in before letting go of the unit. To remove the DVL from the SmartCart, flex the clip downward as the DVL is slid forward off of the shelf.

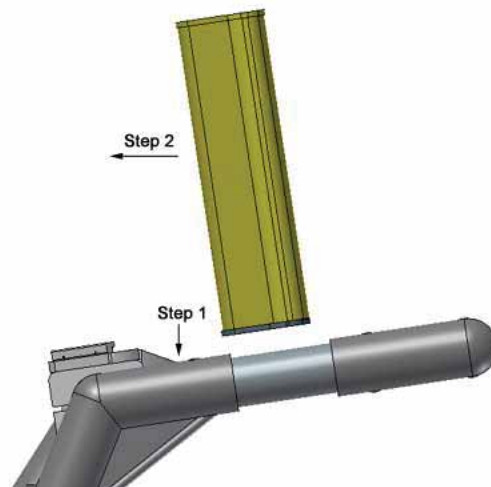


Figure: 5-14 Attaching the digital video logger (DVL). Step 1: Depress flexible clip. Step 2: Slide DVL onto shelf.

The DVL can be pivoted to adjust the view angle. If it is difficult to pivot the DVL, slightly loosen the hand screws on the bottom of the support shelf.

## 5.8 DVL Cable Connection

Once the DVL is in place, attach the cable with the 37-socket female D-connector to the 37-pin receptacle on the back of the Digital Video Logger. This attachment can be secured with the latch.





## 5.9 Attach the Battery Unit

The batteries usually used with the SmartCart are shown below.



Set the battery unit onto the lower inclined shelf on the back of the SmartCart (**Figure 5-15**). The handle on the battery unit should be accessible from the back of the cart with the cable receptacle on the right. The battery unit should rest in this area without moving. To secure the battery onto the cart, put the straps provided over the battery unit and lock into place with the plastic buckle. Tighten the straps if necessary.



*Figure: 5-15 The SmartCart battery.*

Note the battery mass forms part of the overall cart balance which enables users to raise the front wheels with a minimum amount of force. This allows users to easily change direction and assure the rear wheels are always in contact with the ground.

With the SmartCart completely assembled, connect the round 4-pin battery cable to the receptacle on the side of the battery.

## 5.10 Adding GPS Mount to the SmartCart

The SmartCart has an optional bracket designed to hold a Trimble or Novatel GPS (**Figure 5-16**). This bracket can be modified by the user to hold other types of GPS units.

Any GPS unit with a serial output can be attached to the serial port on the back of the DVL and GPS information logged during data collection (**9: p.44**).

For more details about configuring the GPS with a Noggin system, see **13.3.5: p.112**.



Figure: 5-16 SmartCart system with the optional GPS mounting bracket.

## 6 SmartTow Configuration Assembly

All Noggins (100, 250, 500 and 1000) can be operated in the SmartTow configuration.

### 6.1 Noggin 100

The fully-assembled Noggin 100 in the SmartTow configuration is shown in **Figure 6-1**. The system is shown in field operation in **Figure 6-2**. Follow the directions below to assemble the configuration.



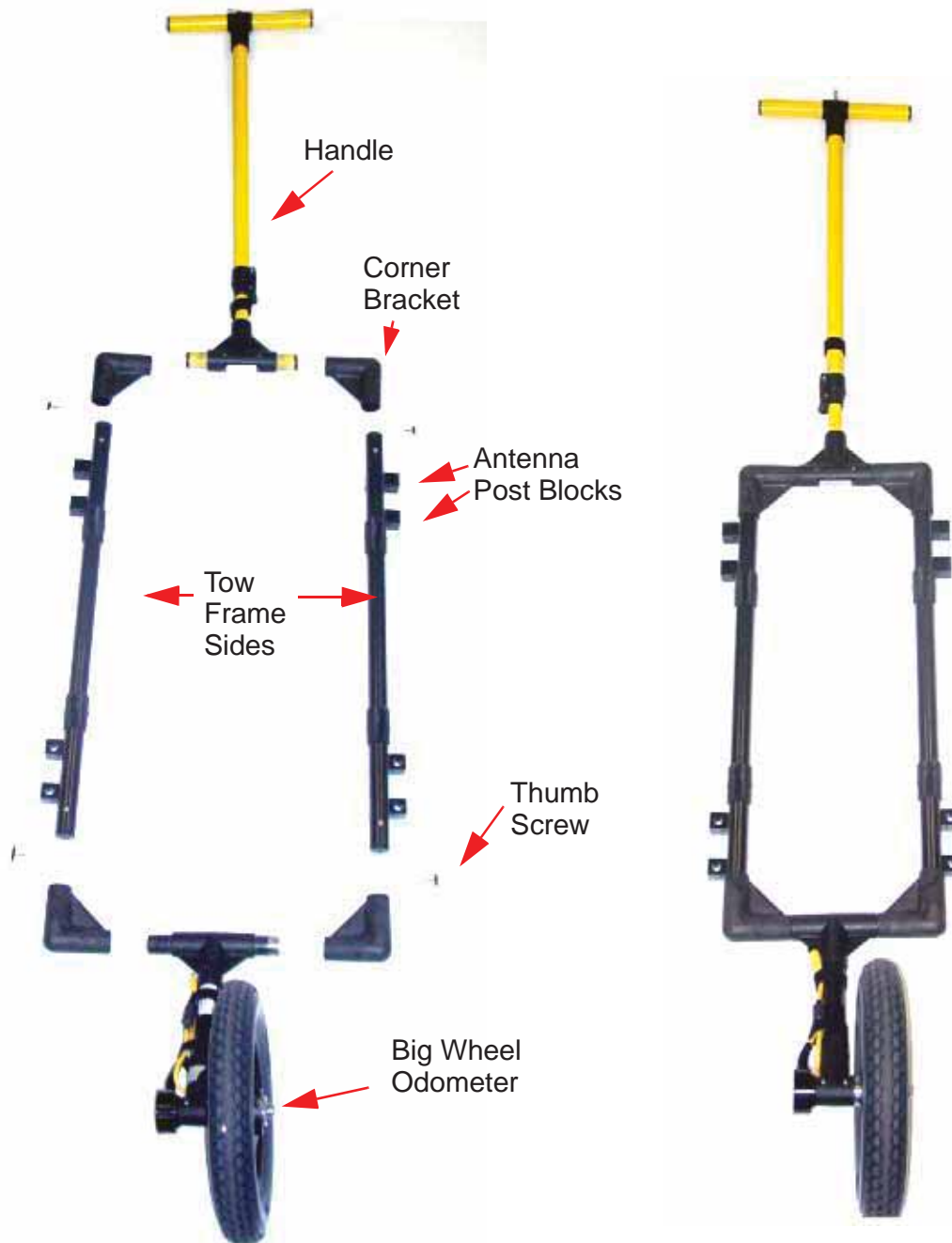
Figure: 6-1 Noggin 100 SmartTow configuration.



Figure: 6-2 Noggin 100 SmartTow configuration in use. Note the belt battery for power and DVL carrier for conveniently carrying the DVL in the field. The cable runs from the electronics housing and up the handle secured by velcro straps.

Assemble the Noggin 100 electronics and antennas as shown in **3: p.4**.

The parts for the Noggin 100 SmartTow frame are shown in **Figure 6-3**. Note that the SmartTow frame is also used as part of the SmartCart separation bars. The assembly kit comes with extra end pieces so both configurations can be assembled. The SmartTow requires the 4 corner brackets shown below while the SmartCart separation bars requires 2 frame ends. **Do not be alarmed when you have extra pieces after assembly!**



*Figure: 6-3 The Noggin 100 SmartTow frame parts (left) and assembled (right). Ensure the antenna post blocks face outward before assembling. The pieces are connected using the 4 thumb screws as shown in the figure below. The Handle and Big Wheel odometer are not connected to the frame with thumb screws but held in place once the 100 MHz antennas are attached.*



Figure: 6-4 Close-up of thumbscrews used to assemble the Noggin 100 SmartTow frame. Be careful not to strip the threads!

Place the SmartTow frame over the Noggin 100, aligning the antenna post blocks on the frame with the antenna mounting posts on the 100 MHz antennas. Ensure the 37 socket cable connection on the Noggin 100 electronics faces the odometer end of the frame and NOT the handle end.

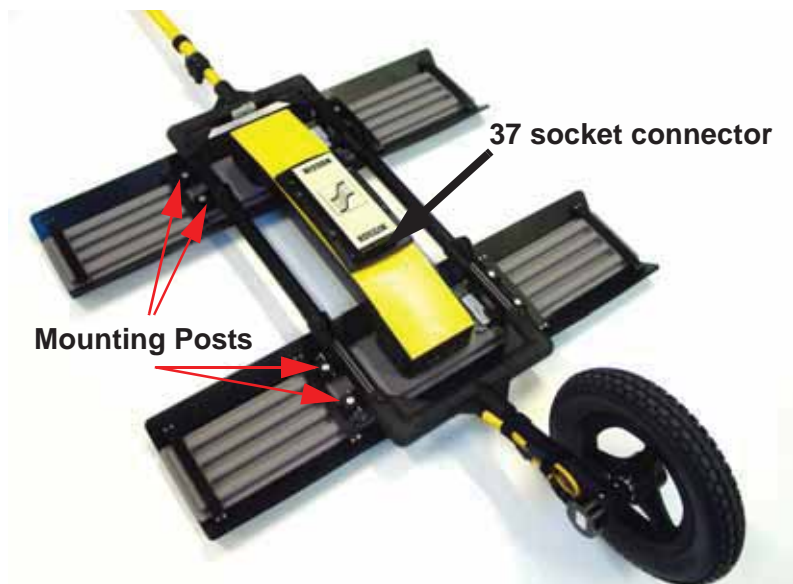


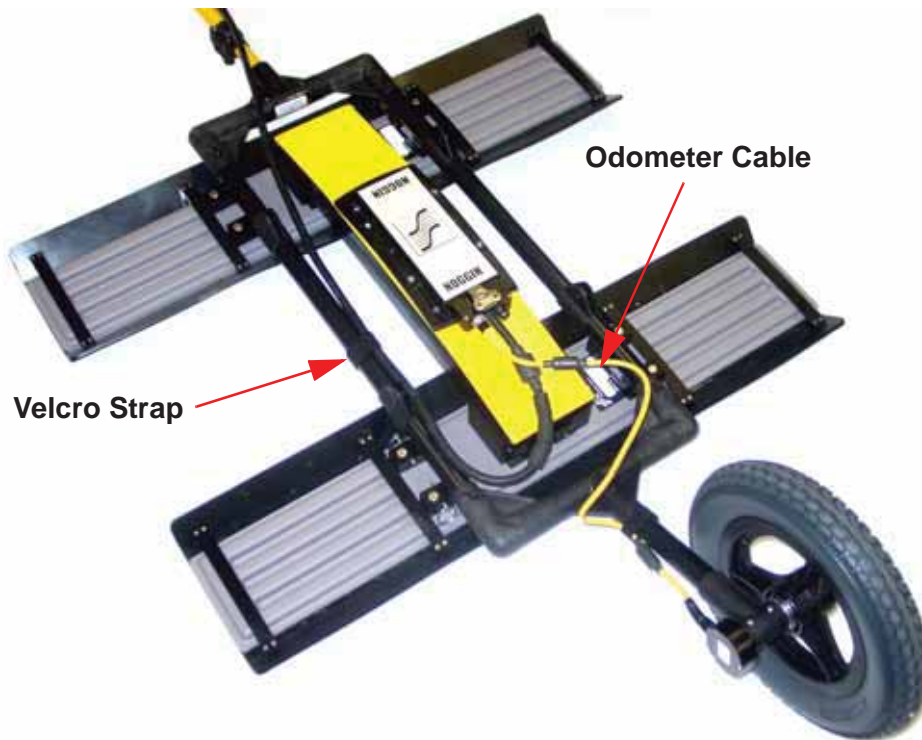
Figure: 6-5 Place the SmartTow frame over the Noggin 100 system with the 8 antenna mounting posts inserted in the post blocks. Ensure the 37-socket connection on the Noggin 100 faces the odometer wheel.



Figure: 6-6 Secure the SmartTow frame to the Noggin 100 by inserting the metal pins into each of the 8 post blocks.

Latch the 37 pin end of the Noggin-to-DVL cable to the receptacle on the Noggin 100 electronics. Then route the cable along the frame and up the handle, keeping it away from the electronics and the antennas. Use the velcro straps to secure the cable to the frame and handle (**Figure 6-7**). Ensure that the cable does not sag and contact the electronics or antennas as this will cause noise in the GPR data. The cable should have a little slack to reduce any stresses on the cable during data collection.

Connect the yellow odometer cable to the receptacle on the Noggin end of the Noggin-to-DVL cable. Again, use the velcro straps to route the odometer cable, keeping it away from the electronics and the antennas (**Figure 6-7**).



*Figure: 6-7 Connect the Noggin-to-DVL cable to the Noggin 100 electronics with the latch. The yellow odometer cable connects to the small round receptacle on the back of the Noggin-to-DVL cable.*

Latch the other end of the Noggin-to-DVL cable to the back of the DVL.

With the SmartTow completely assembled, connect the round 4-pin battery cable to the receptacle on the SmartCart battery and then go to **11: p.48**.

## 6.2 Noggin 250

The fully-assembled Noggin 250 in the SmartTow configuration is shown in **Figure 6-1**. The system is shown in field operation in **Figure 6-2**. Follow the directions below to assemble the configuration.



Figure: 6-8 Noggin 250 SmartTow system



Figure: 6-9 Noggin 250 SmartTow in operation. Note the belt battery used to power the system.

Attach one of the SmartTow Bracket Assemblies to the two front mounting posts on the Noggin 250 and secure with the metal pins.

Attach the second SmartTow Bracket Assembly to the two back mounting posts on the Noggin 250 and secure with the metal pins.



Connect the large black cable to the Noggin 37-pin female connector and latch into place, ensuring the cable lies on top of the back SmartTow Bracket Assembly.



The large odometer wheel attaches to the back SmartTow Bracket closest to the Noggin connector. Orient the odometer so the small yellow wheel is on the upper rim of the large wheel. Secure the odometer T-bar with the U-brackets and pins. Make sure that the black cable turns to the front of the Noggin so it does not interfere with the odometer wheel.





The yellow cable from the odometer connects to the receptacle on the connector to the Noggin.



Odometer calibration is critical for accurate data images. Odometer calibration instructions are available in **13.5.2: p.120**.

Attach the handle to the front SmartTow Bracket Assembly with the U-brackets and pins. The black cable should lie between the SmartTow Bracket and the handle. Secure the cable along the side of the handle using 2 or 3 Velcro straps.



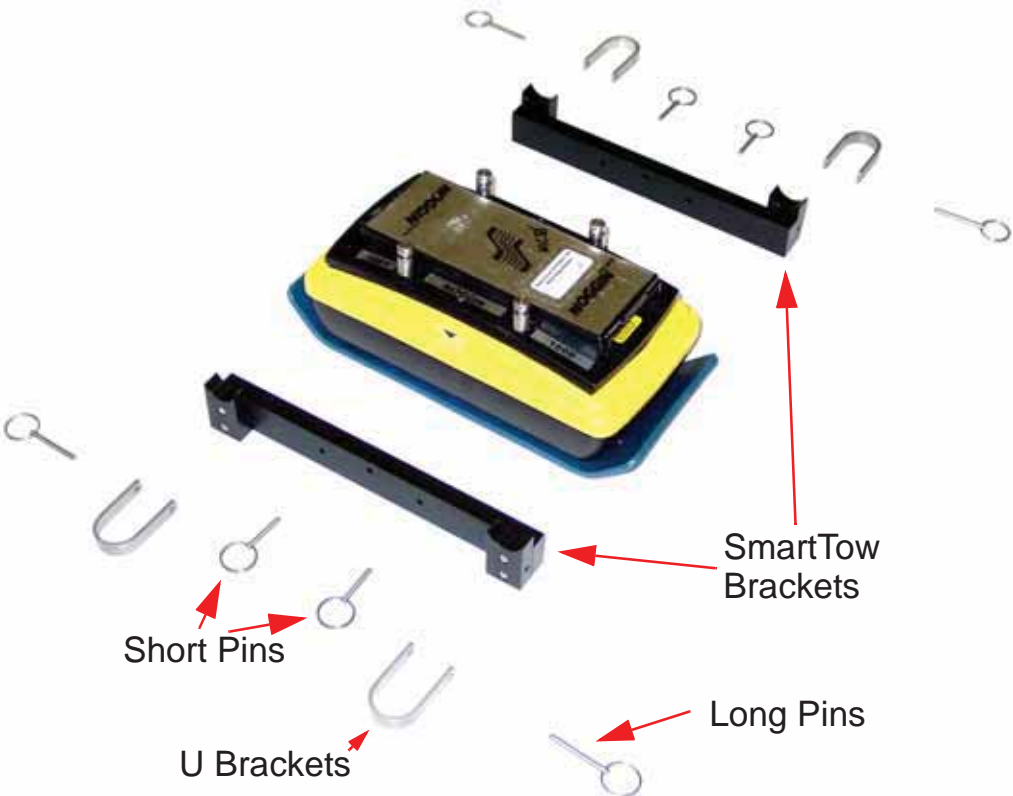
### 6.3 Noggin 500 and 1000

The fully-assembled Noggin 1000 in the SmartTow configuration is shown in **Figure 6-10**. Follow the directions below to assemble the configuration. The Noggin 500 SmartTow system is assembled similarly.

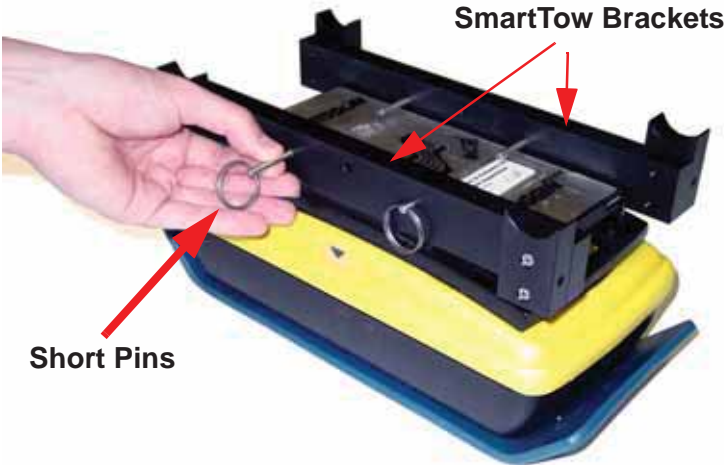


*Figure: 6-10 Noggin 1000 in the SmartTow configuration*

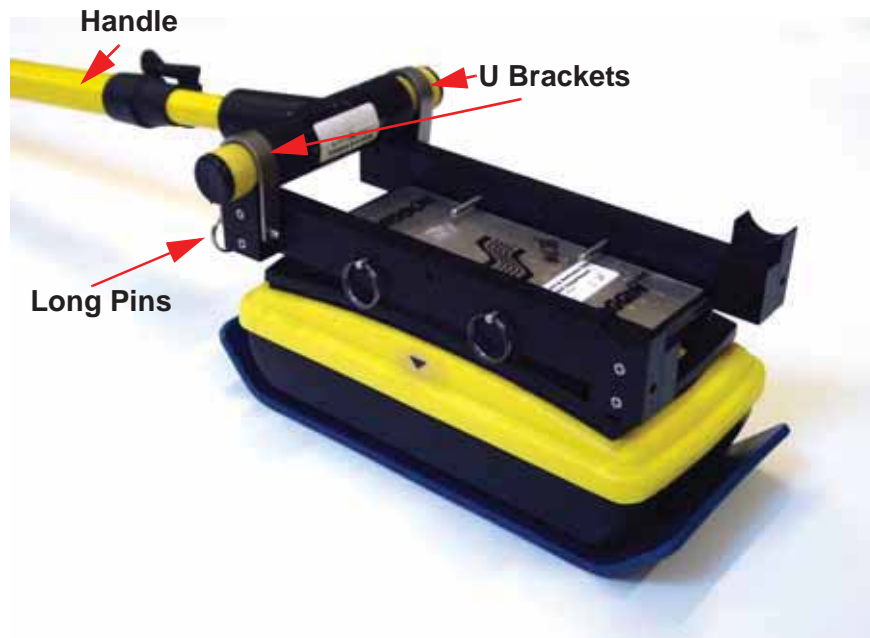
The parts for the Noggin 500/100 SmartTow Brackets are shown below.



Align the two holes on one of the SmartTow Brackets with the two mounting posts on one side of the Noggin, press down firmly and secure with the short metal pins. Then attach the second SmartTow bracket to the other side of the Noggin and secure with the short metal pins.



Attach the handle to the front of the SmartTow Brackets with the U-brackets and long metal pins. The handle should be attached on the end of the Noggin away from the 37 socket cable connection.



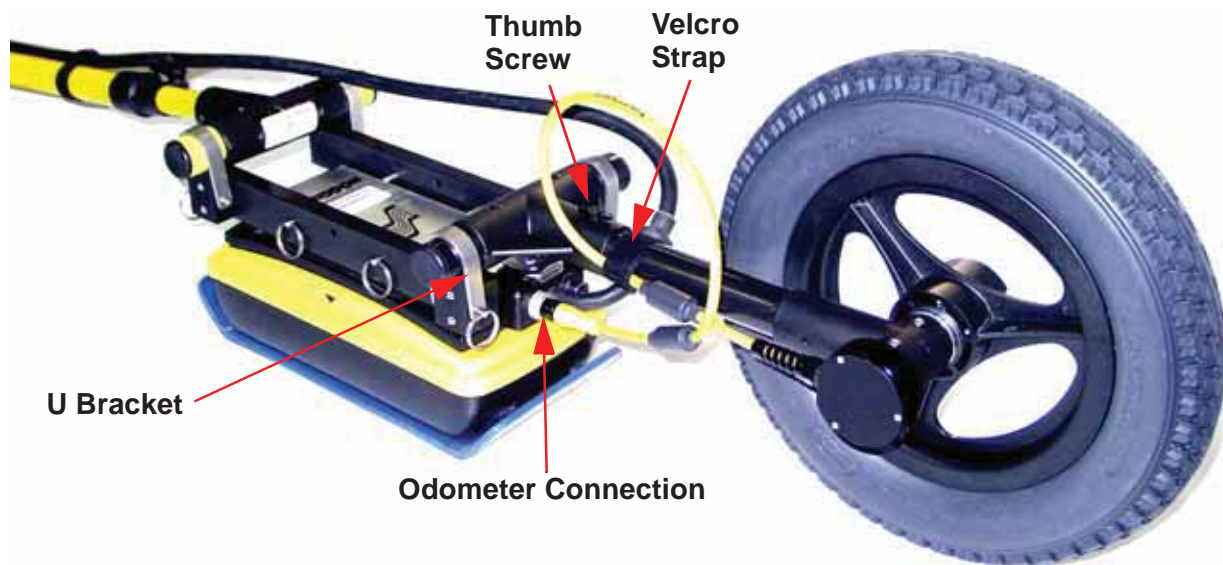
Connect the large black Noggin-to-DVL cable to the 37-socket connector on the Noggin and latch into place, ensuring the cable is looped to provide some slack and it is routed along the top of the SmartTow bracket. Secure the cable to the bracket and along the side of the handle using 2 or 3 Velcro straps.



The large odometer wheel attaches on the end of the Noggin with the 37-socket connector. Use the U-brackets and long metal pins to secure the odometer T-bar to the SmartTow Brackets. Orient the odometer so the black thumbscrew on the T-bar is facing upwards and the yellow odometer cable is on the same side of the odometer wheel as the odometer receptacle on the Noggin cable connection.

Ensure the black Noggin-to-DVL cable turns to the front of the Noggin so it does not interfere with the odometer wheel.

Then connect the yellow odometer cable to the receptacle on the connector to the Noggin. Loop the odometer cable so it does not interfere with the rotation of the odometer wheel and use velcro straps to secure it to the T-bar.



Odometer calibration is critical for accurate data images. Odometer calibration instructions are available in **13.5.2: p.120**.

## 7 SmartHandle Configuration Assembly (Noggin 500 & 1000 only)

The Noggin 500 and 1000 can be operated in the SmartHandle configuration.

The fully assembled Noggin 500 SmartHandle system is shown in **Figure 7-1**. The Noggin 1000 SmartHandle system looks very similar.



*Figure: 7-1 Noggin 500 SmartHandle system.*

Normally the SmartHandle system is used in the “push” configuration shown in **Figure 7-1**. In some situations the “pull” configuration may be a more desirable. **Figure 7-7** shows the SmartHandle system in this configuration.

Note that most Noggin SmartHandle systems come from the factory partially assembled with the odometer bracket, Noggin-to-DVL cable and the handle base already attached to the Noggin unit.



Figure: 7-2 Slide the Noggin odometer bracket over the four, silver mounting posts for both the Noggin 1000 (top) and Noggin 500 (bottom).



Figure: 7-3 Connect the 37 pin connector on the Noggin-to-DVL cable to the 37 socket receptacle on the Noggin unit by tightening the latch.



Figure: 7-4 On the Noggin-to-DVL cable, note the round receptacle on the back of the connector that attaches to the Noggin unit. Connect the yellow odometer cable to this round receptacle.



Figure: 7-5 Press the handle base straight down onto the four, silver mounting posts. The handle base should be pushed all the way down onto the odometer bracket. Insert the four quick-release pins to secure the handle.



Figure: 7-6 The full-length SmartHandle is shown in Figure 7-1. The SmartHandle can be shortened by removing the center handle section using the thumb-screws. Use the Velcro straps to secure the cable onto the SmartHandle, ensuring there is excess cable near the connection at the Noggin to allow the SmartHandle to pivot up and down without straining the cable.



## 7.1 SmartHandle “Pull” Configuration

In some situations, conditions may dictate that pushing the SmartHandle system (**Figure 7-1**) is not practical. An alternative configuration is to pull the SmartHandle system (**Figure 7-7**). To do this, remove the 4 quick-release pins that hold the handle to the Noggin system, remove the handle by pulling straight up and rotate the handle so that it faces the other direction. Then push the handle down onto the Noggin as far as it will go and replace the 4 quick-release pins.



*Figure: 7-7 In conditions where pushing the SmartHandle is difficult, it is possible to turn the handle around and pull the system as shown.*

## 7.2 Cable Connections

The DVL to Noggin cable is a Y-shaped cable with 3 connections; one to the Noggin sensor, one to the DVL and one to the power supply (battery or AC).

**Noggin Connection:** The first connection was done in **Figure 7-3** above, that is, the 37-pin connector on the cable was attached to the 37-socket connector on the Noggin. A latch was used to secure this connection.

From the Noggin the DVL to Sensor Cable runs up the side of the SmartHandle. Use the Velcro straps to secure the cable to the SmartHandle ensuring there is some slack in the cable near the connection at the Noggin so, as the handle is pivoted up and down, there is no strain on the connection (**Figure 7-6**).

**DVL Connection:** The second connection from the DVL to Sensor Cable is to the DVL. One end of the Y-shaped cable has a 37-socket connector. This end plugs into the 37-pin connector on the back of the DVL.

**Power Connection:** The third connection on the SmartHandle cable attaches to a power supply. The round, 4-pin connector attaches to the battery. This configuration usually uses a belt battery.

## 8 Rock Noggin Configuration Assembly (Noggin 500 & 1000 only)

Assembly of the Rock Noggin system for both the Noggin 500 and the Noggin 1000 is described in this section.

The Rock Noggin 500 system is shown in **Figure 8-1**. The Rock Noggin 1000 system looks very similar when assembled.



Figure: 8-1 The Rock Noggin system (left) and in use (right).

The Rock Noggin shipping case contains the complete Rock Noggin system (**Figure 8-2**).

Rock Noggin systems are shipped from the factory partially assembled with the frame and DVL-to-Noggin cable already attached to the Noggin unit (**Figure 8-3**). If your system is already partially assembled, skip to **Figure 8-11**. Detailed assembly starts at **Figure 8-4**. A fully assembled Rock Noggin system is shown in **Figure 8-15**.



*Figure: 8-2 A Rock Noggin system in its shipping case.*



*Figure: 8-3 The Rock Noggin system components after removal from the shipping case. From left to right are the belt battery, the Noggin already attached to the frame and the Digital Video Logger (DVL). The system comes partially assembled. To continue with assembly from this point, see Figure 8-11 and later.*



Figure: 8-4 The Rock Noggin system disassembled into its basic components and ready for assembly. More details of each component are given in the figures below.

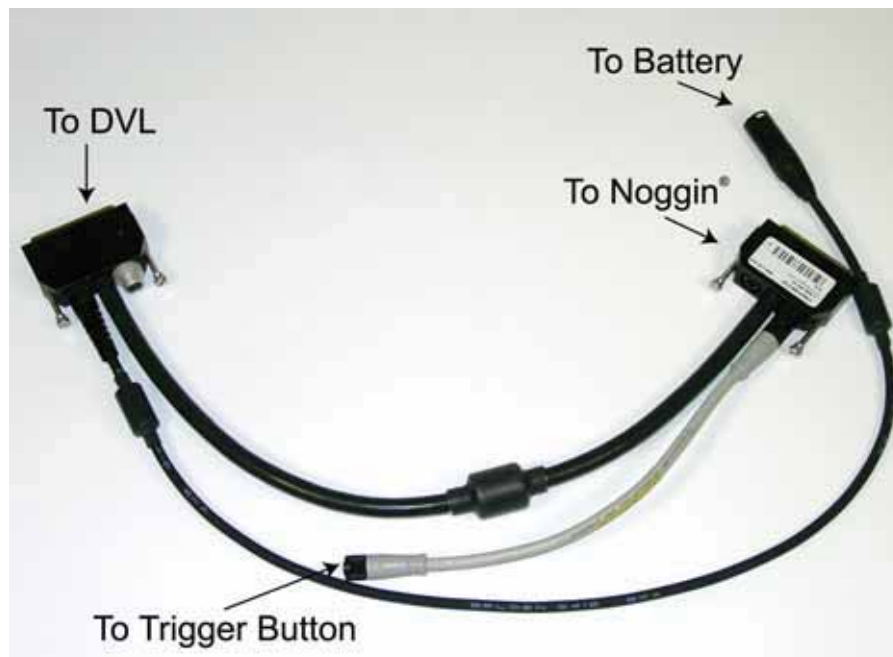


Figure: 8-5 The Rock Noggin cable. The 4 connections are for the Noggin, the Digital Video Logger (DVL), the trigger button and the battery.



Figure: 8-6 The Noggin used with the Rock Noggin can be either a Noggin 500 (shown here) or a Noggin 1000. The connections are identical for both systems. The 4 silver mounting posts visible here are used when attaching the frame to the Noggin (see Figure 8-8).

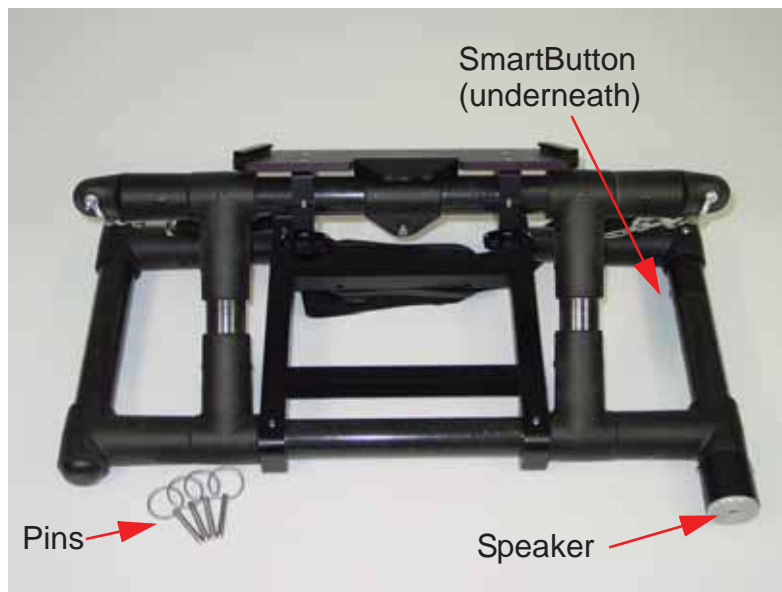
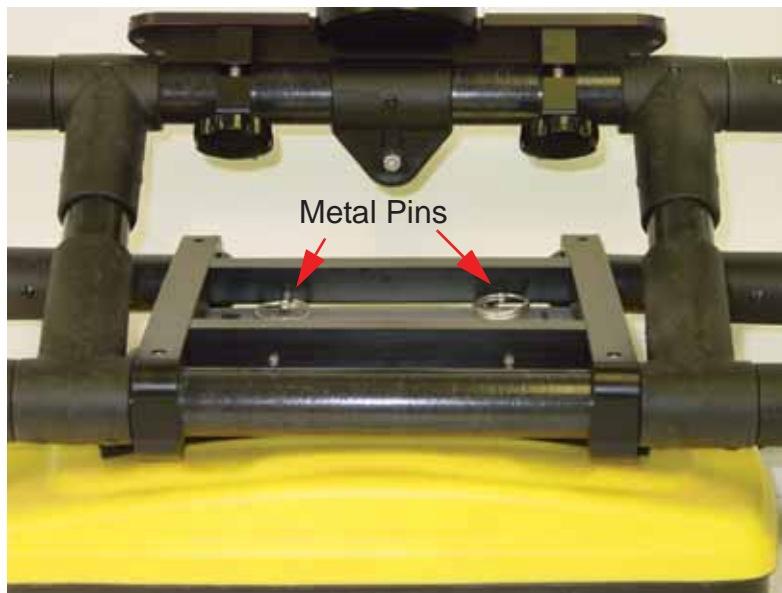


Figure: 8-7 The Rock Noggin frame. On the bottom of the right handle, note the grey speaker that is used to sound an audible tone as data are collected. Also, on the underside of the right handle, note that Smart button (not visible in this view) used to collect data. The frame is attached to the Noggin using the 4 metal pins shown (see below). The Digital Video Logger (DVL) clips onto the shelf at the top of the frame (see Figure 8-11).



*Figure: 8-8 Using the 4 holes on the bottom of the Rock Noggin frame, place the frame on the 4 mounting posts on the top of the Noggin (shown in Figure 8-6). Push the frame down until it cannot go any further. The Noggin should be oriented such that the 37 socket receptacle on the Noggin is on the same side as the SmartButton on the frame.*



*Figure: 8-9 Secure the frame to the Noggin by pushing the 4 metal pins into the holes on the frame as shown.*

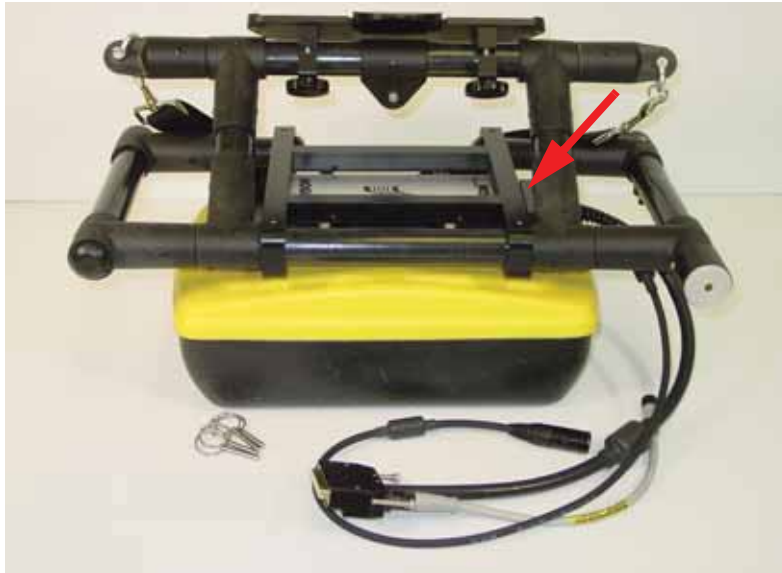


Figure: 8-10 Attach the end of the cable with the 37 pin (male) connection to the Noggin. Use a slotted screwdriver to tighten the connection.



Figure: 8-11 Attach the Digital Video Logger to the frame. Attaching the digital video logger (DVL). Step 1: Depress flexible clip. Step 2: Slide DVL onto shelf.

**Attach the Digital Video Logger (DVL):** The bottom of the Digital Video Logger is designed to slide onto the support shelf attached to the Rock Noggin frame (see **Figure 8-11**). Line up the bottom of the Digital Video Logger with the shelf and slide it back onto the shelf. Push the Digital Video Logger back far enough so that the flexible clip on the front of the shelf catches and holds the Digital Video Logger firmly in place. Wiggle the DVL to make sure it is firmly snapped in before letting go of the unit. (To remove the Digital Video Logger from the Rock Noggin frame, this clip must be flexed downward as the DVL is slid forward off of the shelf.

The two hand-screws on the bottom of the DVL shelf can be loosened to allow the DVL to be rotated to a different position on the Rock Noggin frame.



Figure: 8-12 Connect the end of the grey cable to the receptacle on the handle at the back of the frame. This receptacle is adjacent to the Smart button.

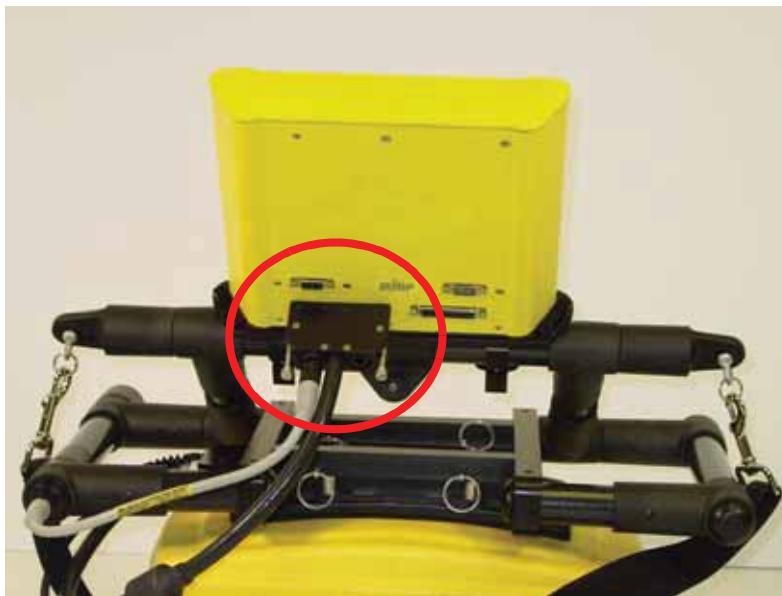


Figure: 8-13 Attach the end of the cable with the 37 socket (female) connection to the back of the Digital Video Logger (DVL). Use a slotted screwdriver to tighten the connection.





Figure: 8-14 The last connection on the cable is a cylindrical, 4 pin connector for the battery.



Figure: 8-15 The Rock Noggin system is now completely assembled and ready to be turned on.

## 9 Connecting GPS

For all Noggin configurations, a GPS with a serial output cable can be attached directly to the 9-pin serial port on the back of the DVL (**Figure 9-1**). The DVL can be configured to read in the GPS data and store it along with the GPR data (**13.3.5: p.112**).



*Figure: 9-1 GPS connect to the back of the DVL using a serial connection. GPS supplied with the system usually come with the optional battery splitter cable to power the GPS from the battery.*

The GPS requires power; user-supplied GPS's will need to be powered using a separate battery.

GPS supplied by Sensors & Software come with a battery splitter cable to allow the 12 Volt system battery to power both the Noggin system and the GPS (**Figure 9-1**).

## 10 Digital Video Logger (DVL)

Data acquisition is controlled by the Digital Video Logger (DVL). The DVL has software to set survey parameters, collect, display and store data.

### 10.1 Compact Flash Drive

The DVL has both an internal and a removable compact flash drive. The DVL firmware resides on the internal drive. Data can be saved to either the internal or removable drive (**Figure 10-1**). The removable compact flash drive is accessible by opening the door on the top of the DVL.

**Ensure the DVL is powered down before removing or inserting the compact flash drive.**

Loosen the finger screws on the top of the DVL, swing the door open and press the button to eject the drive.



*Figure: 10-1 The DVL has a removable compact flash drive for data storage.*

The DVL comes with a removable compact flash drive but the user has the option to purchase additional drives for data storage. It is best to purchase an industrial grade compact flash drive. Normal compact flash drives work but the higher the transfer rates and temperature ranges the better. The DVL can use cards up to a maximum of 2 GB in size. Sandisk, PSI-APRO, SimpleTech, Kingston, Viking, and Pretech are a few manufacturers of compact flash drives. These are widely available in consumer electronics stores.

To transfer data from the removable drive to a PC the user will need to purchase a card reader (**Figure 13-15**). These are widely available in consumer electronics stores.

## 10.2 DVL Temperatures

**It is very important that the DVL only be operated when it can be kept warmer than -10 C otherwise sensitive electronic components including the LCD screen may freeze. Never start the DVL after it has been exposed to cold temperatures.**

If the DVL will be operating in temperatures below -10 C, it should be kept in a wind-proof box insulated with styrofoam or textiles and heated with hand-warmer packs, if necessary. If possible, start the DVL in a warm temperature before placing it in the box. If the protective box is properly insulated, the DVL can usually generate enough heat to keep itself warm.



## 10.3 Running a DVL Detached from a Smart System

When collecting data with a Smart System, the DVL is powered by the system battery. It is possible to detach the DVL from the Smart System and power it independently to review data. There are 2 ways to power the DVL away from the Smart System:

- 1) The optional DVL-to-Power-Supply Cable (100-52-0029) allows the user to power the DVL away from the Smart System using the system battery. The cable connects the battery to the 9-socket connector on the back of the DVL.
- 2) To avoid having to use the system battery to power the DVL, an optional AC power supply (100-55-0018) is available. When combined with the DVL-to-Power-Supply Cable above, this allows the user to power the DVL away from the Smart System using AC power. The AC power supply connects to the DVL-to-Power-Supply Cable which connects to the 9 socket connector on the back of the DVL.

These are optional items that do not come standard with the system. Please contact Sensors & Software to purchase these items.

## 10.4 DVL Carrier

For convenience during data acquisition, especially when using the SmartTow and SmartHandle configurations, the DVL can be carried using the optional DVL Carrier shown in **Figure 10-2**.

The bottom of the DVL is designed to slide onto the support shelf on the DVL Carrier. Line up the bottom of the DVL with the shelf and slide it back onto the shelf. Push the DVL back far enough so that the flexible clip on the front of the shelf catches and holds the DVL firmly in place. Wiggle the DVL to make sure it is firmly snapped in before letting go of the unit. To remove the DVL from the DVL Carrier, flex the clip downward as the DVL is slid forward off of the shelf.



*Figure: 10-2 The DVL and control module can be attached to the optional DVL Carrier for hands-free operation. The DVL can be adjusted to optimize the view angle.*

## 11 Powering Up the System

Once all the cable connections are made between the Noggin, the Digital Video Logger (DVL) and any accessories like odometers and GPS's, the final step is to connect the system to a 12 volt power source, typically one of the batteries shown in **Figure 11-1**.



Figure: 11-1 Batteries for Noggin Smart Systems: SmartCart batteries (left) and belt battery (right).

Connect the round 4-pin battery cable on the Noggin-to-DVL cable to the receptacle on the side of the battery.



The upper red LED light on the DVL panel should be lit. If the battery voltage is low, the light will flash for about 30 seconds and go out. If the light flashes or does not appear, check the connections and make sure the battery is fully charged (see **15.1: p.126** for more information on battery care).

The voltage indicator can be helpful for identifying when the battery needs to be recharged. If the battery voltage drops too low the DVL will cease to operate.

The front of the DVL is shown in **Figure 11-2**. To start the system, press any button on the front panel. The lower red LED on the front panel should illuminate.



Figure: 11-2 Digital Video Logger (DVL) face

At this stage, the Noggin unit will still be powered down. Once Noggin action is requested (see later menu items), the DVL will enable power to the Noggin. If the Noggin is receiving power, the red LED light on the connector to the Noggin will be illuminated.

The water-resistant membrane keypad has a number of buttons that can be pressed to perform various tasks.

**Menu Buttons:** The yellow buttons labelled 1 to 8 correspond to menu choices that appear listed on the screen or along the bottom of the screen when the Digital Video Logger is turned on.

In addition, there are two general-purpose buttons labeled A and B. All buttons are DVL application dependent and roles change. The operation will be self-explanatory from the display screen.

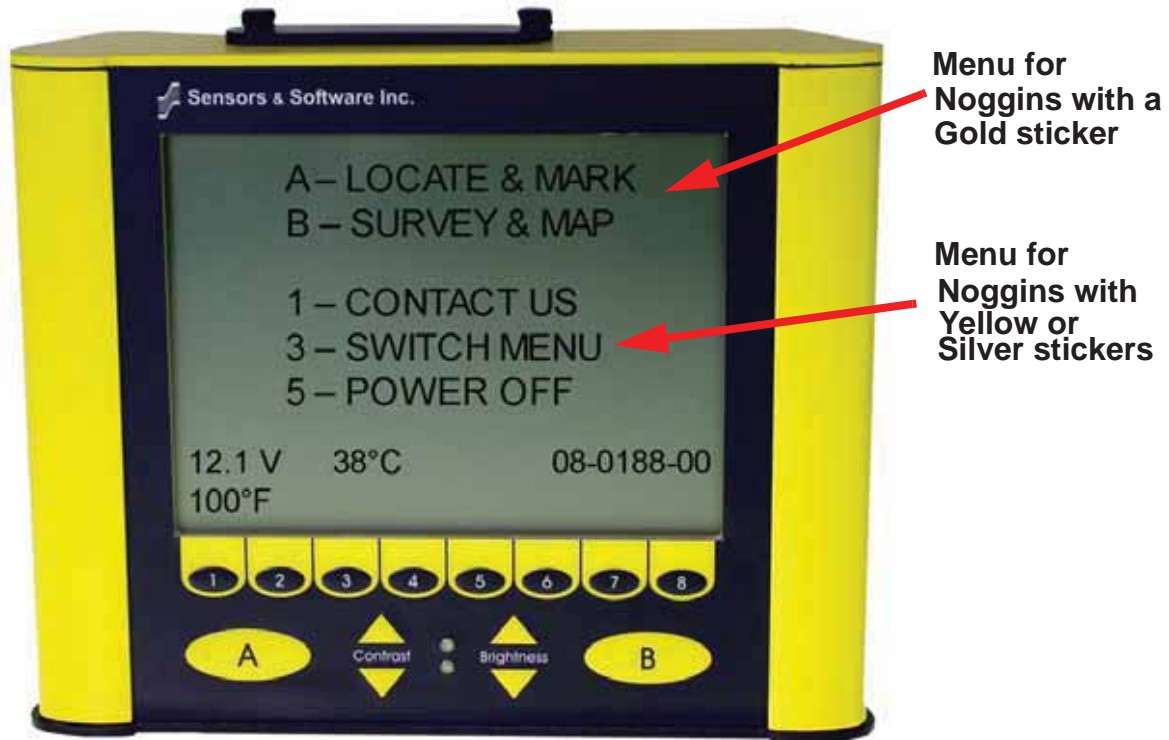
**Screen:** The DVL screen is a gray-scale LCD selected for its wide temperature range and visibility in sunlight. Visibility can be a major problem with viewing GPR data displays outdoors and considerable effort has been expended on getting a readily visible outdoor display.

**Brightness:** The yellow Brightness control arrows are used to increase and decrease the screen brightness. For example, increasing the Brightness setting may improve the visibility of the screen when in a dark area. Note, however, that increasing the screen brightness also increases battery consumption so don't use a bright screen unless necessary.

**Contrast:** The yellow Contrast control arrows are used to increase and decrease the screen contrast. For example, increasing the Contrast setting may improve the visibility of the screen on a bright, sunny day. Increasing the Contrast can also be useful to see weaker features on the screen. Adjusting the contrast has little effect on battery consumption.

Temperature sensors within the DVL automatically compensate the screen setting so that manual adjustments of Brightness and Contrast should seldom be needed after initial setup.

Once the Digital Video Logger powers up, the Main Menu is displayed with 4 choices:



- Pressing the A button enters Locate & Mark mode (**12: p.51**).
- Pressing the B button enters Survey & Map mode (**13: p.74**).
- Pressing the 1 button displays contact information for Sensors & Software Inc.
- Pressing the 3 button switches the menu for use with older Noggin and Noggin<sup>plus</sup> systems (these are systems with a Yellow or Silver Noggin sticker on top of the electronics housing). For details on using this menu system, see the Smart Systems manual.
- Pressing the 5 button will turn the DVL off.

This screen also displays the following information:

- **Battery Voltage:** The system will shut down when the battery voltage reaches about 10.2 Volts (see **15.1: p.126** for more details on the battery).
- **Temperature:** The internal temperature of the DVL is displayed on this screen in Celsius and Fahrenheit.
- **Software Version:** The version of the software loaded on the DVL.

---

**When the Noggin Smart System is not being used, do not leave the battery plugged in. The system draws about 0.1 amps even when it is powered off and this will gradually drain the battery.**

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## 12 Locate & Mark Mode

Locate & Mark mode is simple and fast data collection designed for real-time interpretation of the data to locate targets in the subsurface. Data are not typically saved in this mode; when it is it can only be saved as a screen image. Locate & Mark mode data are NOT saved to digital data files for post-processing using PC-based software.

Locate & Mark mode requires a Noggin system with an odometer wheel. It is not possible to collect data with a Trigger Method of Free Run or Button.

Selecting Locate & Mark from the main menu will display the System Settings screen.

### 12.1 System Settings Screen



#### 12.1.1 Scan

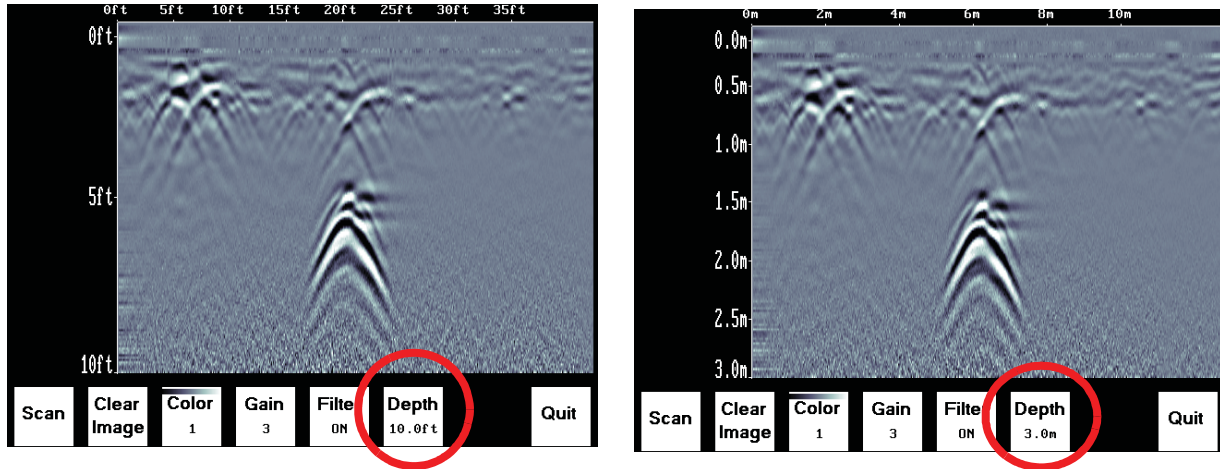
Press the Scan button to start scanning (12.2: p.56).

#### 12.1.2 Language

Select the language for the menus. Current options are English, Chinese or Icons. This section generally uses the English menus but see 12.6: p.70 for a chart showing all the equivalent icons.

### 12.1.3 Units

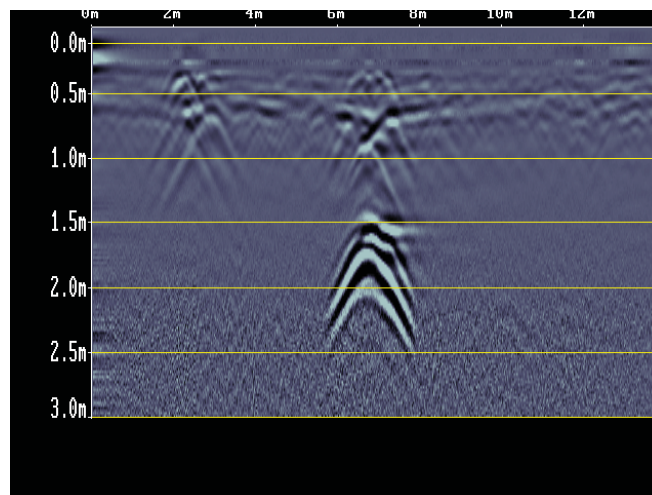
Units for the Position Axis, Depth Axis and Depth Indicator can be either Meters or Feet.



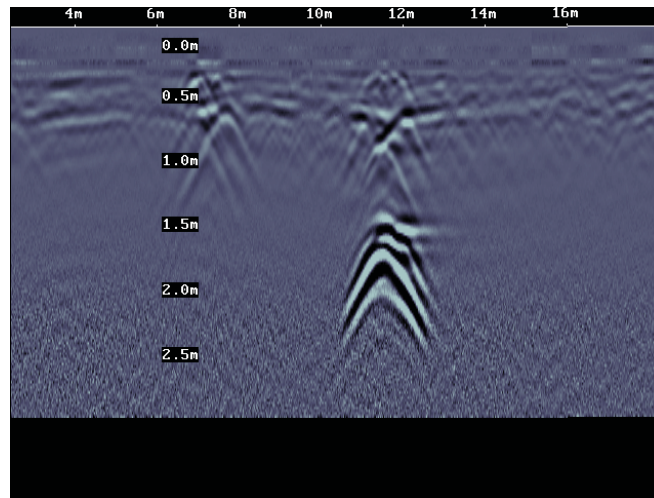
### 12.1.4 Scale

The Scale button toggles to four different Scale options:

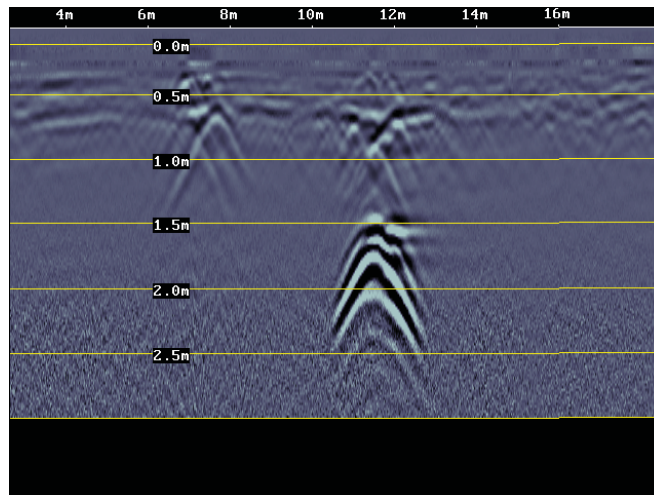
- 1) **Lines** means Depth Lines are plotted on the data image to assist with determining the depth of targets (also see **12.3: p.58**).



- 2) **Text** means Depth Values are plotted in the center of the data image every 8 meters or 26 feet:



- 3) **Both** means both Depth Lines and Values are plotted on the data image:



- 4) **Off** means no Depth Lines and Values are plotted on the data image.

### 12.1.5 Date

Opens the Date Screen to change the current date (12.5: p.69). Images are saved with this date.

### 12.1.6 Time

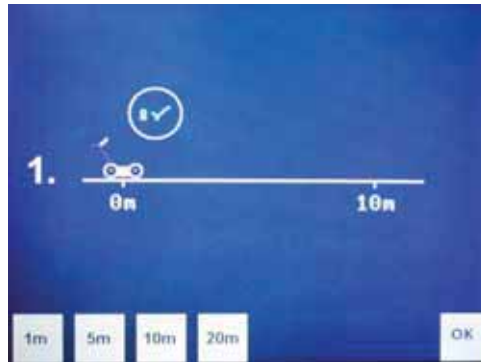
Opens the Time Screen to change the current date (12.5: p.69). Images are saved with this time.

## 12.1.7 Odometer Calibration

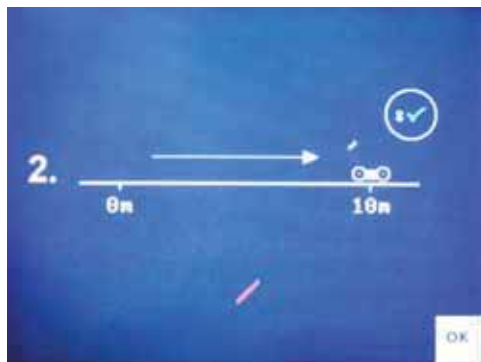
The odometer is factory calibrated but should be periodically calibrated for positional accuracy.

To calibrate the odometer, follow the steps as they appear on the screen:

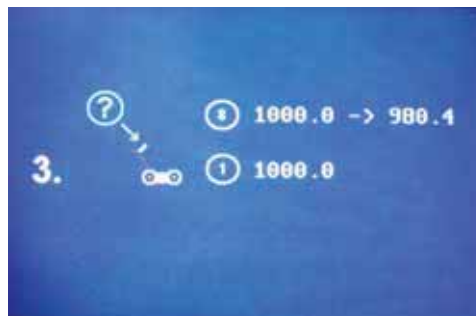
1) Select the length of your odometer calibration distance: 1, 5, 10 or 20 meters or 3, 10, 30 or 60 feet (depending on the units (**12.1.3: p.52**)). The default length is 10 meters or 30 feet. Set the GPR system at the starting position and press '8'.



2) Move the system the calibration distance; a red line rotates as you move to indicate that the odometer is turning. Then press '8'.



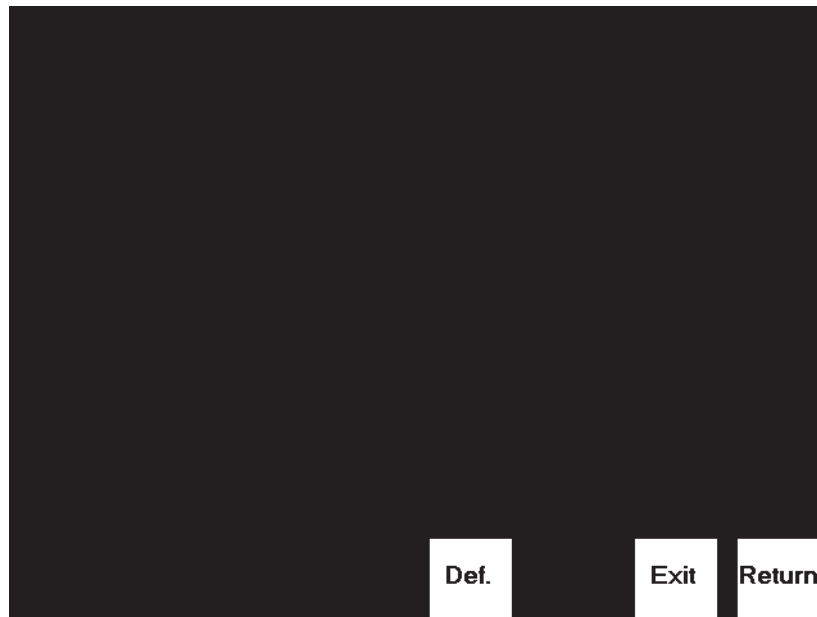
3) This screen displays the new and old calibration values. Press '8' to accept the new calibration value or press '1' to cancel out of the calibration and use the old value.



The odometer calibration in Locate & Mark mode can be different than the odometer calibration in Survey & Map mode (**13.5.2: p.120**).

### 12.1.8 Exit

Opens a sub-menu to confirm Exiting from Locate & Mark mode (Exit). There is also an option to Return to Locate & Mark mode (Return) or restore the system to factory default settings (Def.).



### 12.1.9 System Information

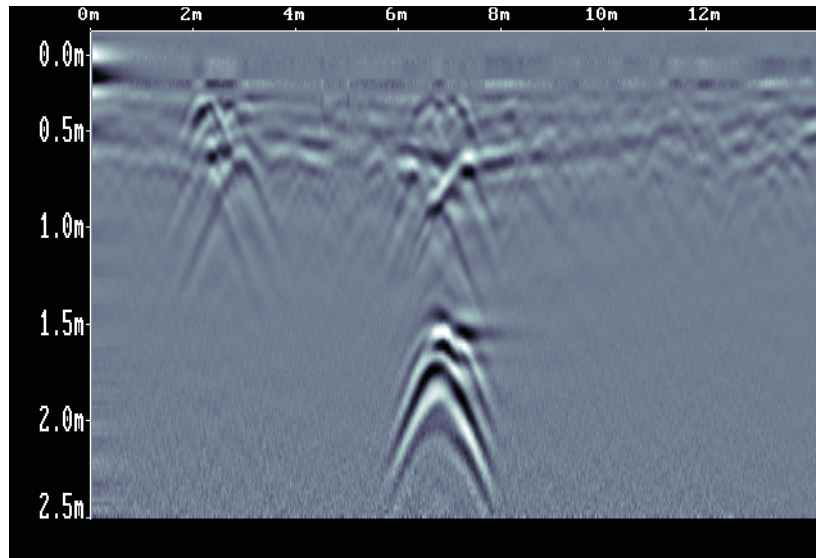
The top of the Systems Setting Screen displays the serial number of the GPR sensor, the software version number, the GPR Sensor frequency (in MHz) and the current battery voltage.

## 12.2 Scanning Screen

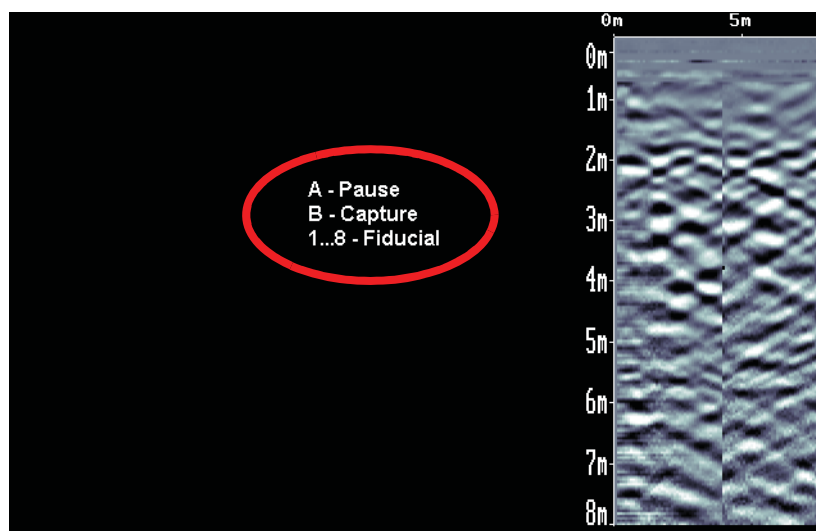
After pressing the Scan button, wait a few seconds for the vertical depth scale to appear on the right side of the screen, and then move the GPR system forward.

A cross-sectional image of the ground scrolls onto the screen from the right to left. The position is displayed on the horizontal axis at the top while the depth is displayed on the vertical axis. The position and depth axes units are meters or feet depending on the units set in the Systems Setting Screen (**Section 12.1.3**).

If the **Scale** or **Both** option is selected (**Section 12.1.3**), horizontal depth lines appear on the image to assist with determining the depth of targets.



Approximately 16 meters or 50 feet of data is displayed on one screen. If the survey line exceeds this distance the image will scroll off the left side of the screen.



When scanning starts, the screen text or symbols are displayed on the screen to indicate the buttons to press to **Pause** data collection (A), save the current screen to an **Image** file (B) or add a numbered **Fiducial** marker at the current position (1 to 8).

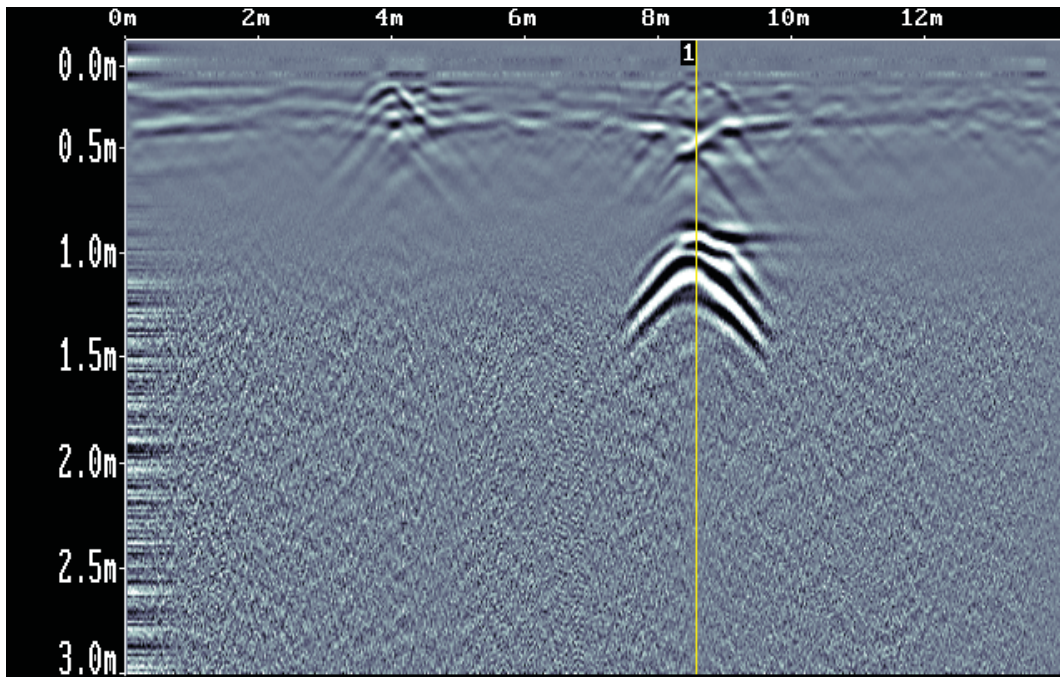


Figure: 12-1 Pressing the 1 to 8 buttons adds a Fiducial, a vertical line in the data image with the number on top.

When the B button is pressed to save an image to the Compact Flash card inserted into the DVL (10.1: p.45), the image number appears on the bottom of the screen with a message to press any button to continue.

A message will appear on the screen if there is no Compact Flash card in the DVL. Images are only saved when a card is present.

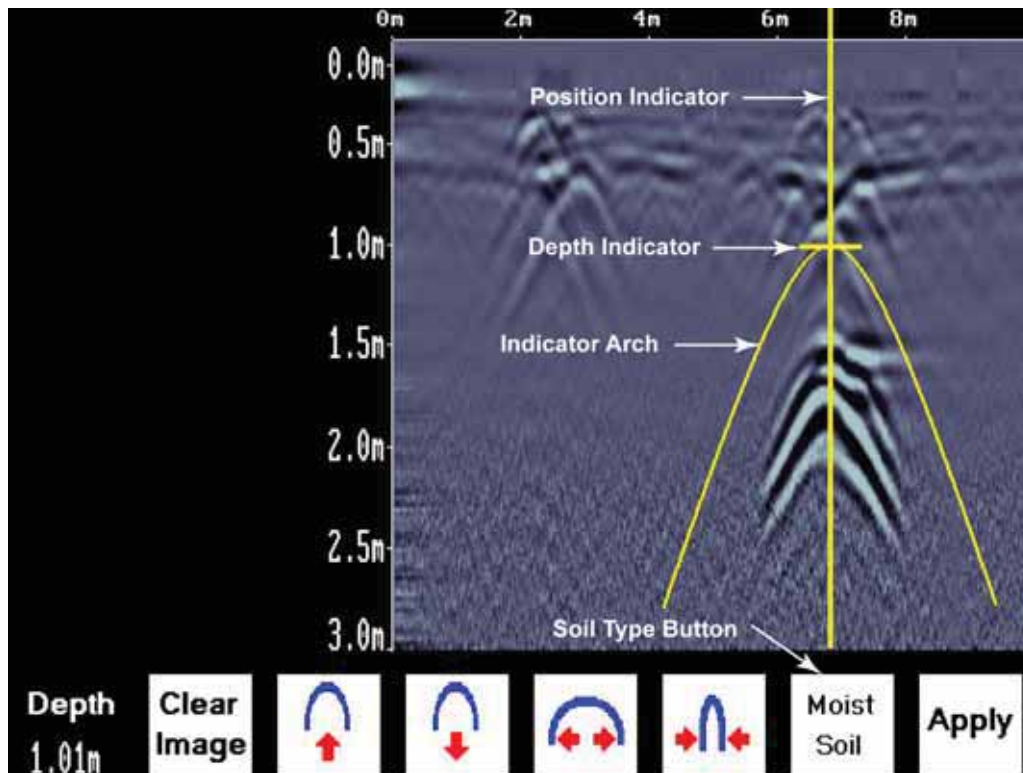
See 12.7: p.73 for information on viewing the data images on a PC.

Pressing the Pause button opens the **Image Settings Screen** to change the current Color Palette, Depth, Filter and Gain (12.4: p.63).

Stopping and pulling the GPR system backwards along the same path automatically opens the **Locating Screen** (12.3: p.58) used to pinpoint the position and depth of a target.

## 12.3 Locating Screen

The Locating Screen is accessed by stopping and pulling the GPR system backwards while scanning. The cursor moves over the image and menu options appear at the bottom of the screen.



### 12.3.1 Locating Cursor

The Cursor consists of 3 parts:

- Position Indicator** Vertical cross-hair is tied to the odometer and corresponds to the location at the center of the GPR sensor. As the cart is pulled backwards, the Position Indicator moves to indicate the current location of the cart in the image.
- Depth Indicator** Horizontal cross-hair found at the peak of the soil type indicator hyperbola indicating the depth. The Depth Indicator moves up or down using the Hyperbola Up and Down buttons.
- Indicator Hyperbola** Idealized representation of a hyperbola; a typical pipe-like target response observed on the GPR image. The width of the hyperbola is controlled by Soil Type setting and the Hyperbola Narrow and Widen buttons.



## 12.3.2 Soil Type

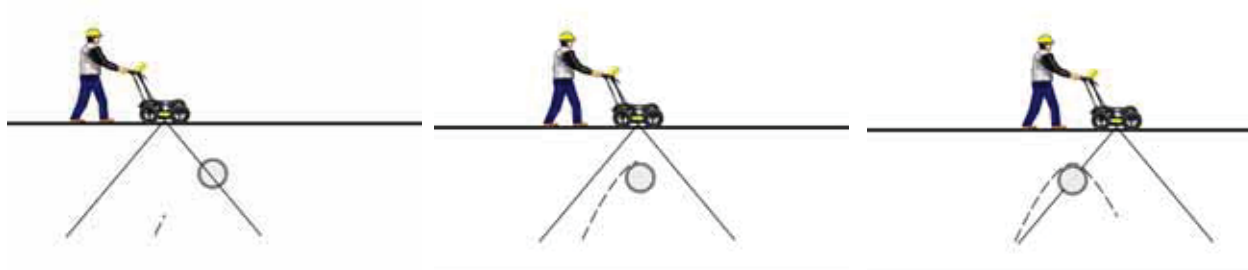
To obtain an accurate depth axis and depth estimations of targets in the GPR image, a Soil Type Calibration must be performed. Soil Type Calibration can be done 3 ways:

- 1) Matching the shape of a target hyperbola,
- 2) Using a target at a known depth, or
- 3) Using the moisture level of the soil.

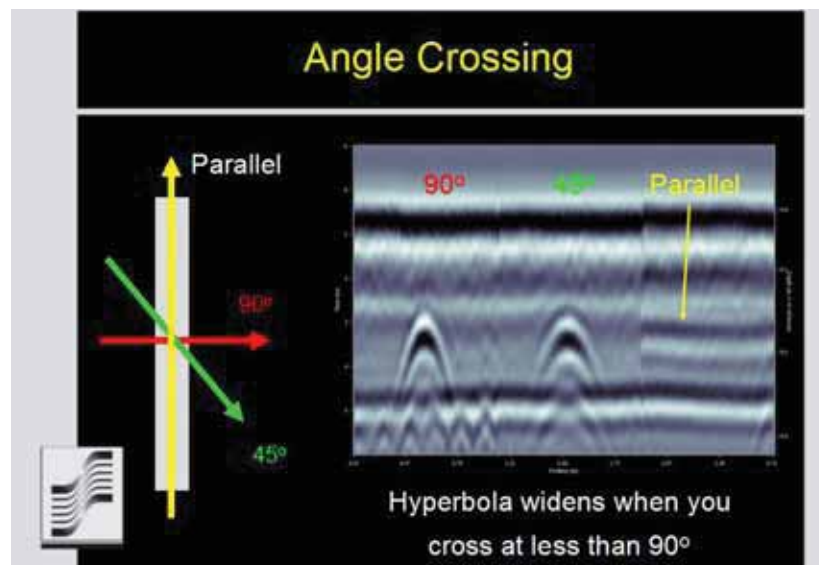
### 12.3.2.1 Matching a Target Hyperbola

Targets like pipes, cables, buried artefacts, tree roots and rocks generate hyperbola-shaped responses on the GPR image.

Hyperbolas occur because GPR energy does not travel into the ground as a pencil-thin beam but more like a 3D cone. Reflections can appear on the record even though the object is not directly below the GPR sensor. Thus, the GPR sensor "sees" the pipe before and after going over top of it and forms an hyperbolic response on the image.

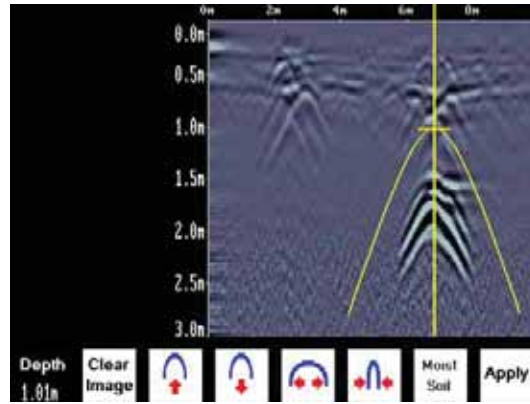


Cross long, linear targets like pipes or cables at a 90 degree angle to produce a target hyperbola suitable for the soil type calibration. The depth estimation of a target will be incorrect if the soil type calibration is done on a target hyperbola produced at an oblique angle (smaller than 90 degrees).

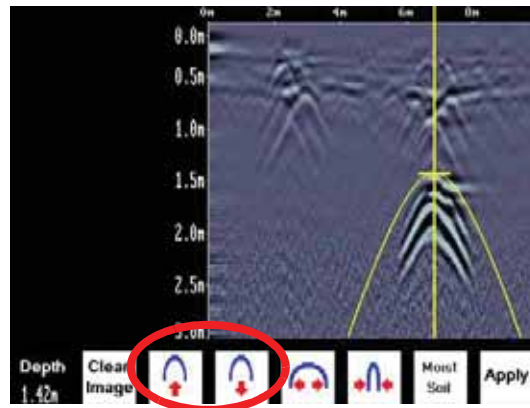


To determine the Soil Type using a Target Hyperbola:

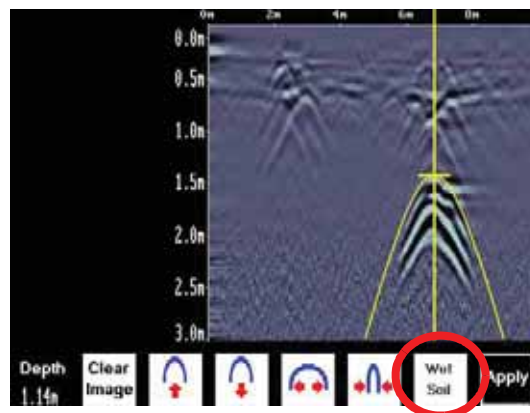
- 1) With a target hyperbola visible on the image, back the GPR system up until the Position Indicator is centered on the target hyperbola in the GPR image; preferably a deep one with long tails because this provides the most accurate soil type calibration.



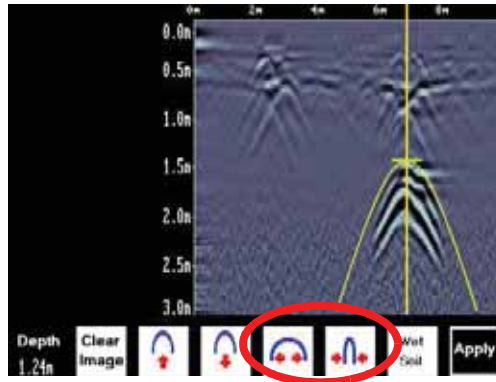
- 2) Use the **Up** and **Down Arrows** to move the Indicator Hyperbola shallower or deeper in the GPR image respectively, until it lies overtop of the target hyperbola.



- 3) Press the **Soil Type** button and toggle through the five different soil types to find the one that roughly fits the shape of the Indicator Hyperbola to the shape of the Target Hyperbola.



- 4) Use the **Wide** and **Narrow Hyperbola** buttons to change the shape of the Indicator Hyperbola to match the shape of the Target Hyperbola on the GPR image. The depth of the target is indicated on the bottom left.



- 5) Press the **Apply** button to save the **Soil Type** and update the Depth Axis on the Scanning Screen. The Depth axis can now be used to estimate the depth of targets while scanning in the area.

### 12.3.2.2 Target at Known Depth

If there are no suitable hyperbolas visible in the image to perform the Target Hyperbola Matching described above, there may be a target of known depth in the area being scanned.

To determine the Soil Type using a target at known depth:

- 1) With the target response visible on the image, use the **Up** and **Down Arrows** to move the Depth Indicator (and Indicator Hyperbola) until it lies on top of the GPR response of the known target.
- 2) Use the **Wide** and **Narrow Hyperbola** buttons to change the shape of the Indicator Hyperbola until the depth of the target, displayed in the bottom left corner of the screen, is correct.
- 3) Once the depth is matched, save the **Soil Type** value by pressing the **Apply** button.

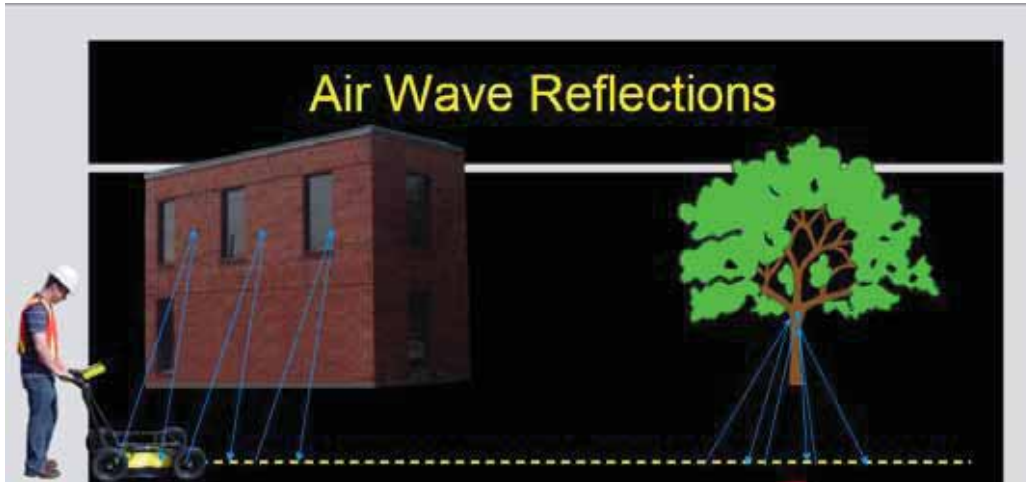
### 12.3.2.3 Soil Moisture

If a good target hyperbola or a target of known depth is not available, the user will have to estimate the Soil Type. The Soil Type is most strongly affected by water so the soil type options relate to the amount of water in the soil.

Change the soil type by pressing the Soil Moisture button until the option that best describes the soil in the area is displayed. The options are **Very Dry**, **Dry**, **Moist**, **Wet** and **Very Wet Soil**.

### 12.3.3 Identifying Air Wave Reflections

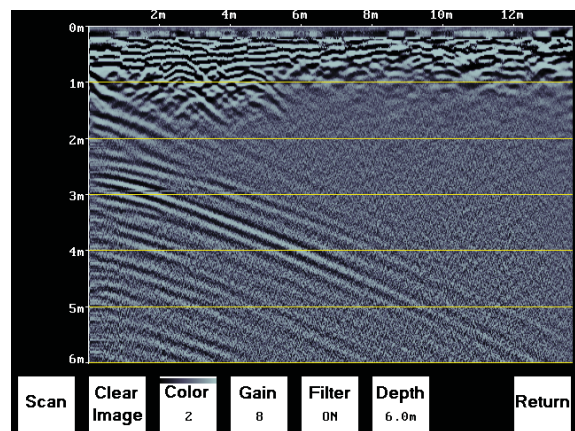
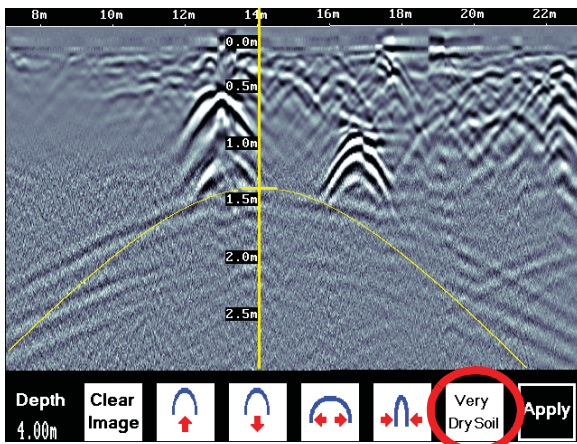
Some hyperbolas in the image can be caused by objects that are not in the subsurface, such as posts, fences, overhead wires and even trees.



An important part of understanding the data image is learning to recognize these unwanted "air" targets and differentiate them from the targets in the ground.

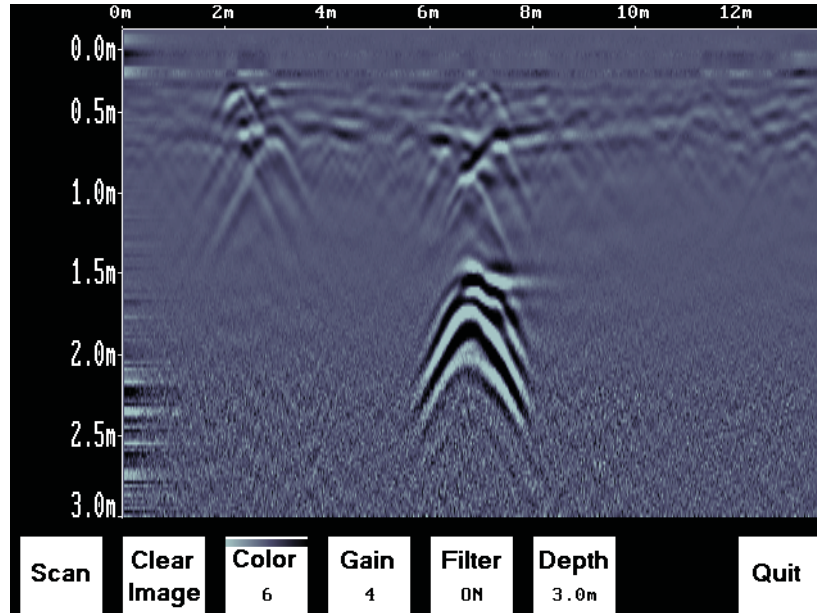
One way of identifying air reflections is to use the target hyperbola method described above. However, hyperbolas from above-ground objects are wider than objects in the ground and out of the range of the maximum Soil Type.

Therefore, if the widest Indicator Hyperbola is still not wide enough to match the target hyperbola, the target hyperbola is likely from an object in the air, not the ground.



## 12.4 Image Settings Screen

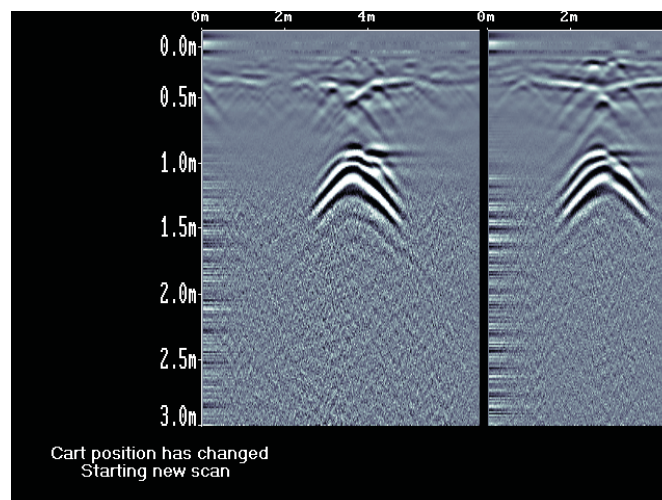
The Image Settings Screen is accessed by pressing the A (Pause) button while in the Scanning Screen or the Locating Screen. Menu options appear along the bottom of the screen:



### 12.4.1 Scan

To exit from the Image Settings Screen and resume Scanning, press the Scan button or the A (Pause) button again. The Scanning Screen returns at the current location with the position information preserved.

If, while paused in the Image Settings Screen, the GPR system has moved more than a few centimeters, when scanning is restarted, a gap called a “Position Break” will appear in the image. The position break is also indicated by a message on the bottom of the screen and the Position Axis along the top of the data image resetting to zero.

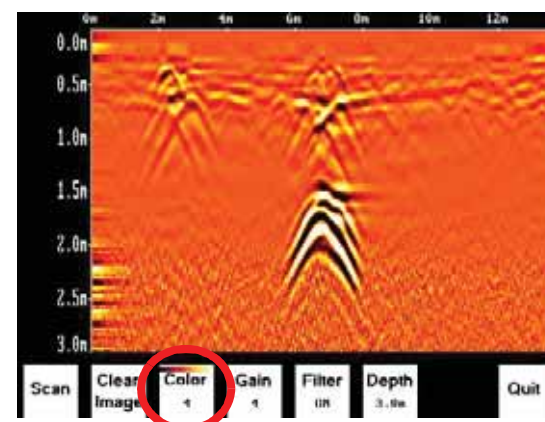
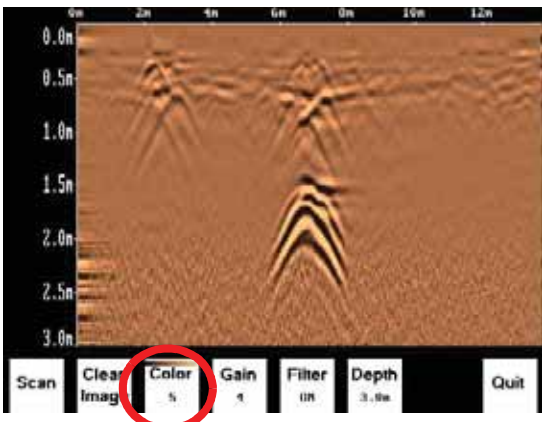
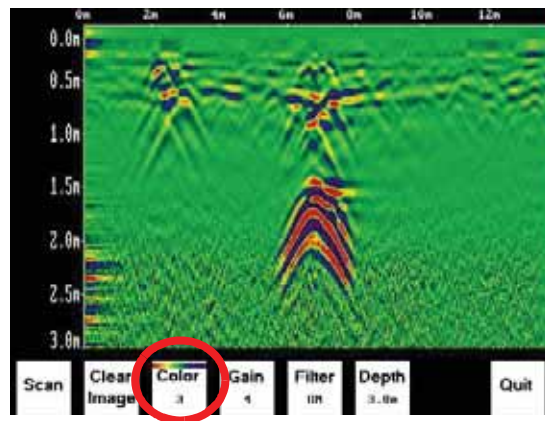
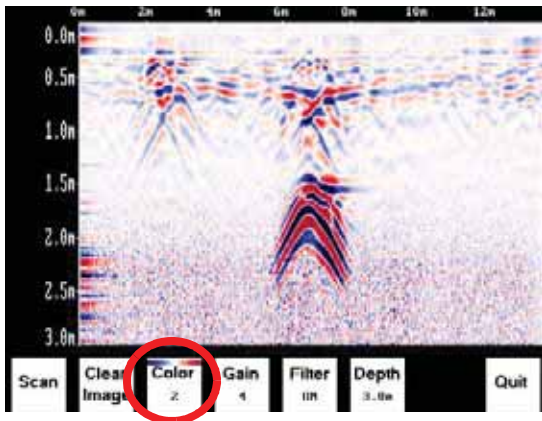


## 12.4.2 Clear Image

Deletes the current data image on the display.

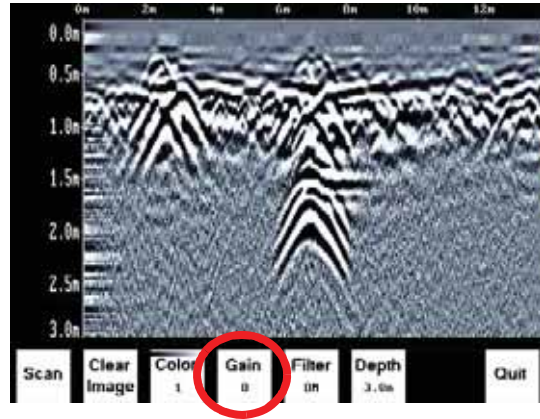
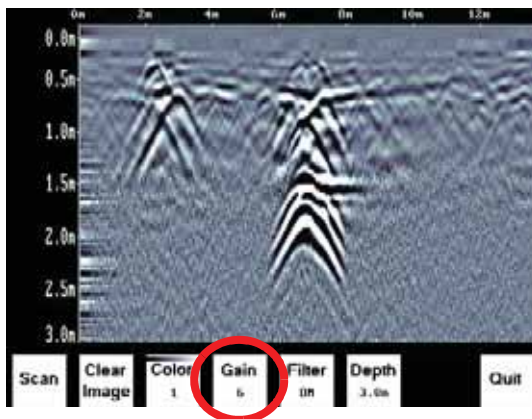
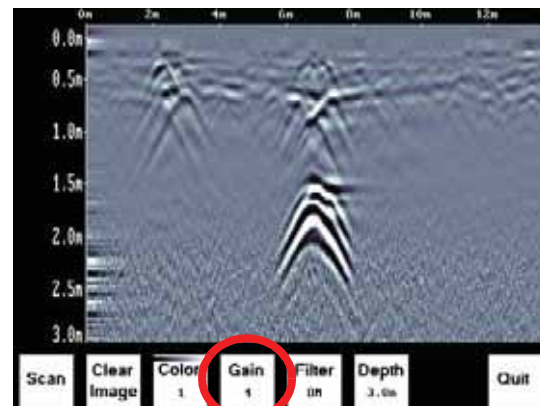
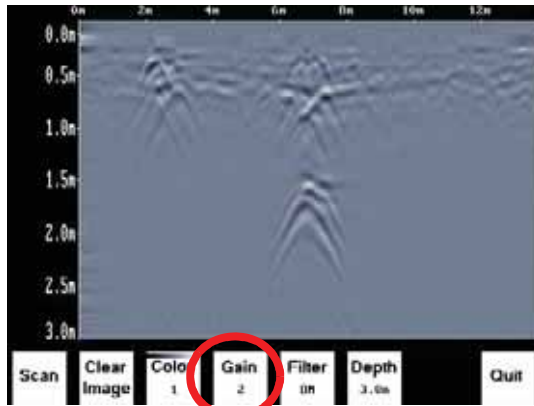
## 12.4.3 Color

GPR images are displayed in colors corresponding to a color palette. In general, stronger GPR signals appear in stronger colors. A number of different color palettes are available to display the image. Some color palettes may show the target better than others.



## 12.4.4 Gain

Since GPR signals are absorbed by the material being scanned, deeper targets have weaker signals. Gain acts like an audio volume control, amplifying the signals and making deeper targets appear stronger in the image. The Gain varies from 1 to 9 with 1 being no gain and 9 being the maximum gain.



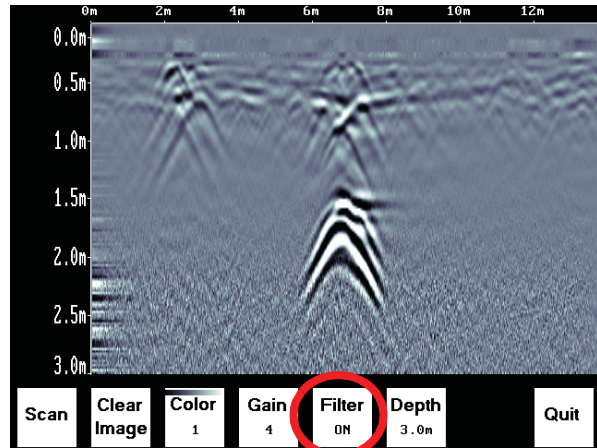
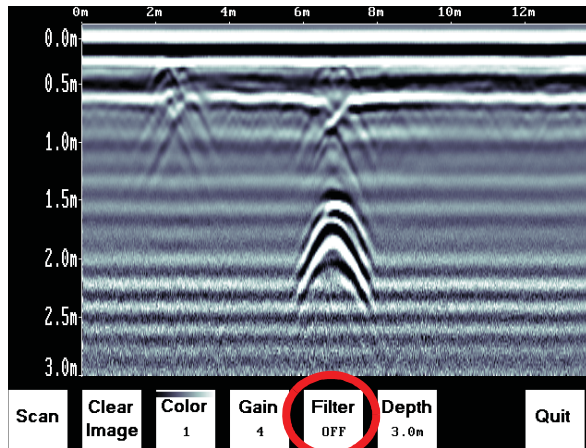
As the Gain changes, the current image on the display updates so it is not necessary to re-collect an image with a different gain setting. Use the lowest gain setting that shows the targets. Try to avoid over-gaining as understanding the image may become more difficult.

## 12.4.5 Filter

The filter has the effect of removing flat-lying reflections in the image and enhancing the dipping reflections and hyperbolas usually caused by targets. It can also assist in identifying very shallow targets that might be masked by the strong signals at the top of the image.

The Filter defaults to ON, so if you are looking for a layer or other flat-lying target, turn the Filter OFF.

The image below shows the same scan with the Filter OFF and ON.

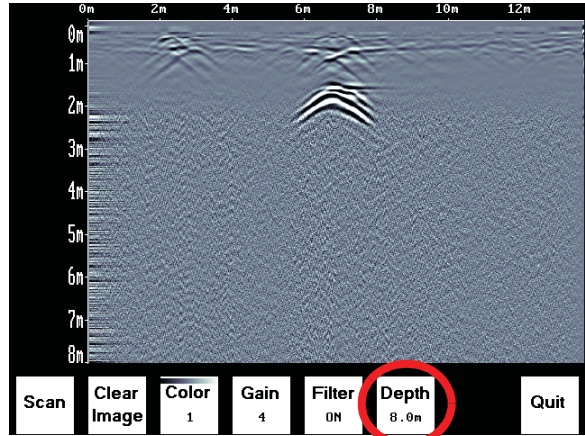
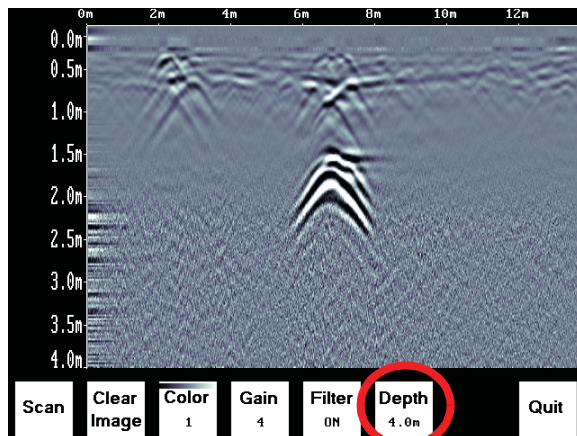
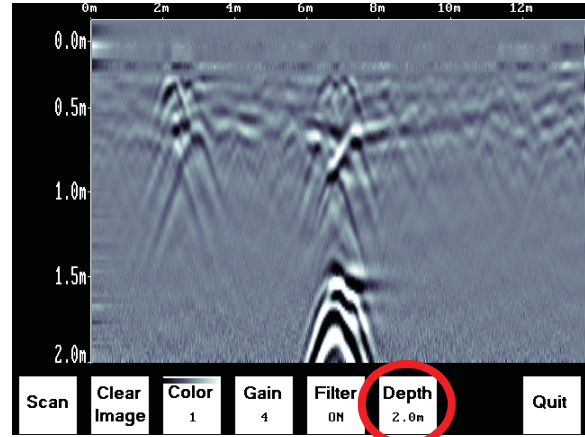
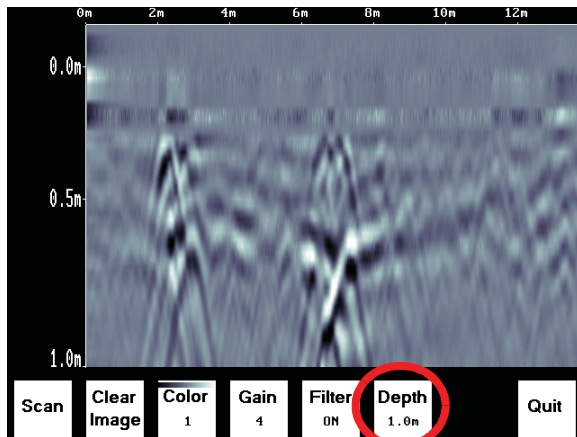




## 12.4.6 Depth

The Depth button controls the depth of GPR data displayed on the screen. There are 9 different depths available ranging from the minimum to maximum depth.

The depth setting is an estimate of the total depth displayed on the Scanning Screen based on the current Soil Type (12.3.2: p.59) and Units (12.1.3: p.52).



The maximum depth setting is based on the Noggin frequency. The approximate maximum depth settings are:

Noggin 100 = 16 meters or 50 feet

Noggin 250 = 8 meters or 25 feet

Noggin 500 = 4 meters or 12 feet

Noggin 1000 = 2 meters or 6 feet

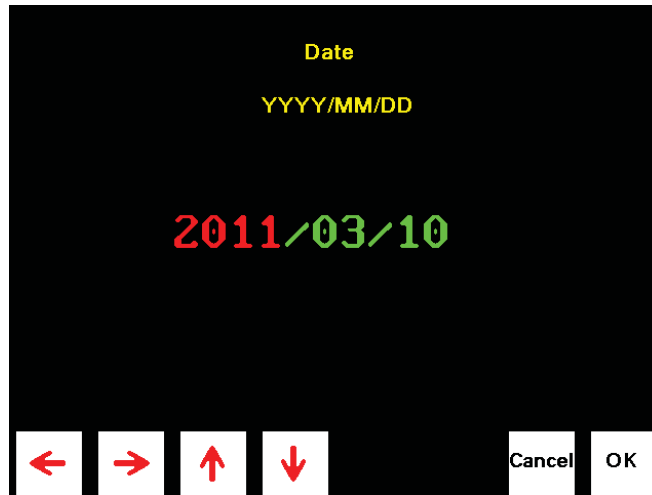
The system always collects data to the maximum depth but the Depth setting on this menu determines how much of the data is displayed on the screen. Therefore, it is possible to scan with a Depth setting of, say 2 meters, pause scanning and then increase the depth setting to 4 meters and re-display the image to look for deeper targets.

## **12.4.7 Quit**

Exits the Scanning and Image Settings Screens and returns to the Systems Settings Screen.

## 12.5 Changing the Date and Time

From the System Settings Screen, select the Date option. The Time option is similar.



Use the Left and Right Arrow buttons to highlight the number to change in red.

Increase the number using the Up Arrow and decrease the number using the Down Arrow.













Pressing OK saves the new date or time and exits the screen.

Pressing Cancel exits the screen without saving the date or time.

## 12.6 English and Equivalent Icons

### 12.6.1 System Settings Screen Menu

Table 1: System Settings Screen Menu

Scan	
 English	
Units	m      ft  
Scale	
Date	 2011 03/10
Time	 12:25
Odom cal.	
Exit	
Def.	
Return	

### 12.6.2 Scanning Screen

Table 2:

<b>A - Pause</b>	
<b>B - Capture</b>	
<b>1...8 - Fiducial</b>	







### 12.6.3 Locating Screen Menu

Table 3: Locating Screen

<b>Clear Image</b>	
Move Hyperbola Up Move Hyperbola Down Widen Hyperbola Narrow Hyperbola	
Very Dry Soil    Dry Soil    Moist Soil    Wet Soil    Very Wet Soil	
<b>Apply</b>	





### 12.6.4 Image Settings Screen Menu

Table 4:

Scan	
Clear Image	
Gain	
Filter	
Depth	
Quit	

### 12.6.5 Date and Time Menus

Table 5:

Next Field Previous Field	
Increase Number Decrease Number	
Cancel	
OK	

## 12.7 Viewing Images on a PC

Images collected in Locate & Mark mode are saved to the Removable Compact Flash drive on the DVL (**10.1: p.45**). To transfer data collected on the removable drive to a PC, eject the compact flash drive from the DVL and insert it into a user-supplied card reader connected to a PC. Use the Windows Explorer program to make a new folder on the PC, read the removable drive and copy the folders containing images files to the new folder.



*Figure: 12-2 Locate & Mark data images saved to the removable drive are easily transferred to a PC. First, power down the DVL, then (i) loosen both of the finger-screws on the top of the DVL so the drive door can swing open freely. (ii) Press the button to partially eject the compact flash drive. (iii) Remove the drive and insert it into a PC card reader (user supplied). Copy the image data folders from the drive into a folder on the PC using the Windows Explorer program. The optional GPR Image View program can then be used to view the data images.*

After transferring data files to the external computer, the data images can be viewed using the optional GPR Image View software.

## 13 Survey & Map Mode

Survey & Map mode is designed for data collection of GPR lines and grids where the data will usually be transferred to a PC for post-processing and display using software programs like EKKO\_View and EKKO\_Mapper.

Selecting Survey & Map mode from the main menu opens the following screen:





## 13.1 Survey & Map Menu

### 13.1.1 Line

Survey lines collected with the Noggin are saved as digital data (.DT1) files that can be viewed on the DVL or exported to an external computer for processing and plotting. The Sensors & Software program EKKO\_View is available to process and display the data on a PC.



Pressing the A button from the Survey & Map menu takes the user to Line data collection. This menu allows the user to select a project number (0-9) and line number to save each data file to (0-99).

Data files from the same area can be organized and saved under a project number selected by the user. As each individual line is collected, it is given a number. By default, the lines number increment sequentially but the user can use the arrow buttons to move to a different line number, if desired.

Details for Data Acquisition are described in **13.2: p.78**.

### 13.1.2 Grid

Survey lines collected with the Noggin are saved as digital data (.DT1) files that can be viewed on the DVL or exported to an external computer for processing and plotting.

Pressing the B button from the Survey & Map menu takes the user to Grid data collection.

Grid collection involves collecting data in an organized pattern over an area. This type of data acquisition allows the GPR data to be presented as plan maps with the EKKO\_Mapper software or 3D volumes with the EKKO\_Mapper 3D software.



**For inexperienced surveyors, laying out a grid with straight lines and all the corners at 90 degree angles can be difficult. Sensors & Software provides a product called EasyGrid to make laying out an accurate grid simple. Contact Sensors & Software for more details.**

The Grid menu allows the user to select a grid number (0-9) and line number to save each data file to (0-99).

Before the data acquisition on a grid begins, the user must define the size of the area to be surveyed, the direction of the survey lines and line spacing. The details of the grid survey are specified in the Grid Setup menu option (**13.3.4: p.107**).

Details for Data Acquisition are described in **13.2: p.78**.

### 13.1.3 Setup

There are many background setup parameters related to the Noggin Smart Systems operation for line and grid surveys that can be edited. This menu allows the user to display and change various settings for the Smart System (**13.3: p.94**). The user can also reset all the parameters to the factory default settings.

### 13.1.4 File Management

The File Management menu allows the user to create GPR Project (GPZ) and Google Earth (KMZ) files from the collected project and grid data, delete data from the DVL and copy data from the internal DVL memory to the removable Compact Flash drive.

### 13.1.5 Run without Saving Data

This option allows the user to go straight into data acquisition. This feature is to allow a “quick look” at the data in the area. The data collected when in this mode are NOT saved and cannot be reviewed later or exported. Data that scrolls off the edge of the screen is gone and cannot be reviewed.

If a GPS receiver is attached to the DVL, GPS information can be logged to a file even when the Noggin data are not being saved (**13.3.5: p.112**).

### 13.1.6 Utilities

This menu has utility programs to:

- a) Change the Date and Time on the DVL (**13.5.1: p.120**)
- b) Calibrate the odometer (see **13.5.2: p.120**),
- c) List or print or transfer system information to assist Sensors & Software in troubleshooting problems with your system (**13.5.3: p.121**) and
- d) Determine how much space is left on the DVL (**13.5.4: p.121**).

### 13.1.7 Set Storage Drive

This setting controls how data are saved on the DVL. The available options are:

- 1) **Internal:** If this setting is selected, the data are saved to the internal memory in the DVL.
- 2) **Removable:** If this setting is selected, the data are saved to the removable compact flash drive accessible by opening the door at the top of the DVL (**Figure 10-1**).

### 13.1.8 Return

This button will return the user to main menu.

## 13.2 Data Acquisition

Selecting the **Line**, **Grid** or **Run without Saving Data** options from the Survey & Map menu will start data acquisition. The Run without Saving Option goes straight to data acquisition while the Line and Grid options require the user to select a project or grid number, file number and press Run before data acquisition begins.

If the Auto Start option is set to ON (**13.3.2.3: p.100**) the system will automatically boot up and be ready for data acquisition. If Auto Start is set to OFF the user must press the Start button to boot up the system.

After acquisition has started, the Start button disappears and a Stop button appears on the right. A Gain button is also visible as well as the current Depth setting and equivalent Time Window length in nanoseconds (**Figure 13-1**).

Data acquisition begins by pressing the Start button on the DVL.

When the Start button is pressed for the first time after the unit is turned on, the Noggin will boot up (this can take up to 30 seconds depending on the software version of the Noggin). During this time the system is self-calibrating and measuring such factors as temperature and battery voltage.

Once this boot up has been completed, data acquisition can begin. For subsequent lines there is only a short delay before data acquisition can begin.

Data acquisition is done by moving the Smart System along the survey line. During data acquisition, the Gain button is dynamic and the screen display of the signal can be changed on the go (**13.2.6: p.81**).

When the survey line is completed, press the Stop button to stop data acquisition. At this point no more data can be collected without starting a new line.

### 13.2.1 Replaying or Overwriting Data

Immediately after a data file has been collected and the Stop button pressed, the data file can be replayed by pressing the left and right arrow buttons to scroll the data to the left and right.

During data replay, the gain (**13.2.11: p.92**) and filter (**13.2.12: p.93**) settings can be changed and the image can be zoomed by pressing the Zoom button and changing the zoom factor. For example, zooming 2 times on data with a depth setting of 5.0 meters will show the first 2.5 meters of data on the screen.

Any data file that has been collected is indicated by an asterisk (\*) beside the line number. The data line can be replayed at any time by selecting the file number and selecting Run. The user then has the option to View, Overwrite or Delete the data file.

## 13.2.2 Screen Overview

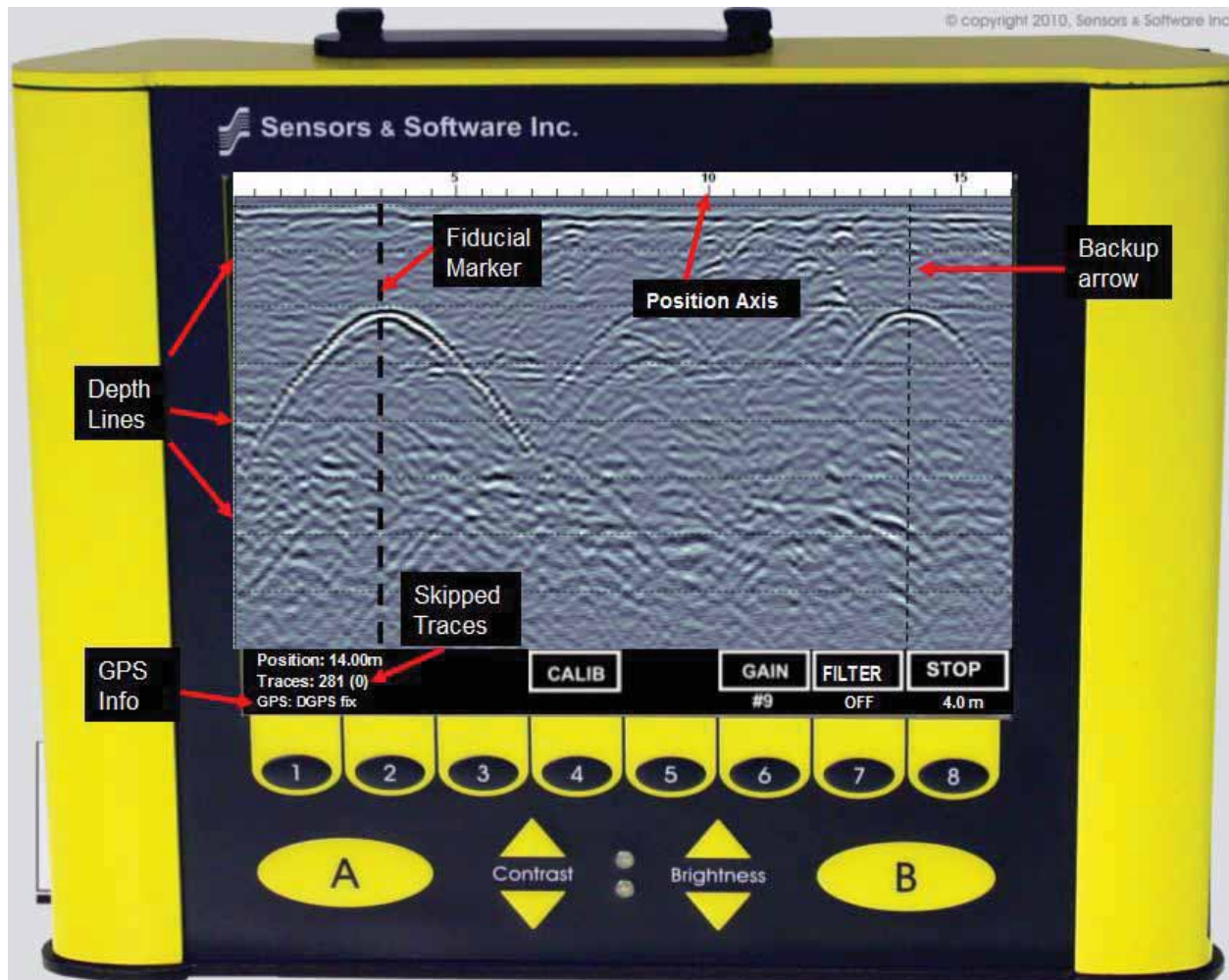


Figure: 13-1 Survey & Map Data Acquisition Screen

The Noggin screen is shown in **Figure 13-1**. It is divided into 3 sections. The top section provides positioning information. The center section contains the actual data and the bottom section contains the menu.

## 13.2.3 Position Information

The top section contains horizontal spatial positioning information in feet or meters depending on the position units setting (**13.3.1.7: p.97**).

## 13.2.4 Data Display

The data image displays the actual data collected or replayed. The image also contains the Depth Lines and any Fiducial Markers the user enters. See the sections below for more details.

### 13.2.4.1 Depth Lines

Depth lines are horizontal lines indicating the estimated depth. They are very useful for getting depth estimates to features of interest in the data.

The Depth Lines are controlled by the current velocity value as well as the depth selected. See **13.3.1.1: p.94** on changing the depth setting and for more details on how depths are determined.

**To display the correct depth, it is the responsibility of the user to calibrate the system to the correct velocity of the material (see 13.2.10: p.88 on how to calibrate the system for velocity). Once a velocity value has been determined see 13.3.1.2: p.95 on how to change the velocity setting.**

Note that it is possible to change the depth units between meters and feet (**13.3.1.7: p.97**).

### 13.2.4.2 Fiducial Markers

A fiducial marker is a dotted vertical line placed on the data section at a specific position during data acquisition. Adding these markers during data acquisition is useful for recording significant positions or the positions of surface objects encountered during the survey.

A fiducial marker is activated by pressing the A button on the keypad during data acquisition. As well, when using the backup arrow (**13.2.7: p.82**) fiducial markers can be added at the current arrow location by pressing the A button.

The position and name of the object encountered at each marker can be recorded in a field notebook. The fiducial marker is written to the trace header of the next trace to be collected. Fiducial markers are numbered sequentially (F1, F2 etc.). When the data are transferred to a PC and reviewed, these markers can assist with data interpretation.

If a GPS receiver is attached to the DVL, a file containing GPS information can be saved. In Fiducial Tagging mode, whenever a fiducial marker is added to the data, a line of GPS information will be added to the GPS file (**13.3.5: p.112**)

## 13.2.5 Menu

The bottom section contains the user menu selection and current program settings. From left to right on the screen, this includes:

- 1) The current position based on the current triggering device (**13.3.2.2: p.98**) and Station Interval (**13.3.3.3: p.103**). The current position also changes when the Backup Arrow is used (**13.2.7.1: p.83**)
- 2) The total number of traces collected. Beside this is the Skipped Traces Number which indicates when the system is being moved too fast (**13.2.7: p.82**)
- 3) GPS information (if GPS receiver attached, see **13.2.5.1: p.81** and **13.3.5: p.112**),
- 4) The Calib button for calibrating the velocity setting (**13.2.10: p.88**).
- 5) The Gain button and current Gain setting (**13.2.6: p.81**),
- 6) The Filter button and current Filter setting (**13.2.12: p.93**),
- 7) The Stop button and the total depth to the bottom of the data image (**13.3.1: p.94**),

### 13.2.5.1 GPS Status

If a GPS receiver is attached to the DVL and enabled (**13.3.5: p.112**) a message will appear in the bottom left corner of the menu indicating whether the GPS data is successfully being logged. The possible messages are:

- 1) **GPS: DGPS fix** means differential GPS data are currently being logged.
- 2) **GPS: GPS fix** means standard GPS data are currently being logged.
- 3) **GPS: fix not valid** means GPS data are NOT currently being logged. This is usually because GPS satellites are not available.
- 4) **GPS: No Input** means the GPS receiver is not operating properly. Check the settings and test the system (**13.3.5: p.112**).
- 5) **GPS: No GGA** means the GPS receiver is not outputting a GGA NMEA string that the DVL requires (**13.3.5: p.112**).

### 13.2.6 Total Distance Per Screen

The total distance that can be displayed on one screen varies depending on the Noggin system, Station Interval (**13.3.3.3: p.103**) and Plot Interval (**13.3.3.4: p.106**). The DVL screen is 640 pixels wide.

As the Station Interval increases, the distance between data traces increases and the total distance per screen increases.

As the Plot Interval increases, the total distance per screen decreases.

**Table 6:**

Noggin	Normal Plot Interval (pixels)	Normal Station Interval (meters)	Total Data Distance per Screen (meters)	Normal Station Interval (inches)	Total Data Distance per Screen (feet)
100	2	0.1	32	3.84	102.4
250	2	0.05	16	1.92	51.2
500	1	0.025	16	0.96	51.2
1000	1	0.01	6.4	0.48	25.6

For more details on total distances and Station Intervals see **13.3.3.3: p.103**.

To see how much data can be collected before the DVL memory is full and data must be deleted or downloaded, see the DVL Recording Space (**13.5.4: p.121**).

## 13.2.7 Collecting Data using the Odometer

If the Smart System is using an odometer wheel, ensure that the Trigger Method is set to “Odometer” (**13.3.2.2: p.98**).



As the Smart System moves, the odometer triggers the system to collect a data trace at fixed distance intervals. This interval is called the “station interval” (**13.3.3.3: p.103**).

For the Noggin 100, the normal station interval is 10 centimeters (3.84 inches).

For the Noggin 250, the normal station interval is 5 centimeters (1.92 inches).

For the Noggin 500, the normal station interval is 2.5 centimeters (0.96 inch).

For the Noggin 1000, the normal station interval is 1.0 centimeter (0.48 inch).

The station interval can be changed to a longer or short distance in the Setup (**13.3.3.3: p.103**).

Each data trace is plotted as a vertical strip (called a “trace”) on the screen (see **Figure 13-1**). The width of this trace, also called the “Plot Interval”, can be changed to 1, 2, 4, or 8 pixels (**13.3.3.4: p.106**).

The normal Plot Interval for Noggin 100 and Noggin 250 traces is 2 pixels.

The normal Plot Interval for Noggin 500 and Noggin 1000 traces is 1 pixel.

The odometer units that appear across the top of the screen can be set to either meters or feet (**13.3.1.3: p.95**).

Smart Systems can normally collect data at a very fast walking pace. However, if the system is moved too quickly, data can be skipped (see below).

During data acquisition, the current odometer position value (in the current units, either meters or feet) is written to the lower left corner of the screen (see **Figure 13-1**).

Note that Smart systems can be configured to collect data either by pushing the system (forward) or pulling the system (reverse). See **13.3.2.1: p.98** about changing the direction of data acquisition.



The odometer should be periodically re-calibrated to ensure accuracy. The procedure for re-calibrating the odometer is described in **13.5.2: p.120**.

### 13.2.7.1 Backup Arrow to Pinpoint Target Positions

The odometer also allows the user to stop the Smart System in the middle of a survey line and back up. When this is done, an arrow and vertical line appear on the data image and move back along the image as the system moves backwards (**Figure 13-1**). This makes it possible to correlate a target in the data image to an exact location on the ground. Once the arrow lines up with the target, mark the ground at the center point of the Noggin.

When the system is moved forward again to continue with the survey, the Smart system does not start collecting data again until you reach the position where you stopped at. This feature is useful for producing a continuous data image even if the system is backed up during the survey line.

Note that it is not possible to back up and have the arrow indicator move more than one screen.

The physical position corresponding to the Back-up arrow is the center of the Noggin.

### 13.2.7.2 Skipping Traces by Moving too Fast

On the lower part of the data acquisition screen, beside the current total number of traces collected is the total number of traces skipped.

If the Smart System is being used with the odometer and is moved too quickly for the Noggin system to keep up, traces are skipped and the quality of the survey is reduced. The skipped traces do not actually create gaps in the data but rather, the last trace that was collected properly is repeated. The Skipped Traces number displays the total number of skipped traces (**Figure 13-1**). If this number exceeds 0 this is due to moving the system too quickly.

If the system is moved too fast, after the data survey line is complete, the DVL will indicate the total number of traces that were “skipped”. If more than 10% of the traces in the survey line were skipped, the user then has the option to Autofix the data. The Autofix process replaces any repeated traces in the data with interpolated traces. While this process does not solve the problem of skipping traces, it will make the data traces look less “blocky” when plotted.

If the number of traces skipped is a significant percentage of the total number of traces collected, i.e. 10% or more, the operator should slow down, decrease the number of Stacks (**13.3.1.5: p.96**) or reduce the Depth setting (**13.3.1.1: p.94**).

## 13.2.8 Collecting Data in Free Run Mode

If the Smart System is not using an odometer, and the user wants to collect data continuously in time, ensure that the Trigger Method is set to “Free Run” (**13.3.2.2: p.98**). This means that the system collects data even if it is not moving. This option is useful for collecting data when using the odometer wheel is not practical:



In Free Run mode, the data acquisition screen (**Figure 13-1**) includes Pause and Continue buttons to pause and restart data collection.

When the Smart System is used in Free Run mode, it is up to the user to keep track of positioning by some other method, for example, a measuring tape, using fiducial markers (**13.2.4.2: p.80**) or GPS (**13.3.5: p.112**).

In Free Run mode, data collection is dependent on two factors,

- 1) the speed that the Noggin system is collecting data and
- 2) the speed the Noggin system is moving.

### 13.2.8.1 Controlling Noggin Data Collection Speed in Free Run

In Free Run mode the user can control the speed the Noggin collects data by increasing or decreasing the number of stacks (**13.3.1.5: p.96**). Increasing the number of Stacks has the effect of slowing down the data collection speed of the Noggin system. Decreasing the number of Stacks has the effect of speeding up the data collection speed.

The user can also control the speed of the Noggin data collection by adjusting a time delay between data collection points. Note that if the time delay is greater than 0.1 seconds and an external Beeper-Trigger is connected to the system, the Beeper-Trigger will emit a beeping sound as the data trace is collected.

### 13.2.8.2 Noggin Ground Speed in Free Run

In Free Run mode, the speed the Noggin moves determines the distance between sample points on the ground (station interval). This type of data collection requires experimenting with the number of stacks and time delay (**13.3.2.2: p.98**) and practicing to find a satisfactory speed for the Noggin. Moving too quickly may result in under-sampling the data making it more difficult to

interpret. Moving too slowly may result in over-sampling the data. This stretches the data image making it more difficult to interpret. As well, maintaining a relatively uniform speed is important for minimizing image distortion.

### 13.2.8.3 Determining Noggin Settings for a Desired Ground Speed

The time delay (**13.3.2.2: p.98**) and number of stacks (**13.3.1.5: p.96**) should be set to values that, when combined with speed the Noggin is moving at, provide an appropriate station interval (**13.3.3.3: p.103**).

Increasing the number of Stacks has the effect of slowing down the data collection speed of the Noggin system. Decreasing the number of Stacks has the effect of speeding up the data collection speed.

This may take a little experimenting to determine the optimal values for stacks, time delay and the actual speed the Noggin is moving at.

To determine the towing speed to collect data, at approximately the desired station interval (**13.3.3.3: p.103**), do the following calculation:

- 1) Set the Depth (**13.3.1.1: p.94**).
- 2) Set the Trigger Method to Free Run and the Trace Delay to zero (0.0) seconds (**13.3.2.2: p.98**).
- 3) Set the number of Stacks to 32 (**13.3.1.5: p.96**).
- 4) Without moving the system, using a stopwatch, time the system to collect and save data in Line Mode (**13.1.1: p.75**) for 120 seconds (2 minutes) and pause the data collection.
- 5) Record the number of traces that were collected in the 120 second time period. This will be visible on the bottom of the data collection screen beside "Trace #".
- 6) Divide the number of traces by the time in seconds to calculate the number of trace per second (trcs/sec) that were recorded.
- 7) To calculate the towing speed necessary to collect traces at approximately the desired station interval, perform the following calculation:
 

For kilometers/hour:	$\text{trcs/sec} * \text{station Interval(m)} * 3.6$
For meters/sec:	$\text{trcs/sec} * \text{station Interval}$
For miles/hour:	$\text{trcs/sec} * \text{station interval(ft)} * 0.68$
For feet/sec:	$\text{trc/sec} * \text{station interval (ft)}$
- 8) If the calculated towing speed is too fast, increase the number of stacks in Step 4 and repeat the calculation. If the calculated towing speed is too slow, decrease the number of stacks in Step 4 and repeat the calculation.
- 9) Create a speed chart by doing this calculation at different numbers of stacks and different time windows/depths.

#### 13.2.8.4 Positions in Free Run Mode

Each data trace is plotted at the Station Interval currently set (**13.3.3.3: p.103**). In Free Run mode the station interval is not fixed so each screen of data can represent any ground distance. This means that the position values displayed in Section A at the top of the data image (**13.2.3: p.79**) are not correct.

When running the system in Free Run mode it is best to set the Position Units (**13.3.1.7: p.97**) to meters and the Station Interval (**13.3.3.3: p.103**) to a value of 1.0 meter. Then the position values appearing on the top of the data image can be interpreted as trace numbers and not an absolute position.

### 13.2.9 Collecting Data using a Button

For situations when an odometer wheel is impractical and the user wants to collect data at discrete locations, ensure that the Trigger Method is set to “Button” (**13.3.2.2: p.98**). This means the Noggin system only collect data when the the DVL B button or the Trigger button (if an external Beeper-Trigger is connected to the system) is pressed.



When collecting data in this mode, increase the number of stacks (**13.3.1.5: p.96**). Generally, the more stacks the better the data quality.

In Button mode, if an external Beeper-Trigger is connected to the system, it “beeps” as each trace is collected. The length of the beep will depend on the number of stacks (the more stacks, the longer it takes to collect a trace and therefore the longer the beep).

When the Smart System is used in Button Mode, it is up to the user to keep track of positioning by some other method, for example, using a measuring tape, fiducial markers (**13.2.4.2: p.80**) or GPS (**13.3.5: p.112**).

Since data collection only occurs by the user pressing the button, usually a fewer number of traces are collected in this mode compared to Odometer or Free Run mode (see above). Therefore, it is often useful to increase the trace width to 4 or 8 pixels so that the data are more easily seen on the DVL screen (**13.3.3.4: p.106**).

## 13.2.10 Calib. (Calibration) Menu

Noggin systems can be used to scan into many different materials including soil, rock, concrete, snow, ice and wood. The radio wave emitted by a Noggin system will travel at different velocities depending on the material being scanned. The depth value (**13.3.1: p.94**) and Depth Lines (**13.2.4: p.79**) are only accurate if the system has been properly calibrated to determine the velocity of the material being scanned. See **13.3.1.1: p.94** for more details about how depth is calculated.

The Calibration function is a tool for determining the velocity of the material being scanned. A velocity value can be input directly (**13.3.1.2: p.95**) or determined in one of two different ways depending on the situation:

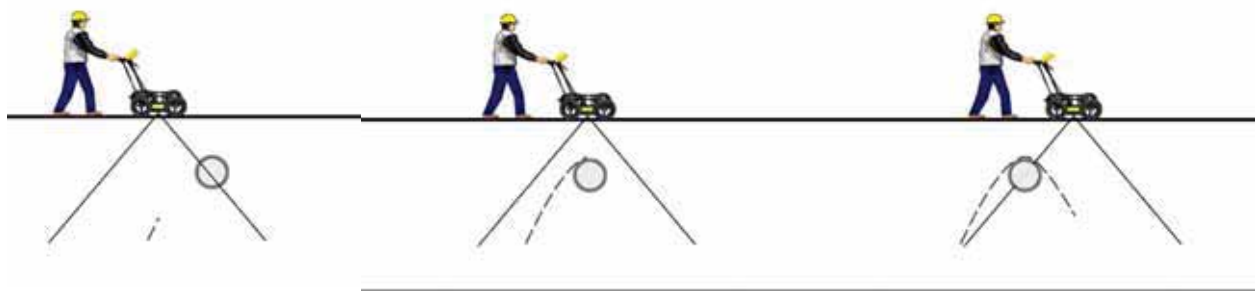
- 1) Hyperbola matching
- 2) Target of known depth

**Note that velocity calibration does NOT automatically update the velocity value under Noggin Setup > System Parameters > Velocity. Once a velocity is determined, the user must enter it into the System Parameters (13.3.1.2: p.95).**

### 13.2.10.1 Hyperbola Matching

The most accurate way of determining the velocity of the material being scanned is to use the hyperbola-fitting method because it extracts the velocity using data collected in the area. This method may not work in all situations because it depends on having a good quality hyperbola (or inverted U) in the data.

A hyperbola is the characteristic GPR response from a small point target like a pipe, rock or even a tree root. This phenomenon occurs because radar energy does not radiate as a pencil-thin beam but more like a 3D cone. Reflections can appear on the record even though the object is not directly below the radar system. Thus, the radar system “sees” the pipe before and after going over top of it and forms a hyperbolic reflection.

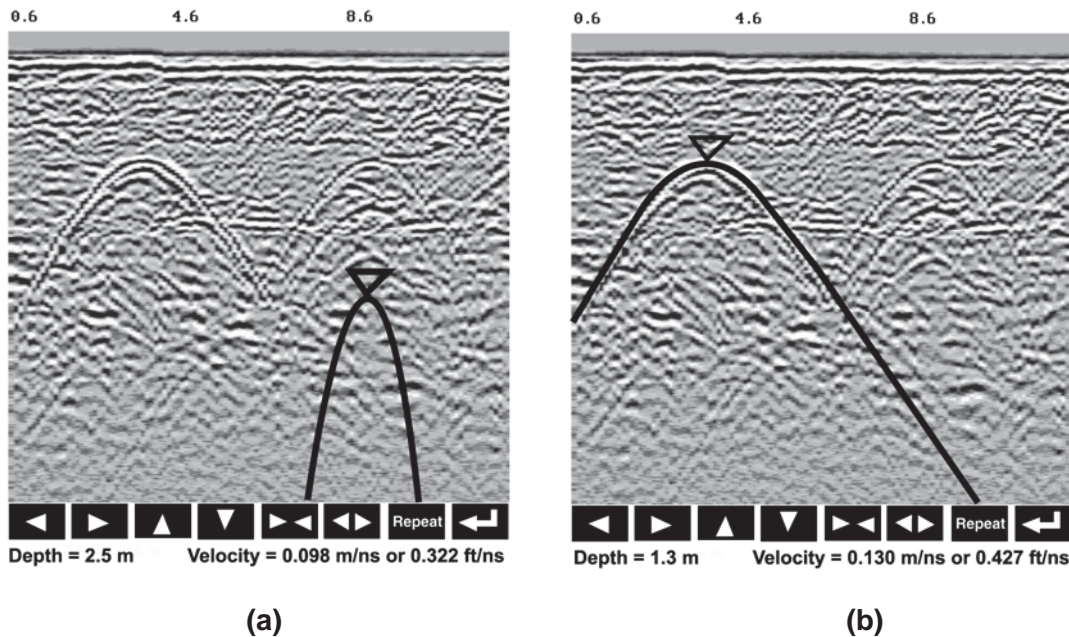


*Figure: 13-2 Hyperbolas in the data result from the conical shape of the GPR energy as it goes into the ground. Targets, like pipes, are detected as the GPR approaches them (left), passes over them (middle) and after it has passed by them (right) because the GPR energy propagates both in front and behind the instrument.*

If the hyperbola has long tails on it, we can match the shape of the hyperbola and determine the velocity of the material in the area.

With the hyperbola visible on the DVL screen, select the hyperbola ( $\cap$ ) button. This will superimpose a hyperbola on the data. This hyperbola can be moved up ( $\blacktriangle$ ), down ( $\blacktriangledown$ ), left ( $\blacktriangleleft$ ) and right ( $\blacktriangleright$ ) using the appropriate arrow buttons. The goal is move the hyperbola until it lies on top of the hyperbola in the data (**Figure 13-3**). Then, the user can adjust the width of the hyperbola to make it wider ( $\blacktriangleleft \blacktriangleright$ ) or narrower ( $\blacktriangleright \blacktriangleleft$ ) until the shape of the hyperbola matches the shape of the hyperbola in the data. After matching the hyperbola, the velocity value is displayed and now can be entered under the System Parameters (**13.3.1.2: p.95**).

Pressing the up, down left, right, wider and narrow buttons once makes a very small change in the position or width of the hyperbola. These buttons must sometimes be pressed many times to move the hyperbola to the correct position or width. To speed up the movement of the hyperbola, use the REPEAT button. For example, to move the hyperbola up a long distance, press the up button ( $\blacktriangle$ ) followed by the REPEAT button. The hyperbola will then start moving upward without having to press any more buttons. When it gets close to the desired location press any button to stop it and then use the up, down, left and right buttons to fine-tune the position. The REPEAT button can also be used after pressing the wider ( $\blacktriangleleft \blacktriangleright$ ) or narrower ( $\blacktriangleright \blacktriangleleft$ ) button.



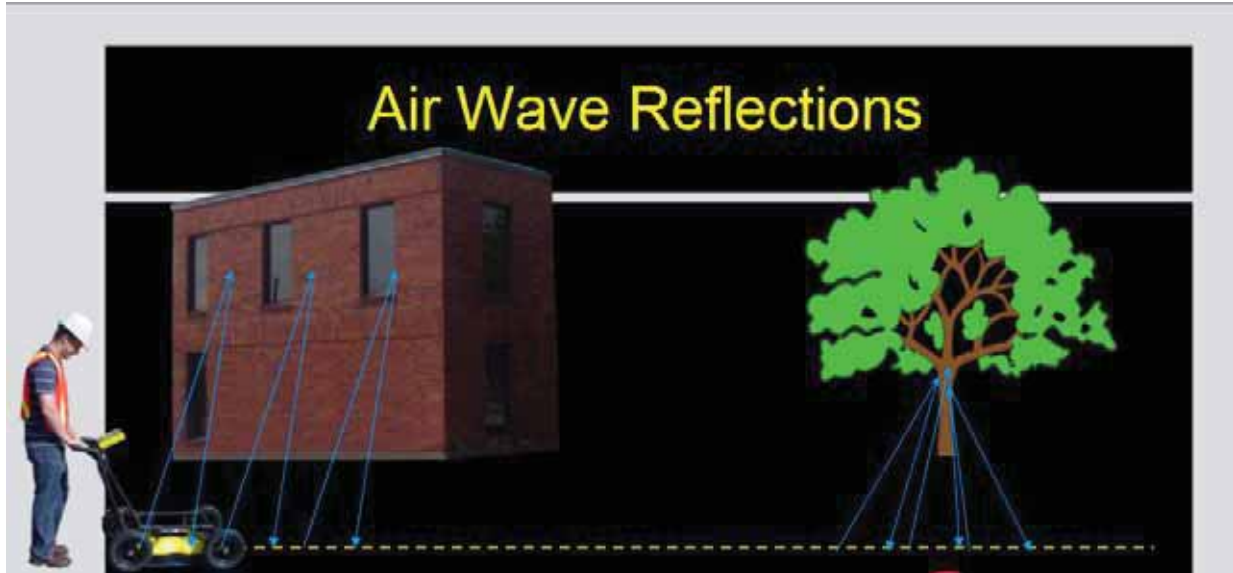
*Figure: 13-3 Hyperbola matching to extract velocity. After pressing the CALIB and Hyperbola ( $\cap$ ) buttons, a hyperbola appears on the screen (a). This hyperbola should be moved overtop of a hyperbola in the data using the arrow keys. It can then be widened or narrowed to match the shape of the hyperbola in the data (b). When the hyperbola shapes match, the velocity is extracted and displayed. The user can then use this velocity value for surveys done in the area.*

Hyperbola Matching calibration can be done during data acquisition and also while viewing previously collected data.

If units are meters then depths will appear in meters and velocities in meters per nanosecond (m/ns). If units are feet then depths will appear in feet and velocities in feet per nanosecond (ft/ns). To change units see **13.3.1.3: p.95**.

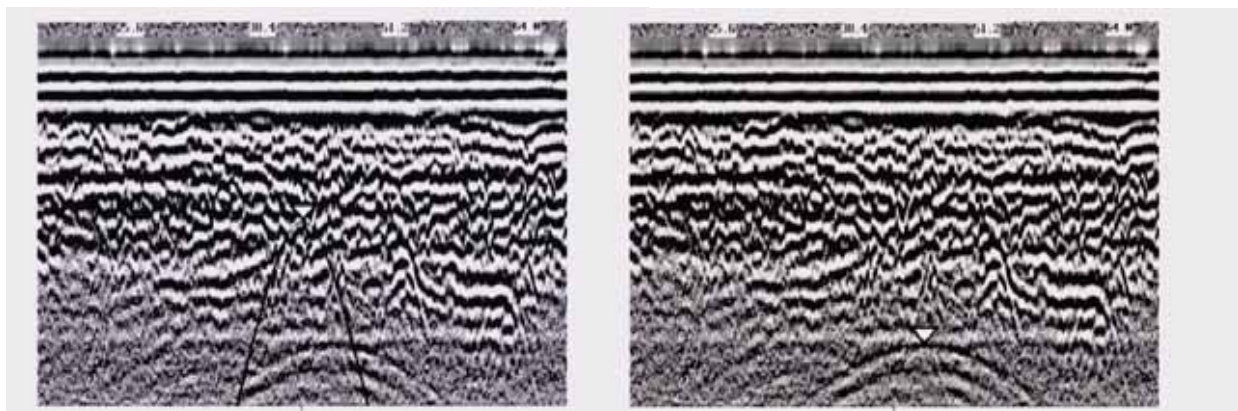
### 13.2.10.2 Identifying Air Reflections

Some hyperbolic reflections can also be caused by objects not in the subsurface such as fences, overhead wires and, in some conditions, even large trees.



An important part of data interpretation is learning to recognize these unwanted “air” events and differentiate them from the desired subsurface events. Good field notes are indispensable for helping identify unwanted events on the data.

One way of identifying air reflections is to use the hyperbola fitting method. If the object is in air, the radar velocity will be 0.3 m/ns or 0.984 ft/ns and will be much faster than if it is in the ground ( $v \sim 0.1$  m/ns or 0.328 ft/ns).

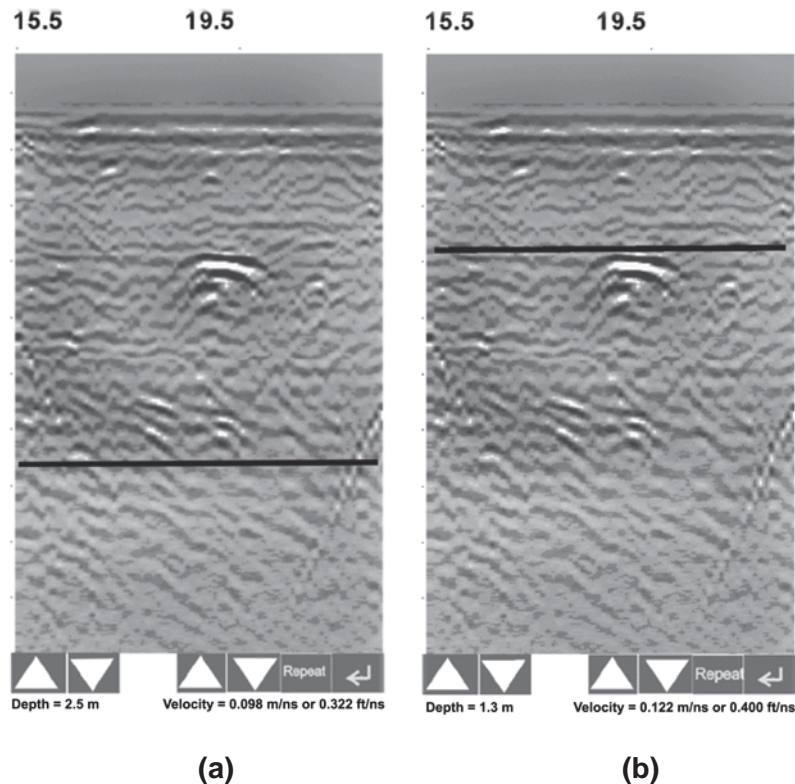


*Figure: 13-4 Hyperbola matching can be used to identify reflections from objects that are not in the subsurface but are from objects above ground. If the hyperbola matching velocity is near the speed of light (0.3 m/ns or 0.984 ft/ns) then the hyperbola was caused by surface object like a overhead wire, tree, etc. After matching the hyperbola (right), the “depth” value displayed on the bottom of the screen is really a measure of how far from the survey line the object is.*



### 13.2.10.3 Target of Known Depth

If there are no suitable hyperbolas visible in the data to perform the Hyperbola Matching described above, it may be the situation that there is a target of known depth in the area being scanned. If this is the case, selecting the button with the circle with a horizontal line through it will superimpose a horizontal line on the data. This line can then be moved up or down until it lies on top of the Noggin response to the known target. Then, the user can adjust the velocity value up or down until the known target depth is correct. Once the depth is matched, the current velocity value is the one used for all subsequent data acquisition.



*Figure: 13-5 Using a target of known depth to extract velocity. After selecting CALIB, choosing the known depth button (a circle with a horizontal line through it) will superimpose a horizontal line on the data (a). Using the depth buttons, this line can then be moved up or down until it lies on top of the Noggin response to the known target (b). Then, the user can use the velocity buttons to adjust the velocity value up or down until the known target depth is correct. Once the depth is matched, the velocity value should be used for all subsequent data acquisition.*

If units are meters then depths will appear in meters and velocities in meters per nanosecond (m/ns). If units are feet then depths will appear in feet and velocities in feet per nanosecond (ft/ns). To change units see **13.3.1.3: p.95**.

## 13.2.11 Gain

During data acquisition, the Gain setting can be changed by pressing the Gain button until the desired setting appears. This can be done while the instrument is collecting data; there is no need to stop first.

The signals that the Noggin system collects from the ground can be very weak, especially from deeper objects. To see these weak signals it is necessary to amplify or apply “gain” to them.

The Gain setting controls how much the signal is amplified. It varies from 1 to 9 with 1 the lowest and 9 the highest. In general, if the target is relatively shallow (1-2 meters) a low gain value can be used. If the target is deeper or if the screen seems to be blank or speckled in the lower part of the data section, increase the gain setting. Remember, however, that if the Noggin signal is not penetrating to the maximum depth setting, even the maximum gain setting will not show any data.

**Figure 13-6** shows the effect of the gain setting. The data on the left has a gain of 1 incrementing to the right up to a gain of 9.

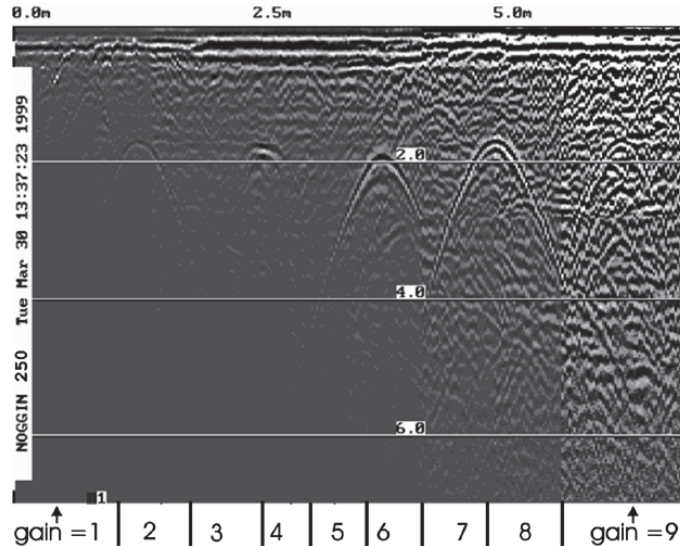


Figure: 13-6 Effects of the Gain setting

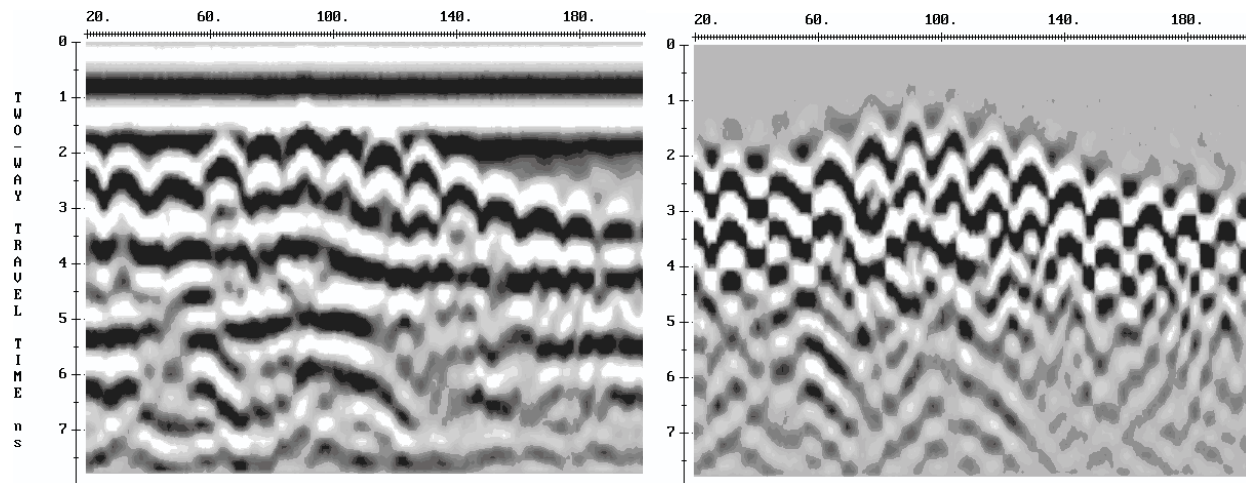
**Note that the gain setting is only for data display. The data are always saved without any gain applied. It is not possible to collect Noggin data with an “incorrect” gain setting.**

If the user finds that they are always using very high or very low gain settings to see the data adequately, the user may want to adjust the Linear Gain setting (**13.3.1.6: p.97**).

### 13.2.12 Filter

The filter has the effect of removing flat-lying events in the data and enhancing dipping and hyperbolic reflections usually caused by pipes and other point targets. It can also assist in seeing very shallow targets that may be masked by the strong signals at the top of the cross-section.

The image below shows the same data with the Filter OFF and ON.



The filter is only applied to the data for display; saved data files contain raw data and are not filtered.

The filter can be turned on and off when replaying data (**13.2.1: p.78**) so it is not necessary to collect the survey line again in order to apply the filter.

### 13.2.13 Error Messages

If an error occurs during data acquisition, an error message will appear in the bottom left section of the data acquisition screen. Note the message number, exit the program and turn off the Digital Video Logger.

Make sure the cables are not damaged and that all cable connections are tightly secured. Sometimes vibrations cause the cable connections to loosen just a bit and break contact and this can cause errors. Disconnecting cables and reconnecting them may provide a better contact and solve the problem. Also check and make sure the battery is adequately charged. Turn the Digital Video Logger back on and try running the system again.

For more information on Troubleshooting the system, see **14: p.122**.

## 13.3 Noggin Setup

Pressing the number 1 on the main menu selects the Setup item. Setup lists the various parameters that can be edited. These parameters are organized under the following headings:

- 1 - System Parameters**
- 2 - Cart Parameters**
- 3 - Line Parameters**
- 4 - Grid Parameters**
- 5 - GPS Parameters**
- 6 - Set Defaults**

To select a setting to edit, press the corresponding number button. Then use the numbered buttons to select the new setting. It is also possible to change all the settings back to the factory default settings by pressing the 6 button (labelled Set Defaults).

The SETUP options are outlined below.

### 13.3.1 System Parameters

The System Parameters settings allow the user to view and modify settings specific to the data collection of the Noggin system. This includes the type of Noggin system, the desired depth of investigation, the velocity of the material being surveyed, the units of depth and position, the number of stacks and the amount of linear gain.

#### 13.3.1.1 Depth

The depth setting is how deep the radar will try to probe in to the subsurface. It is important to realize that the depth setting is an estimated value that is dependent on the velocity of the material being probed.

Ground penetrating radar systems record the **time** for a radio wave to travel to a target and back. They do not measure the depth to that target directly. The depth to a target is calculated based on the velocity at which the wave travels to the target and back. It is calculated as:

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

Where

**D is Depth (m)**

**V is Velocity (m/ns)**

**T is Two-way travel time (ns)**

The Depth units can be changed to meters, feet or time in nanoseconds. For details, see **13.3.1.3: p.95**.

**It is important to remember that just because the Depth setting is set to a certain value, it does not necessarily mean that the Noggin is able to penetrate to that depth and collect data. For example, if the Depth setting is 5 meters but the material penetration is only 3 meters the last 2 meters of the image will not contain subsurface information. Some materials will absorb the Noggin signal and limit penetration to less than the selected depth.**

If the depth setting is deeper than the Noggin signals penetrate, the data in the lower part of the data screen will look blank or speckled rather than signal with continuity.

### 13.3.1.2 Velocity

The wave velocity depends on the properties of the material. The Noggin software allows the user to input a velocity, which changes the total time window collected by the system.

See **13.2.10: p.88** for a discussion about determining velocity.

A table of typical radar velocities in various materials is given below. If in doubt, use a value of 0.10 m/ns. This is a good average velocity that will provide a good estimate of depth in most situations.

Material	Velocity (m/ns)	(ft/ns)
Air	0.300	1.000
Ice	0.170	0.558
Dry Soil	0.130	0.427
Dry Rock	0.120	0.394
Soil	0.100	0.328
Wet Rock	0.100	0.328
Concrete	0.100	0.328
Pavement	0.100	0.328
Wet Soil	0.065	0.213
Water	0.033	0.108

If units are meters then velocities will appear in meters per nanosecond (m/ns). If units are feet then velocities will appear in feet per nanosecond (ft/ns). To change Depth Units see **13.3.1.3: p.95**.

The Noggin will accept units in meters/nanosecond or feet/nanosecond depending on the Depth Units setting.

### 13.3.1.3 Depth Units

This is the setting for the units of the horizontal depth lines that appear on the screen. The available settings are meters, feet or nanoseconds (ns).

- 1) meters
- 2) feet
- 3) nanoseconds

If nanoseconds are selected the “depth” lines (**13.2.2: p.79**) are actually time lines.

### 13.3.1.4 Noggin System

The Noggin System should be set to the type of Noggin currently in use on the Smart System. The Noggins available are:

- 1) Noggin 100
- 2) Noggin 250
- 3) Noggin 500
- 4) Noggin 1000

### 13.3.1.5 Stacks

Some materials tend to absorb radar signals and limit penetration. These materials are said to be lossy. When collecting data in lossy areas or areas with a lot of radio frequency noise, one way of increasing data quality is to collect more than one trace at each survey position, average them and save the averaged trace. This is known as “stacking”. Data quality improves because the noise, which is usually random (like white noise on a TV screen with no station in the area), tends to zero when averaged. Consequently, the usable signal is easier to see. This is known as increasing the “signal-to-noise ratio”.

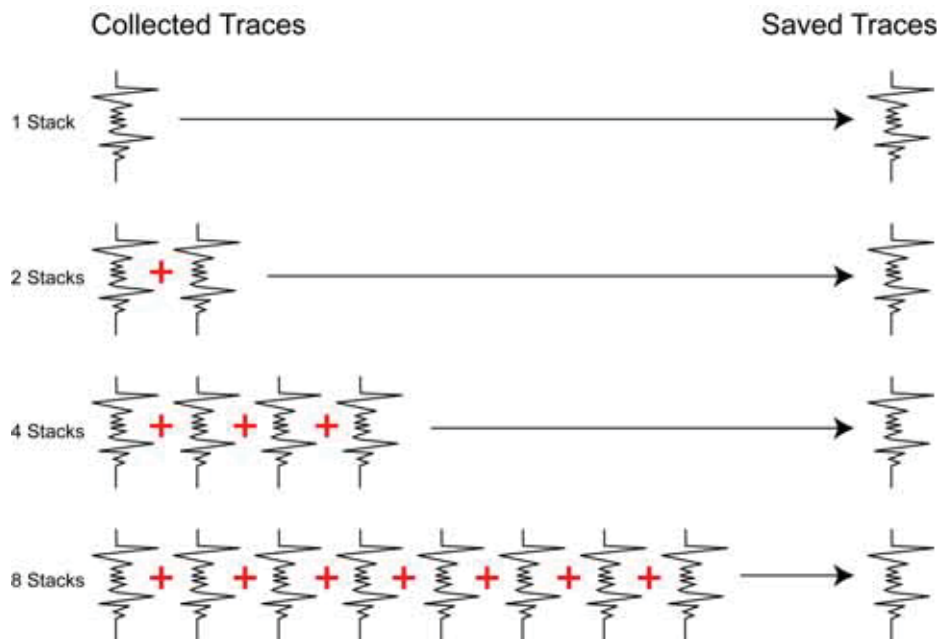


Figure: 13-7 The concept of stacking data. At each data location point, the trace is collected multiple times. These traces are averaged together to calculate the trace that is actually saved. Stacking improves the data quality by increasing the signal to noise ratio.

While stacking improves data quality, it may slow down survey production. The more stacks, the longer it takes to collect data at each survey position. Therefore, it is important to find the optimum number of stacks that still reveal the target adequately. For most surveys, stacking 4 times is suitable.

See the warning in **13.2.7: p.82** about losing data if the Smart System is moving too quickly for the odometer to keep up.

There are 2 types of Stacking Types available: Fixed and DynaQ.

### **Fixed Stacks**

The amount of Fixed Stacking can vary from 1 to 2048 by factors of 2. The default is 4 stacks. For most surveys, stacking 4 to 32 times is suitable.

Stacking is normally reduced when: 1) the survey objective is looking for very strong responses or 2) production speed is vital, such as measurements made from a rapidly moving vehicle.

When the system is run in Free Run mode (**13.3.2.2: p.98**), the user can control the speed the system collects data by increasing or decreasing the number of stacks. Increasing the number of Stacks has the effect of slowing down the data collection speed of the system. Decreasing the number of Stacks has the effect of speeding up the data collection speed of the system.

### **DynaQ**

If the Trigger Method (**13.3.2.2: p.98**) is set to odometer, one of the Stacking Types is DynaQ.

DynaQ is an advanced, patented technology that dynamically adjusts stacking as the system movement speed varies. In most situations, moving the system at a comfortable speed stacks enough to generate data of good quality. In situations where target resolution or maximum penetration depth is critical, moving slower increases the number of stacks and increases the data quality.

The DynaQ information for each data line is written to the header (.HD) file.

#### **13.3.1.6 Linear Time Gain**

As described in **13.2.6: p.81**, the weak signals must be amplified or “gained” to see them on the display. The Gain button is set to a value from 1 to 9 depending on the amount of gain required (1 is lowest gain, 9 is highest gain).

There is also a second level of gain available to the user and that is the Linear Gain setting. The default Linear Gain setting of 0.0 is usually adequate for most ground conditions, however, if advanced users find that they are surveying in areas where high Gain settings are always required to see data, it may be advantageous to increase the Linear Gain setting.

For the experienced user, the setting indicates the gain increases per nanosecond.

The Linear Gain setting can vary from 0.0 to 5.0 in steps of 0.5.

#### **13.3.1.7 Position Units**

This is the setting for the position units used by the odometer. The available options are:

- 1) meters (default)
- 2) feet

## 13.3.2 Cart Parameters

The Cart Parameters settings allow the user to view and modify settings specific to the Smart System. This includes the direction the Noggin will move to collect data, whether or not the odometer is active and whether Auto Start is on or off.

### 13.3.2.1 Cart Direction

This setting determines whether data are collected as the Noggin is pushed forward or pulled in reverse. The back up arrow (13.2.7: p.82) will work in the direction opposite to this setting. The available options are:

- 1) Push (default)
- 2) Pull

### 13.3.2.2 Trigger Method

This setting determines the method used to trigger the Smart System to collect data at each data collection point. The available options are:

- 1) Odometer
- 2) Free Run
- 3) Button

#### Odometer

Selecting this option means that the Smart System will be triggered to collect data using the input from the currently selected odometer (13.3.2.5: p.101). See 13.2.7: p.82 for more details about data acquisition with an odometer.



When collecting data with an odometer, data quality can be increased using the DynaQ stacking option (13.3.1.5: p.96).



## Free Run

Selecting this option means that the Smart System runs continuously in time, independent of any other triggering device (**13.2.8: p.84**). The system automatically collects data at regular, user-determined time intervals. This is called “Free Run” mode and is best for surveys in flat, unobstructed terrain where antennas can be moved easily. For the position of each measurement point, the system assumes the operator has moved the antennas one station interval along the survey line. True position can also be controlled by the user adding markers at known positions along the survey line and Rubberbanding the data in post-processing.

When Free Run operation is selected, a second menu appears to select the time delay between data traces. This, along with the number of stacks allow the user to control the speed of the data acquisition.

The menu prompts the user to input the time delay, in seconds, between each data collection point. To run the system as quickly as possible, set this value to 0.0 seconds. For a longer time delay, use the buttons to set the value.

Note that if an external Beeper-Trigger is attached to the system, any time delay longer than zero (0.0) seconds will cause it to emit a beeping sound to indicate data collection is taking place.

The user can also control the speed the Noggin collects data by increasing or decreasing the number of stacks (**13.3.1.5: p.96**). Increasing the number of Stacks has the effect of slowing down the data collection speed of the Noggin system. Decreasing the number of Stacks has the effect of speeding up the data collection speed of the Noggin system.

The time delay and number of stacks should be set to values that, when combined with speed the Noggin is moving at, provide an appropriate station interval (**13.3.3.3: p.103**). This may take a little experimenting to determine the optimal values for stacks, time delay and the actual speed the Noggin is moving at. To determine the best settings to collect data at approximately the desired station interval (**13.3.3.3: p.103**), use the calculation described in **13.2.8.3: p.85**.

To avoid confusion when collecting data in Free Run, it is usually best to set the Station Interval to 1.0 so that it the “position” that is saved with each trace is actually the trace number.

Data collected in this manner uses another means of determining the actual position of each trace, typically by collecting GPS data in parallel or by adding fiducial markers into the data at known locations during data collection and rubberbanding the data in post-processing.

### Trigger with Button

Selecting this means that the Smart System will be triggered to collect data by pressing the B button on the DVL (13.2.9: p.87) or the button on an external Beeper-Trigger (if attached).



Electrical Beeper-Trigger

Note that when data are collected in Trigger Button mode, the Smart System will emit a beeping sound after the button is pressed to indicate data collection is taking place.

#### 13.3.2.3 Auto Start

If the Auto Start option is set to ON, after the user presses Run to collect a data line, the system will automatically boot up and be ready for data acquisition, rather than having the Start button appear. This prevents the user from having to press the Start button at the start of every new line. **This setting is especially useful when collecting numerous lines as occurs when collecting grid data.** If Auto Start is set to OFF the user must press the Start button to begin data acquisition for each line.

#### 13.3.2.4 Trip Menu

The software records the total distance the system has travelled. This value is displayed but cannot be changed.

The software also records a distance that can be reset by the user. To reset the distance counter, move to the Reset Counter option and press the Zero button.

### 13.3.2.5 Odometer Number

Noggin Smart Systems can take input from several different odometers.

**It is very important that the user selects and calibrates the odometer appropriate for their Smart System.**

When Odometer Number is selected, the user is prompted to select the odometer that is being used with the Smart System.

If a **SmartCart System** is being used, select one of the two SmartCart odometers (usually #1).

If a **SmartHandle system** is being used, select one of the two SmartHandle odometers (usually #1).

If the system is being towed behind a **vehicle** and using the transmission odometer to trigger the system, select one of the two Vehicle odometers (usually #1).

The odometers labelled **Other** are to be used in future configurations.

The number after the odometer is the current Odometer Calibration value for that odometer. To calibrate the odometer, see **13.5.2: p.120**.

### 13.3.3 Line Parameters

The Line Parameters settings allow the user to view and modify settings specific to collecting data as individual lines, namely, the starting position of the line and line direction.

#### 13.3.3.1 Start Position

The Start Position is the position value at the very beginning of a line. This will usually be set to zero (0.0). However, if the user wants a data file to start at a position other than zero, this value can be edited.

#### 13.3.3.2 Line Direction

The Line Direction setting specifies which direction that line will be collected, either Forward or Reverse. Data are usually collected in a forward direction.

If data are collected in the Forward direction the position station Interval is positive, that is, the position value of each data collection point increments positively. For example, for a Noggin 250 system, if the Start Position is 10.0 and the Line Direction is Forward, the positions on the line will increment 10.00, 10.05, 10.10, 10.15 ....

If data are collected in the Reverse direction the position station interval is negative, that is, the position value of each data collection point increments negatively. For example, for a Noggin 250 system, if the Start Position is 10.0 and the Line Direction is Reverse, the positions on the line will decrement 10.00, 9.95, 9.90, 9.85 ....

### 13.3.3.3 Station Interval

As Smart Systems moves, the odometer triggers the system to collect a data trace at fixed distance intervals. This interval is called the “station interval”.

The station interval can be changed to allow a longer or shorter distance between traces. For a successful survey, it is important that several traces be collected over a target. If the target is small, the user may want to shorten the station interval to ensure that data traces are collected over the target. Conversely, if the target is very large or is a flat-lying feature it is probably not necessary to collect a lot of traces over the target, in fact, sometimes this can make the target more difficult to see in the data. In this case it may be beneficial to increase the station interval.

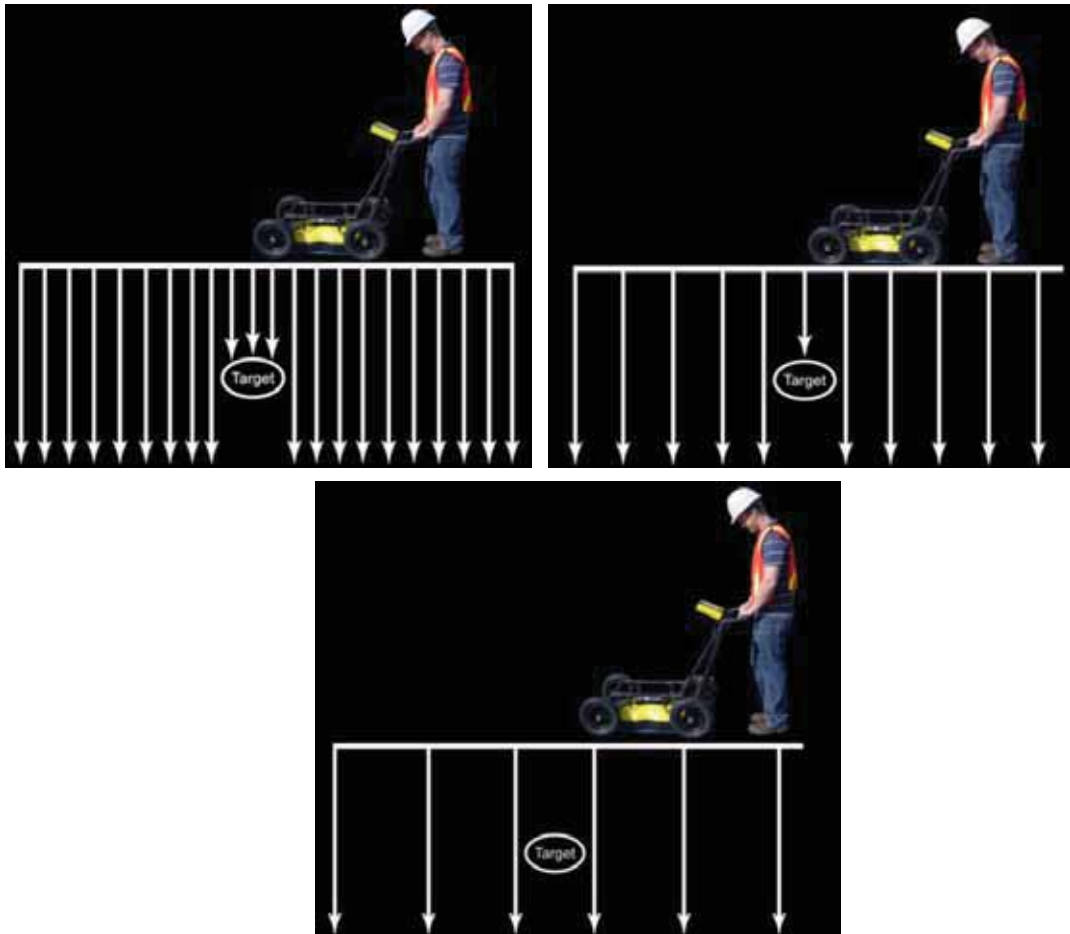


Figure: 13-8 The Station Interval is the distance between sample points on the ground. Be careful not to choose a Station Interval that is larger than the smallest target to be detected.

Note that decreasing the station interval increases the data volume and increasing the station interval reduces the data volume.

The choices available for Station Interval are:

- 1) Short
- 2) Normal
- 3) Long
- 4) X-Long
- 5) Normal x10
- 6) Normal x20
- 7) Normal x 40
- 8) Normal x 50
- 9) Normal x 100

Each choice listed will be followed by an actual value in meters or inches depending on which units are selected and which Noggin system is being used. Here is a chart showing the station interval for each system and setting. Note the calculations for Data per Screen assumes that the Plot Interval is set to Normal for the particular Noggin system (Noggin 100/250 = 2 pixels per trace and Noggin 500/1000 = 1 pixel per screen). If this assumption is not true, see the formula after the charts for calculating this value.

### NOGGIN 100 SYSTEM

Setting	Station Interval	Data per Screen
Short	5.0 cm or 1.92 in	16 m or 51.2 ft
Normal	10.0 cm or 3.84 in	32 m or 102.4 ft
Long	20.0 cm or 7.68 in	64 m or 204.8 ft
X-Long	50.0 cm or 19.20 in	160 m or 512 ft
Norm x10	100.0 cm or 38.4 in	320 m or 1024 ft
Norm x20	200.0 cm or 76.8 in	640 m or 2048 ft
Norm x40	400.0 cm or 153.6 in	1280 m or 4096 ft
Norm x50	500.0 cm or 192.0 in	1600 m or 5120 ft
Norm x100	1000.0 cm or 384.0 in	3200 m or 10240 ft

### NOGGIN 250 SYSTEM

Setting	Station Interval	Data per Screen
Short	2.5 cm or 0.96 in	8 m or 25.6 ft
Normal	5.0 cm or 1.92 in	16 m or 51.2 ft
Long	10.0 cm or 3.84 in	32 m or 102.4 ft
X-Long	25.0 cm or 9.6 in	80 m or 256 ft
Norm x10	50.0 cm or 19.20 in	160 m or 512 ft
Norm x20	100.0 cm or 38.4 in	320 m or 1024 ft
Norm x40	200.0 cm or 76.8 in	640 m or 2048 ft
Norm x50	250.0 cm or 96.0 in	800 m or 2560 ft
Norm x100	500.0 cm or 192.0 in	1600 m or 5120 ft

**NOGGIN 500 SYSTEM**

Setting	Station Interval	Data per Screen
Short	1.0 cm or 0.48 in	6.4 m or 25.6 ft
Normal	2.5 cm or 0.96 in	16 m or 51.2 ft
Long	5.0 cm or 1.92 in	32 m or 102.4 ft
X-Long	12.5 cm or 4.8 in	80 m or 256 ft
Norm x10	25 cm or 9.6 in	160 m or 512 ft
Norm x20	50 cm or 19.2 in	320 m or 1024 ft
Norm x40	100 cm or 38.4 in	640 m or 2048 ft
Norm x50	125 cm or 48.0 in	800 m or 2560 ft
Norm x100	250 cm or 96.0 in	1600 m or 5120 ft

**NOGGIN 1000 SYSTEM**

Setting	Station Interval	Data per Screen
Short	0.5 cm or 0.24 in	3.2 m or 12.8 ft
Normal	1.0 cm or 0.48 in	6.4 m or 25.6 ft
Long	2.0 cm or 0.96 in	12.8 m or 51.2 ft
X-Long	5.0 cm or 2.4 in	32.0 m or 128 ft
Norm x10	10 cm or 4.8 in	64.0 m or 256 ft
Norm x20	20 cm or 9.6 in	128 m or 512 ft
Norm x40	40 cm or 19.2 in	256 m or 1024 ft
Norm x50	50 cm or 24.0 in	320 m or 1280 ft
Norm x100	100 cm or 48.0 in	640 m or 2560 ft

If the Plot Interval is not set to Normal, use the following formula to calculate the total distance per screen:

$$\text{Total Distance Per Screen} = \text{Station Interval} * (640 / \text{Plot Interval})$$

where: Station Interval is in meters or feet, and  
Plot Interval is in Pixels.

For example, if the Station Interval is 10 centimeters (0.1 meters) and the Plot Interval is 4 pixels, the total distance per screen is calculated as follows:

$$0.10 * (640 / 4) = 16.0 \text{ meters per screen}$$

To see how much data can be collected before the DVL memory is full and data must be deleted or downloaded, see DVL Recording Space in **13.5.4: p.121**.

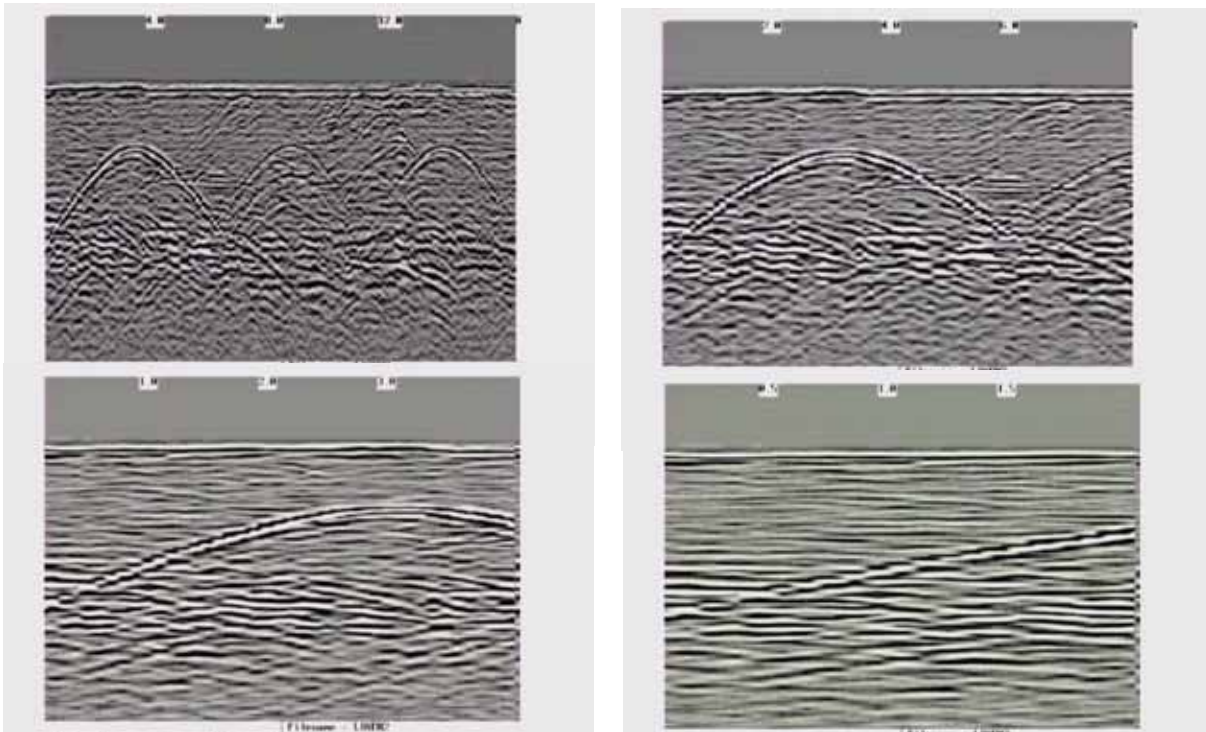
To delete Noggin data see **13.4.2: p.118**.

### 13.3.3.4 Plot Interval

The plot interval setting determines the width of data traces plotted to the screen. Traces can be 1, 2, 4 or 8 pixels wide.

The Normal setting for Noggin 100 and 250 systems is 2 pixels per trace and the Normal setting the Noggin 500 and 1000 is 1 pixel per trace.

It can be useful to plot traces narrower than normal to allow more data to fit onto one screen. It can also be useful to plot traces wider on the screen so that they are easier to see. For example, when collecting data using the button to trigger the system (**13.2.9: p.87**) it is often preferable to make each trace 4 or 8 pixels wide.



*Figure: 13-9 Data traces can be plotted to the screen with a width of 1 pixel (top left), 2 pixels (top right), 4 pixels (bottom left) or 8 pixels (bottom right). The narrower the trace width, the more data that can be plotted on one screen. In this example, plotting the data 1 pixel wide results in 16 meters of data displayed on one screen while 2 pixels results in 8 meters of data, 4 pixels results in 4 meters of data and 8 pixels results in 2 meters of data*

Note that the Plot Interval is strictly for display purposes on the DVL screen in real time. The Plot Interval setting has no effect on the actual data collected and, in fact, data can be viewed later on the DVL screen with any Plot Interval value. Similarly, data downloaded to a PC can be plotted using any trace width.



### 13.3.4 Grid Parameters

The Grid Parameters settings allow the user to view and modify settings specific to collecting data in organized grids. This includes the grid dimensions, line spacing, grid type and survey format.



Data are normally collected on a grid if the user is interested in displaying the data as a 3D volume (using the EKKO Mapper 3D software) or as a plan map (using the EKKO Mapper software). Producing accurate 3D volumes or plan maps is easier if the field survey is properly designed and data are collected correctly.

Positional accuracy of each line is vital if the user wants to be able to relocate targets of interest after the data have been processed.

For linear targets like pipes and utilities, the best GPR response occurs when the GPR survey line crosses the target at right angles. If possible, it is always best to run GPR survey lines perpendicular to the direction of linear targets.

**For inexperienced surveyors, laying out a grid with straight lines and all corners at 90 degree angles can be difficult. Sensors & Software provides a product called EasyGrid to make laying out an accurate grid simple. Contact Sensors & Software for more details.**

#### 13.3.4.1 Grid Type

The Grid Type asks specifically the way that the area of the grid is to be covered by the survey lines. Survey lines can be either a set of parallel lines in the X axis direction (**Figure 13-10**), a set of parallel lines in the Y axis direction (**Figure 13-11**), or, for complete coverage, parallel lines in both the X and Y direction (**Figure 13-12**).

### X Lines Only

Set up a first-quadrant XY grid. Data lines run in the X direction, distance increasing from the Y axis baseline. Line numbers increase in the positive Y direction (see **Figure 13-10**). Lines must be equally spaced. It is not critical that all the lines are the same length. However, it does make processing easier if all the lines start at the same baseline position (usually defined as zero (0.0)).

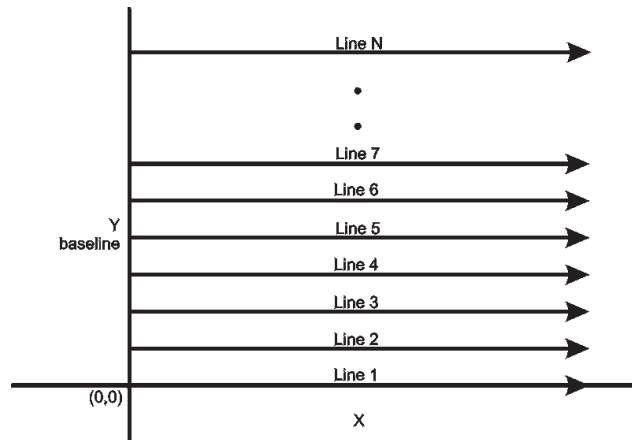


Figure: 13-10 Proper X Line surveying pattern. Following this pattern and starting each line from the same baseline minimizes the data editing required to produce a spatially accurate map of GPR data.

### Y Lines Only

Set up a first-quadrant XY grid. Data lines run in the Y direction, distance increasing from the X axis baseline. Line numbers increase in the positive X direction (see **Figure 13-11**). Lines must be equally spaced. It is not critical that all the lines are the same length. However, it does make processing easier if all the lines start at the same baseline position (usually defined as zero (0.0)).

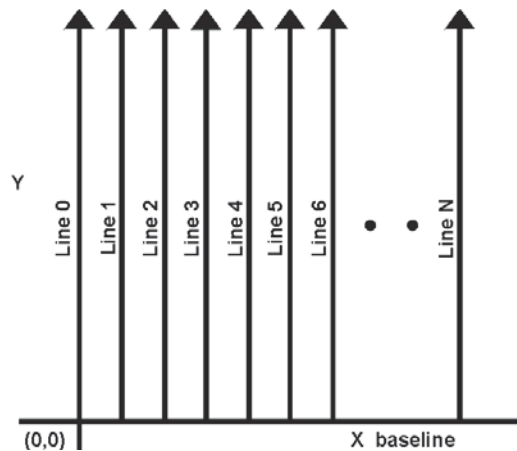


Figure: 13-11 Proper Y Line surveying pattern. Following this pattern and starting each line from the same baseline minimizes the data editing required to produce a spatially accurate map of GPR data.

## XY Lines

Set up a first-quadrant XY grid. X data lines run in the X direction, distance increasing from the Y axis baseline. Line numbers increase in the positive Y direction (see **Figure 13-12**). Lines must be equally spaced. Y data lines run in the Y direction, distance increasing from the X axis baseline. Line numbers increase in the positive X direction. Lines should be equally spaced. The line spacing of the X lines and Y lines can be different.

It is not critical that all the lines are the same lengths. However, it does make processing easier if all the lines start at the same baseline position (usually defined as zero (0.0)).

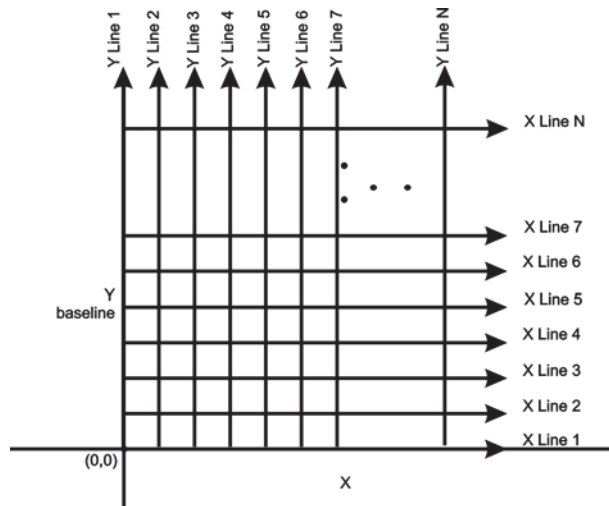


Figure: 13-12 Proper XY grid surveying pattern. Following this pattern and starting each line from the same baseline minimizes the data editing required to produce a spatially accurate map of GPR data.

### 13.3.4.2 Grid Dimensions

For grid data acquisition, the grid size needs to be specified. The user needs to input the length of the X dimension and the length of the Y dimension. The dimensions entered are assumed to be in the same units as the Position Units (**13.3.1.7: p.97**), i.e. meters or feet.

On this screen the user needs to highlight the dimension to be changed. The user can toggle between the X and Y fields by pressing the X/Y button.

The dimension value is incremented or decremented by pressing the +Line or -Line buttons. The dimension value will change by a value equal to the current Line Spacing in that dimension.

For example, if the Line Spacing in the X direction is 0.5 meters, the grid dimension in the X direction will increment or decrement in 0.5 meter intervals.

**Note that the maximum number of lines that can be collected in each direction is 100. Therefore, the X and Y grid dimensions cannot be set to a value that will result in more than 100 lines being collected.**

For example, if the Line Spacing between Y lines (defined as lines parallel to the Y axis) is set to 0.25 meters, the maximum X dimension is  $(100-1) \times 0.25 = 24.75$  meters. (One is subtracted because the first line is at position 0.0 meters.)

To increase the X dimension value, the Y line spacing must be increased. Using the example above, if the Y Line Spacing is increased to 0.30 meters then the maximum X dimension is  $(100-1) \times 0.30 = 29.70$  meters.

If the Grid Type is set to X Lines only or Y Lines only (**13.3.4.1: p.107**), the length of those lines are not restricted by the Line Spacing parameter of the opposite dimension. That is why if an X Lines only grid is selected, the X dimension can be input as a value rather than an increment of the Y Line Spacing. Similarly, if a Y Lines only grid is selected, the Y dimension can be input as a value rather than an increment of the X Line Spacing.

### 13.3.4.3 Line Spacing

For grid data acquisition, the distance between survey lines needs to be specified.

If the grid type is X Lines only (**13.3.4.1: p.107**) then the spacing between the X lines needs to be input.

If the grid type is Y Lines only (**13.3.4.1: p.107**) then the spacing between the Y lines needs to be input.

If the grid type is XY Lines (**13.3.4.1: p.107**) then the spacing between the X lines and Y lines need to be input. The line spacing can be different. The user can toggle between the X line spacing and Y line spacing fields by pressing the X/Y button.

**Note that the maximum number of lines that can be collected in each direction is 100.**

The calculation for determining an appropriate line spacing is complex. One has to consider system frequency, target size and practical considerations. In general, the Noggin 100 should have a line spacing of 1.0 meters or less, the Noggin 250 should have a line spacing of 0.5 meters or less, the Noggin 500 should have a line spacing of 0.25 meters or less and the Noggin 1000 should have a line spacing of 0.10 meters or less.

However, line spacing should really be determined by target size. In most cases the system must pass over a target to detect it. Therefore, the line spacing needs to be on the order of the size of the target or smaller, if practical. This can be adjusted to a larger spacing for larger targets or targets with a linear extent. As well, these rules may have to be bent for practical purposes like survey production rates. The fact is that a tighter line spacing takes longer to collect and this may not be economically possible in all circumstances.

### 13.3.4.4 Survey Format

The Survey Format specifies how the lines will be collected.

#### Forward Only

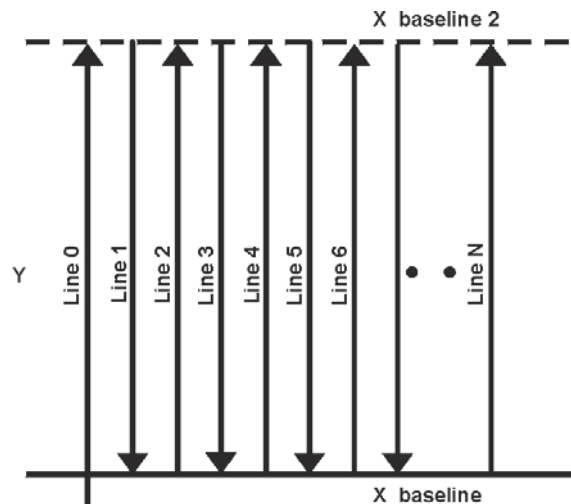
The lines shown in **Figure 13-10**, **Figure 13-11**, and **Figure 13-12** are all collected in the Forward direction only. This means that each line starts at the X or Y baseline.

#### Forward and Reverse

When the length of the survey lines are more than about 20 meters, data acquisition speed may be increased by collecting every second line in the reverse direction (**Figure 13-13**). This is called a Forward and Reverse survey format.

Using forward and reverse format can speed acquisition but can lead to mapping artifacts called “herringbone” if there are positional errors. It is important that the odometer is calibrated (**13.5.2: p.120**), the Grid Dimensions are correct (**13.3.4.2: p.109**) and that lines are always collected starting on a baseline.

Using the Forward and Reverse survey format, X line data are collected in the pattern shown in **Figure 13-13**.



*Figure: 13-13 For collecting GPR data consisting of long data lines it makes more sense to follow a forward and reverse surveying pattern. For the final data to be spatially correct with a minimum of editing, data collected in this pattern should be on lines that extend completely from one baseline to the other.*

When data are collected like this, it is important that lines start and end on established baselines, otherwise, when lines are reversed to the correct orientation for the display, they may be offset from one another.

### 13.3.5 GPS Parameters

The Global Positioning System (GPS) uses special satellites around the Earth to determine the position of a GPS receiver located at any position on the surface of the Earth. GPS receivers can be purchased from a number of manufacturers.



The DVL has a serial port on the back for attaching a GPS receiver (9: p.44). This port will accommodate any GPS receiver that has a standard serial port output.

The GPS receiver can be set up to send one or more types of data strings to the DVL. These strings are called NMEA-0183 strings and each contains positional or other information in specific formats. Each type of string is specified by a 5-character prefix. There are numerous NMEA strings but to integrate the GPS data into the Noggin data, **the GPS must be sending at least one of the following NMEA strings: GPGGA, GPGLL and GPRMC.**

GPS information is logged while collecting Noggin data. The GPS information may be useful for mapping where GPR surveys have been performed or determining where a specific target of interest is located in GPS co-ordinates.

The DVL can be set up to read and log GPS information collected during data acquisition with the Noggin system. GPS information can be logged in two different ways:

- 1) For every trace collected by the Noggin system, or
- 2) Every time the user adds a fiducial to the data by pressing the A button (13.2.4.2: p.80).

The GPS information is logged to an independent file. **Note that the GPS information is NOT automatically integrated with the Noggin data.** After data acquisition is complete, the data can be downloaded to a PC and the software like EKKO\_View Deluxe or EKKO Mapper used to integrate the GPS data with the Noggin data.

For the DVL to read the GPS data string, the GPS settings for the specific GPS receiver being used must be input into this menu. There are 4 important items that must be specified correctly for the DVL to display the GPS strings. These items are: Baud Rate, Stop Bits, Data Bits and Parity. These are discussed in more detail below. The default values listed below are the values that are typically used. Read the GPS Receiver User's Guide or experiment with the settings to find the correct ones.

Once these 4 items are set correctly you should be able to run System Test #1 and have GPS information written to the screen.

When the logging of GPS information is enabled, during data acquisition a message will appear in the bottom left-hand corner of the DVL screen indicating whether GPS data is successfully being received (**13.2.4: p.79**).

### 13.3.5.1 GPS Mode

There are three GPS modes available:

- 1) **Off** mode means that a GPS receiver is not connected to the DVL so no GPS information is being logged. This should be the setting if you do not have a GPS receiver.
- 2) **Reading every x traces** mode means that every time the Noggin collects a user-defined number of traces of GPR data, a data string of GPS information will be added to a file. This file has the same name as the data file i.e. LINE6, but with a GPS extension. This file can be accessed after transferring the GPR data files to an external PC (**13.4.4: p.119**).

For example, if the number of traces is set to 1, the LINE6.GPS may look like this:

```
Trace #1 at position 0.00
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-
35.09,M,5.0,0118*79
$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.6*36
Trace #2 at position 0.05
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-
35.09,M,5.0,0118*79
$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.6*36
Trace #3 at position 0.10
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-
35.09,M,5.0,0118*79
$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.6*36
Trace #4 at position 0.15
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-
35.09,M,5.0,0118*79
$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.6*36
```

Note that when the Reading per Trace option is on, it is still possible to add fiducial markers (**13.2.4.2: p.80**) to the GPS file. These will appear as F1, F2 etc. between the trace numbers. For example, a portion of LINE6.GPS may look like this:

```
Trace #85 at position 4.20
$GPGGA,134850.00,4338.204868,N,07938.429003,W,2,06,2.1,152.60,M,-35.09,M,4.2,0118*74
$GPVTG,152.6,T,,002.3,N,004.3,K,D*43
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,,4.2,2.1,3.7*37
F1
$GPGGA,134850.00,4338.204868,N,07938.429003,W,2,06,2.1,152.60,M,-35.09,M,4.2,0118*74
$GPVTG,152.6,T,,002.3,N,004.3,K,D*43
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,,4.2,2.1,3.7*37
Trace #86 at position 4.25
$GPGGA,134851.00,4338.204362,N,07938.428362,W,2,06,2.1,152.40,M,-35.09,M,5.2,0118*72
$GPVTG,136.9,T,,002.8,N,005.2,K,D*45
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,,4.2,2.1,3.7*37
```

- 3) **Fiducial Tagging** mode means that whenever a fiducial marker (F1, F2 etc.) is added to the data (**13.2.4.2: p.80**), a data string of GPS information will be added to a file. This file has the same name as the data file i.e. LINE6, but with a GPS extension. This file can be accessed after transferring the GPR data files to an external PC (**13.4.4: p.119**).

For example, LINE6.GPS may look like this:

```
F1
$GPGGA,134218.00,4338.190204,N,07938.438411,W,2,05,2.6,154.60,M,-35.09,M,4.0,0118*7B
$GPVTG,356.8,T,,000.2,N,000.4,K,D*4B
$GPGSA,A,3,30,10,13,24,06,,,,,,,,,4.3,2.6,3.4*36
F2
$GPGGA,134219.00,4338.190294,N,07938.438409,W,2,05,2.6,154.45,M,-35.09,M,5.0,0118*7C
$GPVTG,1.3,T,,000.4,N,000.7,K,D*44
$GPGSA,A,3,30,10,13,24,06,,,,,,,,,4.3,2.6,3.4*36
F3
$GPGGA,134221.00,4338.190261,N,07938.438285,W,2,05,2.6,154.05,M,-35.09,M,5.2,0118*79
$GPVTG,10.0,T,,000.2,N,000.4,K,D*72
$GPGSA,A,3,30,10,13,24,06,,,,,,,,,4.3,2.6,3.4*36
F4
$GPGGA,134222.00,4338.190397,N,07938.438255,W,2,05,2.6,153.95,M,-35.09,M,5.0,0118*73
$GPVTG,9.8,T,,000.3,N,000.5,K,D*42
$GPGSA,A,3,30,10,13,24,06,,,,,,,,,4.3,2.6,3.4*36
```

If the GPS mode is set to Reading per Trace or Fiducial Tagging AND the Noggin is Run Without Saving Data (**13.1.5: p.77**), it is still possible to log GPS data strings. Every time a fiducial marker is added to the data (**13.2.4.2: p.80**), a data string of GPS information is added to a file. This file is called TAGGED.GPS and can be deleted using the Noggin File Management (**13.4.2: p.118**).

An example of a TAGGED.GPS file is shown below.

```
New File 09-18-2000 13:53:38
F1
$GPGGA,134227.00,4338.190520,N,07938.438280,W,2,05,2.6,153.98,M,-35.09,M,4.6,0118*7E
$GPVTG,347.7,T,,000.3,N,000.5,K,D*44
$GPGSA,A,3,30,10,13,24,06,,,,,,,,,4.3,2.6,3.4*36
F2
$GPGGA,134228.00,4338.190238,N,07938.438286,W,2,05,2.6,153.87,M,-35.09,M,4.4,0118*75
$GPVTG,5.4,T,,000.2,N,000.4,K,D*42
$GPGSA,A,3,30,10,13,24,06,,,,,,,,,4.3,2.6,3.4*36
F3
$GPGGA,134229.00,4338.190277,N,07938.438273,W,2,05,2.6,153.76,M,-35.09,M,5.4,0118*7A
$GPVTG,23.4,T,,000.1,N,000.2,K,D*73
$GPGSA,A,3,30,10,13,24,06,,,,,,,,,4.3,2.6,3.4*36
F4
$GPGGA,134231.00,4338.190127,N,07938.438362,W,2,05,2.6,154.59,M,-35.09,M,5.0,0118*7A
```



```

$GPVTG,20.2,T,,000.2,N,000.3,K,D*74
$GPGSA,A,3,30,10,13,24,06,,,,,,,,,4.3,2.6,3.4*36
*****
New File 09-18-2000 13:55:36
F1
$GPGGA,134259.00,4338.192453,N,07938.449096,W,2,06,2.4,153.14,M,-35.09,M,5.4,0118*75
$GPVTG,310.9,T,,000.5,N,001.0,K,D*4A
$GPGSA,A,3,04,30,10,13,24,06,,,,,,,,,3.2,2.4,2.1*32
F2
$GPGGA,134301.00,4338.192559,N,07938.449176,W,2,06,2.4,153.17,M,-35.09,M,5.0,0118*7A
$GPVTG,314.4,T,,000.6,N,001.1,K,D*41
$GPGSA,A,3,04,30,10,13,24,06,,,,,,,,,3.2,2.4,2.1*32
F3

```

- 4) **GPR data out port** mode means that the GPR data stream will be output to the serial port of the DVL. This is for users who wish to read the GPR data into their own PC or other device. Contact Sensors & Software Inc. for more details if you want to use this option. Note that this option significantly slows down data acquisition speeds.

### 13.3.5.2 Baud Rate

The baud rate is the speed that data is sent from the GPS receiver to the serial port of the DVL. The available options are: 2400, 4800, 9600 or 19200 (default).

Often, this is the only setting that may need to be edited to allow the DVL to communicate with the GPS receiver.

### 13.3.5.3 Stop Bits

The available settings for Stop Bits are: 1 (default) or 2.

It is not normally necessary to edit this value.

### 13.3.5.4 Data Bits

The available settings for Data Bits are: 7 or 8 (default).

It is not normally necessary to edit this value.

### 13.3.5.5 Parity

The available settings for Parity are: none (default), odd or even.

It is not normally necessary to edit this value.

### 13.3.5.6 End String

The GPS receiver can be set up to send one or more types of data strings to the DVL. These strings are called NMEA-0183 strings and each contains positional or other information in specific formats. Each type of string is specified by a 5-character prefix. There are numerous NMEA strings but examples of three different NMEA strings (GPGGA, GPVTG and GPGSA) are shown below.

```

$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79
$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,,4.2,2.1,3.6*36
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79
$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,,4.2,2.1,3.6*36
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79

```

```

$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.6*36
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79
$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.6*36

```

Before using the GPS with the Noggin, the DVL software needs to know the prefix of the LAST string being sent in each group. In the example above, three strings are being sent each time (GPGGA, GPVTG and GPGSA). Since GPGSA is the last one being sent in each group, the End String needs to be specified as GPGSA.

To see what the End String is for your particular GPS, run System Test #1 and note the first 5 characters on the last line after each series of strings is written to the screen. These are the 5 characters that need to be filled in under End String.

The End String option allows the user to fill in the 5 character GPS prefix. Use the Left and Right buttons to move left or right to different characters in the string. The currently selected character will have an “^” under it. To change the letter of the current character, use the Next button to change it to the next letter in the alphabet and the Previous button to change it to the previous letter in the alphabet. Using these keys all 5 characters can be filled in with the necessary GPS End String.

See the GPS Receiver User’s Guide for details on how to set up the receiver to output specific NMEA strings or groups of NMEA strings.

### 13.3.5.7 System Test #1

After all the settings above have been input and the GPS receiver is attached to the serial port on the DVL, the user can test that the DVL is receiving the GPS output by using the Test #1 option.

If the NMEA strings are successfully being read by the DVL they will appear on the DVL screen. This is a good time to note the prefix of the last NMEA string in the list and input it in the End String setting above.

If the NMEA strings do not appear, check that the port settings, especially the Baud Rate, are correct.

It is also possible that a crossover cable is required between the output cable of the GPS receiver and the serial port on the DVL.

### 13.3.5.8 System Test #2

Once the GPS system is running successfully, System Test #2 can be used to graphically display the GPS data. This screen displays the GPS Time, Latitude, Longitude and Altitude as well as other values indicating the accuracy of the GPS reading. The GPS position is also displayed in a square that can be Zoomed from 2 meters square to 16384 meters square.

## 13.3.6 Set Defaults

To reset all the parameter settings back to the factory default settings press the 6 button (labelled Set Defaults).

## 13.4 Noggin File Management

The File Management option is available by pressing 2 from the Survey & Map menu.

The File Management menu allows the user to create GPR Project (GPZ) and Google Earth (KMZ) Files, delete data from the DVL and copy data from the internal compact flash drive to the removable compact flash drive.

### 13.4.1 Creating GPR Project (GPZ) and Google Earth (KMZ) files

Individual data files created in Survey & Map mode are saved in Line (13.1.1: p.75) and Grid (13.1.2: p.76) project folders.

The “Create GPZ/KMZ Files” option allows the user to save the data in Line and Grid project folders to GPR Project (GPZ) files and, if a GPS was attached to the GPR system (9: p.44), Google Earth (KMZ) files.

GPR Project (GPZ) files are files generated by compressing all the GPR data and support files in a line or grid folder into a single file with the same name as the line or grid folder, for example, Project0.GPZ or Grid7.GPZ. GPZ files are used by Sensors & Software data analysis software like EKKO\_Interp and EKKO\_Project.

Google Earth (KMZ) are files that use GPS information to show, on the Google Earth PC software, where a GPR data were collected (Figure 13-14).



Figure: 13-14 Google Earth (KMZ) files display where the GPR data lines were collected as well as Fiducial markers.

When “Create GPZ/KMZ Files” is selected, a list of all the Line and Grid projects on the Current Data Storage Drive (**13.1.7: p.77**) are displayed.

Use the Up and Down Arrows to highlight a Line or Grid name. Then, press the Tag GPZ and, if available, Tag KMZ buttons. To tag all the line project and grid folders at once, press the Tag All button.

Once tagged, “GPZ” and/or “KMZ” appear beside the Line or Grid name in reverse video. When all the desired tags are selected, press the Create button to generate the files. This process can take several minutes, depending on the number, length and depth of data files in each folder. Progress is indicated on the screen along with the option to Cancel generating the files. When the GPZ and/or KMZ files are created, “GPZ” and/or “KMZ” are written beside the Line or Grid project name.

Note that any generated KMZ and GPZ files are deleted if a change is made to the line or grid project. For example, if you go back into a Line Project and collect another data line or delete a line, the GPZ and KMZ files for that project are automatically deleted and must be regenerated.

### **13.4.2 Deleting Data on the DVL**

After data has been successfully transferred to an external computer or if the data is longer required, the whole Line Project or Grid can be deleted from the Current Data Storage Drive (**13.1.7: p.77**) on the DVL. From the File Management main menu, select Delete Line Project or Delete Grid Project. The next screen lists all the current projects.

To delete a Project, use the up and down arrows to highlight it and then press the DEL button.

Before the project is deleted, the user is asked to confirm the deletion by pressing Yes or No. If the answer to the question is No, the project is not deleted.

This menu also allows the user to delete the TAGGED.GPS file (**13.3.5.1: p.113**).

### **13.4.3 Copy Internal to Removable**

If data were collected to the internal drive of the DVL (**13.1.7: p.77**), the data can be copied to the removable Compact Flash drive so it can be transferred to a PC (**13.4.4: p.119**).

The user is warned that this process will delete any data currently on the removable Compact Flash card.

### 13.4.4 Transferring Noggin Data to a PC using the Removable Drive

To transfer data collected or copied (13.4.3: p.118) to the removable Compact Flash drive to a PC, eject the compact flash drive from the DVL and insert it into a user-supplied card reader connected to a PC. Use the Windows Explorer program to make a new folder on the PC, read the removable drive and copy the Noggin data files to the new folder.



Figure: 13-15 Noggin data files saved to the removable drive are easily transferred to a PC. First, power down the DVL, then (i) loosen both of the finger-screws on the top of the DVL so the drive door can swing open freely. (ii) Press the button to partially eject the compact flash drive. (iii) Remove the drive and insert it into a PC card reader (user supplied). Copy the Noggin data files from the drive into a folder on the PC using the Windows Explorer program. The EKKO\_View program can then be used to view the Noggin data.

### 13.4.5 Viewing Data Files on the External Computer

After transferring data files to the external computer the Noggin data files can be viewed, processed and plotted using the EKKO\_View and EKKO\_Mapper software.

Appendix A contains details about the file format of Noggin data.

## 13.5 Noggin Utilities

Pressing the number 4 on the main menu selects Utilities. This menu has utility programs to change the date and time on the DVL and also calibrate the odometer.

### 13.5.1 Time and Date

The date and time are saved with the data files. The DVL date and time setting can be changed by moving to one or more of the appropriate fields and editing the current setting. The LEFT and RIGHT arrows are used to move between fields. To change any of the numbers or months, use the UP and DOWN arrows to increase or decrease the value. When the desired date and time are set, press ENTER to save the changes.

### 13.5.2 Odometer Calibration

The odometer should be calibrated periodically to ensure accuracy.

Noggin Smart Systems can take input from several different odometers.

**It is very important that the user selects and calibrates the odometer appropriate for their Smart System.**

When Odometer Calibration is selected, the user is prompted to select the odometer that is being used with the Smart System.

If a **SmartCart System** is being used, select one of the two SmartCart odometers (usually #1).

If a **SmartHandle system** is being used, select one of the two SmartHandle odometers (usually #1).

If the system is being towed behind a **vehicle** and using the transmission odometer to trigger the system, select one of the two Vehicle odometers (usually #1).

The odometers labelled **Other** are to be used in future configurations.

Once an odometer is selected, the user is prompted to either:

- 1) manually enter the odometer calibration factor, or
- 2) calibrate the odometer over a known distance.

To achieve the highest accuracy, it is recommended that the user choose option number 2 - Odometer Calibration.

When Odometer Calibration is selected, the user is prompted to select the length of the line to calibrate on. There are 8 different choices in meters and 8 choices in feet. To toggle the units between meters and feet, press the B button. Pressing the A button on this screen gives the additional option to select a user-defined value. The user-defined value can range from 0.01 to 5000 meters or 0.01 to 26400 feet.

When the calibration distance has been selected follow the directions on the screen:

- 1) Set the cart at zero and press A
- 2) Move the cart the selected distance and press B
- 3) Press A to exit.

Odometer calibration values for the SmartCart odometer should be around 1080.

Odometer calibration values for the SmartHandle odometer should be around 1530.

Odometer calibration values for the Vehicle odometer vary but may be around 50.

### **13.5.3 System Information**

This option can be used to list system information that may be useful to troubleshoot a problem with the Noggin. The information is intended for the use of Sensors & Software staff to assist in solving a problem with the Noggin system.

System information can be listed to the screen, printed directly to an attached printer or transferred to a PC.

To print the information to a printer, attach the printer to the parallel port of the DVL and then press the B button.

To transfer the information file to a PC, attach the parallel XFER cable from the parallel port of the PC to the parallel port of the DVL. Then run the WinPXFER program on the PC and press the 1 button.

Sensors & Software technical staff may request that this information be sent to them. A printed copy of the information can be faxed to Sensors & Software Inc. If the data is transferred to a PC, the data file can be e-mailed to Sensors & Software Inc.

### **13.5.4 DVL Recording Space**

This option shows, based on the current data collection settings, the total number of traces that can be collected before the DVL memory is full. It also lists, based on the current Station Interval, the total distance of data that can be collected before the DVL memory is full.

## 14 Troubleshooting

Noggin Smart Systems are designed to minimize user problems; however, all electronic devices are subject to possible failure. The following are troubleshooting hints in the likelihood of occurrence if your Smart System fails to operate.

### 14.1 Power Supply

The most common problem that can occur while trying to run a system is insufficient power. The battery may be dead or have a low voltage. If the system is being run from AC, there may be a problem with the AC power supply or adapter.



If there is enough power to run the DVL, the upper red LED on the front of the DVL will light up when the battery is plugged into the system. If this light is on and the DVL boots up, runs and displays the main menu, next check that the red light on the connector to the Noggin is on. If this light is off then there is a problem with the connection from the DVL to the Noggin. Check the connection and this part of the cable.

If the DVL is running but the Noggin system will not run, go to the main menu and check that battery voltage in the lower left corner is above 10.2 volts. If not, the battery needs to be recharged or replaced for the Noggin to run (see below).

If the battery voltage is less than about 10.2 volts, the DVL may not turn on and the upper red LED will flash or not illuminate.

Check the battery voltage with a voltmeter. Try to do this while the system is still attached to the Smart System to get a true measure of the voltage while under load (it will be necessary to open the SmartCart battery case or belt battery case and connect the voltmeter to the positive and negative battery terminals). If the battery has a low voltage or seems dead, try the system with another battery (if available), or give the battery a good 12-14 hour charge and try running the system again.

If the battery does not charge up to 12 Volts or more, it should be replaced.



Smart System batteries are fused to protect the system. For the SmartCart system, open the battery case and check that the 10 Amp fuse is OK. If necessary, replace it with one of the spare fuses available inside the battery case. The smaller belt batteries available for the SmartHandle systems are also fused. Remove the battery from padded casing and check the 5 Amp fuse. Replace the fuse if necessary.

## 14.2 System Communications

If the system power supply is OK but the Noggin does not respond there may be a communication failure between the DVL and the Noggin. This type of failure is often indicated by a 10000 series error number like 10012.

If an error occurs, an error message will appear in the bottom left section of the Noggin screen. EXIT the program and turn off the Digital Video Logger. Disconnect the power source to completely shut down the system.

Make sure the cables are not damaged and that all cable connections are tightly secured. Use a slotted screwdriver to snug up the connections. Sometimes vibrations cause the cable connections to loosen just a bit and break contact and this can cause errors. Disconnecting cables and reconnecting them may provide a better contact and solve the problem. Turn the Digital Video Logger back on and try running the system again.

If the power supply and cable are OK, the problem is likely a failure of the DVL. The DVL has no user-serviceable parts so it will have to be returned to Sensors & Software Inc. for inspection and possible repair (**14.7: p.124**).

## 14.3 System Overheating

The Noggin systems are designed to operate to a maximum *internal* temperature of 70 C or 158 F. In situations of high ambient temperatures or long exposure to direct sun, this maximum internal temperature may be exceeded and cause the system to fail. While the temperature displayed on the DVL in the lower left corner of the main menu indicates the internal temperature of the DVL and not the Noggin, this temperature should give an idea of whether the Noggin is overheating.

If you suspect that the Noggin system is overheating, shut it off and give it a chance to cool down in a shady location before trying to run it again. Placing a wet cloth on top of the Noggin may help in cooling it down.

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 Noggin.

Contact Sensors & Software Inc. if the problem persists as there may be defective electronic components that need to be replaced (**14.7: p.124**).

## 14.4 DVL Problem

While the DVL has been ruggedized as much as possible, it should be handled in much the same way a notebook computer is. If the DVL does not power up and boot up, there may be a problem with the CPU or the storage media. If this occurs, contact Sensors & Software Inc. (14.7: p.124).

## 14.5 Noggin Problem

When the Smart System is powered up and the user selects data acquisition, the Noggin system goes through a self-calibration sequence. While the self-calibration is occurring the user sees the words "Initializing. Please Wait..." in the lower left corner of the DVL screen.

If an error occurs during the initialization, an error message may appear on the screen indicating there is an internal problem with the Noggin.

Power the system down, check connections, power it up again and retry data acquisition. If the error persists, contact Sensors & Software Inc. (14.7: p.124).

## 14.6 Creating a Test Line for Data Quality

One of the best ways of detecting problems with the GPR system is, shortly after receiving the system and getting comfortable with its operation, to collect a line of data at a convenient, easily accessible location. The line does not have to be too long but 100 - 200 traces is a good guide. This data line should be saved electronically and perhaps plotted out on paper and dated. The test line could be collected say, every 6 months and, by reviewing the previous data, system problems can be detected early. As well, if there is a suspected problem with the system, this test line could be collected and compared with earlier tests.

## 14.7 Contacting Sensors & Software Inc.

If you develop problems with your Noggin system, contact your agent or Sensors & Software Inc.

Sensors & Software Inc.'s hours of operation are 9:00 AM to 5:00 PM Eastern Standard Time, Monday to Friday. You can contact Sensors & Software Inc. at:

**Sensors & Software Inc.**  
**1040 Stacey Court**  
**Mississauga, Ontario**  
**Canada L4W 2X8**  
**Tel: (905) 624-8909**  
**Fax: (905) 624-9365**  
**E-mail: sales@sensoft.ca**

**When contacting Sensors & Software Inc., please have the following information available:**

- 1) Noggin and/or DVL Serial Number.
- 2) Version number of the data acquisition software.
- 3) The error number or message appearing.
- 4) A brief description of when the error is happening and the operating conditions (temperature, humidity, sunshine, system and survey setup, etc.).
- 5) Sensors & Software Inc. technical staff may request a copy of the System Information file be sent to them by fax or e-mail. See **13.5.3: p.121** on how to view this file.

## 15 Care and Maintenance

### 15.1 Battery Care

Smart Systems use 12-volt sealed lead acid batteries. They are fused with a 10 Amp fuse to protect them from short circuit damage.

The SmartCart battery unit uses contains a 9 Amp-hour battery. The battery unit should run the Cart Noggin for 4-5 hours before recharging is necessary. If long days of data surveying are typical, a second battery unit may be a useful item.

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 batteries at room temperature whenever possible.

The Noggin and DVL contain a voltage monitoring circuit that will turn off the unit when the input voltage drops below 10.2 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 LED will not light). 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 from start of fast charge.

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

### 15.2 DVL Internal Battery

If the Smart System has not been powered up for an extended period of time, the internal battery will discharge. The dead battery causes the DVL time and date to reset to January 1, 1988 at 12:00 PM. To correct the time and date see **13.5.1: p.120**.

To recharge the internal battery the Smart System must be powered up and left running for at least one hour and preferably longer.

### 15.3 Cable Care

- 1) The cable connectors as well as the connectors on the Noggin and DVL need to stay clean and free of dust and moisture. Use a brush or air spray to clean dust, lint and other foreign particles from these connectors.

- 2) When the system is not being used, make sure the connections are done up to prevent dust and moisture from collecting inside. If the connectors are exposed, cover them with some sort of dust cap.
- 3) Cables are designed to be as tough as practical.
- 4) Careless use of cables making them carry loads that they are not designed for can cause internal damage.
- 5) Connectors are weak points in any system. With the use of this product in rough, dusty and outdoor environments, users can minimize potential down time if they care for cables and treat connectors with respect.
- 6) 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.

## 15.4 Skid Pads

The bottom of the Noggin unit is covered with one large wear-resistant skid pad. The skid pad is designed to protrude from the bottom of the Noggin and 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 Phillips screwdriver and a new one can be purchased from Sensors & Software Inc.

Note that there are two types of skid pads available. The standard type is flat and covers the bottom of the Noggin. There is also an optional skid pad that covers the bottom of the Noggin but also has curved edges that covers the front and back portions of the Noggin. Contact Sensors & Software for details.



*Figure: 15-1 Noggin with optional curved skid pad.*

## **15.5 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 shipping cases available as options for all Noggins and DVL's.

## **15.6 Spare Parts**

For customers working in remote areas or if downtime in the field is unacceptable, consider buying our optional extended spares kit. This kit includes extra cables, batteries and chargers.

## Appendix A Noggin Data file Format

Noggin data consists of two files, a Header file and a Data file. The files have the same name but different extensions. The format details of these files are given below.

### Header (.HD) File:

The header file, identified by the file extension .HD, is an ASCII file. An example is shown below. The heading identifies what each piece of information represents.

1234

```
Data Collected with Noggin Plus
12/10/2000
NUMBER OF TRACES   = 220
NUMBER OF PTS/TRC  = 156
TIMEZERO AT POINT  = 31
TOTAL TIME WINDOW  = 62
STARTING POSITION    = 0.0000
FINAL POSITION       = 10.9500
STEP SIZE USED     = 0.0500
POSITION UNITS     = m
NOMINAL FREQUENCY  = 250.00
ANTENNA SEPARATION = 0.3048
PULSER VOLTAGE (V) = 100
NUMBER OF STACKS   = 4
SURVEY MODE        = Reflection
```

This file can be read and/or printed using any Word Processor.

### Data (.DT1) File:

The data file contains as many records as there are traces. Each record in turn consists of a header section and a data section. The header section consists of an array of 25 real\*4 numbers and a string of 28 characters which is used for annotation. The 25 element real array contains the following information:

Item #	Description
1	Trace number
2	Position
3	Number of points per trace
4	Topographic data, if available
5	(not used)
6	# bytes/point (always 2 for Rev 3 firmware)
7	Time Window
8	# of stacks
9-10	reserved for GPS X position (double*8 number)
11-12	reserved for GPS Y position (double*8 number)
13-14	reserved for GPS Z position (double*8 number)
15	reserved for receiver x position

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16	reserved for receiver y position
17	reserved for receiver z position
18	reserved for transmitter x position
19	reserved for transmitter y position
20	reserved for transmitter z position
21	timezero adjustment where:point(x)= point(x+adjustment)
22	Zero flag: 0 = data okay, 1=zero data
23	(not used)
24	Time of day data collected in seconds past midnight.
25	Comment flag: 1 = comment attached.
26 - 32	Comment

The data section consists of an array of two-byte integers, one value for every data point.



## Appendix B Health & Safety Certification

Radio frequency electromagnetic fields may pose a health hazard when the fields are intense. Normal fields have been studied extensively over the past 30 years with no conclusive epidemiology relating electromagnetic fields to health problems. Detailed discussions on the subject are contained in the references and the web sites listed below.

The USA Federal Communication Commission (FCC) and Occupational Safety and Health Administration (OSHA) both specify acceptable levels for electromagnetic fields. Similar power levels are mandated by corresponding agencies in other countries. Maximum permissible exposures and time duration specified by the FCC and OSHA vary with excitation frequency. The lowest threshold plane wave equivalent power cited is  $0.2 \text{ mW/cm}^2$  for general population over the 30 to 300 MHz frequency band. All other applications and frequencies have higher tolerances as shown in graphically in Figure B-1.

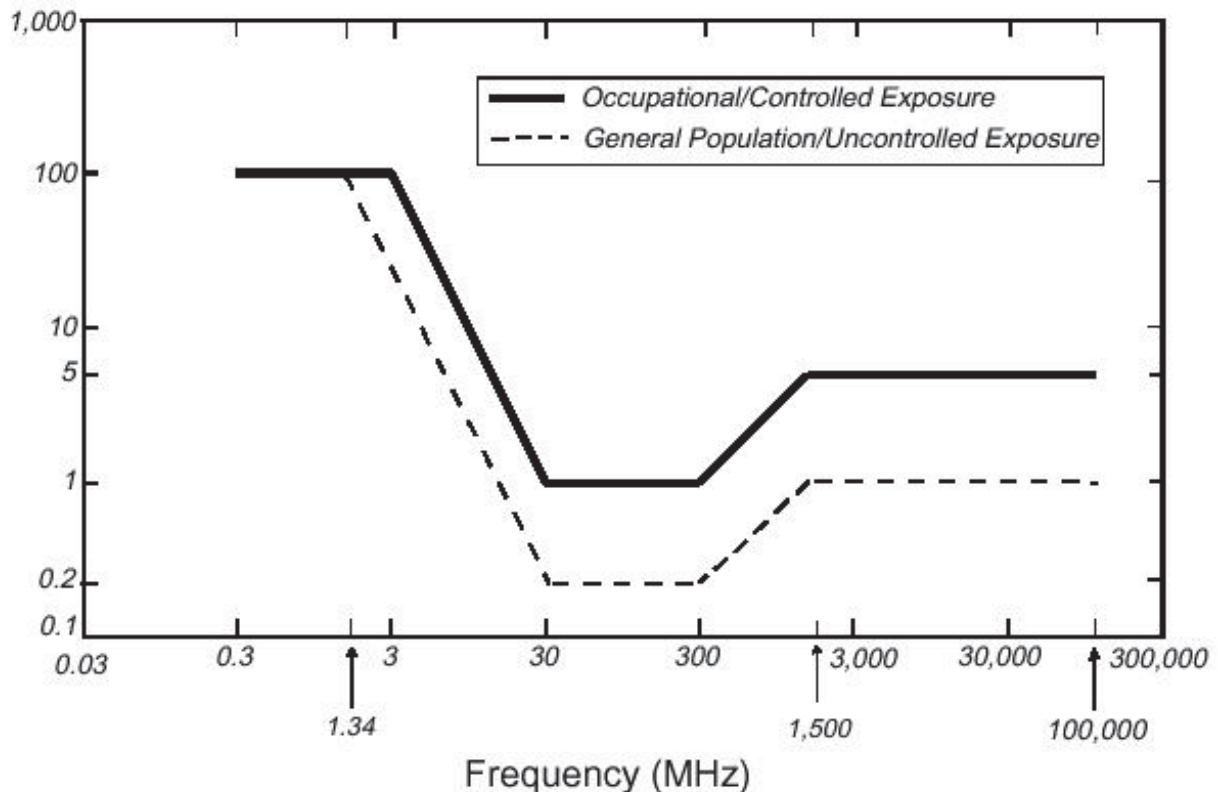


Figure B-1: FCC limits for maximum permissible exposure (MPE) plane-wave equivalent power density  $\text{mW/cm}^2$ .

All Sensors & Software Inc. pulseEKKO, Noggin and Conquest 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. product are less than  $10^{-3} \text{ mW/cm}^2$  which are 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.

## Web Sites

[www.fcc.gov/Bureau/EngineeringTechnology/Documents/bulletin](http://www.fcc.gov/Bureau/EngineeringTechnology/Documents/bulletin)

[www.osha-slc.gov/SLTC](http://www.osha-slc.gov/SLTC) (see radio frequency)

## **Appendix C    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.

Sensors & Software Inc. extensively test their pulseEKKO, Noggin and Conquest subsurface imaging 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.

GPR instruments are considered to be UWB (ultra-wideband) devices. The regulatory regimes worldwide are devising new rules for UWB devices. Sensors & Software Inc. maintains close contact with the regulators to help guide standard development and assure that all products conform. You should continually monitor the "News" link on our website ([www.sensoft.ca](http://www.sensoft.ca)) for updates on standards.

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.

## C-1 FCC Regulations (USA)

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:

- (1) this device may not cause harmful interference and
- (2) 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 ultrawide 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 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 own expense.

### WARNING

Changes or Modifications not expressly approved by Sensors & Software Inc. 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, fire fighting, 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.<sup>1</sup> 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

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1. See 47 C.F.R. §§15.509(b), 15.511(b), and 15.513(b)

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 12<sup>th</sup> 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 dif-

ferent 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: [E.G. QJQ-NOGGIN100 FOR NOGGIN 100 SYSTEM, QJQ-NOGGIN250 FOR NOGGIN 250 SYSTEM, QJQ-NOGGIN500 FOR NOGGIN 500 SYSTEM, QJQ-NOGGIN1000 FOR NOGGIN 1000 SYSTEM]

EQUIPMENT NOMENCLATURE: [E.G. NOGGIN 250]

Send the information to:

Frequency Coordination Branch., OET  
Federal Communications Commission  
445 12<sup>th</sup> Street, SW  
Washington, D.C. 20554  
ATTN: UWB Coordination  
Fax: 202-418-1944

INFORMATION PROVIDED IS DEEMED CONFIDENTIAL

## **C-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



### **C-3 Industry Canada Regulations - English**

Industry Canada published its 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:

- (1) This Ground Penetrating Radar Device shall be operated only when in contact with or within 1 m of the ground.*
- (2) 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:

- (1) 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.*
- (2) 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 licence-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.*

### **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:

- (1) Ce géoradar périphérique doit être utilisé que lorsqu'il est en contact avec ou moins de 1 m du sol.*
- (2) 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:

- (1) 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.*
- (2) 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 dispositif.*

## **Appendix D    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 E    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 are 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 F GPR Glossaries

### F-1 Basic GPR Terms

alpha	exponential attenuation coefficient - normal units dB/m (see attenuation)
K	relative permittivity or dielectric constant
sigma	electrical conductivity - normal units mS/m
v	propagation velocity - normal units m/ns
dB/m	decibels/meter, common unit for attenuation,
m/ns	meter/nanosecond, common unit of GPR velocity, v (see nanosecond)
mS/m	milli-Siemens/meter, common unit for conductivity,
ns	nanosecond, normal unit of GPR time (see nanosecond)
ps	picosecond = 0.001 ns = $10^{-12}$ s, occasion unit of GPR time
us	microsecond = 1000ns = $10^{-6}$ s, occasion unit of GPR time
COR	common offset reflection (survey type where a constant antenna separation is maintained).
CMP	common mid-point (survey type where a transmitter and receiver antenna separation are changed but the mid point remains constant)
GPR	ground penetrating radar
EM	electromagnetic (common abbreviation)
antenna	Device used to couple electromagnetic energy into the ground. Sometimes called a transducer.
antenna separation	Spacing between transmitting and receiving antennas.
attenuation	A reduction in signal amplitude caused by energy dissipation in the transmitting media (see alpha).
bandwidth	The range of frequencies over which a given device transmits or detects signals above a specified amplitude or power
center frequency	Middle of the frequency band defined by a device's bandwidth
conductivity	The ability of a material to conduct electrical current. In isotropic materials the reciprocal of resistivity. Sometimes called specific conductance. Units are siemen/m or S/m. (Or occasionally, mhos/m). For GPR, usually expressed as mS/m. Common symbol
nanosecond	$10^{-9}$ s (One Billionth of a second)
radio wave	Electromagnetic fields that travel through a material as waves and typically have oscillating frequencies in the 1 GHz to 10 GHz range

receiver (Rx)	General term for electronics devices used to detect fields and translate signals into records or displays
resolution	The minimum separation of two objects before their individual responses merge into a single response
signal amplitude	A measure of the strength of the radio wave signal
station interval	Spatial distance between observation points along a survey traverse line or mesh points on a grid
step size	See station interval
transmitter (Tx)	General term used for electronics devices used to create propagating electromagnetic fields
transducer	Name used where GPR antenna, electronics, and shield are combined into one physical unit
sample point	Signal amplitude measured at specific point in time
trace	Sequence of sample points from a single GPR channel that indicate time variation of signal amplitude
cross section	Image that results from side-by-side display of a number of traces which are from adjacent spatial measurement position
gain	Process of amplifying signals to match recording device or display dynamic range

## F-2 Common GPR Terms

zone of influence	The size of an area on a reflecting feature that can be uniquely resolved. (See lateral resolution length).
fresnel zone	See zone of influence.
range resolution length	The radial distance separation between two objects that is needed so that a GPR clearly detects two responses.
lateral resolution length	The lateral separation between two objects that is needed so that a GPR clearly detects two responses.
ringing	Impulsive GPR signals can give rise to reverberating responses that oscillate for a much longer time than the GPR pulse or wavelet. Such a response is referred to as a "ringing" response or "ringing" for short.
hyperbola	Characteristic inverted "U" GPR response from a point target. (Mathematical form of the position-travel time response from a point target)
signal to noise ratio	The ratio of GPR signal amplitude to the average noise amplitude. A large ratio results in a larger penetration depth or detection of weaker signals.
system performance	Measure of system exploration depth indicated by the ratio of transmitter output power or voltage to receiver noise power or voltage.



wavelet or EM pulse	Impulsive GPR's emit an oscillatory electromagnetic pulse which is short in time and space and is often referred to as a wavelet.
penetration depth	The depth of a GPR wavelet can penetrate to before it is attenuated to an undetectable amplitude.
air waves	GPR systems can create and detect energy which travels through air above the ground. Undesired responses from above ground targets are often called 'air waves'.

### **F-3 Advanced GPR Terms**

GPS	global positioning system (satellite based positioning).
DMI	distance measuring indicator.
stacks	number of repeated measurements averaged to get resulting measurements.
reflectivity	measure of amplitude returned by a target.
reflection coefficient	normally named fresnel reflection coefficient and quantifies GPR signal reflection amplitude from a flat interface between two materials.
3 dB bandwidth	Range of spectrum over which the GPR signal amplitude remains above a value equal to the (peak amplitude).
6 dB bandwidth	Range of spectrum over which the GPR signal amplitude remains above a value equal to the (peak amplitude).

