SmartCart

User's Guide

1999-00273-07

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Table of Contents

1   General Overview

Noggin Smart Systems are integrated ground penetrating radar (GPR) data acquisition platforms. Once the unit has been assembled and powered up you can be carrying out a GPR survey in less than a minute. There are three different configurations available, the SmartCart system (see Figure 1-1), the SmartHandle system and the Rock Noggin.

This manual describes the SmartCart system. The SmartCart system consists of the cart structure, a Noggin, an odometer wheel, a digital video logger (DVL), and a battery. Section 2: P.2 describes how to assemble a SmartCart system.

Each Smart System's DVL comes with all the necessary software installed. This includes software to acquire data as well as software to 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 SmartCart system.

2   Assembling the SmartCart

The Noggin SmartCart can be configured for Noggin 250, Noggin 500 or Noggin 1000 operation. For the Noggin 250 SmartCart, refer to Figure 2-10. For the Noggin 500 SmartCart, refer to Figure 2-11 and for the Noggin 1000 SmartCart, refer to Figure 2-12.

Figure: 2-1 Fully assembled SmartCart

The Noggin SmartCart comes fully assembled but in collapsed position (Figure 2-2). The steps necessary to have a fully functioning system are:
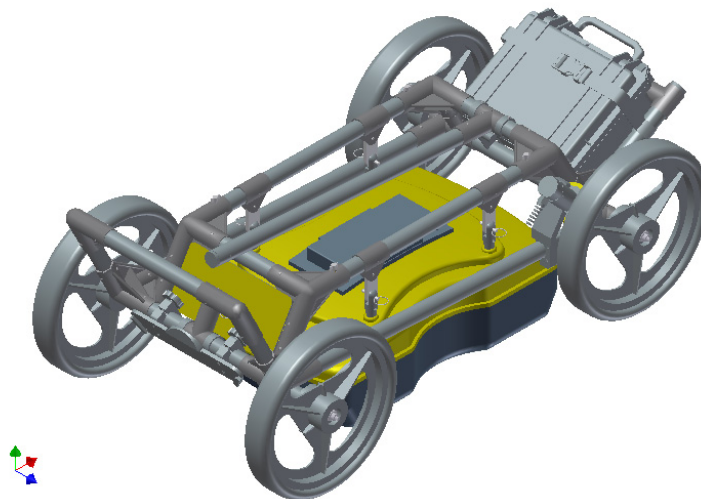
Figure: 2-2 SmartCart in collapsed position.

1. Attach wheels (if necessary): 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 cart frame. This is shown in Figure 2-3
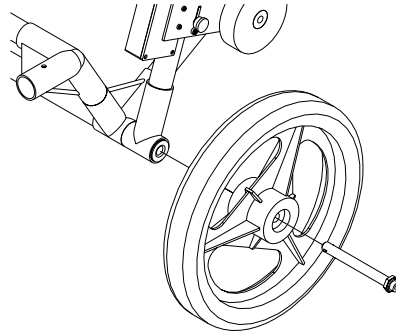
Figure: 2-3 Attaching the wheel.

2) **Unfold the Handle**: Refer to Figure 2-4. 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.)

With the system unfolded, make sure the small odometer wheel makes good contact with the side of the cart wheel. If this contact is too loose, the odometer wheel may slip, resulting in erroneous position measurements. If the odometer wheel seems loose, use a ¼ inch Allen (hexagonal) wrench to loosen the screws on the side of the odometer (see Figure 2-10 or Figure 2-11) and pivot the entire odometer unit until the small odometer wheel makes good contact with the side of the cart wheel. Then tighten the screws to lock the odometer wheel in this position. After this has been done, it will be necessary to re-calibrate the odometer (see Odometer Calibration on page 36).
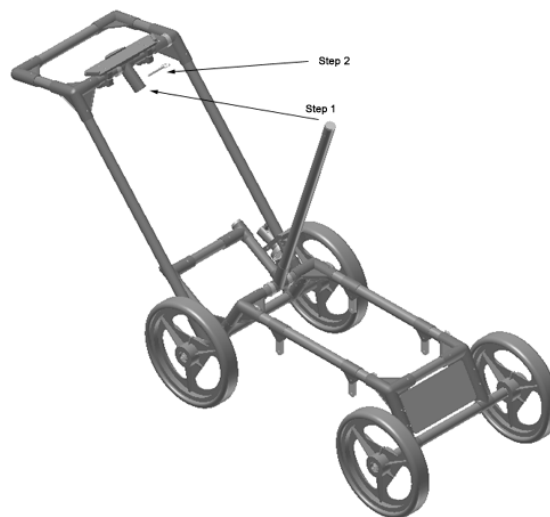
Figure: 2-4 SmartCart set up.

3) **Attach the Noggin:** Before the Noggin unit 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 2-5). 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 OVER-TIGHTEN!**
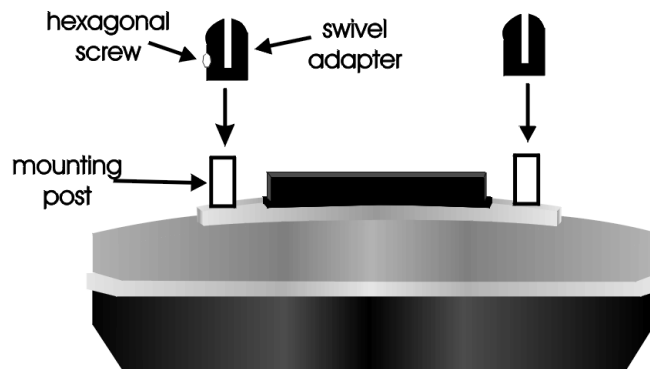
Figure: 2-5 Attaching the swivel adapters to the Noggin 250.

Once all 4 swivel adapters are attached, the Noggin can then be attached to the SmartCart.

The Noggin is usually attached to the cart with the long axis of the Noggin unit parallel to the wheels on the cart (see Figure 2-10, Figure 2-11 and Figure 2-12). For this orientation, make sure 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.

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 2-6). 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.
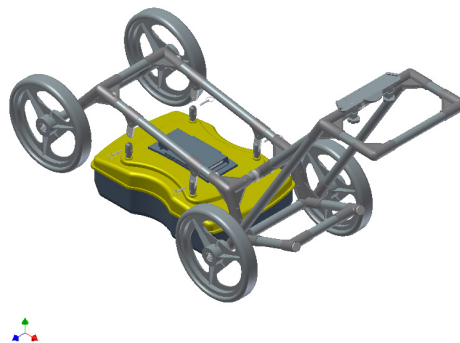
Figure: 2-6 Attaching the Noggin 250 to the cart.

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Noggin 500 and 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 frame of the cart.

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 2-7).

Connect the cable with the 37-pin male D connector to the Noggin and secure this attachment by tightening the hand screws.
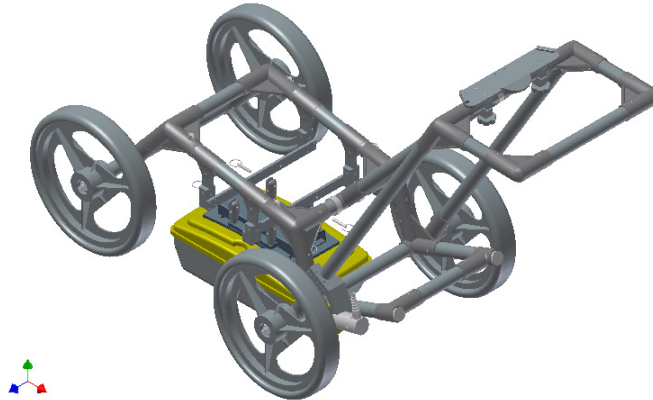
Figure: 2-7 Attaching the Noggin 500 and Noggin 1000 to the cart.

4) **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 2-8). 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 SmartCart, this clip must be flexed downward as the DVL is slid forward off of the shelf.
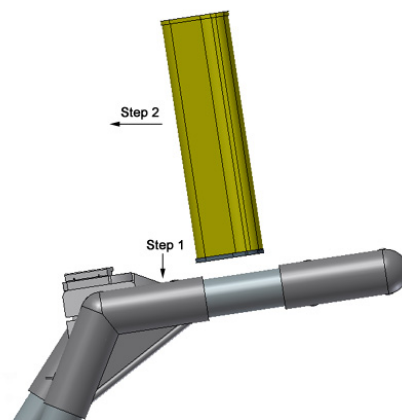
Figure: 2-8 Attaching the digital video logger (DVL). Step 1: Depress flexible clip. Step 2: Slide DVL onto shelf.

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Once the Digital Video Logger 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 by tightening the hand screws.

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

Figure: 2-9 The Noggin SmartCart battery.

5) **Attach the Battery Unit:** Set the battery unit onto the lower inclined shelf on the back of the SmartCart (see Figure 2-9). 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.

With the Noggin SmartCart completely assembled, connect the round 4-pin battery cable to the receptacle on the side of the 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.
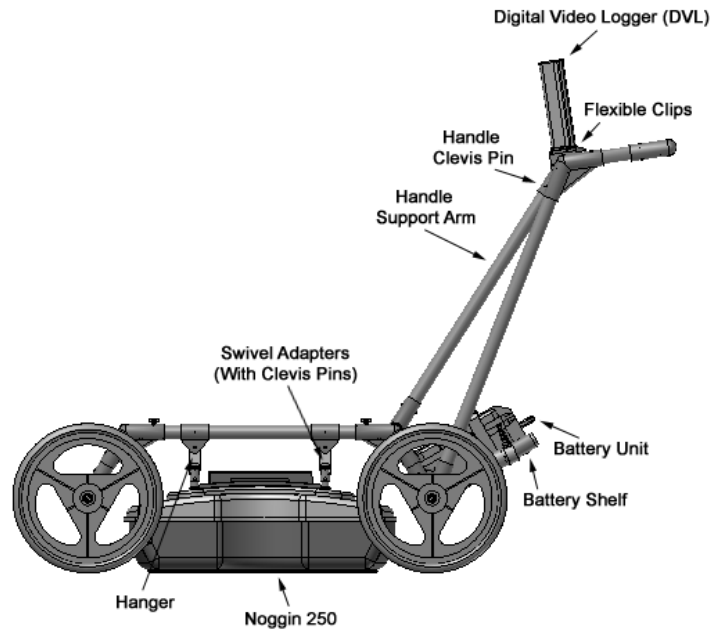
Figure: 2-10 Noggin 250 SmartCart
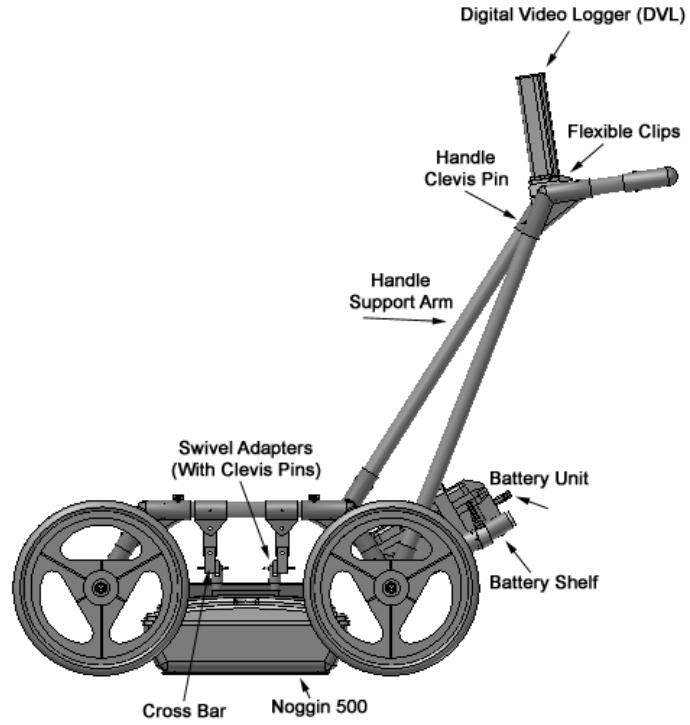
Figure: 2-11 Noggin 500 SmartCart
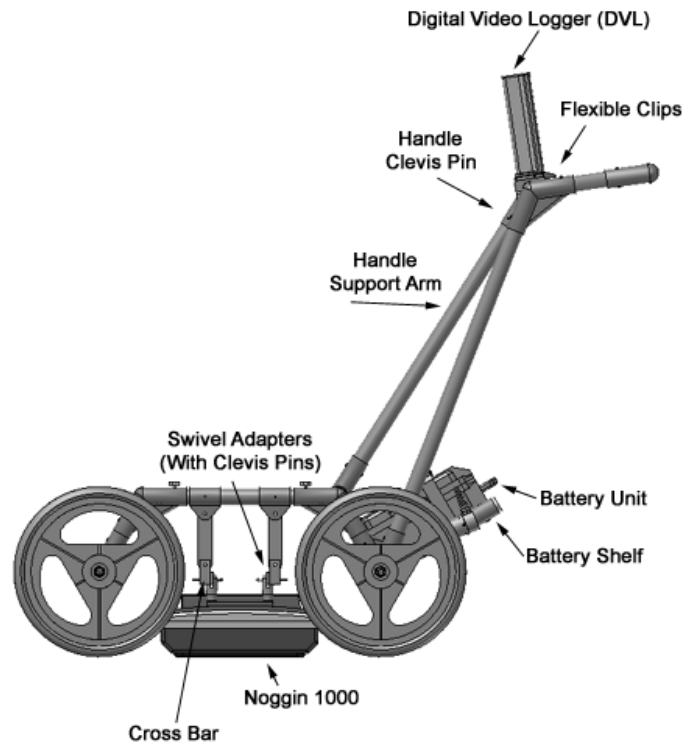
Figure: 2-12 Noggin 1000 SmartCart

2.1 Configuring the SmartCart for a Different Noggin System

The Noggin SmartCart can be configured to carry a Noggin 250, Noggin 500 or a Noggin 1000 system. This can be done by replacing the two support arms on the cart (see Figure 2-13) with the support arms for another system.

Each arm is attached to the cart by two thumb screws. For each arm, remove the screws, detach the arm from the cart and replace it with the new arm.

Important Notes

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: 2-13 Changing the SmartCart's support arms to carry a different Noggin system.

2.2   Adding GPS to the SmartCart

The SmartCart has an optional bracket designed to hold a Trimble or Novatel GPS (see Figure 2-14). 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.

For more details on using GPS with a Noggin system see GPS Setup Menu on page 44. For more details about using GPS with a Noggin*plus* system, see Section 5.3.5: P.85.

GPS SmartCart Mount (HABR0033) is available from Sensors & Software.

Figure: 2-14 SmartCart system with optional GPS bracket (HABR0033).

3   Digital Video Logger

Once all the cable connections are made between the Noggin, the Digital Video Logger (DVL) and 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 Section 7.1: P.97 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 3-1. To start the system, press any button on the front panel. The lower red LED on the front panel should illuminate.

Figure: 3-1 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 grayscale 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.

Compact Flash Drives: 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 (see Section 4.4.4: p.35 for Noggin and Section 5.1.7: P.53 for Noggin^{plus}). The removable compact flash drive is accessible by opening the door on the top of the DVL. **Make sure that 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.

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 manufactuers 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 (see Section 4.5.1: p.48 for Noggin and Section 5.4: p.90 for Noggin^{plus}). These are widely available in consumer electronics stores.

Figure: 3-2 The DVL has a removable compact flash drive for data storage.

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

A – NOGGIN
B – NOGGIN PLUS
1 – CONTACT US

5 – POWER OFF

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- Pressing the A button starts the software for standard Noggin systems. Details about the Noggin system software can be found in Section 4: P.14.

- Pressing the B button starts the software for Noggin^{plus} systems. Details about the Noggin^{plus} system software can be found in Section 5: P.51.

- Pressing the 1 button displays contact information for Sensors & Software Inc.

- Pressing the 5 button will turn the DVL off.

Note that Noggin^{plus} systems will operate with both the Noggin and Noggin^{plus} software while standard Noggin systems will only operate with the Noggin software.

This screen also displays the following information:

- **Battery Voltage:** The system will shut down when the battery voltage reaches about 10.2 Volts (see Section 7.1: P.97 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.

3.1   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 use it away from the system to review, print or download data. There are 2 ways to power the DVL away from the Smart System:

The optional DVL II to Power Supply Cable allows the user to power the DVL away from the Smart System using the system battery. As shown in Figure 3-3, the cable connects the battery to the 9-socket connector on the back of the DVL.
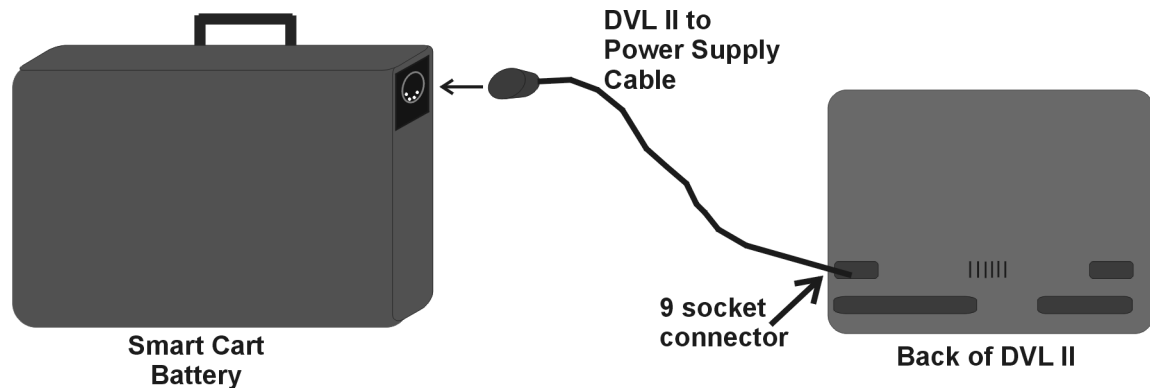
Figure: 3-3 The optional DVL II to Power Supply (CABL0029) cable can be used to power the Digital Video Logger (DVL) from the system battery.

To avoid having to use the system battery to power the DVL, an optional AC power supply is available. This, when combined with the DVL II to Power Supply Cable, allows the user to power the DVL away from the Smart System using AC power. As shown in Figure 3-4, the AC power supply connects to the DVL II to Power Supply Cable which connects to the 9 socket connector on the back of the DVL.
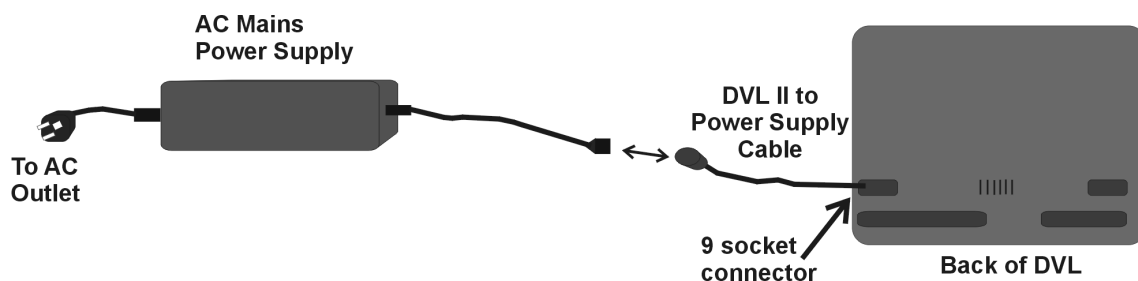
Figure: 3-4 The DVL II to Power Supply cable (CABL0029) can be combined with an optional AC power supply (PSUP0018) to power the Digital Video Logger (DVL) without the system battery.

4   Noggin

4.1   Overview of Noggin Menu Options

The Noggin main menu has the following choices:

>   **A – RUN**
>   **B – DEMO**
>
>   **1 – NOGGIN SETUP**
>   **2 – TRANSFER ALL BUFFERS**
>   **3 – DELETE ALL BUFFERS**
>   **4 – TRANSFER SETUP**
>   **7 – RETURN**

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4.1.1   Run

Pressing the A button starts the Noggin data acquisition program (see Section 4.3: P.29).

4.1.2   Demo

Pressing the B button starts the Noggin Demonstration program. This program simulates data acquisition (without actually moving the system) by displaying a default data set. This data set cycles continuously until the user exits from the demo program. This allows the user to see and experiment with the different menu items and different settings to see the effect they have on the data presentation.

It is useful to run the demonstration program while reviewing the Noggin Screen Overview described in Section 4.2: P.19.

4.1.3   Noggin Setup

There are many background setup parameters related to the Noggin Smart System operation that can be edited. This menu allows the user to display and change various settings for different aspects of the Smart System. The user can also reset all the parameters to the factory default settings. See Section 4.4: P.35.

4.1.4   Transfer All Buffers

There are two methods available to transfer Noggin data files from the DVL to a PC. The usual method is to save the Noggin data to the removable compact flash drive that is accessible using the door on the top of the DVL. After powering down the DVL, this drive can be removed and inserted into a card reader attached to a PC (Section 4.5.1: p.48).

The **Transfer All Buffers** option requires the use of the optional PXFER cable and WinPXFER software so this menu is **not** required for users transferring Noggin data using the removable compact flash drive.The **Transfer All Buffers** menu option is used to transfer all the Noggin data from the DVL to an external computer (PC) using the parallel ports. For details, see Appendix F1.

4.1.4.1   Copy Internal to Removable

Noggin data files can be saved to the Internal drive or the Removable drive on the DVL (see Section 4.4.4: p.35). The Transfer All Buffers menu also has an option to copy Noggin data saved on the Internal drive to the Removable drive so it can be transferred to a PC (see Section 4.5.2: p.49).

4.1.5   Delete All Buffers

Pressing the number 3 on the main menu allows the user to delete ALL the data buffers currently saved on the DVL. See Section 4.5.5: P.49.

4.1.6   Transfer Setup

Transfer Setup requires the use of the optional PXFER cable so this menu is **not** required for users transferring Noggin data using the removable compact flash drive. This menu allows the user to set the transfer mode to Normal or Turbo depending on what type of PXFER cable they have (see Appendix F1.2 PXFER Cable Types).

The menu also allows the user to enter Upgrade mode to update the firmware on the DVL. **Upgrade** requires the use of the optional PXFER cable so this menu is **not** required for users who upgrade their DVL firmware using a removable compact flash drive.

Selecting Enter Upgrade Mode puts the DVL into listen mode to allow a software upgrade to be transferred from an external PC to the DVL using the PXFER and WinPXFER cable. Avoid pressing this button until the instructions in a software upgrade tell you to. Once pressed, the DVL must have the power disconnected to exit from this menu item.

4.1.7   Return

This button will return the user to main menu.

4.1.8   Noggin Screen Overview

The Noggin screen is shown in Figure 4-1. It is divided into 3 sections. The very top section (Section A) contains velocity, total depth and positioning information. The center section (Section B) contains the actual data and the bottom section (Section C) contains the menu.

Each screen of data is saved in the Digital Video Logger as an individual PCX graphics file called a SPI file. Although each screen is saved as an individual file, these files can be viewed together as a continuous chart up to 250 screens long. These data can be viewed on screen (see Section 4.2.3: P.21), printed directly to a printer attached to the DVL (see Section 4.2.2: P.19) or transferred to an external computer (see Section 4.5.1: P.48).
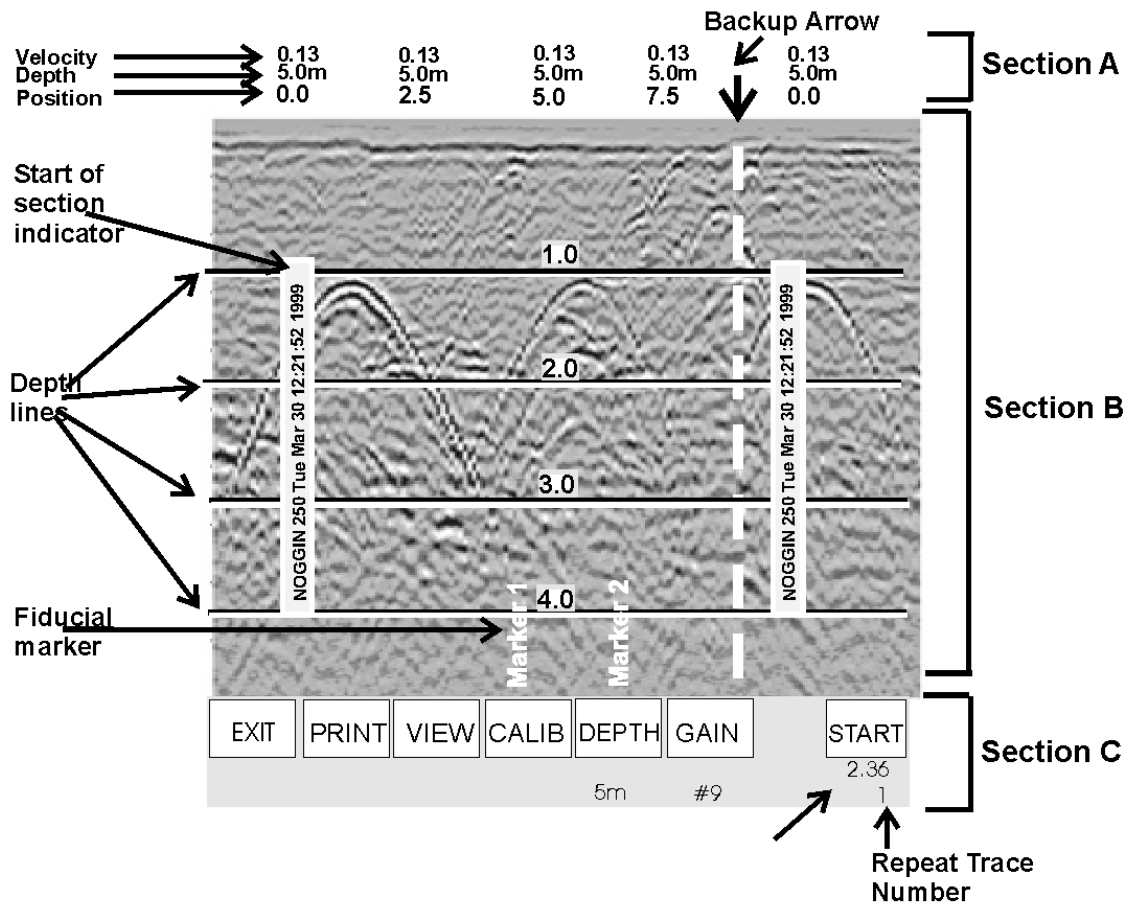
Figure: 4-1 Noggin Data Acquisition Screen

4.1.9   Section A - Data Parameters

Section A displays three items:

1)   The total depth to the bottom of the data image in Section B,

2)   The velocity used to calculate the total depth and the depth lines (see Depth Lines in Section 4.1.10: P.17) and

3)   The position indicator in meters or feet (depending on the odometer units set, see Units Used on page 36).

Rather than displaying total depth and depth lines the user can select to display the total time window in nanoseconds (see Units Used on page 36).

Note that it is possible to change the position label size (see Label Size on page 38).

4.1.10   Section B - Data Display

This section contains the actual data collected or replayed. The section also contains the depth indicator lines, battery voltage indicator (which is visible each time you start), start of section indicators, and any fiducial markers the user enters. See the sections below for more details.

4.1.10.1 Depth Lines

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

The positions of the Depth Lines are controlled by the current velocity value as well as the depth selected. See Section 4.2.5: P.27 on selecting different depths and Section 4.7.1: P.50 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 Section 4.2.4: P.21 on how to calibrate the system).

Note that it is possible to change the depth units and the depth label size (see Section 4.4.1: P.35).

4.1.10.2 Battery Voltage Indicator

When the Start button is pressed, the current battery voltage will be displayed on the extreme left side of the screen.

The voltage indicator can be helpful for identifying when the battery needs to be recharged. If the battery voltage drops below 10.2 volts the DVL will cease to operate and this monitoring capacity will not be available.

4.1.10.3 Start of Section Indicator

Any time the Start button is pressed, the current date and time are written vertically on the screen to indicate the start of a new section (see Time and Date on page 35 on how to set time and date on the DVL). The position indicator is also reset to zero. The current date and time can be recorded in a field notebook along with the survey location to help the user organize where each section of data was collected (Figure 4-2).

| | System | | | Survey | | | | Battery |
Buffer	Trace #	Speed#	Line	Start	End	Comments		Volts

Location: _____   Page ____ of ____

Date:_____
Operator:_____
Job #:_____

Table 1: Field Notes Example

Figure: 4-2 Example field notes

4.1.10.4 Fiducial Markers

A fiducial marker is text written vertically on the 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.

The position and name of the object encountered at each marker can be recorded in a field notebook. Then, when the data are reviewed, these markers are visible right on the data section and can assist with data interpretation.

A fiducial marker is activated by pressing the A button on the DVL keypad during data acquisition.

The first time the A button is pressed, the text "Marker 1" will be written to the screen at the current position. The marker number will then increment each time it is pressed, for example, Marker 2, Marker 3 etc. (see Figure 4-1).

Note that it is possible to automatically place a dashed vertical line at every position label (see Odometer Markers on page 36).

4.1.11   Section C - Menu

The bottom section contains the user menu selection and current program settings. This menu is described in more detail in Section 4.2: P.19.

During data acquisition it also displays the current odometer position and the Repeat Trace Number that indicates if the system is moving too quickly and reducing data quality (see Section 4.3.1: P.29).

4.2   Noggin Menu Options

The default menu selection is divided up into 7 sections: Exit, Print, View, Calib., Depth, Gain and Start. Each of these options is addressed below.

Execution of a menu item is done by pressing the key immediately below the menu item. Pressing the key will change the setting for that menu item. For example, pressing the key below the Depth menu item will start to cycle through the different depth settings available.

4.2.1   Exit

This button will terminate the Noggin program and return the user to Noggin main menu. The user can then run the Noggin again, run the demo program, change DVL settings, download data to an external PC, delete data or return to the main menu.

Note that when the Start button is pressed and data acquisition begins (see Section 4.2.7: P.28), the Exit button turns into a Stop button (see Section 4.2.8: P.28). Data acquisition must be stopped by pressing the Stop button before it is possible to exit from this menu.

4.2.2   Print Menu

This menu item allows the user to:

1)   Print data images directly to an attached printer or,

2)   Transfer one or more screens (or buffers) of data to an external computer (PC) as a single PCX graphics file. This type of transfer is appropriate when the user wants to transfer the data to an external computer for use with third-party graphics software packages like Microsoft Paint and Word.

Printing Data to an attached Printer

The Noggin data images can be printed directly to a few select, but common, printers. The supported printers are HP LaserJet printers, most Epson printers and the Seiko DPU5400 thermal printer (available from Sensors & Software). As well, any printer that can emulate these printers can be used (see your printer's User's Guide for emulation modes available). For example, Canon BubbleJet printers can usually be configured to emulate an Epson and most HP printers will work using the Laser driver.
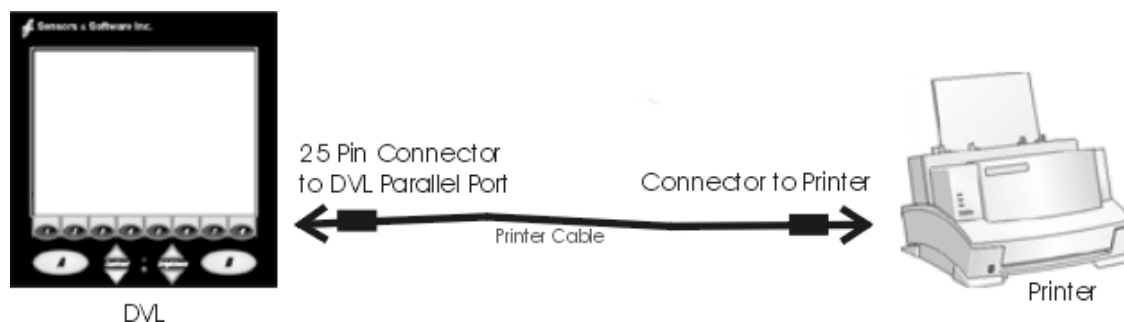
Figure: 4-3 Attaching a printer to the DVL using a standard printer cable.

On the back of the DVL there is a standard 25 socket parallel port. A printer can be attached to the parallel port on the DVL with a standard printer cable, just as you would attach a printer to any computer (Figure 4-3).

Always power down the DVL before attaching a printer. This will prevent damage to the parallel port.

On the Digital Video Logger, after the Print option is selected, the user must define the section to be printed. The user has the option to print **ALL** the current buffers, **Select** the buffers to print or print a certain number of buffers. If a certain number of buffers are selected, i.e. **50**, **75**, **100**, **150** or **200**, the latest buffers are printed first. For example, if there are currently 145 buffers on the DVL and the user selects to print 100 buffers, buffers 46 to 145 will be printed.

If the **Select** option is chosen, the user manually determines the point in the buffers where to begin printing and where to end printing. The left edge of the page must be established first. This is done by lining up the left edge of the Digital Video Logger screen with the edge of the plot desired. Use the arrow buttons on the screen to move the section back and forth. A single arrow moves the image 8 pixels either right (▶), or left (◀). A double arrow will move the image 640 pixels or 1 full page to the right (▶▶) or left (◀◀). A single arrow with a vertical line will move the section either to the start (y ◀), or end (▶ y) of the section. If the start or end of section button is pressed, the image will page through one screen at a time. Data scrolling can be stopped by pressing any button. Once the left edge is in place, pressing the OK button will lock the left edge of the plot.

Figure: 4-4 Noggin Print Screen

The right edge of the plot must now be defined the same as the left, however now using the right edge of the Digital Video Logger screen. Note that the right edge cannot exceed the left edge.

Next, select the type of printer attached (LASER for HP LaserJets and many other HP printers, EPSON for Epson or Canon BubbleJet printers or SEIKO for the Seiko DPU5400 Thermal printer). Text will appear on the bottom of the DVL screen indicating the image is printing on the printer.

If an error occurs during the printing operation, press the A button to Abort. Try to resolve the problem and try again. It may be necessary to turn the DVL off and power it back on and try printing again.

When the print is complete the user is returned to the Noggin screen.

Transferring Noggin Data Files to a PC using WinPXFER

This method of transferring Noggin data to a PC requires the use of the optional PXFER cable and WinPXFER software so this menu is **not** required for users transferring Noggin data using the removable compact flash drive (see Section 4.5.1: p.48).

Using the PXFER cable and the WinPXFER program, one or more screens (or buffers) of data can be transferred to a PC as a single PCX graphics file. The details for are described in Appendix F2.

It is also possible to transfer all the Noggin data files to an external PC using the PXFER cable and the WinPXFER program. This type of data transfer is described in Appendix F1.

4.2.3   View Menu

The View function allows the user to scroll back through previously recorded data in the same manner as the Print function (see Section 4.2.2: P.19).

4.2.4   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 values on the Depth menu (see Section 4.2.5: P.27) and on Depth Lines (see Section 4.1.10: P.17) are only accurate if the system has been properly calibrated to determine the velocity of the material being scanned. See Section 4.7.1: P.50 for more details about how depth is calculated.

The Calibration function allows the user to input the velocity of the material being scanned. Velocity can be determined in one of four different ways depending on the situation:

1)   Hyperbola matching

2)   Target of known depth

3)   Select a media

4)   Input a velocity value

4.2.4.1   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: 4-5 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 (⌒) button. This will superimpose a hyperbola on the data. This hyperbola can be moved up (▲), down (▼), left (◀) and right (▶) using the appropriate arrow buttons. The goal is move the hyperbola until it lies on top of the hyperbola in the data (see Figure 4-6). Then, the user can adjust the width of the hyperbola to make it wider (◀ ▶) or narrower (▶ ◀) until the shape of the hyperbola matches the shape of the hyperbola in the data. After matching the hyperbola, the velocity value is extracted and used for all subsequent data acquisition.

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 (▲) 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 (◀ ▶) or narrower (▶ ◀) button.

Figure: *4-6 Hyperbola matching to extract velocity. After pressing the CALIB button 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 used to make depth estimates more accurate in subsequent data.*

Hyperbola Matching calibration can only be done during data acquisition. It cannot be done when viewing previously collected data. Further, the Hyperbola Matching calibration is only available after at least half a screen of data with the same depth setting have been collected. **If less than half a screen of data are collected and the CALIB button is selected, only calibrations selecting a material or inputting a velocity are available** (see below).

Depths will appear in metres or feet depending on which units are selected. Velocities appear in both metres per nanosecond (m/ns) and feet per nanosecond (ft/ns). To change units see Units Used on page 36.

4.2.4.2   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 ~ 0.1 m/ns or 0.328 ft/ns).
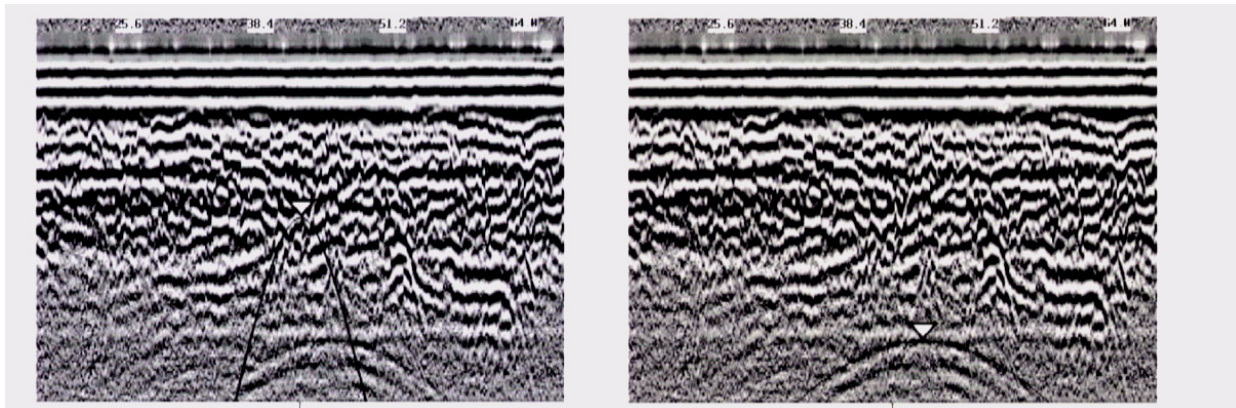
Figure: 4-7 Hyperbola matching can be used to identify reflections from objects that are not in the subsurface but are from objects above ground. If the hyperbola matching velocity is near the speed of light (0.3 m/ns or 0.984 ft/ns) then the hyperbola was caused by surface object like a overhead wire, 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.

4.2.4.3   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.
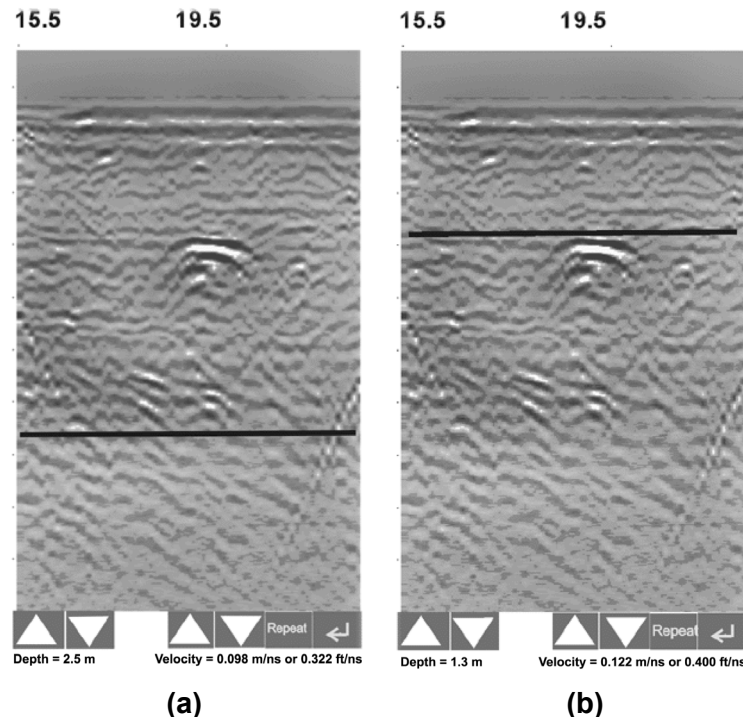
| | **(a)** | **(b)** |

Figure: 4-8 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 adjust the velocity value up or down until the known target depth is correct. Once the depth is matched, the extracted velocity value is automatically used for all subsequent data acquisition.

If units are metres then depths will appear in metres. If units are feet then depths will appear in feet. Velocities appear in both metres per nanosecond (m/ns) and feet per nanosecond (ft/ns). To change units see Units Used on page 36.

4.2.4.4   Selecting a Media

If a good hyperbola or a target of known depth is not available, the user will have to estimate the velocity by selecting the predominant material in the area. This can be done by selecting the MEDIA button and selecting one of the 8 choices. The velocity associated with each of these choices is given in the following chart:

Material	Velocity (m/ns)	(ft/ns)
Very Dry Soil	0.170	0.558
Dry Soil	0.130	0.427
Dry Rock	0.120	0.394
Soil	0.100	0.328
Rock	0.100	0.328
Wet Soil	0.080	0.262
Wet Rock	0.080	0.262
Very Wet Soil	0.065	0.213

4.2.4.5   Input a Velocity Value

It is also possible to input a velocity value directly. When the Velocity button is selected the user sees the current velocity and can use the up and down arrows to increase or decrease that value. 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

Velocities appear in both metres per nanosecond (m/ns) and feet per nanosecond (ft/ns). To change units see Units Used on page 36.

4.2.5   Depth Menu

This button cycles through 5 different depth ranges. The velocity of the material determined under Calibration (Section 4.2.4: P.21) affects the total apparent depth scanned. See Section 4.7.1: P.50 for more details about how depth is calculated.

The Depth units can be changed to metres, feet or time in nanoseconds. For details, see Units Used on page 36. As well, all the Depth values can also be doubled or halved by changing the Window Zoom option (see Window Zooming on page 43).

It is important to remember that the properties of the material control the actual depth being scanned. 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 section will look blank or speckled rather than signal with continuity.

4.2.6   Gain Menu

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 4-9 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.
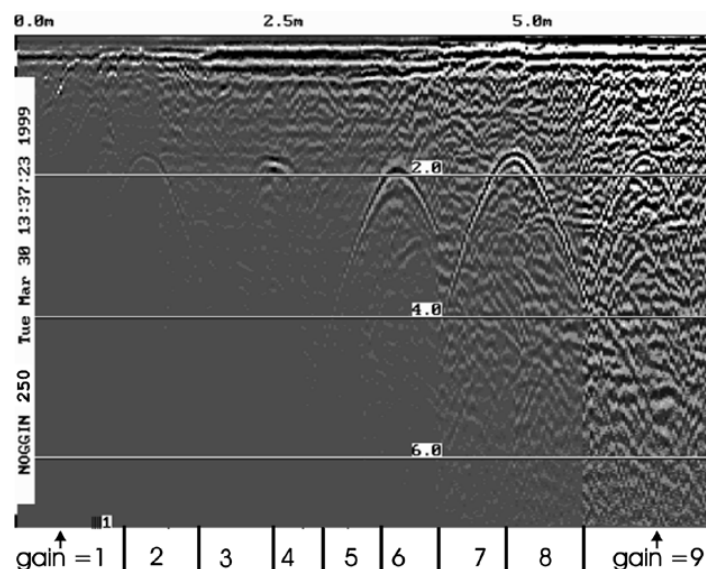
Figure: 4-9 Effects of the Gain setting

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 under Setup (see Linear Gain on page 42).

4.2.7   Start Menu

The Start button will begin the acquisition of data and displaying of data to the screen. After acquisition has started, the Start button disappears and a Stop button (used to halt acquisition) appears on the left. As well, when data acquisition begins, the Exit, Print and View buttons are removed.

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

When the Start button is pressed for the first time after the system is turned on, the Noggin will boot up (this can take about 10 seconds depending on the software version). The operator should not start data collection until the system has finished booting (see the bottom left corner of the screen) and the STOP button has appeared on the left. The current battery voltage will then be displayed on the left side of the screen. This battery voltage appears only briefly before starting data collection.

Anytime the Start button is pressed, the current date and time are written vertically on the screen to indicate the start of a new section (see Time and Date on page 35 to set time and date). **The position indicator is also reset to zero**. The current date and time can be recorded in a field notebook along with the survey location to help the user organize where each section of data was collected.

4.2.8   Stop Menu

After the Start button is pressed, it disappears from the menu and the Exit button turns into a Stop button. Data acquisition can be stopped by pressing the Stop button.

4.2.9   Filter Menu

The Filter menu option is only visible during data acquisition. Pressing the Filter button turns the Background Subtraction filter on and off. For more details on Background Subtraction, see Section 4.3.7: P.33.

4.3   Noggin Data Acquisition

Data acquisition is done simply by pushing the Smart System along the survey line. This is usually done with the odometer used as the triggering device, however, it is possible to change the triggering method and run the Smart System in continuous operation or using the trigger button (see Trigger Method on page 37).

During data acquisition, the settings for Depth (Section 4.2.5: P.27) and Gain (Section 4.2.6: P.27) can be changed by pressing the corresponding button until the desired setting appears. This can be done while the instrument is collecting data; there is no need to stop first.

As well, during data collection, the Filter button is available on the DVL screen. Pressing the Filter button toggles the Background Subtraction Filter on and off (see Section 4.3.7: P.33).

4.3.1   Collecting Data using the Odometer

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". For the Noggin 250, the normal station interval is 5 centimeters (about 2 inches). For the Noggin 500, the normal station interval is 2.5 centimeters (about 1 inch). For the Noggin 1000, the normal station interval is 1.0 centimeter (about 0.48 inch). The station interval can be changed in the Setup (see Station Interval on page 39).

Each data trace is plotted as a vertical strip on the screen (see Figure 4-1). The width of this strip can be changed to 1, 2, 4, or 8 pixels (see Plot Interval on page 42). The normal trace width for Noggin 250 traces is 2 pixels while the normal width for Noggin 500 and Noggin 1000 systems is 1 pixel.

The odometer units that appear across the top of the screen can be set to either metres or feet (see Units Used on page 36).

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

During data acquisition, the current odometer position value (in the current units, either metres or feet) is written to the lower right corner of the screen (see Figure 4-1).

Note that Smart systems can be configured to collect data either by pushing the system (forward) or pulling the system (reverse). See Cart Direction on page 37 about changing the system direction.

The odometer should be periodically re-calibrated to ensure accuracy. The procedure for re-calibrating the odometer is described in Section 4.4.7: p.36.

4.3.1.1   Reducing Data Quality by Moving too Fast

On the lower right corner of the data acquisition screen, under the current odometer position value (see Figure 4-1) is a single digit number that usually displays one (1). This value is the Repeat Trace number.

If the Smart System is being used with the odometer and is moved too quickly for the Noggin 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 Repeat Trace number displays the number of traces that are being plotted to the screen. If this number exceeds 1 or if the user notices the data looking smeared or "blocky", this is probably due to moving the Smart System too quickly. To eliminate this, either reduce the system speed or, if possible, reduce the Depth setting (see Section 4.2.5: P.27).

Note that skipping traces is not usually a problem because in order for the system to do this it has to be moving at a running pace. It is more likely to happen if the depth setting is very deep (> 10 metres).

4.3.1.2   Backing up the System 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 (see Figure 4-1). 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 centre point of the Noggin.

When the Smart System is moved forward again to continue with the survey, it 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.

Sometimes it may be desirable to back up to a point and then continue collecting data starting at that point. To do this, reset the odometer by pressing Stop and then Start again. When the Smart System is moved forward, it will collect data immediately.

The physical position corresponding to the Back-up arrow can be changed from the centre of the Noggin to any other position. See Arrow Reference on page 43 on changing the Arrow Reference value.

4.3.2   Collecting Data in Free Run Mode

It is possible to change the triggering method from the odometer and have the Noggin system run in Free Run (or continuous mode) (see Trigger Method on page 37). This means that the system collects data even if it is not moving. This option is not typically used when an odometer wheel is present but it useful for collecting data when using the odometer wheel is not practical.

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 (see Fiducial Markers on page 18) or GPS (see GPS Setup Menu on page 44).

In this 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.

4.3.2.1   Controlling Data Collection Speed in Free Run Mode

In Free Run mode the user can control the speed the Noggin collects data by increasing or decreasing the number of stacks (for more details on Stacking, see Stacks on page 69). 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 user can also control the speed of the Noggin data collection by adjusting a time delay between data collection points. Note that any time delay more than 0.0 seconds causes the system to emit a beeping sound as the data trace is collected.

4.3.2.2   Noggin Speed In Free Run Mode

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 (see Trigger Method on page 37) 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 uniform speed is important for minimizing image distortion.

4.3.2.3   Positions in Free Run Mode

Each data trace is plotted as a vertical strip on the screen (see Plot Interval on page 42). 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 (see Figure 4-1) are not correct.

When running the system in Free Run mode it is best to set the units (see Units Used on page 36) to metres and the Station Interval (see Station Interval on page 39) to a value of 1.0 metre. Then the position values appearing on the top of the data image can be interpreted as trace numbers and not an absolute position.

4.3.3   Collecting Data using the Trigger (or B) Button

It is possible to change the triggering method from the odometer and have the Noggin system only collect data when the Trigger button (or B button on the DVL) is pressed (see Trigger Method on page 37). This option is useful for collecting data when using the odometer wheel is not practical.

After the user selects this option, a menu appears to select the number of stacks for each trace. Generally, the more stacks the better the data quality (for more details on Stacking, see Stacks on page 69).

In Trigger Button mode, the system "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 Trigger 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 (see Fiducial Markers on page 18) or GPS (see GPS Setup Menu on page 44).

Since data collection only occurs by the user pressing the trigger button, usually a fewer number of traces are collected in this mode compared to odometer triggering mode 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 (see Plot Interval on page 42).

4.3.4   Noggin Data Screens

Total Distance Per Screen

The total distance that can be displayed on one screen varies depending on the Noggin system, Station Interval and Plot Interval (see Figure 4-1). 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.

Noggin 250

For the Noggin 250, each trace is normally 2 pixels wide. Since the screen is 640 pixels wide, each screen has 320 traces. When the station interval is set to Normal (5 centimetres or 1.92 inches), each screen displays 16.0 metres or 51.2 feet of data.

Noggin 500

For the Noggin 500, each trace is normally 1 pixel wide. Since the screen is 640 pixels wide, each screen has 640 traces. When the station interval is set to Normal (2.5 centimetres or 0.96 inches), each screen displays 16.0 metres or 51.2 feet of data.

Noggin 1000

For the Noggin 1000, each trace is normally 1 pixel wide. Since the screen is 640 pixels wide, each screen has 640 traces. When the station interval is set to Normal (1.0 centimetres or 0.48 inches), each screen displays 6.4 metres or 25.6 feet of data.

Total Data Distance on the DVL

The maximum number of screens (or buffers) that can be saved on the Digital Video Logger is 250. When default values are used for Station Interval and Plot Interval, this gives a total survey distance of 4000 metres (2.4 miles) for both the Noggin 250 and Noggin 500. For the Noggin 1000, the total survey distance in 250 screens is 1600 metres (1.2 miles). For more details on total distances and Station Intervals see Section 4.4.13: p.39.

4.3.5   Saving Data

The user has two options for saving data (see Section 4.4.4: p.35):

1)   Do not save data, or
2)   Save up to 250 screens (or buffers) of data and then prompt user to delete data.

When data are saved on the DVL, it acts like a continuous roll chart up to 250 screens long. If there are data that need to be permanently saved, make sure they are transferred to an external computer before they are overwritten (see Section 4.5: p.48).

4.3.6   Deleting Data

The easiest way to delete all the data currently on the DVL is to go to the main menu and press 3 (see Section 4.5.5: P.49).

The user is prompted to delete data when the maximum number of screens (250) has been reached. When this occurs, the user MUST delete 10%, 25%, 50%, 75% or 100% of the screens. Note that when less than 100% of the screens are being deleted, the oldest screens are deleted first.

It is also possible to delete all or some of the current screens of data before 250 have been collected. To do this, stop the system, press the B button and then follow the directions to delete 10%, 25%, 50%, 75% or 100% of the screens. Note that when less than 100% of the screens are being deleted, the oldest screens are deleted first.

4.3.7   Special Buttons During Data Acquisition

4.3.7.1   Fiducial Markers

During data acquisition, the user can press the A button to put a fiducial marker on the data (see Section 4.1.10.4: p.18).

4.3.7.2   Background Subtraction Filter

BEWARE THAT THE BACKGROUND SUBTRACTION PROCESS REMOVES DATA. IT SHOULD ONLY BE TURNED ON WHEN THIS TYPE OF FILTERING IS NECESSARY.

The background subtraction process has the effect of removing flat-lying events in the data and enhancing dipping events (like the response from pipes and other point targets). It can also assist in seeing very shallow targets (< 0.5 meters) that may be masked by the strong signals at the start of the trace.
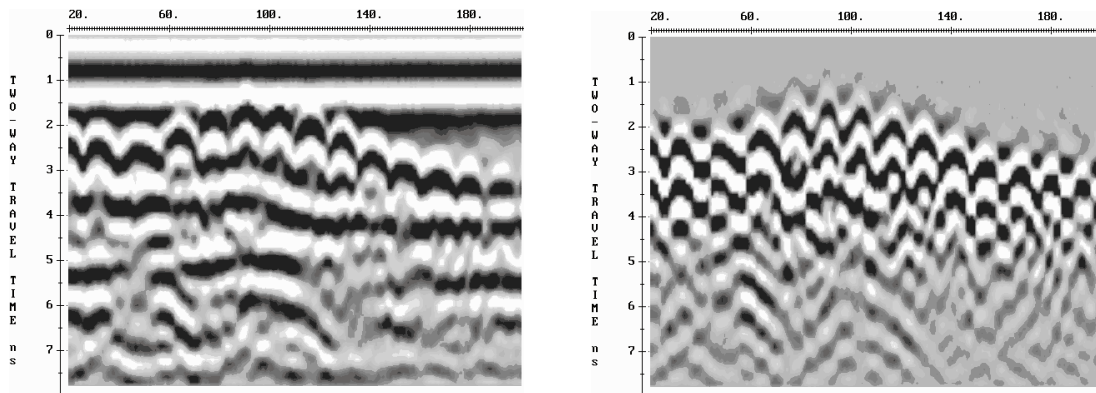
Figure: 4-10 A data section before (top) and after (bottom) background subtraction. This process is effective for emphasizing dipping reflectors like the responses from point targets like pipes.

Pressing the Filter button during data acquisition turns on (or off) the Background Subtraction filter. When it is turned on, the text ON is displayed under the Filter button. Stopping data acquisition turns the Background Subtraction filter off.

4.3.8   Error Messages

If an error occurs, an error message will appear in the bottom left section of the DVL screen. 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 Section 6: P.94.

4.4   Noggin Setup

4.4.1   Editing DVL Settings

Pressing the number 1 on the main menu selects the SETUP item. SETUP lists the settings that can be edited in the Noggin software. Pressing the 1 button (labelled NEXT) moves forward through the list and pressing the 2 button (labelled PREV) moves backward through the list. To select a setting to edit, press the 3 button (labelled SET). Then use the numbered buttons to select the new setting or press the A button to exit without changing the setting. When all the desired changes have been made, press the 8 button (labelled SAVE) to save the new settings and return to the main menu. To discard the edits and return to the previous settings, press the 7 button (labelled QUIT).

4.4.2   Default Settings

It is possible to change all the settings back to the default settings by pressing the 6 button (labelled RESET).

The SETUP options are outlined below.

4.4.3   Time and Date

The date and time are written to the data image every time data are collected. 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.

4.4.4   Save Data Mode

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

1)   No saving of data buffer: If data are not saved, then only data currently on the screen can be seen. As data scrolls off the screen it is gone and cannot be recovered or viewed. In this case the View button will not appear.

2)   Save data - Internal: If this setting is selected, the data are saved to the internal drive in the DVL. After the maximum 250 number of buffers has been reached, the program prompts the user to delete 10%, 25%, 50%, 75% or 100% of the data buffers. The oldest buffers are deleted first.

3)   Save data - Removable: If this setting is selected, the data are saved to the removable drive accessible by opening the door at the top of the DVL. After the maximum 250 number of buffers has been reached, the program prompts the user to delete 10%, 25%, 50%, 75% or 100% of the data buffers. The oldest buffers are deleted first.

4.4.5   Units Used

This is the setting for the position and depth units. The available options are:

1) metres (default)
2) feet
3) metres and time
4) feet and time

Options 3 and 4 mean that position will be displayed in metres or feet and depth will displayed in time (nanoseconds). If time is selected the "depth" lines (Figure 4-1) are actually time lines.

4.4.6   Odometer Markers

This setting determines whether a vertical dashed line is put on the data image each time a position label is written to the screen. The available options are:

1) Place a fid at each label
2) No fids at position labels (default)

4.4.7   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 from the Setup menu, 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) to actually 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 metres and 8 choices in feet. To toggle the units between metres 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 metres or 0.01 to 26400 feet.

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

    1)   Set the system at zero and press A
    2)   Move the system 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.

4.4.8　Cart Direction

This setting determines whether data are collected as the Smart System is pushed forward or pulled in reverse. The back up arrow (see Backing up the System to Pinpoint Target Positions on page 30) will work in the direction opposite to this setting. The available options are:

    1)   Forward (push the cart) (default)
    2)   Reverse (pull the cart)

4.4.9　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)   Trigger with Odometer
    2)   Free Run Operation
    3)   Trigger with Button

Trigger with Odometer: Selecting this option means that the Smart System will be triggered to collect data using the input from the currently selected odometer (see Odometer Number below). See Section 4.3.1: P.29 for more details about data acquisition with an odometer.

Free Run Operation: Selecting this option means that the Smart System runs continuously in time, independent of any other triggering device (see Section 4.3.2: P.31). When continuous operation is selected, two other menus appear to select the number of stacks and time delay between data traces. These options allow the user to control the speed of the data acquisition.

The user can control the speed the Noggin collects data by increasing or decreasing the number of stacks (for more details on Stacking, see Stacks on page 69). 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 second menu to appear 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 any time delay longer than zero (0.0) seconds causes the Smart System to emit a beeping sound to indicate data collection is taking place.

The number of stacks and time delay should be set to values that, when combined with speed the Noggin is moving at, provide an appropriate station interval. This may take a little experimenting to determine the optimal values for stacks, time delay and the actual speed the Noggin is moving at.

Trigger with Button: Selecting this means that the Smart System will be triggered to collect data by pressing the trigger button (if the Smart System has a trigger button) or the B button on the DVL (see Section 4.3.3: P.32).

After the user selects this option, a menu appears to select the number of stacks for each trace (for more details on Stacking, see Section 5.3.1.5: p.69).

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.

4.4.10   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 Section 4.4.7: p.36.

4.4.11   Label Size

This setting determines the size of the position labels across the top of the data image and the depth labels beside the horizontal depth lines. The sizes available are:

1) Small
2) Medium (default)
3) Large
4) Extra Large

4.4.12   Noggin System

The Noggin System should be set to the type of Noggin currently in use on the Smart System. Noggin SmartCarts can be used with the Noggin 250, 500 and 1000 systems.   Noggin SmartHandle systems can be used with the Noggin 500 and 1000 systems.

The systems available are:

      1)   Noggin 250 System
      2)   Noggin 500 System
      3)   Noggin 1000 System

4.4.13   Station Interval

If the Smart System is using an odometer for data collection, 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.

Short
Normal

Long

Figure: 4-11 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 are:

1) Short
2) Normal
3) Long
4) X-Long
5) Normal x 10
6) Normal x 20
7) Normal x 40
8) Normal x 50
9) Normal x 100

Each choice listed will be followed by an actual value in metres 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 and Total Data per 250 Screens assumes that the Plot Interval is set to Normal for the particular Noggin system (Noggin 250 = 2 pixels per trace and Noggin 500 and 1000 = 1 pixel per screen). If these assumptions are not true, see the formulas after the charts for calculating these values.

NOGGIN 250 SYSTEM

Setting	Station Interval	Data per Screen	Total Data for 250 Screens
Short	2.5 cm or 0.96 in	8 m or 25.6 ft	2 km or 1.2 miles
Normal	5.0 cm or 1.92 in	16 m or 51.2 ft	4 km or 2.4 miles
Long	10.0 cm or 3.84 in	32 m or 102.4 ft	8 km or 4.8 miles
X-Long	25.0 cm or 9.6 in	80 m or 256 ft	20 km or 12.1 miles
Norm x10	50.0 cm or 19.20 in	160 m or 512 ft	40 km or 24.2 miles
Norm x20	100.0 cm or 38.4 in	320 m or 1024 ft	80 km or 48.5 miles
Norm x40	200.0 cm or 76.8 in	640 m or 2048 ft	160 km or 97.0 miles
Norm x50	250.0 cm or 96.0 in	800 m or 2560 ft	200 km or 121.2 miles
Norm x100	500.0 cm or 192.0 in	1600 m or 5120 ft	400 km or 242.4 miles

NOGGIN 500 SYSTEM

Setting	Station Interval	Data per Screen	Total Data for 250 Screens
Short	1.0 cm or 0.48 in	6.4 m or 25.6 ft	1.6 km or 1.2 miles
Normal	2.5 cm or 0.96 in	16 m or 51.2 ft	4 km or 2.4 miles
Long	5.0 cm or 1.92 in	32 m or 102.4 ft	8 km or 4.8 miles
X-Long	12.5 cm or 4.8 in	80 m or 256 ft	20 km or 12.1 miles
Norm x10	25 cm or 9.6 in	160 m or 512 ft	40 km or 24.2 miles
Norm x20	50 cm or 19.2 in	320 m or 1024 ft	80 km or 48.5 miles
Norm x40	100 cm or 38.4 in	640 m or 2048 ft	160 km or 97.0 miles
Norm x50	125 cm or 48.0 in	800 m or 2560 ft	200 km or 121.2 miles
Norm x100	250 cm or 96.0 in	1600 m or 5120 ft	400 km or 242.4 miles

NOGGIN 1000 SYSTEM

Setting	Station Interval	Data per Screen	Total Data for 250 Screens
Short	0.5 cm or 0.24 in	3.2 m or 12.8 ft	0.8 km or 0.61 miles
Normal	1.0 cm or 0.48 in	6.4 m or 25.6 ft	1.6 km or 1.2 miles
Long	2.0 cm or 0.96 in	12.8 m or 51.2 ft	3.2 km or 2.4 miles
X-Long	5.0 cm or 2.4 in	32.0 m or 128 ft	8.0 km or 6.1 miles
Norm x10	10 cm or 4.8 in	64.0 m or 256 ft	16.0 km or 12.1 miles
Norm x20	20 cm or 9.6 in	128 m or 512 ft	32.0 km or 24.2 miles
Norm x40	40 cm or 19.2 in	256 m or 1024 ft	64.0 km or 48.5 miles
Norm x50	50 cm or 24.0 in	320 m or 1280 ft	80.0 km or 60.6 miles
Norm x100	100 cm or 48.0 in	640 m or 2560 ft	160 km or 121.2 miles

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

Total Distance Per Screen = Station Interval * (640 / Plot Interval)

where: Station Interval is in metres or feet, and

Plot Interval is in Pixels.

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

0.10 * (640 / 4) = 16.0 metres per screen

The total distance per screen can then be multiplied by 250 to calculate the total distance per 250 screens. For example:

16.0 m * 250 = 4000 metres

4.4.14 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 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 (see Section 4.3.3: P.32) it is often preferable to make each trace 4 or 8 pixels wide.
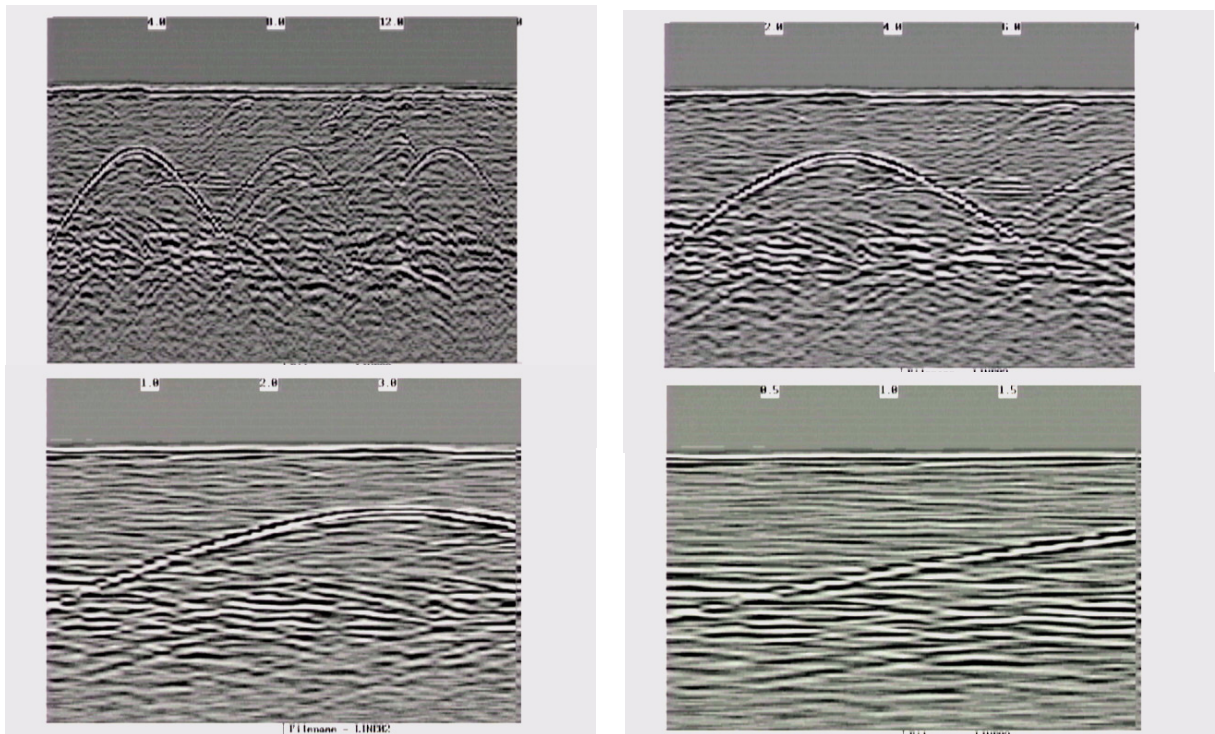
Figure: 4-12 Data traces can be plotted to the screen with a width of 1 pixel (top left), 2 pixels (top right), 4 pixels (bottom left) or 8 pixels (bottom right). The narrower the trace width, the more data that can be plotted on one screen. In this example, plotting the data 1 pixel wide results in 16 metres of data displayed on one screen while 2 pixels results in 8 metres of data, 4 pixels results in 4 metres of data and 8 pixels results in 2 metres of data

4.4.15 Linear Gain

As described in Section 4.2.6: P.27, the weak signals must be amplified or "gained" to see them on the display. The Gain button can be 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 2.5 is usually adequate for most ground conditions, however, if the user finds that they are surveying in areas where high Gain button settings are always required to see data, it may be advantageous to increase the Linear Gain setting. Conversely, if the user finds that low Gain button values work to see the data, it may be useful to decrease the Linear Gain setting.

The choices available for Linear Gain are:

    1)   0.0
    2)   0.5
    3)   1.0
    4)   1.5
    5)   2.0
    6)   2.5 (default)
    7)   3.0
    8)   5.0

4.4.16   Arrow Reference

Section 4.3.1: P.29 describes the Back-up Arrow that appears when a Smart System is backed up. The Back-up Arrow allows the user to pinpoint the exact ground position corresponding to a target response on the data image. The Arrow Reference value is used to change the physical position that corresponds to the Back-up Arrow. If the Arrow Reference value is set to the default value of zero (0.0) metres, the Back-up arrow position corresponds with the center point of the Noggin.

However, the Arrow Reference value can be changed so that the Back-up Arrow corresponds to a position at any offset from the center of the Noggin. For example, setting the Arrow Reference value to +0.25 meters moves the Back-up Arrow to line up with a position 25 centimeters in front of the Noggin centre point (on the Noggin 500 SmartCart this roughly corresponds to the front axle). Setting the Arrow Reference value to -0.25 meters moves the Back-up Arrow to line up with a position 25 centimeters in behind the Noggin centre point (on the Noggin 500 SmartCart this roughly corresponds to the back axle). In this way, the Arrow Reference value can be changed to correspond with any position desired by the user.

One reason the user may want to change the Arrow Reference value is so that the Noggin does not cover the actual target location. This makes it easier to spray paint a mark or put a flag on the ground where the target occurs.

To change the Arrow Reference value, use the Increase and Decrease buttons. The Increase button will increment the value by 0.025 meters or 2.5 centimeters. The Decrease button will decrement the value by 0.025 meters or 2.5 centimeters. Positive values correspond to positions in front of the Noggin and negative values are positions behind the Noggin. Note that the Arrow Reference value is always expressed in metres regardless of the settings of the other units. When the Arrow Reference value has been set, press 4 to save it.

    1)   Increase
    2)   Decrease
    3)   Set to Zero
    4)   Save and Return

4.4.17   Window Zooming

Window Zooming allows the user to double or half all the default depth settings. For example, for the Noggin 250 system, if the Window Zooming is set to the default of 100%, the five Depth settings are: 2.5, 5.0, 7.5, 10.0 and 15.0 metres.

If the Window Zooming option is changed to 50% then the Depth settings are reduced to one half, specifically, 1.25, 2.5, 3.75, 5.0, and 7.5 metres.

Similarly, if the Window Zoom option is set to 200% then the Depth settings are doubled, specifically, 5.0, 10.0, 15.0, 20.0 and 30.0 metres.

This option allows the user to make larger or smaller depth ranges than the default.

The choices available are:

1) 50%
2) 100% (default)
3) 200%

4.4.18   GPS Setup Menu

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. This port will accommodate any GPS receiver that has a standard serial port output.

This feature allows GPS information to be logged while collecting Noggin data. The GPS information may be useful for 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) to display GPS information on the data image every certain number of data traces collected by the Noggin system, or 2) to display GPS information on the data image every time the user presses the A button during data acquisition.

In order 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 (see Figure 4-1).

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) **Display every X traces** mode means that every time the Noggin collects a user-defined number of traces trace of GPR data, a data string of GPS information will be written to the data image.

For example, the data may look like this:
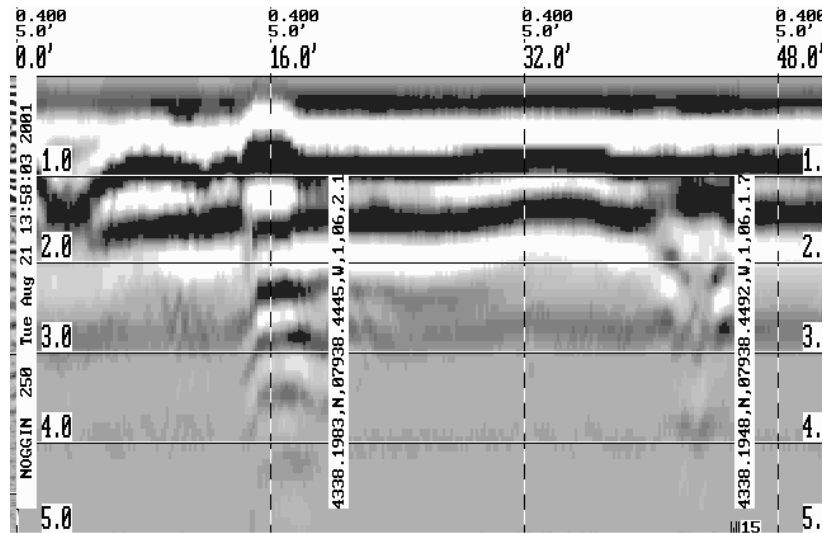
Figure: 4-13 Noggin Data with GPS information written to the screen every 150 traces

When this option is selected, the user is prompted to enter the number of traces to collect before the GPS information is written to the data image.

With a Noggin 250 system, there are 320 traces per screen so using a value of 160 traces would ensure that there are 2 GPS positions on each screen.

With a Noggin 500 and Noggin 1000 system, there are 640 traces per screen so using a value of 320 traces would ensure that there are 2 GPS positions on each screen.

3) **Tagging with the A Button** mode means that whenever the A button is pressed during data acquisition, a data string of GPS information will be written onto the data image.

For example, the data may look like this:
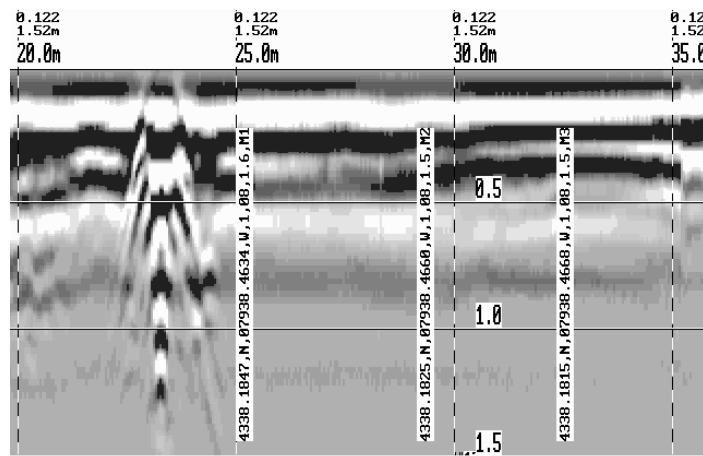
Figure: 4-14 Noggin Data with GPS information written to the screen when the A button is pressed.

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 (default) or 19200.

Stop Bits

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

Data Bits

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

Parity

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

End String

The GPS receiver can be set up to send one or more types of data strings. 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.

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 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 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.

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 metres square to 16384 metres square.

4.4.19   Transfer Rate

Transfer Rate is a variable from 1 to 8 that corresponds to the speed of the data transfer from the Noggin to the DVL. A value of 8 provides the fastest transfer speed while a value of 1 is the slowest.

For standard Smart Systems the Transfer Rate value must be set to 8.

The Transfer Rate value will only be decreased for systems with data cables longer than standard lengths. Please contact Sensors & Software before changing the Transfer Rate on your system.

4.4.20   Reset Counter

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

The Noggin 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 SET button.

4.5   Noggin File Management

4.5.1   Transferring Noggin Data to a PC using the Removable Drive

Files collected with the Noggin system are saved either to the Internal or the Removable drive on the DVL. 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 Noggin data (SPI*.PCX) files to the new folder.

If data were collected to the internal drive of the DVL (Section 4.4.4: p.35), the data can be copied to the removable drive so it can be transferred to a PC (see Section 4.5.2: p.49).

Figure: 4-15 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 Win-PXFER program can then be used to view the Noggin data.

4.5.2 Copying Noggin Data from the Internal Drive to the Removable Drive

If data were collected to the internal drive of the DVL (Section 4.4.4: p.35), the data can be copied to the removable drive so the data transfer method described above can be used. To copy Noggin data from the internal drive to the removable drive, from the Noggin menu select **2 - Transfer All Buffers** and then select **3 - Copy Internal to Removable**.

4.5.3 Transferring Noggin Data to a PC using the Optional PXFER Cable

Files collected with the Noggin system are saved to the Internal or the Removable drive on the DVL. While the method described above, of transferring data by ejecting the removable drive, is the usual method of data transfer, data can also be transferred to a PC using the optional PXFER cable and the WinPXFER program. This process is described in Appendix F Using the PXFER Cable and WinPXFER Software.

4.5.4 Viewing Noggin Data Files using Win_SpiView

Noggin data transferred to a PC can be viewed using the Win_SpiView software.

When you are using the Win_SpiView program the data buffer files (SPIxx.PCX) can be copied to any folder on the PC.

4.5.5 Deleting all Buffer Files on the DVL

Pressing the number 3 on the main menu allows the user to delete ALL the data buffers (up to 250 screens) currently saved on the internal or removable drive in the DVL.

Before the buffers are deleted, the user is asked, "Do you want to delete all the buffers?" To answer YES to this question press the A button. To answer NO to the question press the B button and the buffers are not deleted.

4.6 Transfer Setup

Transfer Setup requires the use of the optional PXFER cable so this menu is **not** required for users transferring Noggin data using the removable compact flash drive. This menu allows the user to set the transfer mode to Normal or Turbo depending on what type of PXFER cable they have (see Appendix F1.2 PXFER Cable Types).

The menu also allows the user to enter Upgrade mode to update the firmware on the DVL. **Upgrade** requires the use of the optional PXFER cable so this menu is **not** required for users who upgrade their DVL firmware using a removable compact flash drive.

Selecting Enter Upgrade Mode puts the DVL into listen mode to allow a software upgrade to be transferred from an external PC to the DVL using the PXFER and WinPXFER cable. Avoid pressing this button until the instructions in a software upgrade tell you to. Once pressed, the DVL must have the power disconnected to exit from this menu item.

4.7   Advanced Topics

4.7.1   How Depth is Determined

Ground penetrating radar systems record the time for a radio wave to travel to a target and back. The depth to that target is calculated based on the velocity at which the wave travels to the target and back. It is calculated as:

D = V x T/2
Where   D is Depth (m)
**   V is Velocity (m/ns)**
**   T is Two-way travel time (ns)**

The wave velocity depends on the properties of the material. The Noggin software allows the user to input different velocities, which changes the total depth range displayed on the screen. The velocities of common materials are:

Material	Velocity (m/ns)	(ft/ns)
Air	0.3	1
Ice	0.17	0.57
Dry Soil	0.15	0.5
Dry Rock	0.12	0.4
Soil	0.1	0.33
Wet Rock	0.1	0.33
Concrete	0.1	0.33
Pavement	0.1	0.33
Wet Soil	0.065	0.22
Water	0.033	0.11

5   Noggin*plus*

5.1   Overview of Noggin*plus* Menu Options

The Noggin*plus* main menu has the following choices:

DATA STORAGE: Removable

A – LINE
B – GRID

1 – NOGGIN PLUS SETUP
2 – FILE MANAGEMENT
3 – RUN WITHOUT SAVING DATA
4 – UTILITIES
5 - SET STORAGE DRIVE
7 – RETURN

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5.1.1   Line

Survey lines collected with the Noggin*plus* are saved as digital data files that can be viewed on the DVL or exported to an external computer for processing and plotting. Sensors & Software programs like EKKO_View, EKKO_Mapper and EKKO_3D are available to process and display the data.

Pressing the A button from the main Noggin*plus* menu takes the user to Line data collection. This menu allows the user to select a project number and line number to save each data file to.

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 line number. These line numbers are usually in sequential order but this is up to the user.

5.1.2   Grid

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

Pressing the B button from the main Noggin*plus* 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 displayed as 3D volumes with the EKKO_3D software or presented as plan maps with the EKKO_Mapper or EKKO_Pointer 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 and line number to save each data file to.

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 (see Section 5.3.4: P.79).

5.1.3   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 different aspects of the Smart system (see Section 5.3: P.67). The user can also reset all the parameters to the factory default settings.

5.1.4   File Management

The file management option allows Line and Grid data to be downloaded from the DVL to an external computer via the parallel XFER cable (see Section 5.4.1: p.90). This option can also be used to delete data from the DVL.

5.1.5   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^{plus} data are not being saved (see Section 5.3.5: P.85).

5.1.6   Utilities

This menu has utility programs to:

        a) Change the Date and Time on the DVL (see Section 5.5.1: P.92)

        b) Calibrate the odometer (see Section 5.5.2: P.92),

        c) Use the optional PXFER cable and the WinPXFER software installed on a PC to transfer upgraded firmware to the DVL (see Section 5.5.3: P.93),

        d) List or print or transfer system information to assist Sensors & Software in troubleshooting problems with your system (see Section 5.5.4: P.93) and

        e) Determine how much space is left on the DVL (see Section 5.5.5: P.93).

        f) For the optional PXFER cable used to transfer data from the DVL to a PC, set the PXFER Transfer Mode to Normal or Turbo (see Section 5.5.6: p.93)

5.1.7   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 compact flash drive 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 (see Section 3: p.10).

5.1.8   Return

This button will return the user to main menu.

5.2   Noggin*plus* Data Acquisition

Selecting the Line, Grid or Run without Saving Data options from the main Noggin*plus* 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 number, file number and press Run before data acquisition begins.

If the Auto Start option is set to ON (see Section 5.3.2.3: p.72 for details) 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 (used to halt acquisition) appears on the right. A Gain button is also visible as well as the current Depth setting and equivalent Time Window length in nanoseconds (see Figure 5-1).

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 sensitivity can be changed on the go (see Section 5.2.6: P.57).

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.

5.2.1   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 the scroll the data to the left and right. As well, during data replay, the data can be enlarged or "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 metres will show the first 2.5 metres of data on the screen.

Any data file that has been collected 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.

5.2.2   Screen Overview

The data acquisition screen is shown in Figure 5-1. It is divided into 3 sections.
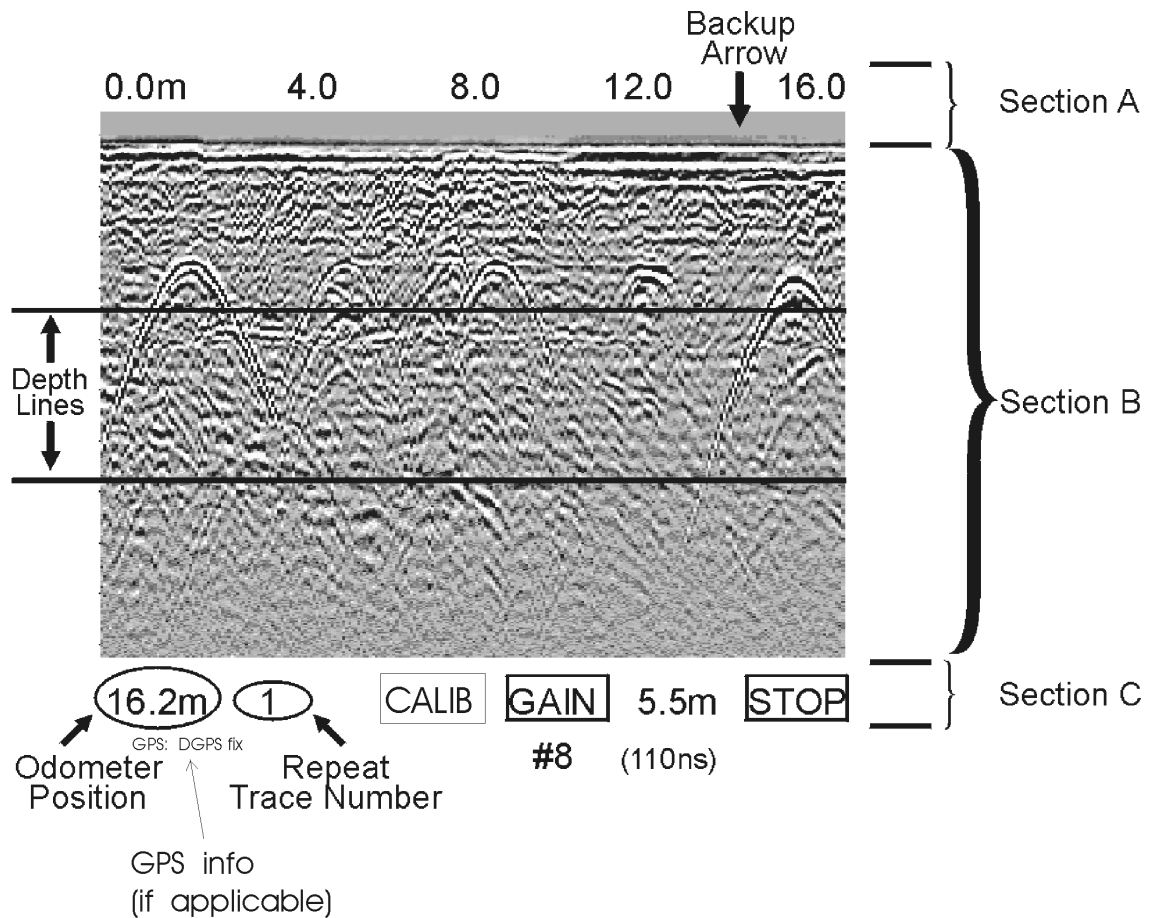
Figure: 5-1 Noggin^{plus} Data Acquisition Screen

The Noggin screen is shown in Figure 5-1. It is divided into 3 sections. The very top section (Section A) positioning information. The center section (Section B) contains the actual data and the bottom section (Section C) contains the menu.

5.2.3   Section A – Position Information

The very top section (Section A) contains horizontal spatial positioning information in feet or metres depending on the position units setting (see Position Units on page 70)

5.2.4   Section B - Data Display

This section contains the actual data collected or replayed. The section also contains the depth indicator lines and any fiducial markers the user enters. See the sections below for more details.

If a GPS receiver is attached to the DVL, a file containing GPS information can be saved (see Section 5.3.5: P.85).

5.2.4.1   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 Depth on page 67 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 Section 5.2.11: P.62 on how to calibrate the system). Once a velocity value has been determined see Velocity on page 68 on how to change the velocity setting.

Note that it is possible to change the depth units between metres and feet (see Position Units on page 70).

5.2.4.2   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 (Section 5.2.7: P.58) 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 Fuducial Tagging mode, whenever a fiducial marker is added to the data, a line of GPS information will be added to the GPS file (see Section 5.3.5: P.85)

5.2.5   Section C - Menu

The bottom section (Section C) contains the user menu selection and current program settings. This includes:

1) The total depth (and time window) to the bottom of the data image in Section B (see Section 5.3.1: P.67),

2) The Gain button and current Gain setting (see Section 5.2.6: P.57),

3) GPS information (if GPS receiver attached, see below and Section 5.3.5: P.85),

4) The current position based on the current triggering device (see Trigger Method on page 71) and Station Interval (see Section 5.3.3.3: p.75),

5) The Repeat Trace Number which indicates when the system is being moved too fast (see Section 5.2.7: P.58) and

6) The Calib button for calibrating the velocity setting (see Section 5.2.11: P.62).

If a GPS receiver is attached to the DVL (see Section 5.3.5: P.85) 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 (see Section 5.3.5: P.85).

5) **GPS: No GGA** means the GPS receiver is not outputting a GGA NMEA string that the DVL requires (see Section 5.3.5: P.85).

5.2.6   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 metres) 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 5-2 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.
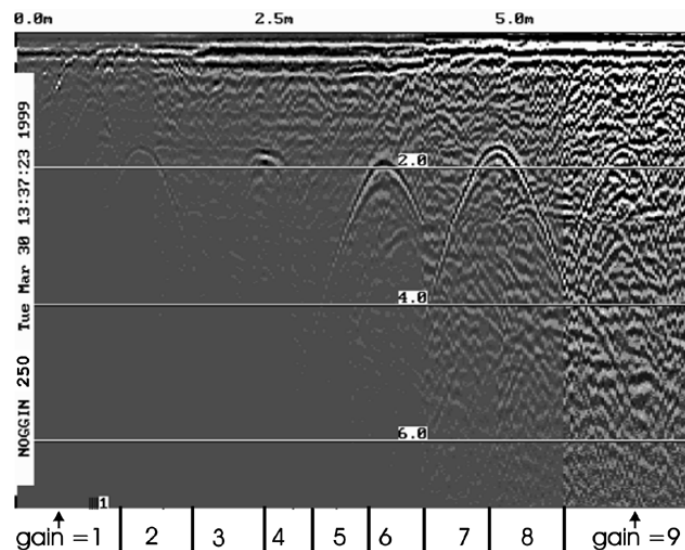
Figure: 5-2 Effects of the Gain setting

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*plus* 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 under Setup (see Linear Time Gain on page 70).

5.2.7   Collecting Data using the Odometer

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". For the Noggin 250, the normal station interval is 5 centimeters (about 2 inches). For the Noggin 500, the normal station interval is 2.5 centimeters (about 1 inch). For the Noggin 1000, the normal station interval is 1.0 centimeter (about 0.48 inch). The station interval can be changed to a longer or short distance in the Setup (see Station Interval on page 75).

Each data trace is plotted as a vertical strip on the screen (see Figure 5-1). The width of this strip can be changed to 1, 2, 4, or 8 pixels (see Plot Interval on page 78). The normal trace width for Noggin 250 traces is 2 pixels while the normal width for Noggin 500 and Noggin 1000 systems is 1 pixel.

The odometer units that appear across the top of the screen can be set to either metres or feet (see Depth Units on page 68).

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

During data acquisition, the current odometer position value (in the current units, either metres or feet) is written to the lower left corner of the screen (see Figure 5-1).

Note that Smart systems can be configured to collect data either by pushing the system (forward) or pulling the system (reverse). See Cart Direction on page 71 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 Section 5.5.2: P.92.

5.2.7.1   Reducing Data Quality by Moving too Fast

On the lower part of the data acquisition screen, beside the current odometer position value is a single digit number that usually displays one (1) (see Figure 5-1). This value is the Repeat Trace number.

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 Repeat Trace number displays the number of traces that are being plotted to the screen. If this number exceeds 1 or if the user notices the data looking smeared or "blocky", this is probably due to moving the system too quickly. To eliminate this either slow down the system speed, decrease the number of Stacks or reduce the Depth setting (see Section 5.3.1: P.67).

If the system is being moved too fast, after the data survey line is complete, the DVL will indicate the total number of traces that 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".

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 or reduce the Depth setting (see Section 5.3.1: P.67).

5.2.7.2   Backing up the Smart System 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 (see Figure 5-1). 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 centre 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 centre of the Noggin. This position can be changed from the centre of the Noggin to any other position. See Arrow Offset on page 72 on changing the Arrow Offset value.

5.2.8   Collecting Data in Free Run Mode

It is possible to change the triggering method from the odometer and have the Noggin system run in Free Run (or continuous mode) (see Trigger Method on page 71). 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.

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 (see Fiducial Markers on page 56) or GPS (see Section 5.3.5: P.85).

In this 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.

5.2.8.1   Controlling Data Collection Speed in Free Run Mode

In Free Run mode the user can control the speed the Noggin collects data by increasing or decreasing the number of stacks (for more details on Stacking, see Stacks on page 69). 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 Noggin system. The user can also control the speed of the Noggin data collection by adjusting a time delay between data collection points. Note that any time delay more than 0.0 seconds causes the system to emit a beeping sound as the data trace is collected.

5.2.8.2   Noggin Speed in Free Run Mode

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 (see Trigger Method on page 71) 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 uniform speed is important for minimizing image distortion.

5.2.8.3   Positions in Free Run Mode

Each data trace is plotted as a vertical strip on the screen (see Plot Interval on page 78). 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 (see Section 5.2.3: P.55) are not correct.

When running the system in Free Run mode it is best to set the units (see Position Units on page 70) to metres and the Station Interval (see Section 5.3.3.3: p.75) to a value of 1.0 metre. Then the position values appearing on the top of the data image can be interpreted as trace numbers and not an absolute position.

5.2.9   Collecting Data using the Trigger (or B) Button

It is possible to change the triggering method from the odometer and have the Noggin system only collect data when the Trigger button (or B button on the DVL) is pressed (see Section 5.2.9: P.60). This option is useful for collecting data when using the odometer wheel is not practical.

After the user selects this option (see Trigger Method on page 71), a menu appears to select the number of stacks for each trace. Generally, the more stacks the better the data quality (for more details on Stacking, see Stacks on page 69).

In Trigger Button mode, the system "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 Trigger 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 (see Fiducial Markers on page 56) or GPS (see Section 5.3.5: P.85).

Since data collection only occurs by the user pressing the trigger button, usually a fewer number of traces are collected in this mode compared to odometer triggering mode 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 (see Plot Interval on page 78).

5.2.10   Noggin*plus* Data Screens

Total Distance Per Screen

The total distance that can be displayed on one screen varies depending on the Noggin system, Station Interval and Plot Interval (see Section 5.3.3.4: p.78). 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.

Noggin 250

For the Noggin 250, each trace is normally 2 pixels wide. Since the screen is 640 pixels wide, each screen has 320 traces. When the station interval is set to Normal (5 centimetres or 1.92 inches), each screen displays 16.0 metres or 51.2 feet of data.

Noggin 500

For the Noggin 500, each trace is normally 1 pixel wide. Since the screen is 640 pixels wide, each screen has 640 traces. When the station interval is set to Normal (2.5 centimetres or 0.96 inches), each screen displays 16.0 metres or 51.2 feet of data.

Noggin 1000

For the Noggin 1000, each trace is normally 1 pixel wide. Since the screen is 640 pixels wide, each screen has 640 traces. When the station interval is set to Normal (1.0 centimetres or 0.48 inches), each screen displays 6.4 metres or 25.6 feet of data.

Total Data Distance on the DVL

For more details on total distances and Station Intervals see Section 5.3.3.3: p.75.

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 Section 5.5.5: P.93.

5.2.11   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 (see Section 5.3.1: P.67) and on Depth Lines (see Section 5.2.4: P.55) are only accurate if the system has been properly calibrated to determine the velocity of the material being scanned. See Depth on page 67 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 (see Section 5.3.1.2: p.68) or determined in one of two different ways depending on the situation:

1) Hyperbola matching

2) Target of known depth

Note that unlike the Calibration with Noggin systems (see Section 5.2.11: P.62), the Noggin^{plus} Calibration does NOT automatically update the velocity value in the software. In the Noggin^{plus} calibration, once a velocity is determined, the user must enter it into the System Parameters (see Velocity on page 68).

5.2.11.1 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: 5-3 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 (⌒) button.   This will superimpose a hyperbola on the data. This hyperbola can be moved up (▲), down (▼), left (◀) and right (▶) using the appropriate arrow buttons. The goal is move the hyperbola until it lies on top of the hyperbola in the data (see Figure 5-4). Then, the user can adjust the width of the hyperbola to make it wider (◀ ▶) or narrower (▶ ◀) 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 (see Velocity on page 68).

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 (▲) 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 (◀ ▶) or narrower (▶ ◀) button.

| (a) | (b) |

Figure: 5-4 Hyperbola matching to extract velocity. After pressing the CALIB button 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.

In Noggin^plus mode, hyperbola Matching calibration can be done during data acquisition and also while viewing previously collected data.

If units are metres then depths will appear in metres and velocities in metres 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 Depth Units on page 68.

5.2.11.2 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 ~ 0.1 m/ns or 0.328 ft/ns).
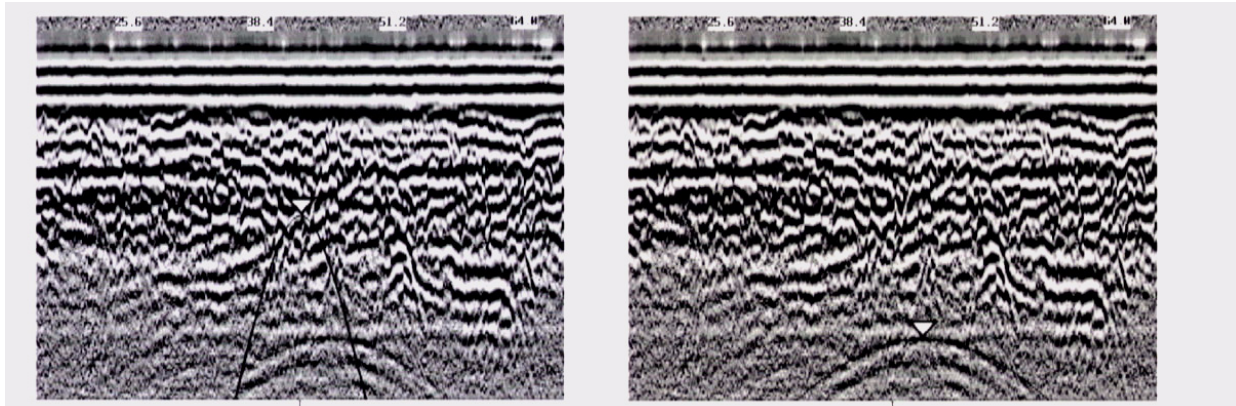
Figure: 5-5 Hyperbola matching can be used to identify reflections from objects that are not in the subsurface but are from objects above ground. If the hyperbola matching velocity is near the speed of light (0.3 m/ns or 0.984 ft/ns) then the hyperbola was caused by surface object like a overhead wire, 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.

5.2.11.3 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.

(a)   **(b)**
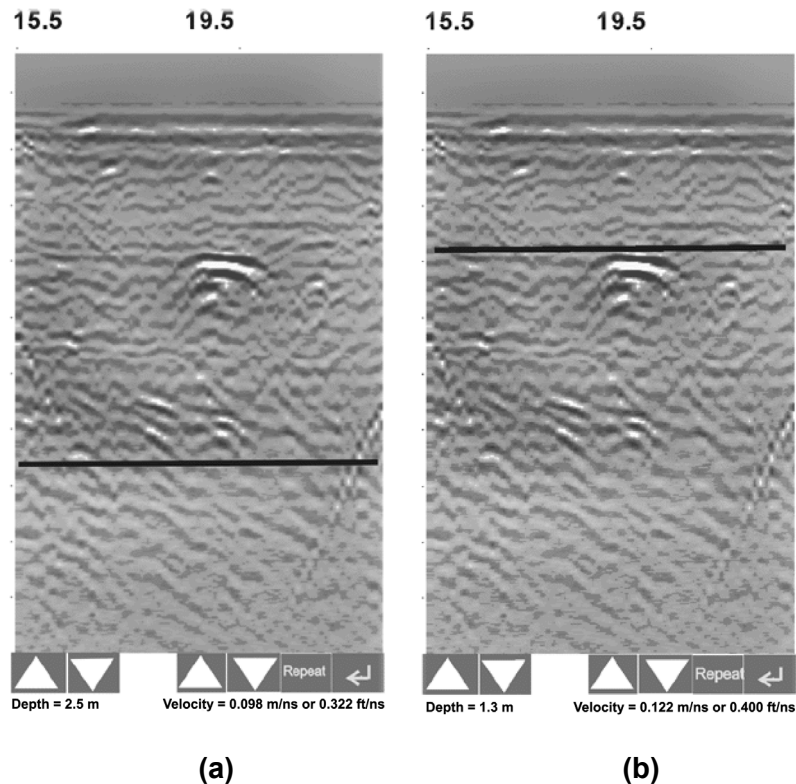
Figure: 5-6 Using a target of known depth to extract velocity. After selecting CALIB, choosing the known depth button (a circle with a horizontal line through it) will superimpose a horizontal line on the data (a). Using the depth buttons, this line can then be moved up or down until it lies on top of 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 metres then depths will appear in metres and velocities in metres 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 Depth Units on page 68.

5.2.12 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 Section 6: P.94.

5.3   Noggin*plus* 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:

<div align="center">

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

</div>

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.

5.3.1   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.

5.3.1.1   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:

<div align="center">

D = V x T/2

</div>

Where   D is Depth (m)
                  V is Velocity (m/ns)
                  T is Two-way travel time (ns)

The Depth units can be changed to metres, feet or time in nanoseconds. For details, see Depth Units below in this section.

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 metres but the material penetration is only 3 metres the last 2 metres 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.

5.3.1.2 Velocity

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

See Section 5.2.11: P.62 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 metres then velocities will appear in metres per nanosecond (m/ns). If units are feet then velocities will appear in feet per nanosecond (ft/ns). To change units see Depth Units on page 68.

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

5.3.1.3 Depth Units

This is the setting for the units of the horizontal depth lines that appear on the screen. The available settings are metres, feet or nanoseconds (ns). If nanoseconds are selected the "depth" lines (see Section 5.2.2: P.55) are actually time lines.

1) metres
2) feet
3) nanoseconds

5.3.1.4 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 250
2) Noggin 500
3) Noggin 1000

5.3.1.5   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".
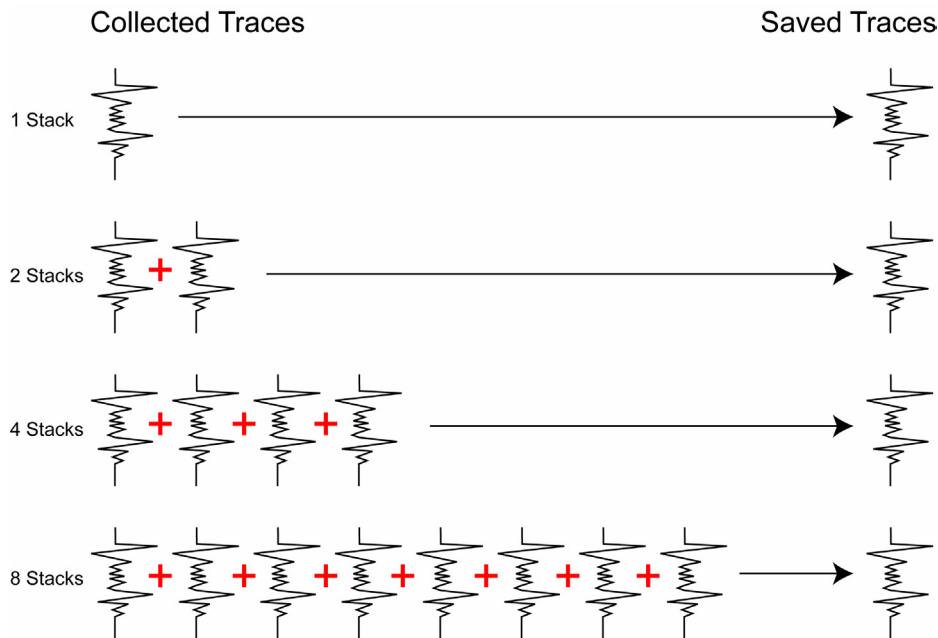
Figure: 5-7 The concept of stacking data. At each data location point, the trace is collected multiple times. These traces are averaged together to calculate the trace that is actually saved. Stacking improves the data quality by increasing the signal to noise ratio.

The amount of Stacking can vary from 1 to 2048 by factors of 2.

While stacking improves data quality, it also forces the user to 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 lowest number of stacks that still reveal the target adequately. For most surveys, stacking 4 times is suitable.

See the warning in Section 5.2.7: P.58 about losing data if the Smart System is moving too quickly for the Noggin system to keep up.

5.3.1.6   Linear Time Gain

As described in Section 5.2.6: P.57, the weak signals must be amplified or "gained" to see them on the display. The Gain button described in Section 5.2.6: P.57 can be 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 2.0 is usually adequate for most ground conditions, however, if advanced users find that they are surveying in areas where high Gain button settings are always required to see data, it may be advantageous to increase the Linear Gain setting. Conversely, if the user finds that low Gain button values work to see the data, it may be useful to decrease 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.

5.3.1.7   Position Units

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

> 1) metres (default)
> 2) feet

5.3.2   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.

5.3.2.1   Cart Direction

This setting determines whether data are collected as the Noggin is pushed forward or pulled in reverse. The back up arrow (see Section 5.2.7: P.58) will work in the direction opposite to this setting. The available options are:

> 1) Push (default)
> 2) Pull

5.3.2.2   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

Trigger with Odometer: Selecting this option means that the Smart System will be triggered to collect data using the input from the currently selected odometer (see Odometer Number below). See Section 5.2.7: P.58 for more details about data acquisition with an odometer.

Free Run Operation: Selecting this option means that the Smart System runs continuously in time, independent of any other triggering device (see Section 5.2.8: P.59). When continuous operation is selected, two other menus appear to select the number of stacks and time delay between data traces. These options allow the user to control the speed of the data acquisition.

The user can control the speed the Noggin collects data by increasing or decreasing the number of stacks (for more details on Stacking, see Stacks on page 69). 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 second menu to appear 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 any time delay longer than zero (0.0) seconds causes the Smart System to emit a beeping sound to indicate data collection is taking place.

The number of stacks and time delay should be set to values that, when combined with speed the Noggin is moving at, provide an appropriate station interval.   This may take a little experimenting to determine the optimal values for stacks, time delay and the actual speed the Noggin is moving at.

Trigger with Button: Selecting this means that the Smart System will be triggered to collect data by pressing the trigger button (if the Smart System has a trigger button) or the B button on the DVL (see Section 5.2.9: P.60).

After the user selects this option, a menu appears to select the number of stacks for each trace (for more details on Stacking, see Stacks on page 69).

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.

5.3.2.3   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.

5.3.2.4   Arrow Offset

Section 5.2.7: P.58 describes the Back-up Arrow that appears when the Smart System is backed up. The Back-up Arrow allows the user to pinpoint the exact ground position corresponding to a target response on the data image. The Arrow Offset value is used to change the physical position that corresponds to the Back-up Arrow. If the Arrow Reference value is set to the default value of zero (0.0) metres, the Back-up arrow position corresponds with the centre point of the Noggin.

However, the Arrow Offset value can be changed so that the Back-up Arrow corresponds to a position at any offset from the centre of the Noggin. For example, setting the Arrow Offset value to +0.25 metres moves the Back-up Arrow to line up with a position 25 centimetres in front of the Noggin centre point (on the Noggin 500 SmartCart this roughly corresponds to the front axle). Setting the Arrow Reference value to -0.25 metres moves the Back-up Arrow to line up with a position 25 centimetres in behind the Noggin centre point (on the Noggin 500 SmartCart this roughly corresponds to the back axle). In this way, the Arrow Offset value can be changed to correspond with any position desired by the user.

One reason the user may want to change the Arrow Offset value is to ensure that the Noggin does not cover the actual target location. This makes it easier to spray paint a mark or put a flag on the ground where the target occurs.

Positive values correspond to positions in front of the Noggin and negative values are positions behind the Noggin. Note that the Arrow Offset value is always expressed in metres regardless of the settings of the other units.

5.3.2.5   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.

5.3.2.6   Transfer Rate

Transfer Rate is a variable from 1 to 8 that corresponds to the speed of the data transfer from the Noggin to the DVL. A value of 8 provides the fastest transfer speed while a value of 1 is the slowest.

For standard Smart Systems the Transfer Rate value must be set to 8.

The Transfer Rate value will only be decreased for systems with data cables longer than standard lengths. Please contact Sensors & Software before changing the Transfer Rate on your system.

5.3.2.7   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 Section 5.5.2: P.92.

5.3.3   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.

5.3.3.1   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.

5.3.3.2   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 stepsize 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 stepsize 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 ….

5.3.3.3   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.

Short

Normal

Long

Figure: 5-8 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 are:

1) Short
2) Normal
3) Long
4) X-Long
5) 10x Normal
6) 20x Normal
7) 40x Normal
8) 50x Normal
9) 100x Normal

Each choice listed will be followed by an actual value in metres 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 250 = 2 pixels per trace and Noggin 500 and 1000 = 1 pixel per screen). If this assumption is not true, see the formula after the charts for calculating this value.

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:

Total Distance Per Screen = Station Interval * (640 / Plot Interval)

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

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

        0.10 * (640 / 4) = 16.0 metres 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 Section 5.5.5: P.93.

To delete Noggin^{plus} data see Section 5.4.5: P.91.

5.3.3.4   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 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 (see Section 5.2.9: P.60) it is often preferable to make each trace 4 or 8 pixels wide.
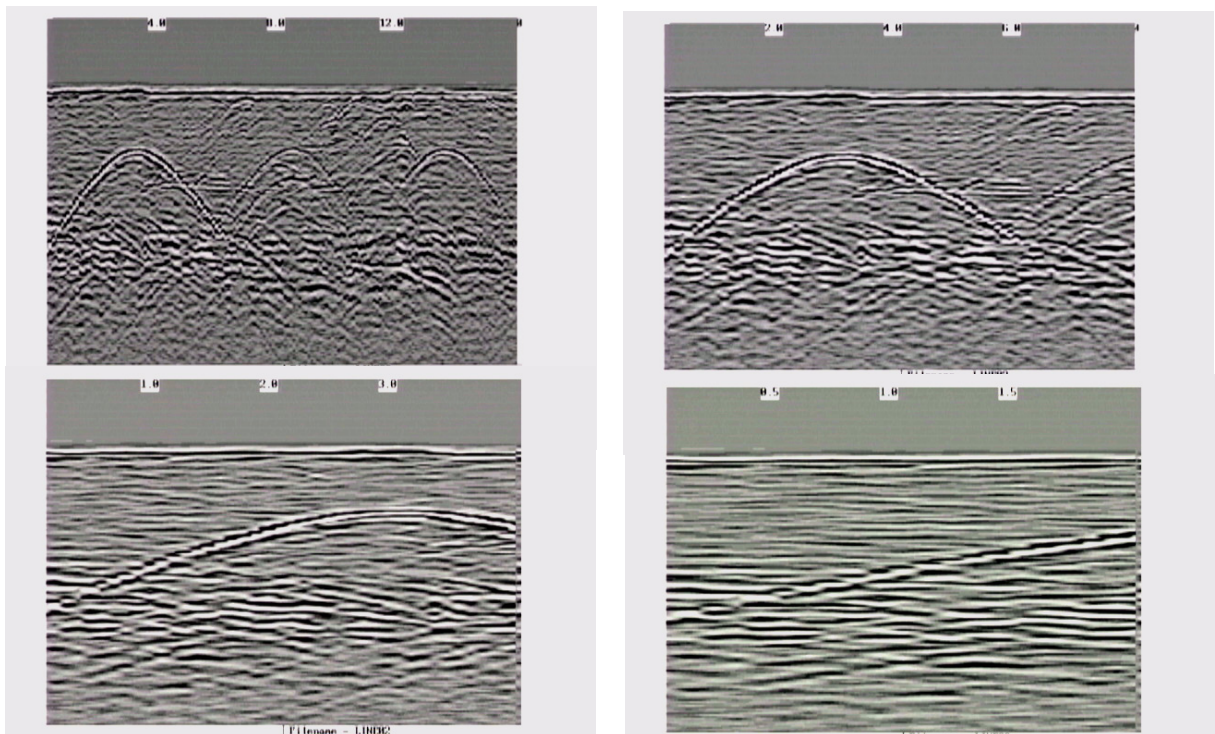
Figure: 5-9 Data traces can be plotted to the screen with a width of 1 pixel (top left), 2 pixels (top right), 4 pixels (bottom left) or 8 pixels (bottom right). The narrower the trace width, the more data that can be plotted on one screen. In this example, plotting the data 1 pixel wide results in 16 metres of data displayed on one screen while 2 pixels results in 8 metres of data, 4 pixels results in 4 metres of data and 8 pixels results in 2 metres of data

Note that the Plot Interval in Noggin*plus* 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.

5.3.4   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_3D software) or as a plan map (using the EKKO_Mapper and/or EKKO_Pointer 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.

5.3.4.1   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 5-10), a set of parallel lines in the Y axis direction (Figure 5-11), or, for complete coverage, parallel lines in both the X and Y direction (Figure 5-12).

X Lines Only - Forward

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 5-10). 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)).
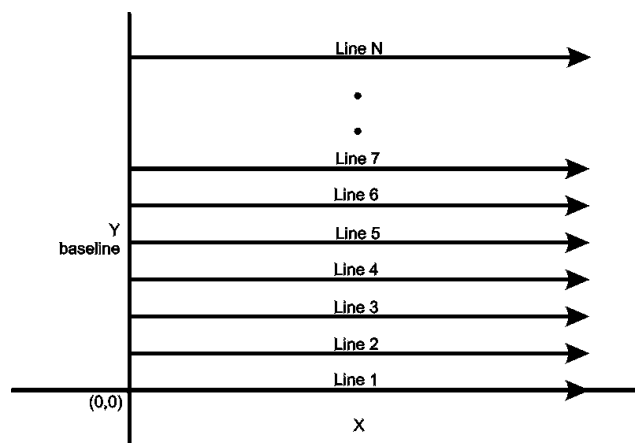
Figure: 5-10 Proper X Line surveying pattern. Following this pattern and starting each line from the same baseline minimizes the data editing required to produce a spatially accurate map of GPR data.

Y Lines Only - Forward

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 5-11). 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: 5-11 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 - Forward

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 5-12). 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)).
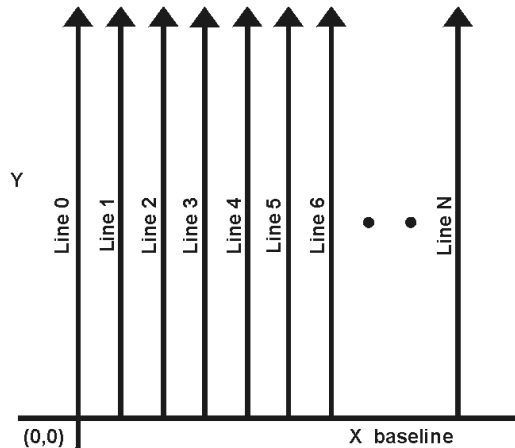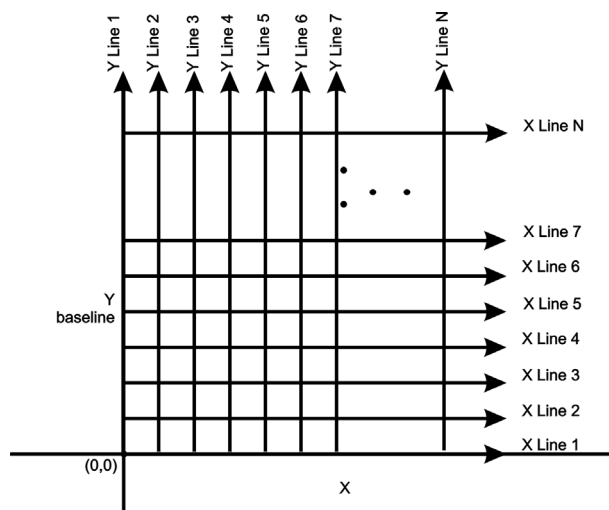

Figure: 5-12 Proper XY grid surveying pattern. Following this pattern and starting each line from the same baseline minimizes the data editing required to produce a spatially accurate map of GPR data.

5.3.4.2   Survey Format

The Survey Format specifies how the lines will be collected. The lines shown in Figure 5-10, Figure 5-11, and Figure 5-12 are all collected in the Forward direction only. This means that each line starts at the X or Y baseline.

When the length of the survey lines are more than about 20 metres, data acquisition speed may be increased by collecting every second line in the reverse direction (Figure 5-13, Figure 5-14, and Figure 5-15). 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 (Section 5.5.2: P.92), the Grid Dimensions are correct (see Grid Dimensions on page 83) and that lines are always collected starting on a baseline.

X Lines Only – Forward and Reverse

Using the Forward and Reverse survey format, X line data are collected in the pattern shown in Figure 5-13.
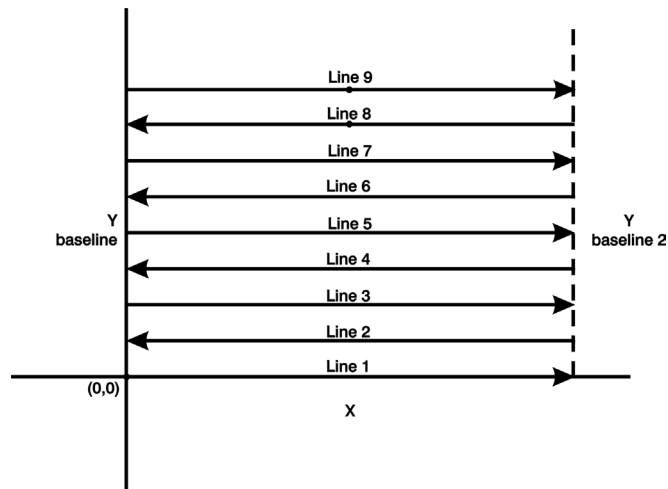
Figure: 5-13 For collecting GPR data consisting of long data lines it makes more sense to follow a forward and reverse surveying pattern. For the final data to be spatially correct with a minimum of editing, data collected in this pattern should be on lines that extend completely from one baseline to the other.

Y Lines Only – Forward and Reverse

Using the Forward and Reverse survey format, Y line data are collected in the pattern shown in Figure 5-14.

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.
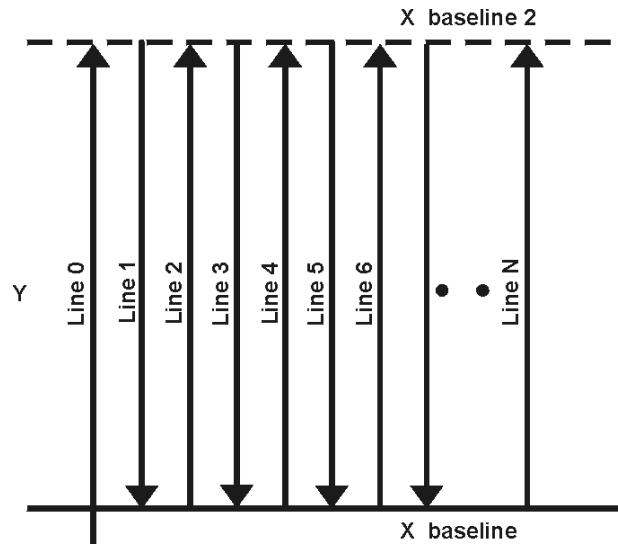
Figure: 5-14 For collecting GPR data consisting of long data lines it makes more sense to follow a forward and reverse surveying pattern. For the final data to be spatially correct with a minimum of editing, data collected in this pattern should be on lines that extend completely from one baseline to the other.

XY Lines – Forward and Reverse

Using the Forward and Reverse survey format, XY line data are collected in the pattern shown in Figure 5-15.

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.

Figure: 5-15 For collecting GPR data on a grid 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.
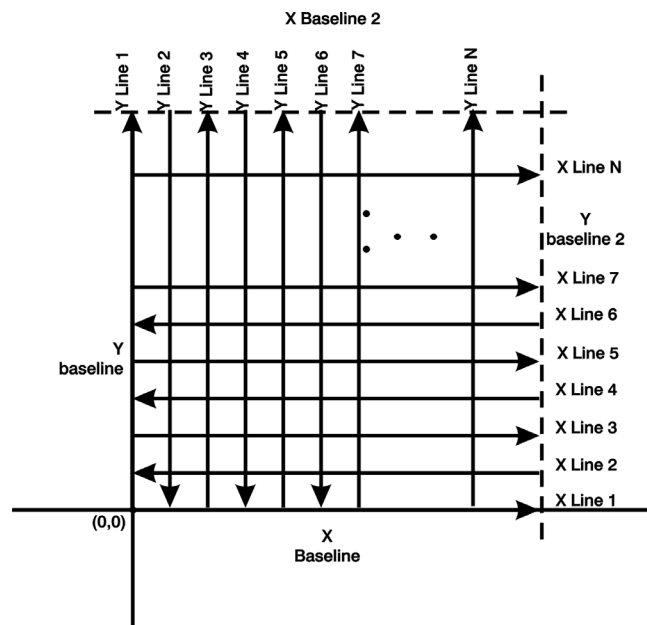
5.3.4.3   Grid Dimensions

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 (see Section 5.3.1.7: P.70), i.e. metres 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 metres, the grid dimension in the X direction will increment or decrement in 0.5 metre 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 metres, the maximum X dimension is (100-1) X 0.25 = 24.75 metres. (One is subtracted because the first line is at position 0.0 metres.)

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 metres then the maximum X dimension is (100-1) X 0.30 = 29.70 metres.

If the Grid Type is set to X Lines only or Y Lines only (see Section 5.3.4: P.79), 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.

5.3.4.4   Line Spacing

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

If the grid type is X Lines only (see Section 5.3.4: P.79) then the spacing between the X lines needs to be input.

If the grid type is Y Lines only (see Section 5.3.4: P.79) then the spacing between the Y lines needs to be input.

If the grid type is XY Lines (see Section 5.3.4: P.79) 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 250 should have a line spacing of 0.5 metres or less, the Noggin 500 should have a line spacing of 0.25 metres or less and the Noggin 1000 should have a line spacing of 0.10 metres 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.

5.3.5   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. 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^{plus} data, **the GPS must be sending at least one of the following NMEA strings: GPGGA, GPGLL and GPRMC.**

This feature allows GPS information to be logged while collecting Noggin^{plus} data. The GPS information may be useful for mapping where GPR surveys have been performed (see Reading per Trace mode below) or determining where a specific target of interest is located in GPS co-ordinates (see Fiducial Tagging mode below).

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

1) For every trace collected by the Noggin^{plus} system, or

2) Every time the user adds a fiducial to the data by pressing the A button (see Fiducial Markers on page 56).

This feature provides a means of logging GPS information to an independent file. **Note that the GPS information is NOT automatically integrated with the Noggin^{plus} data.** After data acquisition is complete, the data can be downloaded to a PC and the EKKO_View Deluxe software can be used to integrate the GPS data with the Noggin^{plus} data.

In order 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 (see Section 5.2.4: P.55).

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*plus* 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 (see Section 5.4.1: p.90).

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 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) **Fuducial Tagging** mode means that whenever a fiducial marker (F1, F2 etc.) is added to the data (see Section 5.2.4: P.55), 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 (see Section 5.4.1: p.90).

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*plus* is Run Without Saving Data (see Section 5.1.5: P.52), it is still possible to log GPS data strings. Every time a fiducial marker is added to the data (see Section 5.2.4: P.55), a data string of GPS information is added to a file. This file is called TAGGED.GPS and can be exported and/or deleted using the Noggin*plus* File Management (see Section 5.4: P.90).

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 slows down data acquisition speeds.

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 (default) or 19200.

Stop Bits

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

Data Bits

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

Parity

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

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*plus*, 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.

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 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 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.

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 metres square to 16384 metres square.

5.3.6   Set Defaults

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

5.4   Noggin*plus* File Management

The File Management option is available by pressing 2 from the main Noggin*plus* menu.

The File Management menu allows the user to delete data from the DVL and copy data from the internal compact flash drive to the removable compact flash drive.

The **Export** options in this menu require the use of the optional PXFER cable and WinPXFER software so this menu is **not** required for users transferring Noggin*plus* data using the removable compact flash drive. These options allow the user to export Noggin*plus* data or the TAGGED.GPS file (see Section 5.3.5: P.85) to a PC using the optional PXFER cable. This is described in Appendix F1.

5.4.1   Transferring Noggin Data to a PC using the Removable Drive

Files collected with the Noggin system are saved either to the Internal or the Removable drive on the DVL. 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 Noggin*plus* data files to the new folder.

If data were collected to the internal drive of the DVL (Section 5.1.7: p.53), the data can be copied to the removable drive so it can be transferred to a PC (see Section 5.4.2: p.91).
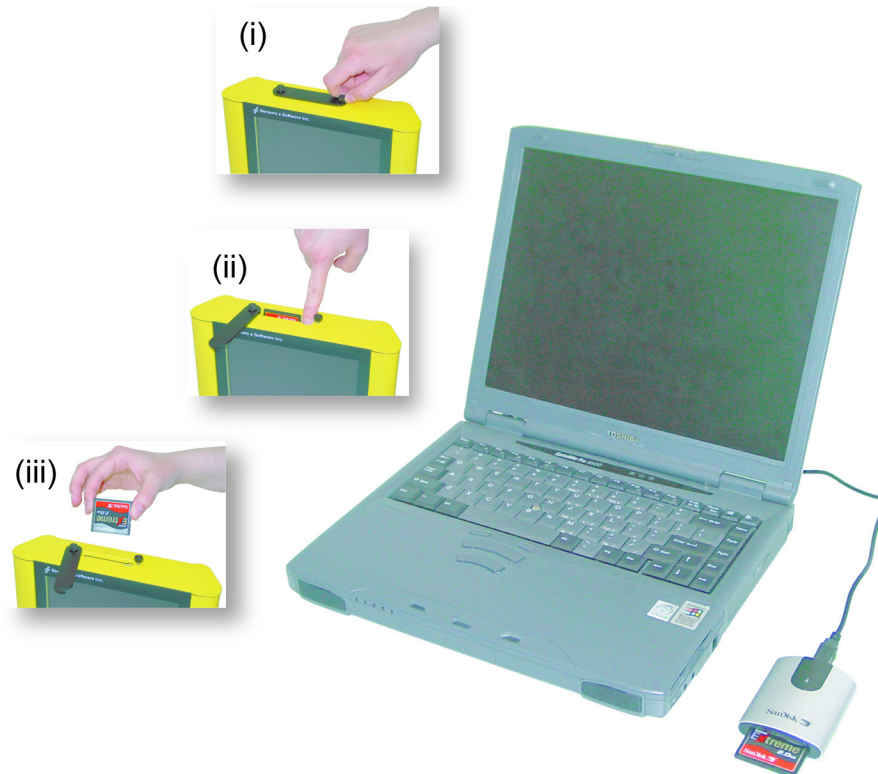
Figure: 5-16 Noggin data files saved to the removable drive are easily transferred to a PC. First, power down the DVL, then (i) loosen both of the finger-screws on the top of the DVL so the drive door can swing open freely. (ii) Press the button to partially eject the compact flash drive. (iii) Remove 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 WinPXFER program can then be used to view the Noggin data.

5.4.2   Copying Noggin*plus* Data from the Internal Drive to the Removable Drive

If data were collected to the internal drive of the DVL (Section 5.1.7: p.53), the data can be copied to the removable drive so the data transfer method described above can be used. To copy Noggin data from the internal drive to the removable drive, from the Noggin*plus* menu select **2 - File Management** and then select **7 - Copy Internal to Removable**.

5.4.3   Transferring Noggin*plus* Data to a PC using the PXFER Cable

Files collected with the Noggin*plus* system are saved to the Internal or the Removable drive on the DVL. While the method described above, of transferring data by ejecting the removable drive, is the usual method of data transfer, data can also be transferred to a PC using the optional PXFER cable and the WinPXFER program. This process is described in Appendix F Using the PXFER Cable and WinPXFER Software.

5.4.4   Viewing Data Files on the External Computer

After transferring data files to the external computer the Noggin*plus* data files can be viewed, processed and plotted using the EKKO_View, EKKO_3D and EKKO_Mapper software.

Appendix A Noggin plus Data file Format contains details about the file format of Noggin*plus* data.

5.4.5   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 or Grid project can be deleted from 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.

It is also possible to use the TAG button to select several projects and delete them all at once. Use the up and down arrows to highlight the projects, the TAG button to tag each project and then press the DEL button to delete the data from the DVL.

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.

5.5   Noggin*plus* 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.

5.5.1   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.

5.5.2   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) to actually 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 metres and 8 choices in feet. To toggle the units between metres 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 metres 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.

5.5.3   Upgrade

Upgrade requires the use of the optional PXFER cable so this menu is **not** required for users who upgrade their DVL firmware using a removable compact flash drive.

The menu allows the user to enter Upgrade mode to update the firmware on the DVL. Selecting Upgrade puts the DVL into listen mode to allow a software upgrade to be transferred from an external PC to the DVL using the PXFER and WinPXFER cable. Avoid pressing this button until the instructions in a software upgrade tell you to. Once pressed, the DVL must have the power disconnected to exit from this menu item.

5.5.4   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 (see Section 5.4.1: p.90) 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.

5.5.5   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.

5.5.6   Transfer Mode

Transfer Mode requires the use of the optional PXFER cable so this menu is **not** required for users transferring Noggin^{plus} data using the removable compact flash drive. This menu allows the user to set the transfer mode to Normal or Turbo depending on what type of PXFER cable they have (see Appendix F1.2 PXFER Cable Types).

6   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.

6.1   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.

6.2   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 (see Section 6.6: P.96).

6.3   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 (see Section 6.6: P.96).

6.4   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. (see Section 6.6: P.96).

6.5   Noggin Problem

When the Smart System is powered up and the user selects data acquisition in Noggin or Noggin*plus* mode, the Noggin system goes through a self-calibration sequence. While the self-calibration is occurring the user sees the words "Booting Noggin" in the lower left corner of the DVL screen. These words are followed by a number that counts up from 1. Normally, once the count reaches 6 the text disappears and the Noggin is ready to collect data. Sometimes, however, this count goes beyond 6 and keeps going without stopping. This indicates an internal problem with the Noggin. No error message will be displayed on the screen and the only way to exit from the screen is to pull out the power connection.

If this error occurs, power the system down, power it up again and retry data acquisition. If the error persists, contact Sensors & Software Inc. (see Section 6.7: P.96).

6.6   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.

6.7   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:

<div align="center">

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

</div>

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 Section 5.5.4: P.93 on how to view, print and download this file.

7   Care and Maintenance

7.1   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 15 Amp-hour battery. The battery unit should run the Cart Noggin for 6-8 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.

7.2   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 Section 4.4.1: P.35 or Section 5.5.1: P.92.

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

7.3   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.

7.4 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: 7-1 Noggin with optional curved skid pad.

7.5   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.

7.6   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*plus* Data file Format

Noggin*plus* 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
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 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.
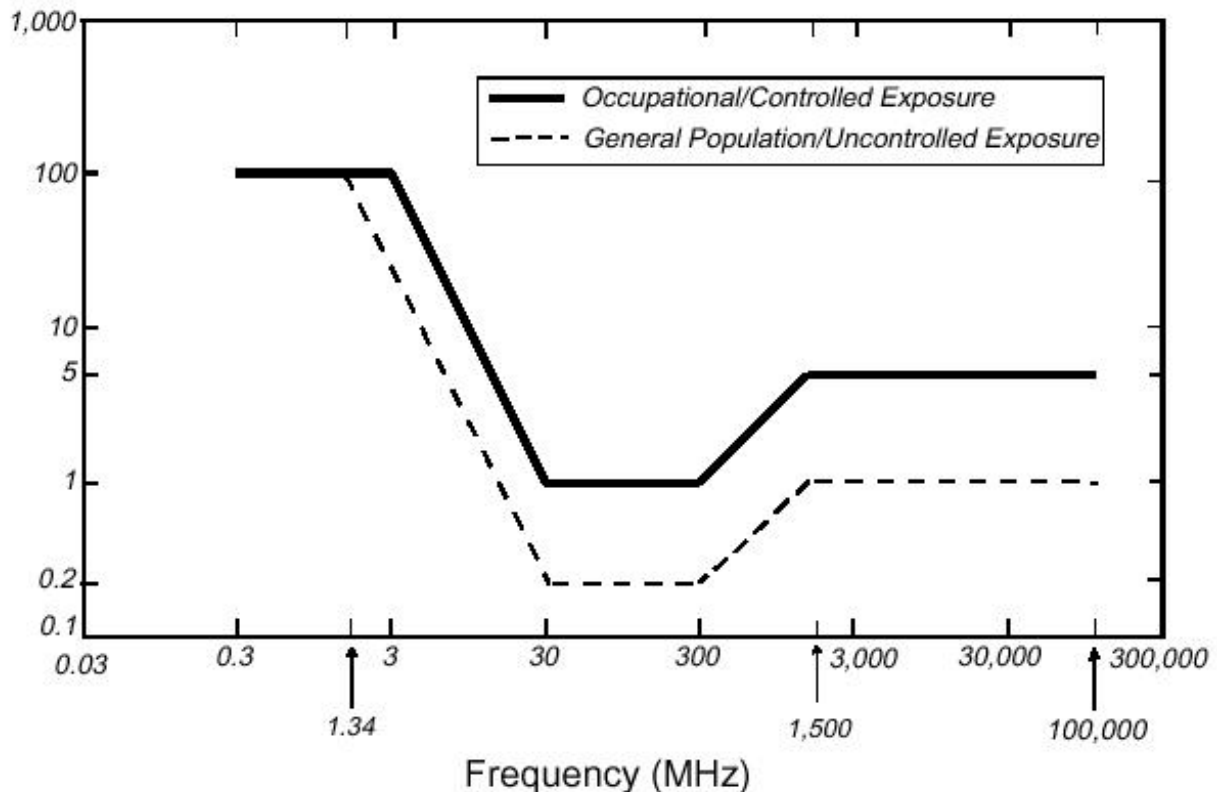

Figure B-1: FCC limits for maximum permissible exposure (MPE) plane-wave equivalent power density mW/cm^2.

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} 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/EngineeringTechnlogy/Documents/bulletin

www.osha-slc.gov/SLTC (see radio frequency)

Appendix C   FCC Regulations

This device complies with Part 15 of the USA Federal Communications Commission (FCC) Rules. Operation in the USA is subject to the following two conditions:

(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. [1] 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) requires users of GPR equipment to coordinate the use of their GPR equipment as described below:

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 the following address:

Frequency Coordination Branch., OET
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554

ATTN: UWB Coordination

The form given on the following page is a suggested format for performing the coordination.

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-NOGGIN250 FOR NOGGIN 250 SYSTEM)]

EQUIPMENT NOMENCLATURE: [E.G. NOGGIN 250]

Send the information to:

Frequency Coordination Branch., OET
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554

ATTN: UWB Coordination
Fax: 202-418-1944

INFORMATION PROVIDED IS DEEMED CONFIDENTIAL

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 Using the PXFER Cable and WinPXFER Software

F1   Transferring Data to a PC using the PXFER Cable

Pressing the number 2 on the main Noggin menu transfers ALL the data buffers (up to 250 screens) from the DVL to an external computer. This type of transfer allows the user to view the data on the external computer using the Win_SpiView software.

There are two ways of transferring data to an external PC. This section describes transferring all data files to an external computer. The other method is to transfer one or more screens of data as a single PCX graphics file (see Transferring One or More Noggin PCX Files to an External PC using WinPXFER on page 6). This other type of transfer is appropriate when the user wants to transfer a small amount of data to an external computer for use with third-party graphics software packages like Microsoft Paint and Word.

To transfer all the data buffers from the DVL to an external computer, the computer must be connected to the DVL using the special parallel XFER cable that is supplied with the system (Section F1: p.1). Note that this is a special cable and standard 25 pin to 25 pin or Laplink cables will not work. As well, the computer must have the WinPXFER program running on it (Section F1: p.1).

F1.1   Connecting the Digital Video Logger to a PC

The Smart System comes with a separate cable called the parallel XFER cable. This cable is designed to connect the DVL to an external computer.
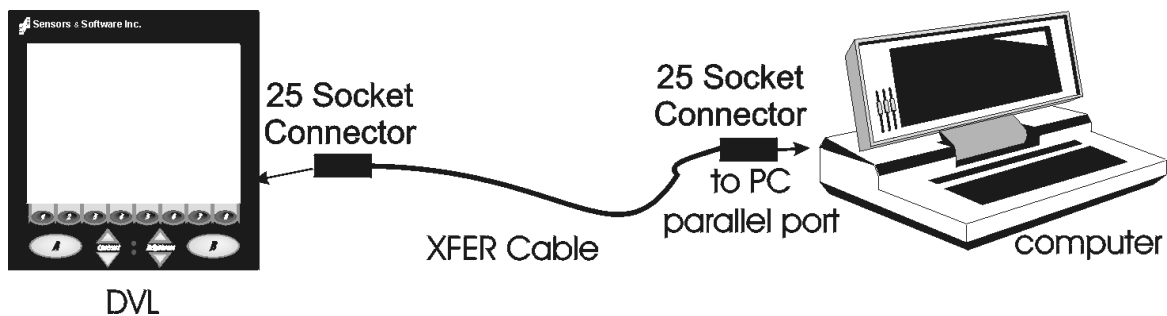

Figure F-1: Parallel XFER cable (CABL0023) connections

The 2 connections that must be made before attempting to transfer data are:

1)   Attach the 25 socket parallel connector to the 25 socket parallel port on back of the Digital Video Logger, and
2)   Attach the 25 socket parallel connector the parallel port of the external computer.
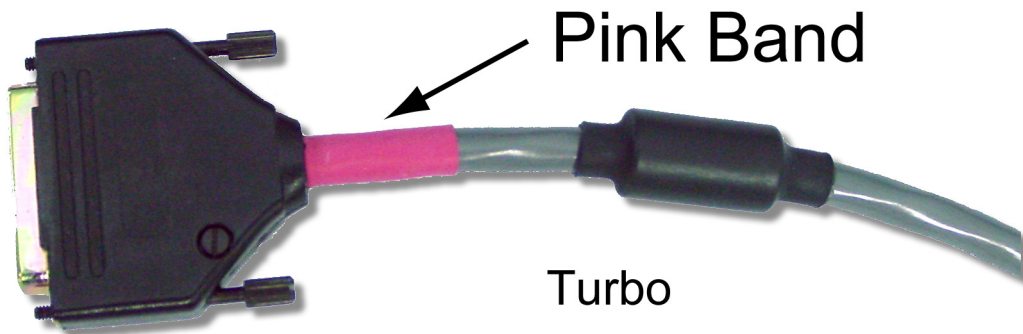

WARNING: To avoid damaging any of the components, turn off the DVL and computer before making any of these connections.
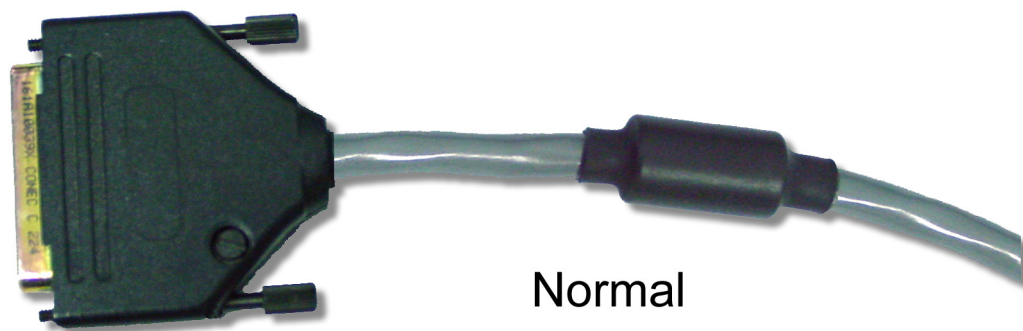

F1.2 PXFER Cable Types

There are two types of PXFER cable, Normal and Turbo. The Turbo PXFER cable can be identified by the pink band visible near the connector at either end. The Normal PXFER cable does not have this pink band.

Figure F-2: Turbo PXFER cable.

Figure F-3: Normal PXFER cable.

Data transfer can only occur if the DVL is set to the correct type of cable (see F1.4: p.F-4). As well, the WinPXFER software must be set to the correct type of cable (see F1.2: p.F-2).

F1.3 Installing and Running the WinPXFER Program

The Smart system comes with a CD-ROM containing the WinPXFER program.

To install the WinPXFER program, follow the directions in the "Software Installation" document that accompanies the CD. Briefly, running the SETUP.EXE program from the WinPXFER folder on the CD will install WinPXFER on the computer.

Once the WinPXFER program has been installed on the computer and the user is ready to transfer data to the computer, the WinPXFER program needs to be run. This can be done using the WinPXFER shortcut on the Desktop, double-clicking the WinPXFER.EXE program in Windows Explorer or pressing Start – Programs – Sensors & Software GPR and finally WinPXFER.
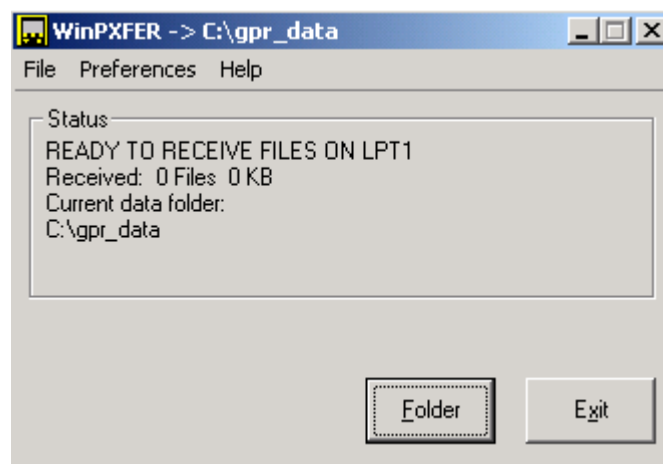

Figure F-4: WinPXFER main screen

When the WinPXFER program has been run, it will display a screen as shown in Figure F-4.

This means that it is ready to receive data transferred from the DVL to the LPT port number 1.

This command assumes that the data buffers are being transferred across Parallel Port 1 (LPT1). If using Parallel Port 2 (LPT2) or higher (LPT3, LPT4 etc.), specify the parallel port number under the Port menu item from WinPXFER.

The name of the folder that the Noggin data will be transferred into is listed under the "Current data folder". In the example in Figure F-4, the data will be transferred to the C:\gpr_data folder. The data folder can be changed by pressing the Folder button and choosing another folder.
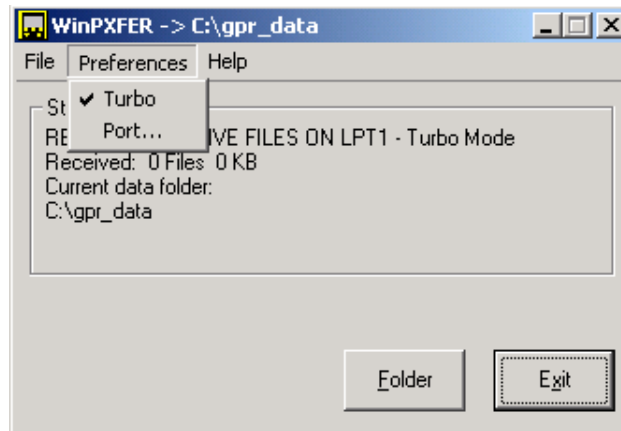
Figure F-5: Turbo mode under Preferences should only be checked if a Turbo PXFER cable is being used.

It is vital that WinPXFER be configured properly for the type of PXFER cable (see F1.2: p.F-2). If the PXFER cable is a Normal cable, the Turbo option under Preferences should NOT be checked when attempting to transfer data. If the PXFER cable is a Turbo cable, the Turbo option under Preferences should be checked when attempting to transfer data.

F1.4 Setting the DVL to the PXFER Cable Type

Noggin Mode: The DVL needs to be configured for the type of PXFER cable being used (see F1.2: p.F-2). In Noggin mode, select **4 - Transfer Setup** from the Noggin main menu. The choices are Normal and Turbo.

Noggin^{plus} Mode: The DVL needs to be configured for the type of PXFER cable being used (see F1.2: p.F-2). In Noggin^{plus} mode, select **4 - Utilities** from the Noggin^{plus} main menu and then **Transfer Mode**. The choices are Normal and Turbo.

F1.5 Transferring Noggin Data Buffer Files

Once the parallel XFER cable is connected and the WinPXFER software is installed and running (see above), it is now possible to transfer all data buffer files to the external computer.

On the DVL, from the main menu, select number 2 – TRANSFER ALL BUFFERS.

The data will be transferred from the DVL to the computer and saved in the current working directory. The progress of the data transfer will be displayed on the DVL screen and the external computer.

When the data transfer is complete, on the external computer, exit from the WinPXFER program. Press any button on the DVL to return to the main menu.

F1.6 Exporting Noggin*plus* Data

Once the parallel XFER cable is connected (see above) and the WinPXFER software is installed and running, it is now possible to export data to the external computer.

All the data in one or more Line or Grid Projects or the TAGGED.GPS file (see Section 5.3.5: p.85) can be transferred to an external computer. From the main File Management menu, the user selects whether to export Line data, Grid data or the TAGGED.GPS file. If Line or Grid data is selected, the next screen lists the current projects.

One project can be highlighted and selected for export. Use the up and down arrows to highlight the project and then press the XFER button to transfer to the PC.

It is also possible to use the TAG button to select several projects and export them all at once. Use the up and down arrows to highlight the projects, the TAG button to tag each project and then press the XFER button to transfer all the projects to the PC.

The data will be transferred from the DVL to the computer and saved in a sub-folder from the current data directory indicated on the WinPXFER program, for example, \DATA\PROJECT2. The progress of the data transfer will be displayed on the DVL screen and the external computer.

When the data transfer is complete, exit from the WinPXFER program. Press any button on the DVL to return to the main menu.

F2 Transferring One or More Noggin PCX Files to an External PC using WinPXFER

There are two ways of using the PXFER cable and the WinPXFER software to transfer Noggin data to an external computer. The first is to transfer one or more screens (or buffers) of data as a single PCX graphics file. This method is described in this section. The second way of transferring data files to an external computer is to copy all the individual SPI (PCX) files from the DVL (see Section F1: p.1). This method is useful when the user wants to view the data on an external computer using the Win_SpiView software.

The data transfer function can only be used after the parallel XFER cable has been connected from the DVL to the external computer and after the WinPXFER program has been installed on the external computer and run. Section F1: p.1 describes how to attach the parallel XFER cable and also how to install and run the WinPXFER program.

Once WinPXFER has been run on the external computer, it is ready to receive data image files from the Digital Video Logger.

On the Digital Video Logger, after the Print option is selected, the user must define the section to be printed. The left edge of the page must be established first. This is done by lining up the left edge of the Digital Video Logger screen with the edge of the plot desired. Use the arrow buttons on the screen to move the section back and forth. A single arrow moves the image 8 pixels either right (▸), or left (◂). A double arrow will move the image 640 pixels or 1 full page to the right (▸▸) or left (◂◂). A single arrow with a vertical line will move the section either to the start (y ◂), or end (▸ y) of the section. If the start or end of section button is pressed, the image will page through one screen at a time. Data scrolling can be stopped by pressing any button. Once the left edge is in place, pressing the OK button will lock the left edge of the plot.

The right edge of the plot must now be defined the same as the left, however now using the right edge of the Digital Video Logger screen. Note that the right edge cannot exceed the left edge.

Next, select a name for the image file from the options CART-1 to CART-4. As long as the WinPXFER program is running on the external PC, the file will be transferred to the current directory indicated by WinPXFER. When the data image file transfer is complete, the user will find a data image (CART-n.PCX) file on the external computer in the current directory.

When the data transfer is complete, on the external computer, exit from the WinPXFER program. Press any button on the DVL to return to the Noggin screen.