

SIR[®] 4000 Manual

MN72-574 Rev F

Geophysical Survey Systems, Inc.

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This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) the device may not cause harmful interference, and (2) this device must accept any interference received including interference that may cause undesired operation.

This Class B digital apparatus complies with Canadian ICES-003

Contains FCC ID: VRA-SG9011089E

Warning: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment or residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the introduction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

Shielded cables must be used with this unit to ensure compliance with the Class B FCC limits.

Canadian Emissions Requirements

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

Notice

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

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Chapter 1: Introduction

This manual is designed for novice and experienced users of ground penetrating radar. It is intended as both a reference and a teaching tool and it is recommended that you read the entire manual, regardless of your level of GPR experience. For information about GPR theory, please see the general geophysics references that can be found in Appendix F.

If you experience operation problems with your system, GSSI Technical Support can be reached Monday-Friday, 8:30 am – 5 pm EST, at 1-800-524-3011, or at (603) 893-1109 (International).

1.1: Unpacking Your System

Thank you for purchasing a GSSI SIR® 4000 (hereafter referred to as SIR 4000). A packing list is included with your shipment that identifies all of the items included in your order. You should check your shipment against the packing list upon receipt of your shipment. If you find an item is missing or was damaged during the shipment, please call or fax your sales representative to immediately report the problem.

Your SIR 4000 system contains the following items:

- 1 - Digital Control Unit (DC-4000) with preloaded operating system.
- 1 - Transit Case
- 2 - Batteries
- 1 - Charger
- 1 - Sunshade
- 1 - Operation Manual
- 1 - GSSI Manual CD
- 1 - USB Drive
- 1 - Universal Mounting Bracket

Your choice of antenna, cables, and post-processing software is available for an additional purchase.

1.2: General Description

The SIR 4000 is a lightweight, portable, ground penetrating radar system that is ideal for a wide variety of applications. It is designed to operate GSSI single digital antennas, single analog antennas, or dual frequency antennas. The system will not support the simultaneous operation of a digital and analog antenna. The various components of the SIR 4000 are described below.

The major features of the control unit are the keypad, control knob, 10.4 inch LED display with 1024 by 768 pixel resolution, connector panels (HDMI Video Out, USB 2.0, Ethernet, Serial Port I/O, digital and analog antenna connectors, power, GPIO Connector, micro-USB), battery slot, and indicator lights. The display screen allows you to view data in real time or in playback mode. It is readable in bright sunlight, although a sunshade for the unit is available. Prolonged exposure to direct sunlight will cause the screen to heat up and may affect screen visibility.

There are two latching panels on the sides of the unit. These contain the battery slot, Micro-USB port, and Ethernet port. To open the panels, rotate the locking pin counter-clockwise until it is loose. To close the panel press it firmly, push the locking pin in, and rotate the pin clockwise until it tightens. See the figure below for further detail.



Side panel when closed and locked.



Side panel when closed and unlocked.

The battery slot (left side of the unit) accepts the provided 10.8 V Lithium-Ion rechargeable battery. Survey time with a fully charged battery is approximately two and a half (2.5) hours. Batteries are recharged with the included battery charger. A single battery can also be charged inside the unit by connecting the SIR4000 to a standard AC source using the optional AC adapter. Fully recharging a battery takes approximately one and a half to two (1.5-2.0) hours. While the unit is in use be sure to keep the right and left side panel covers closed to ensure that no dust or dirt enters the unit's interior.

Note: It is always recommended to remove the battery from the battery slot when storing or transporting the SIR 4000.

Compatibility

The SIR 4000 is not compatible with the following GSSI software or systems:

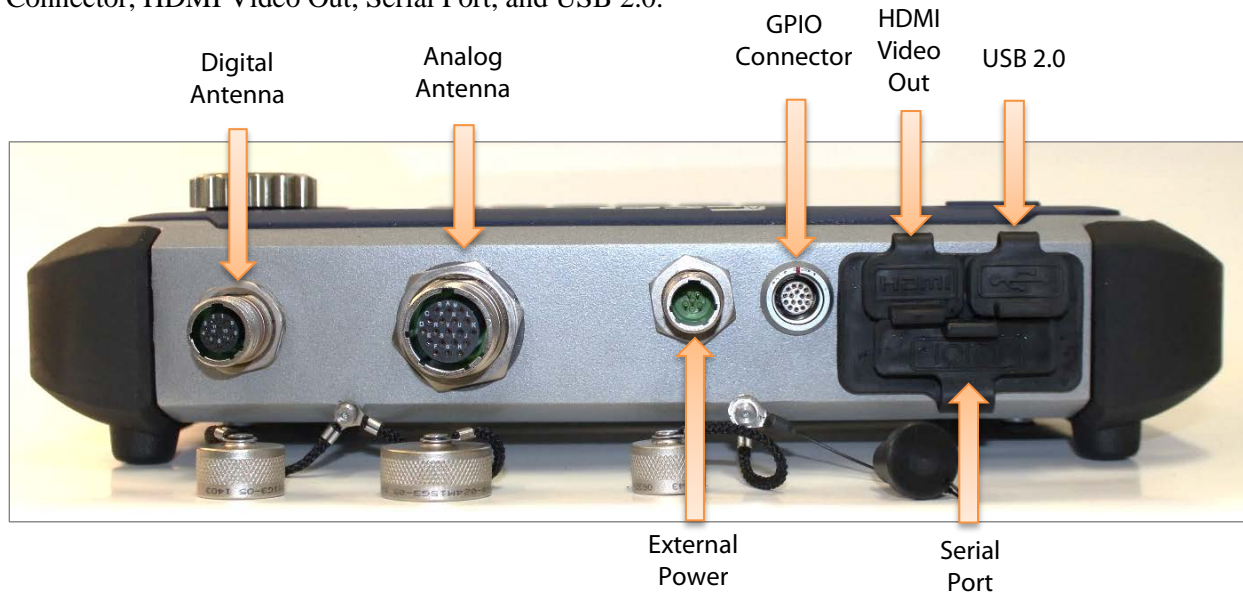
StructureScan Optical: When using either the black pad or the optical reader.

RADAN 5 or 6: Data collected with a SIR 4000 is not compatible with RADAN 5 or 6. You will need RADAN 7 or a later version in order to view and process data collected with the SIR 4000.

Orange Control Cables: The SIR 4000 will not work with the short, orange attenuated control cable that was sold with the SIR 2000. The SIR 4000 will only work with non-attenuated cables (blue or black in color). Repeated use of the orange attenuated cable with the SIR 4000 may cause damage to the SIR 4000 circuitry.

Hardware Connections - Top

The SIR 4000 has seven connectors located on the top of the unit. These connectors, shown below, are: 13 pin Digital Antenna Connection, 19 pin Analog Antenna Connection, External Power, GPIO Connector, HDMI Video Out, Serial Port, and USB 2.0.



Digital Antenna Connector: The 13-pin connector is for a GSSI digital antenna control cable. You will notice the antenna connection on the SIR 4000 has five notches cut from the metal. These mate with the five raised nubs on the digital control cable to ensure proper alignment.

- Screw the cable connector collar onto the SIR 4000 to make proper contact. The cable should only be hand-tightened. Do not use a wrench to tighten the connection as over-tightening will result in damage. The cable connector collar should be screwed down far enough to cover the red line on the SIR 4000 connector.
- *The only proper time to attach or detach an antenna is with system power off. Be sure to unplug any external power and to remove the battery before attaching or detaching antennas.*

Analog Antenna Connector: The large, protruding 19-pin connector is for a GSSI analog antenna control cable. You will notice the antenna connection on the SIR 4000 has five notches cut from the metal. These mate with the five raised nubs on the analog control cable to ensure proper alignment.

- Screw the cable connector collar onto the SIR 4000 to make proper contact. The cable should only be *hand-tightened*. Do not use a wrench to tighten the connection as over-tightening will result in damage. The cable connector collar should be screwed down far enough to cover the red line on the SIR 4000 connector.
- *The only proper time to attach or detach an antenna is with system power off. Be sure to unplug any external power and to remove the battery before attaching or detaching antennas.*

External Power Adapter: Plug in the optional AC power adaptor to run the system from 110-240 V, 47-63 Hz power.

GPIO Connector: This is a General Purpose Input/Output connector. It will operate numerous future accessories and peripherals available from GSSI. Output signals include power, GPS and others.

HDMI Video Out: This will allow you to duplicate the screen on the SIR 4000 when connected to an external monitor or projector.

Serial I/O (RS232): This is a standard serial connection that can be used to establish communication between the SIR 4000 and a GPS as well as supply power. Please see Chapter 7: Using a GPS with your SIR 4000 for additional information.

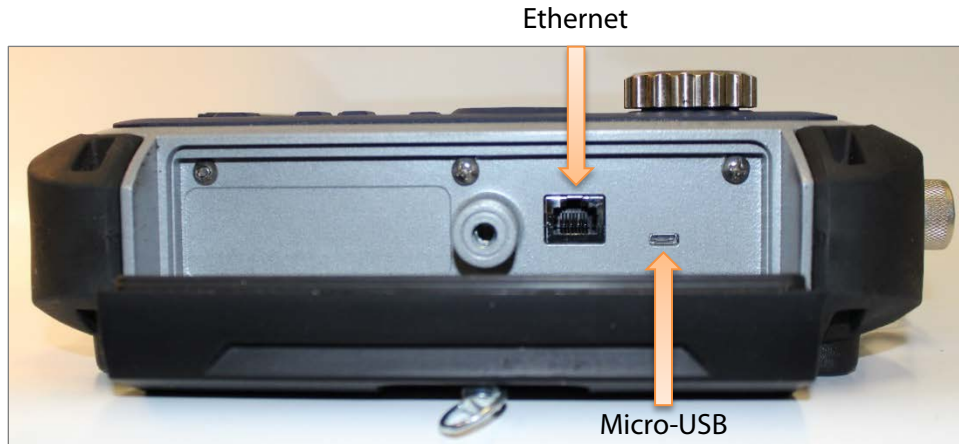
USB 2.0: This port is for connection to a variety of USB peripherals, including a mouse, keyboard, or memory device.

- The internal memory capacity is approximately 32 gigabytes. Please see Chapter 6: Data Transfer and File Maintenance for additional information.

Hardware Connections – Right Side

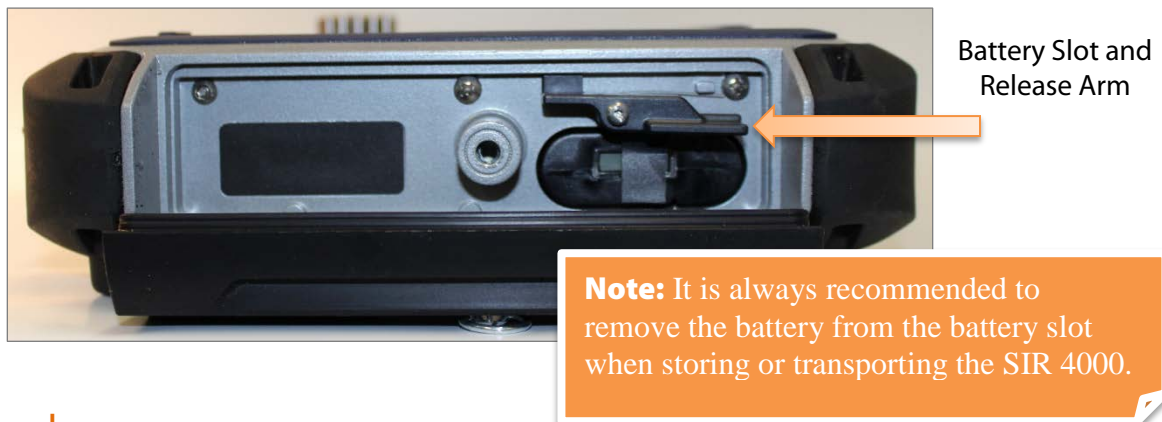
Micro-USB: Allows connection of an external USB memory device for data transfer.

Ethernet: This connection is reserved for future functionality.



Hardware Connections – Left Side

Battery Slot: The battery slot features a release arm, or latch, to secure the battery when one is inserted. The slot has an eject spring to eject the battery when the latch is released.



Note: It is always recommended to remove the battery from the battery slot when storing or transporting the SIR 4000.

Keypad

A built-in keypad, as well as the control knob, will control the SIR 4000. The keypad has sixteen (16) buttons, two (2) indicator lights, and a control knob. All of the keypad button functions will have alternative keyboard implementation, except the Power Button.

Power Button: This button turns the SIR 4000 on and off. To start up the system, insert a battery or connect the optional AC power adapter and push the green power button. To turn the system off press and hold the power button for approximately four (4) seconds until the screen turns black. Should a fault occur it may require ten (10) seconds for the system to respond.

Power Status LED: When the system is turned on the indicator light will flash red. When the system is ready the LED will remain a solid red.



Control Knob: Cycles through the menu tree, quickly changes numeric values, and makes selections.

- Turning the knob clockwise moves down through a menu or numeric values. Turning the knob counter-clockwise moves up through a menu or numeric values.
- Pressing the knob either toggles between On/Off options or enables a secondary menu. After modifying the secondary option a second press of the knob locks-in the selection.

Directional Keypad: This grouping of five buttons is located right below the wheel. The Enter button is in the center. These buttons allow you to navigate through the menu tree and make selections.

- Move through the menus by pressing the Up or Down buttons.
- Pressing the Enter button either toggles between On/Off options or enables a secondary menu.
- Modify the menu setting by using either the Up, Down, Left, or Right buttons.
- After modifying the secondary option a second press of the Enter button locks-in the selection.

Back Button: Returns to the main screen from whichever menu is currently selected or open.

Start Button: Begin data collection.

- Short press begins data collection (disabled during data collection).
- Long press during data collection ends collection of the current file and immediately opens a new one or prompts you to save or discard the current file.

Stop Button: End data collection or playback.

- Short press stops data collection.
- Long press ends data collection or playback and return to the main menu.

Marker Input Button: Pressing this button while collecting or playing back data will place a User mark in the data. User marks are used in post-processing to evenly distribute the number of scans collected in Time Mode between two known points, or marks.

- User marks are helpful for noting distance traveled if you are not using a survey wheel and for noting the location of objects or obstacles such as columns, trees, pits, etc.
- User marks will appear as long, dashed, vertical red lines through the data window.
- Add user marks by pressing either the Marker Input button on the SIR 4000 keypad or by pressing the marker button on whichever cart of handle is connected to the system.

Software Control Buttons: Six (6) buttons are located below the display screen and change function depending upon the current mode in use on the SIR 4000. For a list of each function see Chapter 2: Getting Started and Expert Mode Setup.

1.3 Cautions and Warnings

- 1 The Display Screen:** Do not use alcohol to clean the display screen as this may damage the rubber gasket around the screen and impact the IP rating. GSSI recommends using warm water or Windex (or another ammonia-based) cleaner. There is not an anti-glare coating on this screen as there was with the acrylic SIR 3000 screen protector. The screen is protected by a non-removable chemically hardened glass.
- 2 Power off before connection/disconnecting an antenna:** GSSI recommends turning off the SIR 4000 before connecting or disconnecting an antenna. Failure to do so may cause internal damage.
- 3 Weatherproofing:** The SIR 4000 is IP65 rated when all doors are closed and connections are correctly made. *If it does get wet internally*, immediately power down the system and open all doors and connections. Leave it for a minimum of 12 hours in a warm dry place. The SIR 4000 is factory sealed and no attempt should be made to open it.
- 4 USB Ports:** Do not plug two USB drives into the SIR 4000 at the same time. This includes the USB 2.0 Port and the Micro USB Port. You can have a USB device, such as a keyboard or mouse, plugged in at the same time as USB drive. Unlike the SIR 3000, the USB ports must not be used to connect the SIR 4000 directly to a computer. This does not provide any additional functionality.

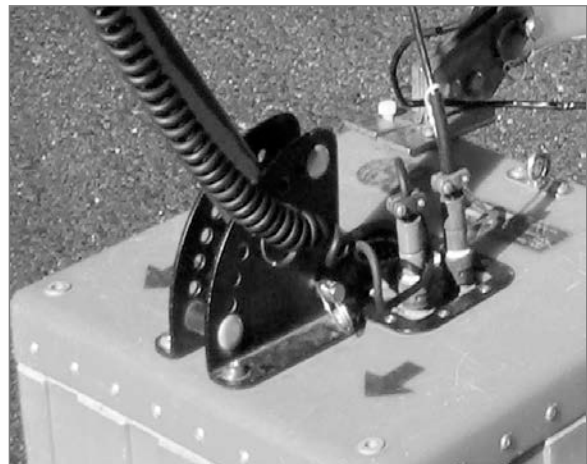
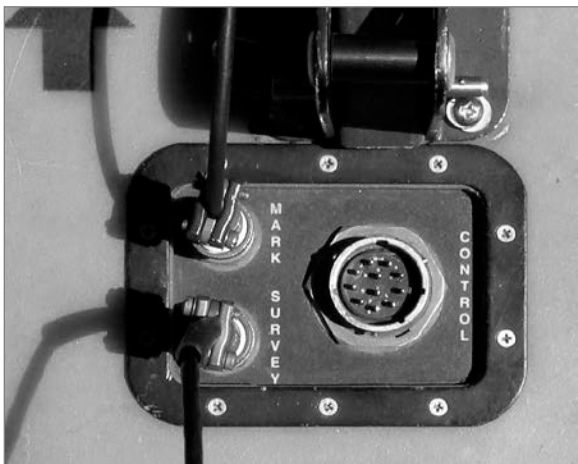
Chapter 2: Getting Started and Expert Mode Setup

Chapter 2 provides instructions for connecting hardware inputs, and introduces the different menus and functions available in Expert Mode. Expert Mode is usable for all GPR applications, is the most versatile data collection method, and allows total control of collection parameters. If desired, 2D profiles can later be transferred to a PC for processing in GSSI's RADAN post-processing software.

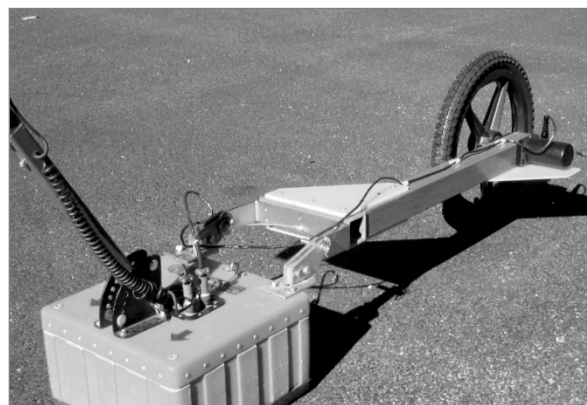
2.1: Hardware Setup

Hardware setup for the SIR 4000 is very simple. As an example we will use the 400 MHz (Model 50400S) antenna with single survey wheel. Follow the steps below.

- 1 Single Survey Wheel Encoder:** Attach the survey handle between the two vertical mounting plates on the top of the antenna with the two removable pins, adjust the angle for comfort, and connect the marker cable from the handle to the antenna at the MARK port.

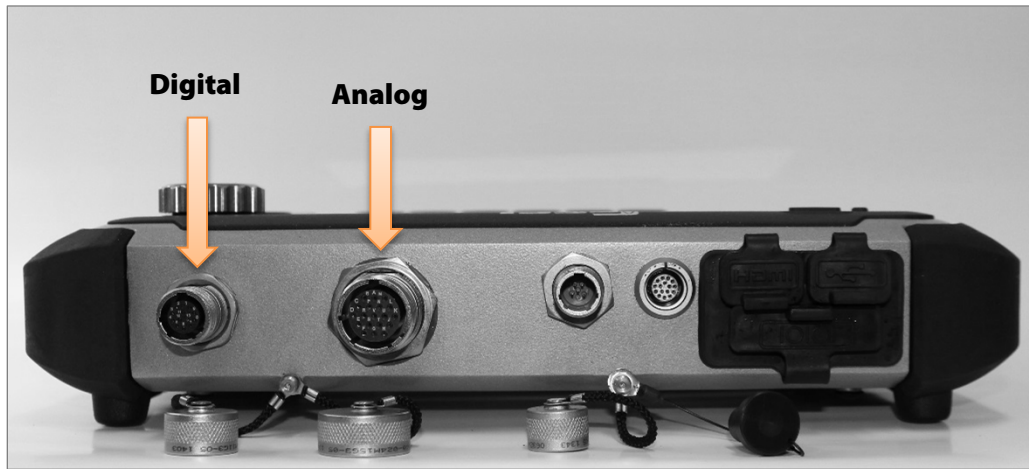


- 2 For Use with the Single Survey Wheel Encoder:** Attach the survey wheel to the brackets at the back of the antenna (as shown below) and connect the cable from the survey wheel to the SURVEY port on the top of the antenna. Be sure that the triangular plate protecting the survey wheel encoder faces down.



- 3 Analog Antennas:** Connect the female end of the antenna control cable to the antenna. Then connect the male end to the 19 pin analog antenna connection on the back of the SIR 4000. Connect the two protective caps together.

- 4 Digital Antennas:** Connect the female end of the antenna cable to the antenna. Then connect the male end to the 13 pin digital antenna connection on the back of the SIR 4000. Connect the two protective caps together.



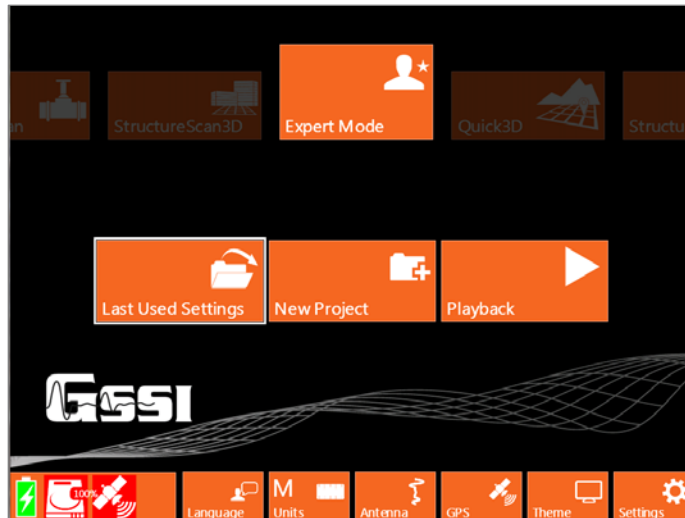
- 5** Connect power source (battery or optional AC power adapter) to the SIR 4000 and push the power button to turn on the system.
- 6** Existing carts may require mounting hardware to attach to the universal mounting bracket included with the SIR 4000.

Note: If you purchased a SIR 4000 with a cart as in the UtilityScan System, or purchased the cart system separately, please see Appendix C: Mounting Your SIR 4000 on a Cart.

The cart also incorporates a survey wheel that is used in place of the larger survey wheel pictured above. For a StructureScan Standard system, please consult the hardware setup instructions in the small, laminated Quick Start Guide that came with the system.

2.2: Introduction Screen

After the SIR 4000 boots up and goes past the splash screen, you will see the Introduction screen. This screen allows you to select from the following options and modes. It also includes a toolbar at the bottom and status information. Note: the setup screen will change depending on whether a digital or analog antenna is connected. If no antenna is connected, only Playback Mode is available.



Modes

The following modes have different options available in the subsequent Setup display based upon application and whether 2D or 3D data is being collected. Applications that are in development will be greyed out in the Introduction screen.

Digital 2D (Digital Antennas Only)

With Digital 2D Mode the user has complete control over all 2D data collection parameters. All parameters in this mode are customizable, whereas in an application specific mode some options are limited based on what is necessary and customary for successful data collection.

Digital 3D (Digital Antennas Only)

In Digital 3D Mode the user has all of the same controls from Digital 2D Mode as well as options to setup, collect, and playback data in a 3D grid.

Expert Mode

With Expert Mode the user has complete control over all 2D data collection parameters. All parameters in this mode are customizable, whereas in an application specific mode some options are limited based on what is necessary and customary for successful data collection.

Quick 3D

In Quick 3D Mode the user has all of the same controls from Expert Mode as well as options to setup, collect, and playback data in a 3D grid.

StructureScan 2D

StructureScan 2D provides quick options for locating shallow structural features in concrete and marking their location directly on the survey surface. The mode is preconfigured for use with high frequency (high resolution) antennas.

UtilityScan

Similar to StructureScan 2D, UtilityScan provides quick 2D options for locating buried utilities in soils.

StructureScan3D

This mode is for collecting very high resolution 3D data over concrete. The data can be viewed in a 3D cube to identify targets at different depths to help note clear locations for cutting or coring.

Last Used Settings, New Project, and Playback

These options allow you to either collect or playback data starting from different points.

Last Used Settings

Starts the system in the last used application mode and project. These may be inappropriate settings if the antenna was changed.

New Project

Opens a new project in whichever application mode is currently selected and requires you to create a new Project Name.

Playback

Starts the system in the currently selected mode and prompts you to select a file or multiple files for playback from the last project selected.

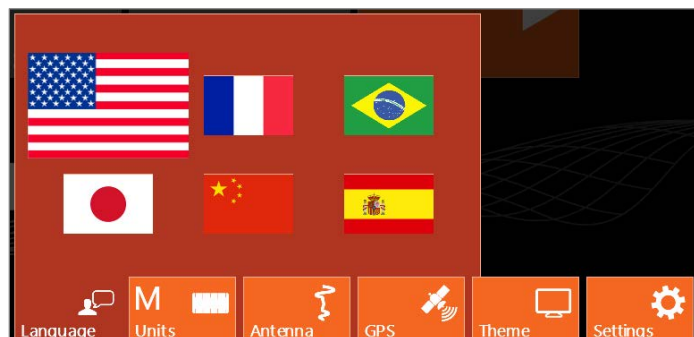
Toolbar

The bottom toolbar provides access to system settings and universal setup options. Selecting any of the Software Control buttons, located immediately under each icon, will open and close each window.



Language

There are six (6) language options on the SIR 4000 including English, Japanese, French, Chinese, Portuguese, and Spanish. Use the Control Knob or the Arrow keys to move through the different languages. The menu will automatically close once a language is selected using either the Control Knob or the Enter button. You can also back out of the menu by pressing the Back button.



Units

Select between Metric and English Units of measure. The menu will automatically close once a unit of measure is selected using either the Control Knob or the Enter button. You can also back out of the menu by pressing the Back button.



Antenna

This menu is available if you are using an older analog antenna without “Smart ID.” If a digital or “Smart ID” antenna is connected the system will auto-detect the antenna and display the appropriate Antenna Model on the Antenna button and access to the menu will be disabled. This menu is also disabled when no antenna is connected.

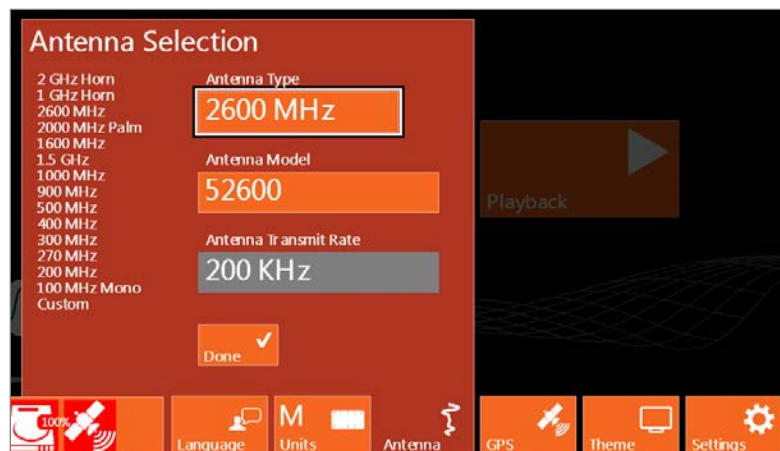


If an older analog antenna is connected to the SIR 4000 you will be able to select from a list of antenna frequencies.

Antenna Type: Choose an antenna frequency from the list of available frequencies.

Antenna Model: If multiple models of the chosen Antenna Type are available, you can select which model of antenna is connected. The antenna model is shown on a sticker affixed to the antenna housing.

Antenna Transmit Rate: The antenna transmit rate is in KHz, with a Custom rate capped at 100 KHz. You can modify the antenna transmit rate if Antenna Type is set to Custom. A higher transmit rate enables faster data collection and more stacking to reduce random noise. Some of the older antennas are not capable of transmitting at high speeds and setting them at a high transmit rate may cause an error. Consult your antenna documentation or call GSSI Tech Support if you have any question about transmit rate. All GSSI 5100 and 52000 series antennas (2.6 GHz, 2.0 GHz Palm, 1.6 GHz, 1.5 GHz, 1.0 GHz, 400 MHz, 270 MHz, 200 MHz) can be operated at 100-200 KHz. Rates are limited per regulations of the region where the unit is operated. If you are using another GSSI antenna, consult Appendix E for the proper transmit rate.



GPS

Allows you to configure your SIR 4000 to collect GPS data during data collection. Make the following selections to enable GPS collection.

GPS Type: None is set when GPS is not connected. Custom should be selected if a GPS is connected and needs to be configured.

Baud Rate: Match the baud rate with the one you are using on your GPS. Available baud rates range from 4800 up to 230400.

Format: Select which format to use when displaying point, Degrees Minutes Seconds, Degrees Minutes Decimal Minutes, and Decimal Degrees.

Lat/Long: Displays the current position in whichever format is currently selected.

Fix Quality: Shows whether or not a GPS or DGPS signal is recording.

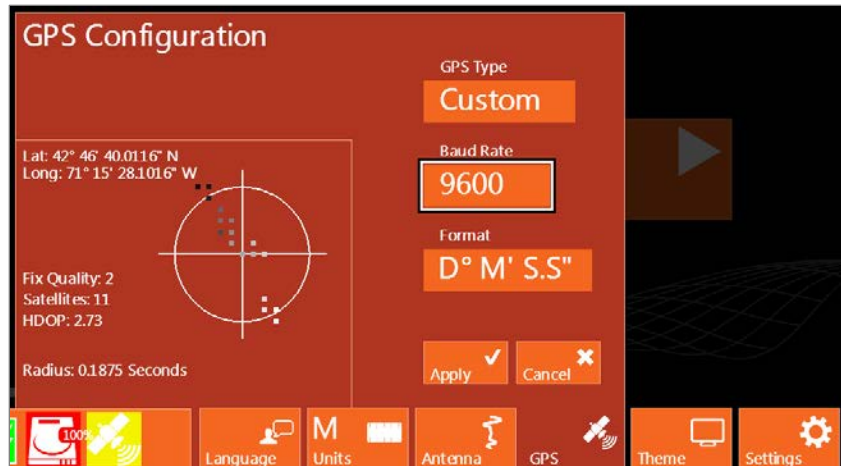
Satellites: Displays the number of satellites that are currently in view of the GPS. These satellites are displayed on the plot in the middle of the GPS Configuration window.

HDOP: The Horizontal Dilution of Precision is the relative accuracy of the horizontal position. The system needs an HDOP of 2 or less in order to collect data.

Radius: This indicates the size of the Circular Error Probability which appears in the center of the GPS window as a bull's eye. This is the radius of a circle, which centers on the mean of the GPS accuracy in seconds.

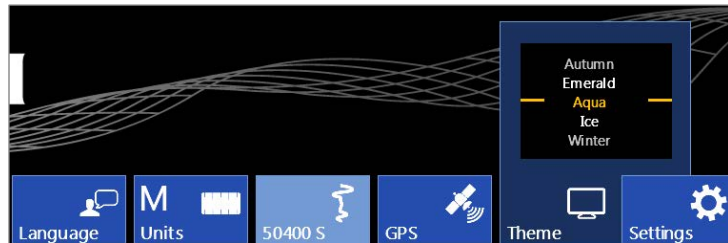
Steps to setup the SIR 4000 to match GPS Settings:

- 1 Connect your GPS to the SIR 4000 through the Serial Port.
- 2 Turn on your GPS.
- 3 If planning to recall a default or custom setting, proceed to Last Used Setting or New Project. Select the saved setup you plan to use and then return to the Introduction Screen.
- 4 Select the GPS control button.
- 5 Select Custom from GPS Type.
- 6 Select the Baud Rate that matches the one set on your GPS.
- 7 Press the green Start button on the right side of the SIR 4000.
- 8 Wait for the GPS to acquire enough satellites and accuracy so that the HDOP is 2 or less.
- 9 Select Apply to save the GPS configuration and exit the menu.



Theme

Select from preformatted color themes for the display on your SIR 4000. Once a theme is selected it will carry through to any of the modules and become the default for the next time you turn the system on. Scroll through the different theme options using either the Control Knob or the Up and Down Arrows. Select a Theme by pushing the Control Knob or the Enter key.



Settings

This button opens additional calibration and configuration options, and the Software Control buttons change to include the following functions:



Date/Time: Modify the current Date and Time on the system. Use the Control Knob to select and modify the fields. Select Apply using either the Control Knob or Arrow keys to accept any changes.



Firmware: View the current software and firmware installed on the SIR 4000. You can also update the software and firmware from this menu by selecting Update. Detailed instructions for updating the SIR 4000 software and firmware are available in the Appendices.

Component	Version ID
Radar Control	1.1.90
Local GPR	
System ID	8 (SN008)
User Interface	1.0.7-A12
Boot Loader	2.0.0.9
GPR Control	2.1.5.35
GPR Antenna	2.0.5.7
GPR MAC (ID)	00:26:26:0

Note: Verify on the GSSI Support Website if there is an available software or firmware update. You don't always need to update the firmware when updating the software.

Mark components to be updated with the wheel.
When all desired components are marked, select the "Update" button.

Update Done

WiFi: The WiFi setup is reserved for future functionality.

Quit: Exits the current Settings menu and returns to the Introduction screen.

Status

This real-time monitor is always visible during both setup and data collection. It shows power, storage, and GPS status.



Battery

Shows the current status of the SIR 4000 battery, and indicates average run time remaining.

AC Power Supply: >255 minutes (SIR 4000 is plugged into AC power).

Green Battery: 30-255 minutes remaining.

Yellow Battery: 15-29 minutes remaining (Battery status icon will begin to pulse).

Red Battery: Less than 15 minutes remain. Battery icon will continue to pulse; replace battery.

Storage

Indicates the amount of used memory on the SD card. The SIR 4000 has 32 GB of internal memory.

GPS

The GPS monitor indicates whether or not a GPS is connected and the quality of the GPS signal.

Green GPS Icon: The GPS is enabled, detected, and the data has an HDOP of 2 or less.

Yellow GPS Icon: The GPS is enabled, detected, and the data has an HDOP greater than 2.

Red GPS Icon: The GPS is enabled, but not detected.

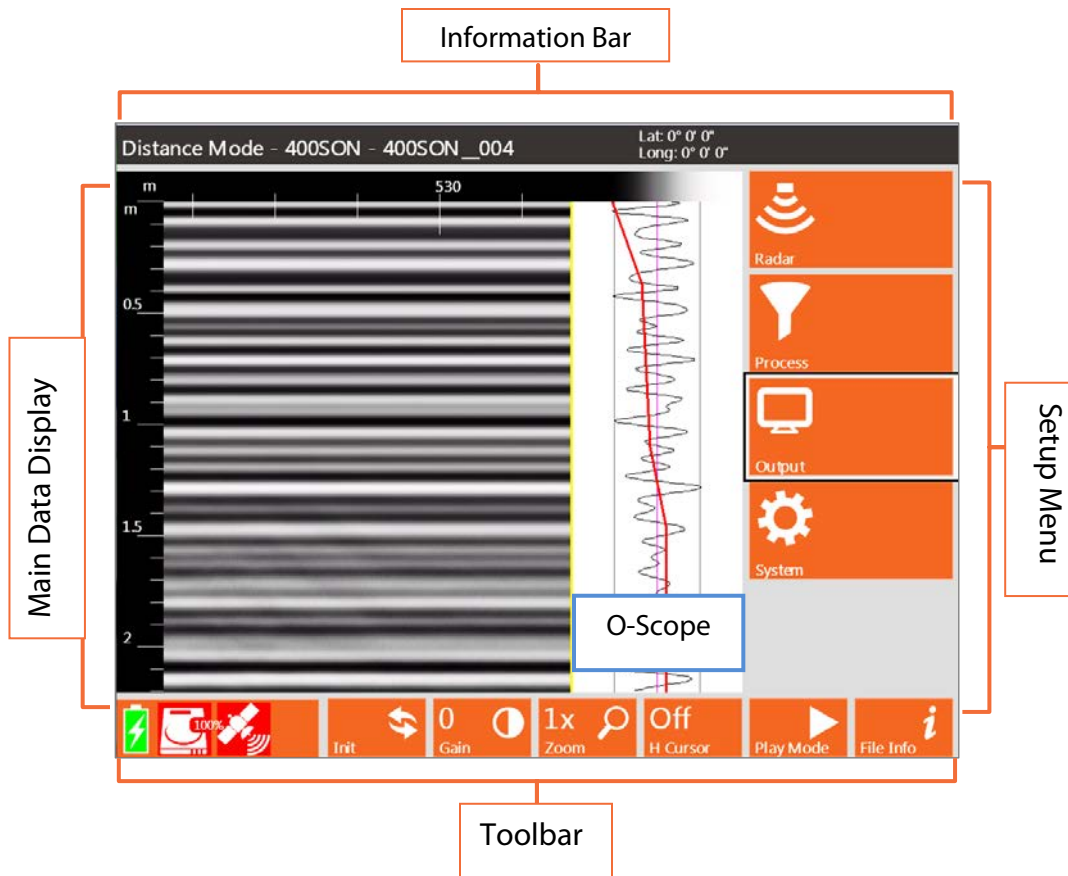
Grey GPS Icon: The GPS is either not enabled in the GPS menu or it is not detected.

2.3: Setup Collect/Playback Screen

The SIR 4000 Setup Screen displays a preview of the data, an Information Bar, Setup Menu, and Toolbar.

Information Bar (top): An information bar appears at the very top of the screen and is updated based on whether the SIR 4000 is currently in Collect or Playback Mode.

- The left-hand side displays the current mode (Distance, Time, Point, or Playback) and file information (Project Folder – File Name).
- The middle displays GPS coordinates if the system is configured to collect GPS points.
- During collection the right-hand side displays either the scan number if in Time or Point data collection mode or distance if the Collection Mode is set to Distance.



Main Data Display (left): The main data display window shows a radar profile in linescan format. Successive single scans are assigned color values based on amplitude change and displayed next to each other in sequence to form a continuous image.

- The vertical scale on the left of this data display window shows time, depth, or height.
- New scans will be placed at the right side of the window and data will scroll from right to left.
- The horizontal scale will be in the units of measure selected in the Introduction Screen and with the density set in the Setup Menu.

O-Scope (middle): In the middle of the screen you will see a window that shows a single radar scan in an oscilloscope-style (O-scope) depiction. This will show successive single scans as you move your antenna across an area while in the Setup Screen.

- Time or depth increases down the screen at the same vertical scale that is selected from the Setup Menu to the right of the Main Data Display.
- At the top of the window you will see a color bar. This shows you the distribution of colors across the range of reflection amplitudes from negative, on the left, to positive, on the right. The exact color and distribution depends on your choice of Colormap, Color Stretch, and Color Slide selected from the Setup Menu.
- The red line that travels the length of the O-Scope is the Time Variable Gain Curve. Refer to the section on Gain Mode under Setup Menu – Process for information on modifying the gain curve.

Setup Menu (right): To the right of the O-Scope display is the Setup Menu. This window is where you will navigate through the various commands, set system parameters, data paths, colors, and how to save data. There are four (4) main menu options, Radar, Process, Output, and System. For more information on each see the sections Setup Menu – Collect Mode or Setup Menu – Playback Mode.

Toolbar (bottom): The bar across the bottom of the screen is the Setup or Playback Toolbar and provides different options for modifying how the data appears during setup, collection, or playback. Different Applications will have partially customized or completely redefined Toolbars based upon necessity. In Expert Mode the Toolbar includes Init(ialize), Gain (Display Gain), Zoom (Horizontal Zoom), Run Mode, Play Mode, and File Info. These commands are each explained in more detail later on in this chapter when each button is defined.

Setup Menu – Radar

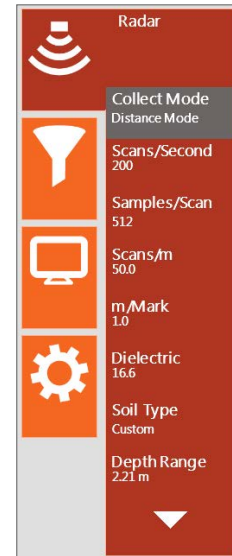
Under Radar, there are fourteen (14) settings that can each be accessed by rotating the Control Knob or using the Directional Keypad. The settings are:

Collect Mode

Collect Mode allows you to collect either distance-, time-, or point-based data.

Distance Mode: Distance- based collection is performed with a survey wheel. The system records a certain number of scans per unit of distance. Distance Mode is more accurate than Time Mode and it is strongly recommended that you collect data in this mode if possible. To calibrate the survey wheel see Section 2.2 Introduction Screen – Settings – Calibrate SW.

Note: Distance-based data is required for 3D files.



Time Mode: In time-based data collection, the system is recording a certain number of scans per second. The data density over an area depends on the speed at which the antenna is moved over the ground. The rate is set in the Scans/Second setting option. The option is often used when it is not feasible to use a survey wheel during data collection.

Point Mode: Point-based data collection is usually selected only for very deep applications or very difficult terrain. The system will record one scan every time the external marker or Start button is pressed. The antenna is then moved to the next location and the next scan is collected.

Scans/Second

Scans/second is the number of scans the system will collect per second. The SIR 4000 will collect minimum of 4 and maximum of 400 scans/second.

- If you are collecting time-based data, this is the number of scans that will be saved each second.
- If you are collecting distance-based data with a survey wheel, this number represents the maximum possible collect rate. If you exceed this maximum rate the over-speed beeps will sound. It is recommended that the scans/second be set lower as lower scan rates will auto stack and improve the signal to noise ratio.

Menu Option	Collect Mode	Playback Mode
Collect Mode	X	
Scans/Second	X	
Samples/Scan	X	
Scans/Unit	X	
Units/Mark	X	
Static Stacking*	X	
Dielectric	X	X
Soil Type	X	X
Depth Range	X	
Time Range	X	
Position Mode	X	
Offset	X	
Surface (%)	X	
Exit	X	X
*Available only in Point Mode		

For example: Scans/Second is set to 60 and you have configured the system to collect 60 scans a foot. If you move more than one foot per second the system will attempt to collect scans which are not available.

Assuming your Antenna Transmit Rate is 200 KHz, the scans/second should be at least 240 whenever you are collecting with a survey wheel and are collecting a maximum of 512 Samples/Scan.

If you set Scans/Second higher than the selected transmit rate and the number of samples/scan, the SIR 4000 will lower it to the maximum possible. However, it is recommended that the scans/second be set lower than the maximum. This will allow the system to auto stack points thereby improving the signal to noise ratio.

Samples/Scan

Each scan curve is made up of individual data points, called Samples. More samples generate a smoother the scan curve and improve vertical resolution. This also affects scan speed; more points collected means lower maximum scans/second.

- You can choose from a preset list of 256, 512, 1024, 2048, 4096, 8192, or 16384 samples/scan. FIR filters should only be used with 256-2048 samples/scan.
- As sample number increases, max scan rate drops and file size increases.
- GSSI recommends sampling at 512 or 1024 samples/scan for most applications. More samples will be required for deep geologic or polar ice thickness applications. Below is the equation to use when choosing a sample rate.

$$\text{Samples/Scan} > ((10 * \text{Time Range}) / \text{Pulse Duration})$$

Antenna Model	Frequency (MHz)	Pulse Duration (ns)
42000S	2 GHz Horn	0.5
41000SA	1 GHz Horn	1
52600S	2.6 GHz	0.4
62000	2 GHz Palm	0.5
51600S	1.6 GHz	0.7
5101	1 GHz	1
3101A	900 MHz	1.1
50400S	400 MHz	2.5
50270S	270 MHz	3.7
5106	200 MHz	5
3207	100 MHz	10

Scans/Unit

Scans/Unit adjusts the number of scans per unit of horizontal distance. This parameter is the scan spacing when you are collecting with the survey wheel. The unit of measure is based on the Units selected from the Introduction Screen and the Horizontal Units selected from the Output Menu.

- Smaller scan spacing: produces higher resolution data, creates larger file sizes, and may require slower data collection. For example, if Scans/Unit is set to 12 and the system is set to English feet (rather than Metric units) you will collect 12 scans per foot, or 1 per inch.
- Scan spacing can be customized for certain applications. For example, 5-10 scans/inch (60-120 scans/foot) is the optimal range for shallow structural features in concrete. With lower frequency antennas, like a 400 MHz, a coarser scan density of 12-24 scans/foot is typical.

Units/Mark

You can also set how many units (i.e., feet or meters) will be collected between system marks. These marks will appear at the top of the data display along the horizontal scale.

Static Stacking

This option is only available in Point Mode. It uses the number of scans entered and averages them to output a single composite scan at each location. This function minimizes high-frequency or random noise.

Dielectric

Dielectric constant represents the ratio of permittivity of a substance to permittivity in a vacuum. We use this term to describe how quickly GPR moves through materials. Materials that have a lower dielectric value allow GPR to propagate more quickly. See Appendix C for a chart of dielectric values of common materials and a deeper discussion of dielectrics. Values range between 1 (air) and 81 (water).

- If you know the dielectric value of the material through which you are surveying, you can enter it here and get an in-field time to depth calculation.
- Higher dielectric values mean slower travel time and shallower penetration. For example, in air, which has a dielectric constant of 1, radar energy will travel at 12 inches per ns. Since the time range is in two-way travel time, 1 ns on the vertical scale translates to 6 inches if the DIEL is set to 1. The distance traveled per ns is reduced by the square root of the dielectric constant. The dielectric constant of water is 81, so that water slows down the radar wave by a factor of 9 ($\sqrt{81}=9$). The range in water is thus 6/9 inches per ns.
- The prime determinant of the dielectric constant of soils and sediments is water content, with wetter areas having a higher value. Generally speaking, water raises a material's dielectric constant, and surveys should be performed on dry material whenever possible.

Material	Dielectric Constant
Snow/Ice	3.0
Dry Sand	4.0
Pavement	6.0
Rock	8.0
Dry Soil	9.0
Ave. Soil	14.0
Wet Soil	20.0
Wet Sand	25.0
Water	81
Custom	1-81

Soil Type

Several different Soil Type options are included on the SIR 4000. Selecting a Soil Type will automatically update the Dielectric with a value which is representative of that soil.

Custom: Automatically appears if the Dielectric Constant is manually changed, or when a hyperbola fitting or ground truth are performed during data collection. For more information on hyperbola fitting and ground truth see section 2.4 The Command Bar – Output in Collect Mode.

Depth Range

Depth Range is the vertical scale displayed in whichever units are selected under the Output -> Vertical Units menu.

- Depth Range can be set from 1-10000 cm (0.4-3900 in).
- Modifying Time Range will automatically update the Depth Range.

Time Range

Time Range is the vertical scale in nanoseconds (ns) within which the SIR 4000 will record reflections. It is proportional to depth viewed because a higher Time Range will allow the energy to penetrate deeper and return deeper reflections.

- It is important to remember that the Time Range is two-way travel time, so that a range of 50 ns means that the deepest possible reflector is at 25 ns.
- A very long range may require a greater number of samples to create enough data dots for the scan curve. Refer to the section above to determine the appropriate number of samples/scan.
- Time Range can be set from 1-20000 ns.
- Please see Appendix D for a list of common ranges for individual antennas.
- Modifying Depth Range will automatically update the Time Range.

Effects of Changing Dielectric, Soil Type, Depth Range, or Time Range

Changing either Dielectric, Soil Type, Depth Range, or Time Range will affect other settings during setup, data collection, and playback. Below are two charts showing how a change will affect the other settings.

During Setup: When a value is being changed the effects will not appear in the other settings until Enter is pressed. Prior to changing settings verify that you have the appropriate Vertical Scale selected.

Vertical Scale Setting	Changing the Dielectric or Soil Type	Changing the Time Range	Changing the Depth Range
Time	- Depth Range changes. - Time Range: no change.	- Depth Range changes. - Dielectric or Soil Type: no change.	Dielectric changes, Soil Type becomes Custom. Time Range: no change.
Depth	- Time Range changes. - Depth Range: no change.	Dielectric changes, Soil Type becomes Custom. Depth Range: no change.	Time Range changes. Dielectric or Soil Type does not change.

During Data Collection (Depth Calibration/Hyperbola matching) and Playback:

Vertical Scale Setting	Changing the Dielectric	Changing the Time	Changing the Depth
Time	No visual effect.	Time Parameter cannot be changed during collection.	Dielectric changes when a known depth is entered.
Depth	Depth Range changes as Dielectric is changed.	Time Parameter cannot be changed during collection.	Dielectric changes when a known depth is entered.

Position Mode

This option controls the position of the beginning of the time range (0 ns). This is the start of the recorded scan trace. Typically, having the system auto locate itself is sufficient to adequately set the position during data collection. However, you can also manually adjust this location. Toggle between the two options, Manual or Auto, by pushing the Control Knob or the Enter button.

Manual: Allows you to set an Offset and Surface %. Offset is the time lag between the initial pulse and when the signal first leaves the antenna. Surface % is a visual shift in the scan to begin at the initial reflection. When switching from Manual back to Auto the system will automatically reset the position of 0 ns based on the Surface % selected.

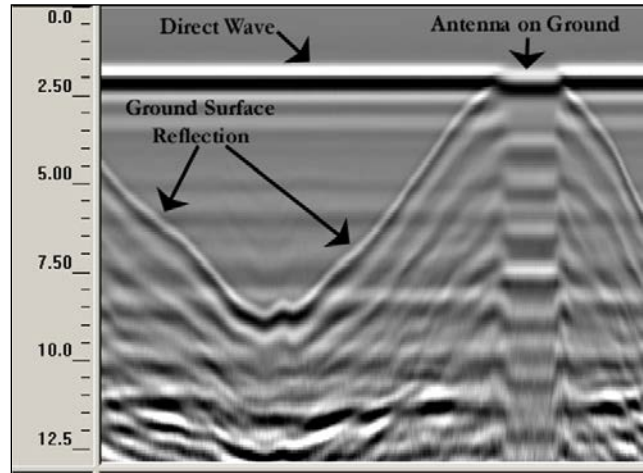
Auto: Anytime the antenna is re-initialized, as when pressing the **Init** button or first entering the Setup Collect Screen, the SIR 4000 will set the Position automatically.

- For most applications and surveys, to acquire an accurate Position using Auto Mode the antenna should be placed on the surface to be scanned prior to entering the Setup Collect Screen.
- This choice is automatically set to Manual with sample densities of 4096, 8192, or 16384.

Offset

This is an internal system parameter that describes the time lag (in ns) between the SIR 4000 triggering the pulse inside of the control unit until we consider it to have transmitted from the antenna itself. There is no way to accurately measure the exact moment the pulse leaves the antenna, so we use the direct wave to determine the appropriate point to set the offset.

- The direct wave is the pulse that travels inside of the antenna housing, directly from the transmitter to the receiver, and it is considered to be the first response in the data. As long as the antenna dipoles are not very far apart, as is the case with a separated bistatic antenna pair, the direct wave occurs sooner than any reflections from the ground. If the direct wave is visible in the data, we can be sure that we have 100% of our data. The ground surface can also be used to perform a depth calculation. The value is in nanoseconds from trigger pulse inside the SIR 4000. If you adjust this parameter use caution not to lose the direct wave.
- Adjusting the Offset is only available when Position Mode is set to Manual. When it is set to Auto, the SIR 4000 auto calculates the Offset.
- In the associated image (above), the antenna was moved up and down over the ground surface. Notice how the surface reflection moves up to join the direct wave.



Surface (%)

This display option allows you to visually ‘cut out’ the flat part of the scan and begin at the direct wave, thereby showing only the scan from the first reflected target. This should represent the ground surface.

- The entire scan is still collected and saved, but not displayed during data collection. This allows you to set the display to show an in-field time to depth calculation.
- It is set as a percentage of the total vertical window. The SIR 4000 will examine the offset and the antenna type selected from the Introduction Screen to automatically find the proper surface. It will set near to the first positive peak of the direct wave.

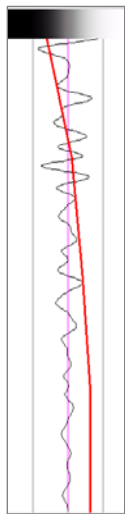
Setup Menu - Process

Filters used during data collection or playback with the SIR 4000 will be saved as a separate DZX file. When data are opened in the processing software RADAN it will open first without any applied filters and then it will apply the DZX file and created a processed file.

Under Process, there are thirteen (13) settings that can each be accessed by rotating the Control Knob or using the Directional Keypad. These settings are listed below as well as which modes they are available in:

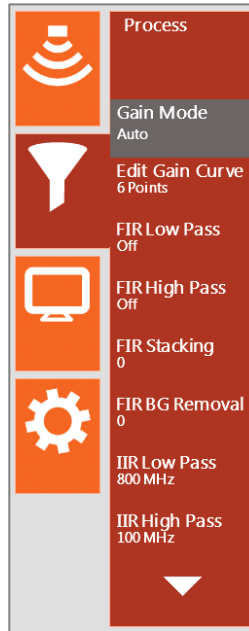
Gain Mode

Gain is the artificial addition of signal in order to counteract the natural effects of attenuation. As a radar scan travels into the ground, some of the scan is reflected, some of it is absorbed, and the remaining signal continues penetrating until it is completely absorbed in the media. Therefore, as the scan gets deeper, it also becomes weaker.



Gain is applied to the scan to make more visible the subtle variations in weaker data. It is applied using a Time-Variable Gain Curve, shown visually by a red line in the O-Scope window on the Setup screen. Values increase from left to right and the location of gain points is shown by a change in the slope of the curve.

There are two Gain options to choose from and you push either the Control Knob or Enter button to toggle between them:



Menu Option	Collect Mode	Playback Mode
Gain Mode	X	X
Edit Gain Curve	X	X
FIR Low Pass	X	X
FIR High Pass	X	X
FIR Stacking	X	X
FIR BG Removal	X	X
Custom Filter*	X	X
IIR Low Pass	X	X
IIR High Pass	X	X
IIR Stacking	X	X
IIR BG Removal	X	X
Signal Floor	X	X
Filters Off	X	X
Exit	X	X

*Only available with an air-launched horn antenna.

Manual: Selecting Manual Gain allows you to change the number of gain points and to add strength to the signal at your own discretion.

- Manual Gain is not recommended for inexperienced users as it is possible to ‘create’ features in the data by over-gaining areas.

Auto: Selecting Auto Gain causes the system to re-initialize and adjust the time-variable gain curve based on the current scan and the selected number of gain points.

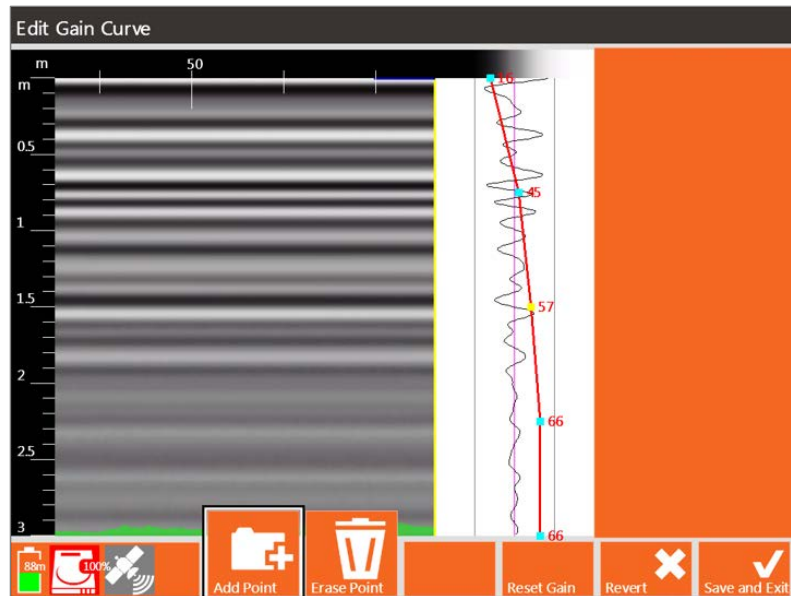
- This is useful if you find that your data is clipped (over-gained) or too weak to see (under-gained) over a particular section of your survey area. Just place the antenna on the area where the data is clipped or weak and either toggle the gain to Manual, and then back to Auto, or press the Init button at the bottom of the SIR 4000 keypad. This will cause the system to reset the gains to a lower level to prevent clipping or a higher level to strengthen weak reflections.

Edit Gain Curve

This menu option allows you to modify the number of gain points along the time-variable gain curve and, if in Manual Gain, strengthen or weaker individual points.

Pressing Edit Gain Curve with either the Control Knob or Enter button will activate the time-variable gain curve for editing and open new button functions for the bottom of the keypad.

- With the time-variable gain curve activated, use the Control Knob or arrow keys to move between different gain points.



Add Point: Use this button to add up to eight (8) gain points to the gain curve. These points will be evenly spaced throughout the data scan.

Erase Point: Use this button to remove gain points from the gain curve. The minimum number of gain points is two (2). As points are removed, the remaining gain points are evenly redistributed throughout the data scan.

Revert: Returns to the main Setup Screen without saving any changes to the time-variable gain curve.

Save and Exit: Saves changes to the time-variable gain curve and returns to the Setup Screen.

When using Manual Gain you can modify the individual gain points using the following steps. Use caution when manually adjusting gain point values. If you add too much gain to a single point it could create a false layer in the data.

- 1 Press the Control Knob or Enter key to select a gain point and then use the knob or arrow keys to adjust to strengthen or weaken the point.
- 2 Press the Control Knob or Enter key a second time to save and deselect the modified gain point.

Note: The SIR 4000 is only displaying about 25% of the actual amplitude range. This means that even if your data appears slightly clipped, the SIR® 4000 is likely still recording the full amplitude range of the reflection. If you use a -12 dB display gain, you will see an accurate representation of the recorded scan. This also means that when you view your data in RADAN, it will appear under-gained and you will need to add some display gain.

FIR Low Pass and IIR High Pass

These options, and the following seven (7), allow you to set data collection filters to either remove interference or smooth noise. A Low or High Pass filter is an antenna-specific frequency filter and should be modified each time a different antenna is connected. These filters are used to downplay external interference, and clean up the signal.

FIR filters have a Finite-duration Impulse Response and, when encountering a feature in the data, are guaranteed to output a finite filtered version of that feature. These filters will produce symmetrical results so reflections will not be shifted in time or position. By setting these at different ends of the antenna's bandwidth, you are determining the range of frequencies that the antenna is filtering out.

Pressing FIR Low/High Pass with either the Control Knob or Enter button will allow you to scroll through different frequencies.

- FIR Filters should not be used with 4096 samples/scan or higher.
- The maximum Low and High Pass filter values are 5000 MHz.
- Select Off to disable either filter.

FIR Low Pass: The selected frequency in MHz is the upper limit of the filter. Any frequency lower than selected Low Pass frequency will be allowed to pass through the filter and be recorded by the system (i.e. system will record any frequency *lower* than XX MHz).

FIR High Pass: The selected frequency in MHz is the lower limit of the filter. Any frequency higher than selected High Pass frequency will be allowed to pass through the filter and be recorded by the system (i.e. system will record any frequency *higher* than XX MHz).

FIR Stacking

In addition to FIR frequency filters, another option is Stacking. Stacking is a high-frequency noise reduction filter which operates in the horizontal direction. Each new scan has a 1/n influence in the data, so this filter has a tendency to smooth high frequency targets and accentuate low frequency horizontal features, like layers. As the number of stacked scans (n) increases, the influence of each new scan drops.

The FIR Stacking filter input is in number of scans. Pressing FIR Stacking with either the Control Knob or Enter button will allow you to select a number of scans.

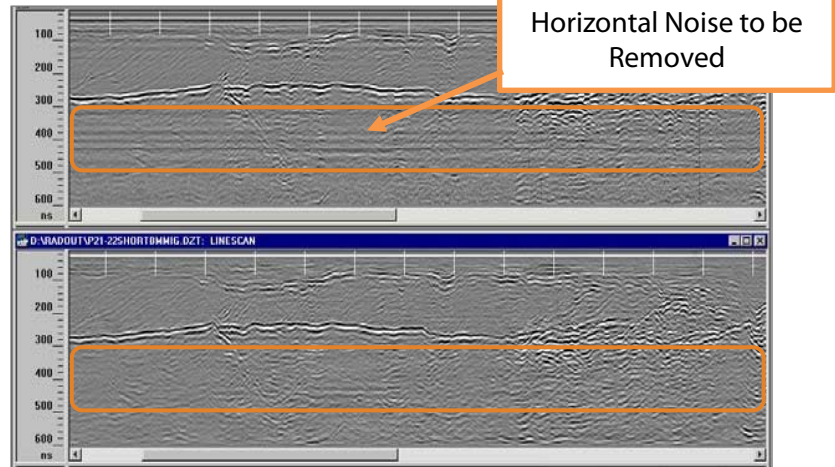
- High frequency noise generally has a 'snowy' appearance.
- The larger the number you put in here, the smoother the data will be. It is possible to over smooth and 'smudge' out real data.
- A larger number also means that the system is performing a great deal of extra calculations and data collection speed may be reduced.
- The Stacking filter maximum value is 1023 scans.

FIR BG Removal

Background Removal is a filter which removes horizontal bands of noise similar to those seen in the image below. Sometimes these bands are caused by 'real' horizontal reflectors, but they can also be caused by low frequency noise such as antenna ringing. These layers can obscure other 'real' horizontal or point source reflectors.

Filter length should be set to the number of scans equal to the feature length to be removed. Any continuous feature within the data, such as a water table reflector or a stratigraphic boundary between two soil types, may also be filtered out by performing Background Removal. Be careful; it is easy to filter out desired reflectors.

The FIR Background Removal filter input is in number of scans. Pressing FIR BG Removal with either the Control Knob or Enter button will allow you to select a number of scans.



- Determine the length in scans of the feature or noise that you want to remove from the data and input that number. Features, or horizontal reflections, of this size or larger will be removed.
- The Background Removal filter maximum value is 1023 scans.
- It is recommended that this filter be set last. When Background Removal is turned on the previewed linescan data and individual scan will gradually be averaged out by the filter and only noise will be visible. This makes it impossible to preview the effects of other filters.

Custom Filter

This filter overrides the FIR Low/High Pass filters with a custom filter provided with an antenna. Custom Filters are only available with certain antennas and are sent with the antenna when it is purchased.

IIR Low Pass and IIR High Pass

IIR filters (Infinite Impulse Response) are a holdover from analog circuits. It is a simpler and potentially cruder type of filter than the FIR filter. The IIR filter is used to remove noise, but may change the waveform shape. When an IIR filter encounters a feature in the radar data, it produces an output that decays exponentially towards zero but never reaches it, hence the name “infinite.” IIR filters are not necessarily symmetrical and while they achieve excellent amplitude response, their phase response is non-linear and so they can cause slight phase shifts in the data.

By setting these at different ends of the antenna’s bandwidth, you are determining the range of frequencies that the antenna is filtering out. Pressing IIR Low/High Pass with either the Control Knob or Enter button will allow you to scroll through different frequencies.

- IIR Filters should not be used with 4096 samples/scan or higher.
- The maximum Low and High Pass filter values are 5000 MHz.
- Select Off to disable either filter.

IIR Low Pass: The selected frequency in MHz is the upper limit of the filter. Any frequency lower than selected Low Pass frequency will be allowed to pass through the filter and be recorded by the system.

IIR High Pass: The selected frequency in MHz is the lower limit of the filter. Any frequency higher than selected High Pass frequency will be allowed to pass through the filter and be recorded by the system.

IIR Stacking

In addition to IIR frequency filters, another option is Stacking. Stacking is a high-frequency noise reduction filter which operates in the horizontal direction. Each new scan has a 1/n influence in the data, so this filter has a tendency to smooth high frequency targets and accentuate low frequency horizontal

features, such as layers. As the number of stacked scans (n) increases, the influence of new scans decreases.

The IIR Stacking filter input is in number of scans. Pressing IIR Stacking with either the Control Knob or Enter button will allow you to select a number of scans.

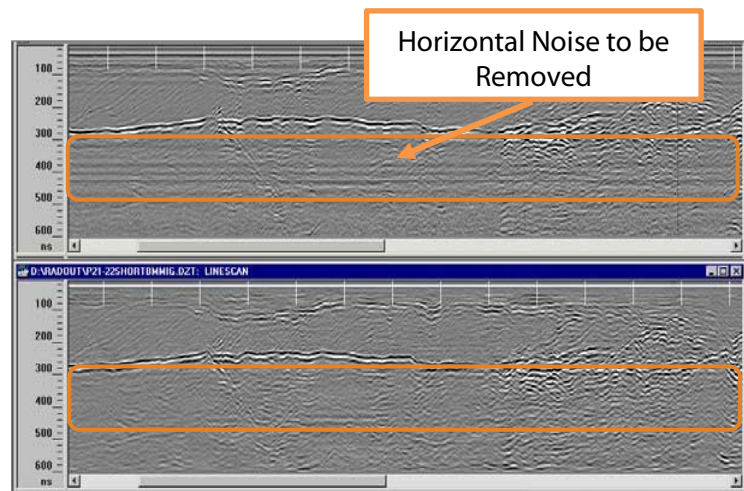
- High frequency noise generally has a ‘snowy’ appearance.
- The larger the number you put in here, the smoother the data will be. It is possible to over-smooth and ‘smudge’ out real data.
- A larger number also means that the system is performing a great deal of extra calculations and data collection speed may be reduced.
- The Stacking filter maximum value is 1023 scans.

IIR BG Removal

Background Removal is a filter which removes horizontal bands of noise similar to those seen in the image below. Sometimes these bands are caused by ‘real’ horizontal reflectors, but they can also be caused by low frequency noise such as antenna ringing. These layers can obscure other ‘real’ horizontal or point source reflectors.

Filter length should be set to the number of scans equal to the feature length to be removed. Any continuous feature within the data, such as a water table reflector or a stratigraphic boundary between two soil types, may also be filtered out by performing Background Removal. Be careful to not filter out desired reflectors.

The IIR Background Removal filter input is in number of scans. Pressing IIR BG Removal with either the Control Knob or Enter button will allow you to select a number of scans.



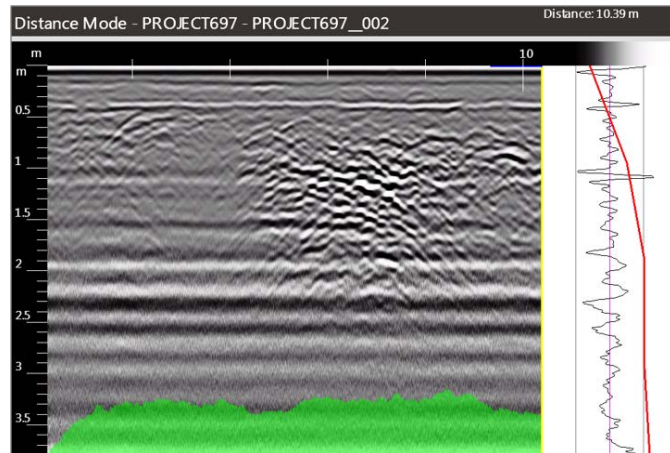
- Determine the length in scans of the feature or noise that you want to remove from the data and input that number in to the SIR 4000. Features, or horizontal reflections, of this size or larger will be removed.
- The Background Removal filter maximum value is 1023 scans.
- It is recommended that this filter be set last. When Background Removal is turned on the previewed linescan data and individual scan will gradually be averaged out by the filter and only noise will be visible. This makes it impossible to preview the effects of other filters.

Signal Floor

When Signal Floor is turned on it overlays a green field on the Linescan display. This green field is an estimate of the effective depth of each scan based on an analysis of the noise to signal loss (attenuation). Note: strong, real reflectors may still be located beneath the Signal Floor.

Press the Control Knob or Enter key to toggle Signal Floor On or Off.

This process does not affect the data being collected. It is a visual indication only.



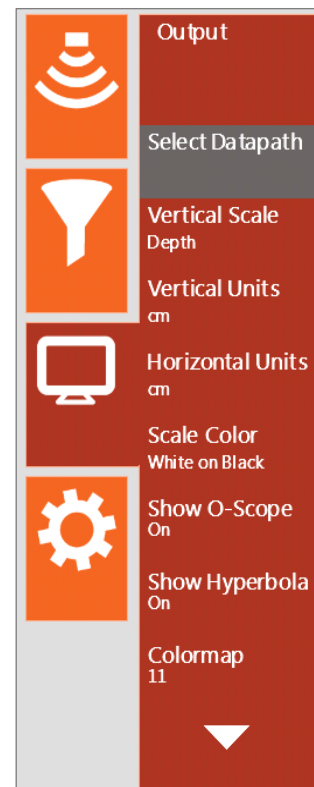
Filters Off

This removes any FIR high pass, FIR low pass, IIR high pass, or IIR low pass filters that were previously applied. After turning off the filters they can only be recovered by turning them on individually or by recalling a previously saved or factory default setup.

Setup Menu - Output

This menu controls the data display and file maintenance. There are fourteen (14) sub-menus to the Output menu depending upon which collection mode is selected:

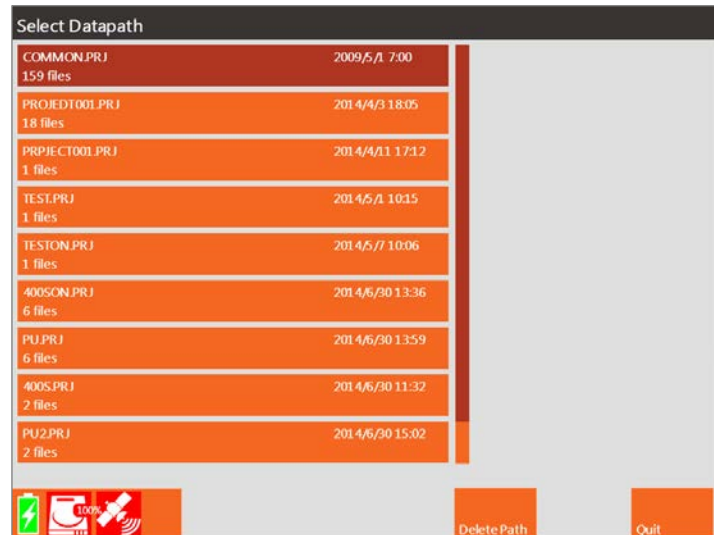
Menu Option	Collect Mode	Collect/ Playback Point Mode	Playback Mode
Select Datapath	X	X	X
Vertical Scale	X	X	X
Vertical Units	X	X	X
Horizontal Units	X	X	X
Scale Color	X	X	X
Show O-Scope	X	X	X
Show Hyperbola	X		X
Colormap	X		X
Color Stretch	X		X
Color Slide	X		X
Spacing		X	
Amplitude		X	
Fill		X	
Exit	X	X	X



Select Datapath

This is the location in which your files are stored on the SIR 4000. There are two basic types of paths: Common and User-defined.

- Common is the default file path and files in this directory will be named with the word FILE and then a number. For example, the first data file will be FILE__001, then FILE__002, and so on.
- User-defined paths allow you to change the location of your data. This is useful if you are surveying multiple areas or if you prefer to name your files during collection with a site name instead of doing it later after download. Files will be named after the data path. For example a data path named GRID will contain files named GRID__001, GRID__002, and so on.



When Select Datapath is pressed using either the Control Knob or the Enter key it opens a list of the different project folders saved on the SIR 4000. Use the Control Knob or Enter key to scroll the list and select a new project folder by pressing the Control Knob or Enter key. After a new selection is made you'll return the Collect Setup Screen.

- You can only choose from existing data paths. In order to create a new data path, return to the Introduction Screen and select New Project.
- When New Project is selected the Edit Project Name menu opens allowing you to change the name of the data path. This name will also be used as the default filename.

You can also delete old project folders through this menu. To do so scroll through the list of project names and when the project folder you wish to delete is highlighted press the Delete Path control button.

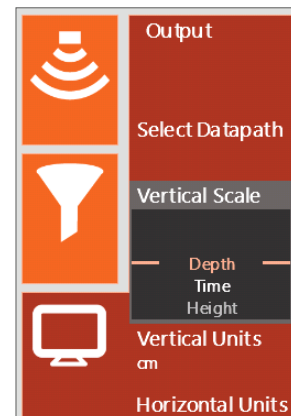
Vertical Scale

The Vertical Scale menu options allows you to choose how the vertical scale on the left-hand side of the data display appears. It can be set to either Depth, Time, or Height.

Depth: When Depth is selected the SIR 4000 performs a time to depth conversion based on the dielectric value that you have set in Radar -> Dielectric or Radar->Soil Type. It will then display the vertical scale in depth based on the units of measure chosen under Output -> Vertical Units.

Time: Measured in nanoseconds (ns). When set to time, the vertical scale displays two way travel time (TWTT).

Height: Inverts the screen so that time-zero is at the bottom. This can be a useful display if you are scanning upside-down.



Vertical Units

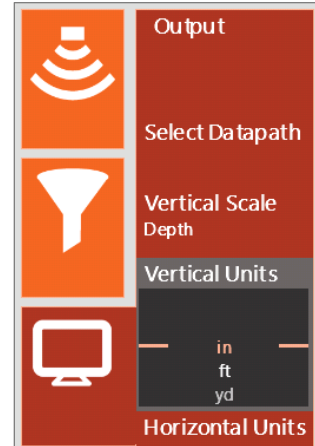
Sets which units of measure are displayed based on which Vertical Scale is currently selected.

- As an example: if you are using a very high frequency antenna to scan 18 inches into concrete, you may choose to display depth in inches instead of feet.

Time: Nanoseconds (ns) is the only option available.

Distance: Which units are available is based on the units of measure set in the Introduction -> Units menu. If Metric, then centimeters (cm) and meters (m) are available. If English, then inches (in), feet (ft), and yards (yd) are available.

Height: Which units are available is based on the units of measure set in the Introduction -> Units menu. If Metric, then centimeters (cm) and meters (m) are available. If English, then inches (in), feet (ft), and yards (yd) are available.



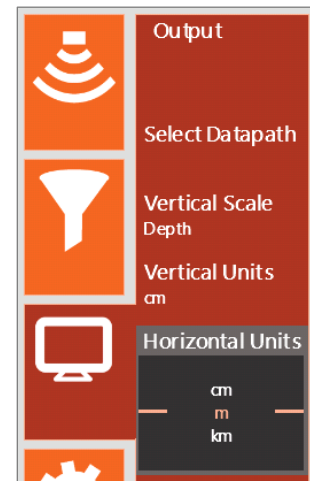
Horizontal Units

Sets which units of measure are displayed based on the Units selected from the Introduction Screen.

- As an example if you are collecting a long geologic profile you can display the distance in kilometers instead of meters.

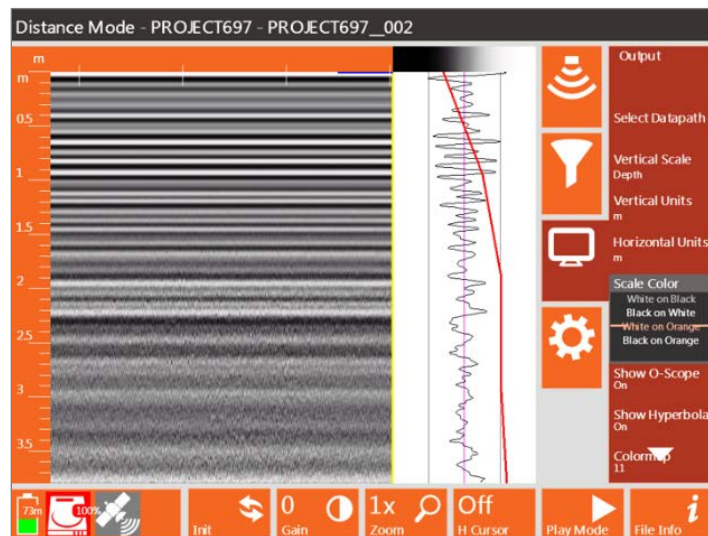
Metric: Horizontal units of measure available for Metric are centimeters (cm), meters (m), or kilometers (km).

English: Horizontal units of measure available for English are inches (in), feet (ft), yards (yd), or miles (mi).



Scale Color

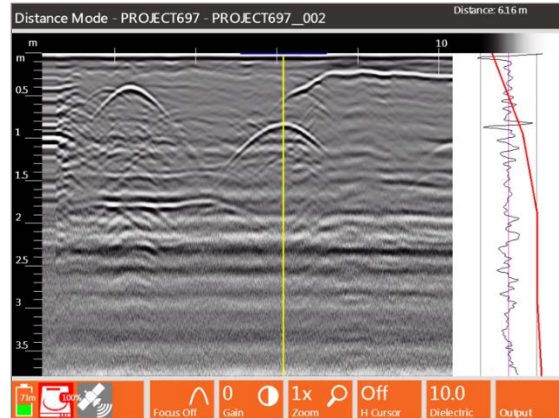
Change the color of the text and background for the vertical and horizontal scales in data display. The choices are either white or black text on a white, black, or orange background. This will change the display in both the Setup Screen, during data collection, and during playback.



Show O-Scope

Toggles the O-Scope display On or Off for use during data collection. Selecting Off will not turn off the O-Scope display in the Setup Screen.

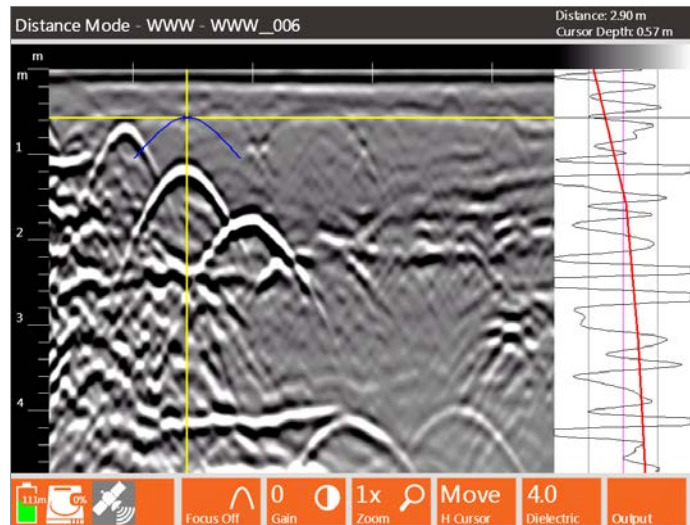
- During data collection you will not have the option to turn the O-Scope display On or Off. This choice is only made while in the Setup Screen.
- Toggle Show O-Scope On or Off by pressing the Control Knob or the Enter key.



Show Hyperbola

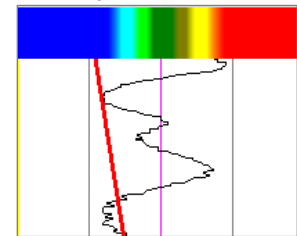
Toggles a hyperbola On or Off while in setup or during collection. The hyperbola appears at the intersection of the vertical and horizontal cursor. By default the horizontal cursor is placed at the top of the data display.

- The hyperbola is used during data collection to do real-time hyperbola fitting. Hyperbola fitting measures the geometry of visible hyperbolas in the data to generate an estimated Dielectric Constant.
- During data collection you'll also have the option to turn the hyperbola On or Off.
- Toggle Show Hyperbola On or Off by pressing the Control Knob or the Enter key.



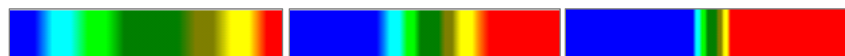
Colormap

This menu option offers 30 available Colormap options (i.e. color tables). Select the menu by pressing the Control Knob or Enter key and then scroll through Colormap #0-29. The currently selected Colormap appears at the top of the O-Scope display and indicates how colors are distributed between negative (left) and positive (right) amplitude changes.



Color Stretch

Selecting Color Stretch allows you to adjust how the selected Colormap is distributed over a scan's amplitude range. A Color Stretch greater than one (1) compresses the colors towards zero (0). A Color Stretch less than one (1) expands the colors towards the maximum negative and positive amplitudes.

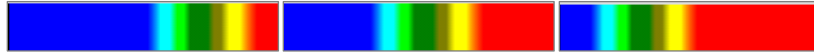


Left Color Stretch = 0; Middle Color Stretch = 1; Right Color Stretch = 3

Color Slide

Selecting Color Slide allows you to shift the center point of the selected Colormap over a scan’s amplitude range (amplitude zero crossing). A negative number shifts towards the positive amplitudes and positive number shifts towards the negative amplitudes.

- Adjusting the Color Slide over a particular value range allows you to see more subtle variations in the data.



Left Color Slide = -0.20; Middle Color Slide = 0; Right Color Slide = 0.20

Spacing – Point Mode Only

This is the number of pixels displayed between each individual scan collected using Point Mode. Values range from 1-50. You can select different spacing using the Control Knob or the arrow keys.

Amplitude – Point Mode Only

Similar to Display Gain, Amplitude increases the amplification of each scan to bring out the weaker reflections. It is in decibels (dB) and can range from 1-100. You can select different spacing using the Control Knob or the arrow keys.

Fill – Point Mode Only

This is the percent of the scan’s positive peaks that are filled in and will appear black during data collection and playback.



Setup Menu – System

This menu includes general settings such as how files are saved and default setups. There are eight (8) options under the System menu:

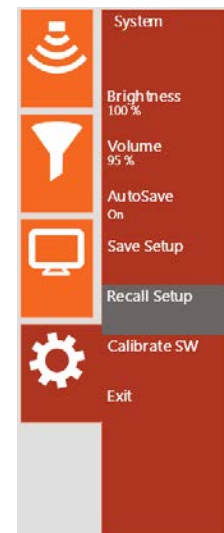
Brightness

This controls screen brightness. The scale runs from 0-100% with 100% being the brightest and the screen will be black when set at zero (0). The darker the screen is, the longer the battery will last because the screen consumes more power when the brightness is increased.

Volume

This adjusts the volume of the control unit. The system makes noise at certain points during setup, data collection, and playback. The scale runs from 0-100%. 100% is the loudest; 0% mutes the volume.

Menu Option	Collect Mode	Playback Mode
Brightness	X	X
Volume	X	X
WiFi	X	X
AutoSave	X	X
Save Setup	X	X
Recall Setup	X	X
Calibrate SW	X	X
Exit	X	X



WiFi

This option toggles the SIR 4000 WiFi On and Off (configuration is reserved for future functionality).

AutoSave

You can toggle AutoSave to On or Off by pressing the Control Knob or the Enter key. When AutoSave is set to On each time you end data collection the profile is automatically saved in the project folder under the filename shown at the top of the screen. If AutoSave is set to Off you will be prompted each time you end data collection to either save or delete the current file. If you choose to save the file it saves in the project folder under the filename shown at the top of the screen.

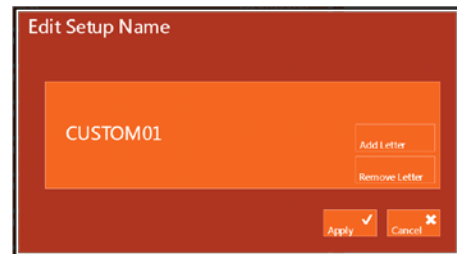
- **When collecting a manual 3D grid without using the SIR 4000 3D grid mode you should set AutoSave to Off.** When you finish collecting a transect of data, the file save prompt pauses data collection so that you can reposition to start collecting the next transect.

Save Setup

You can save all of the settings from the Radar, Process, and Output menus to be recalled at a later date. When Save Setup is pressed using either the Control Knob or the Enter key a menu opens with sixteen (16) available setups, Setup01 – Setup16. Setup00 is the current setup, which is automatically saved anytime data is collected.

You can also create a New Setup from the control button at the bottom of the screen. Pressing this button opens the Edit Setup Menu where you can customize the name.

- Use the Control Knob or arrow keys to select and modify letters.
- You can Add Letters to or Remove Letters from the end of the Setup Name.
- To save the custom setup select Apply.



Recall Setup

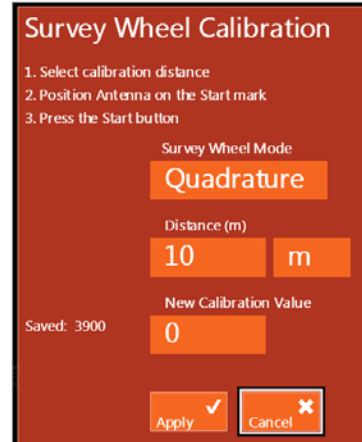
You can recall a setup that was saved by selecting Recall Setup. When Recall Setup is selected by either pressing the Control Knob or the Enter key, a list of available setups will appear.

- Setup00, while not listed, is always available and represents the current settings
- Setups are available for most antenna and cart configurations user-created setups appear at the bottom of the list.



Calibrate SW

Calibrate the survey wheel when you change wheels or the ground surface changes. Begin by selecting a Survey Wheel Mode, either Quadrature or Pulse, and then follow the instructions. *Quadrature Mode* is intended for dual channel encoders and will track rotations and the direction the encoder turns. This means that data are collected in forward and reverse directions. *Pulse Mode* is intended for single channel encoders and tracks encoder rotations, not the direction. This mode is useful for field delineation; pulling the wheel backwards will not collect data, but a cursor will move backwards across the screen. The cursor will help determine where a particular target is located along your transect. After calibration select Apply to save the New Calibration Value or cancel to exit the Calibrate SW menu without saving.

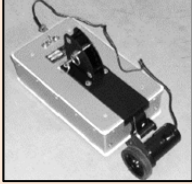


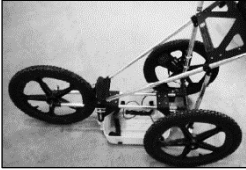


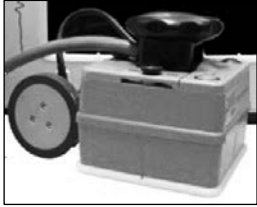



- 1** Select calibration distance – The default distance is 10 meters or feet but this distance can be changed. The longer the calibration distance the more accurate the calibration should be.
- 2** Position Antenna on the Start mark – The antenna or system can be positioned anywhere at the start as long as you use the same point on the antenna or system when you stop.
- 3** Press the Start button – This is the green Start button located on the keypad of the SIR 4000.
- 4** Move antenna to the stop mark – This should match the same location on the antenna or system where you started.
- 5** Press the Stop button – This is the red Stop button located on the keypad of the SIR 4000.
- 6** Select Apply to save the current calibration setting.

Note: The SIR4000 saves the survey wheel encoder calibration value in counts/ meter no matter your selected units of measure. That means that if you are used to working in English (Imperial) units and are familiar with a Model 620 tow-behind wheel calibration value of ~127/ft, the new calibration value you will see will be ~417.

Survey Wheel Factory Default Calibration Settings

Note: These default values are provided for convenience, but it is always advisable to calibrate your survey wheel to obtain a more accurate value. These values are recalled when a factory default setting is recalled from Recall Setup.

	<p>Model 611 (3 5/6" wheel) survey wheel for 3101 Series (900 MHz) antenna</p> <p><u>2000 ticks</u></p>		<p>Model 620 (16" wheel): 400 MHz and 200 MHz tow-behind</p> <p><u>417 ticks</u></p>
	<p>Model 613 StructureScan Cart</p> <p><u>2000 ticks</u></p>		<p>Model 623/624/625 Survey Cart 2-or 3-Wheel UtilityScan Cart:</p> <p><u>1785 ticks</u></p>
	<p>Model 614/615 Survey Handcart Blue metal StructureScan Cart with or without bar code reader</p> <p><u>4030 ticks</u></p>		<p>Model 643/644 Survey Cart Large 4-Wheel UtilityScan Cart:</p> <p><u>3140 ticks</u></p>
	<p>Model 62000 Palm Antenna 2 GHz Palm Antenna with attached single survey wheel</p> <p><u>22146 ticks</u></p>		<p>Model 652/653 /654/655 Survey Cart Small 4-Wheel UtilityScan Cart:</p> <p><u>3850 ticks</u></p>

2.4: The Toolbar

The six keys across the bottom of the data display window have different functions depending on whether you are in Setup Collect/Playback Mode, data collection, or data playback.

In Setup Collect Mode

In Setup Collect Mode, the Toolbar will appear like this:



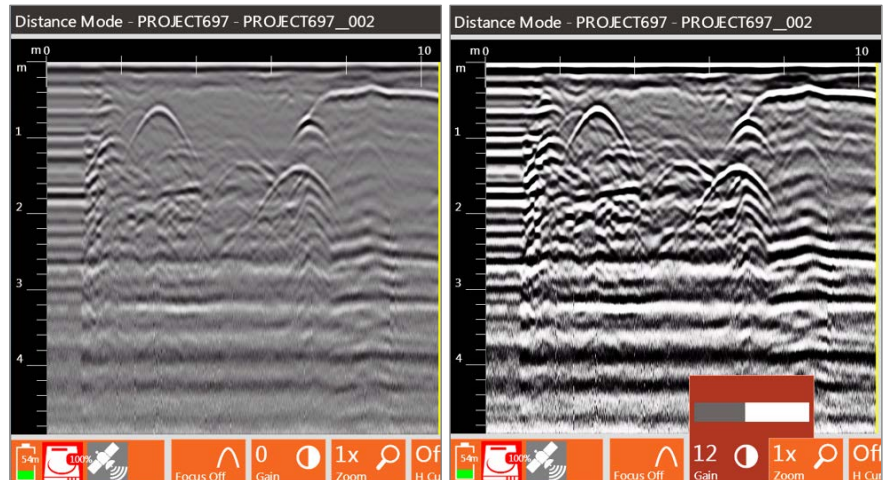
Init(ialize)

This button stops and instantly restarts the transmitter. Through the Initialization process all settings that are set to Auto, such as Gain or Position, will reset based on the current quality of the scan trace.

- To Initialize the system just press the Init control button one time.

Gain

This Gain option is also referred to as display gain. It increases the amplitude of your data by multiplying every sample by a constant value. This will enhance weaker reflections, but those already strong reflections may be over-gained. This function is useful for a quick viewing of data that is attenuated or otherwise under-gained to guarantee that it was not clipped.

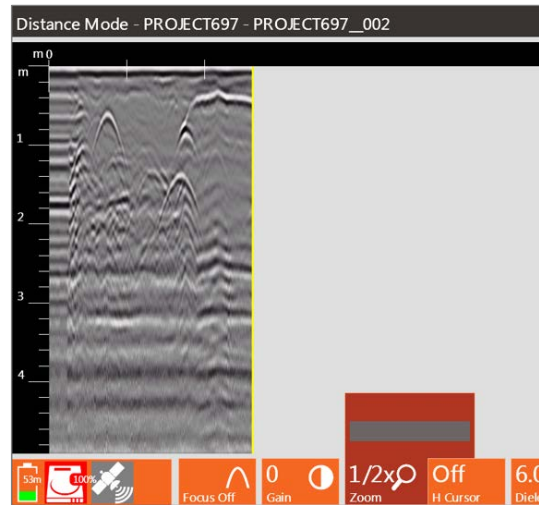


- You can change the Gain from -12 to 60. Negative values weaken the entire signal, and positive values strengthen it.
- To modify Gain press the Gain control button and use either the Control Knob or Right/Left Arrow keys to adjust the gain amount.
- ***Display Gain is only for display and is not saved with the data.***

Zoom

This option modifies the horizontal scale by zooming in or out by factors of 1/2x, 1x, 2x, 4x, or 8x.

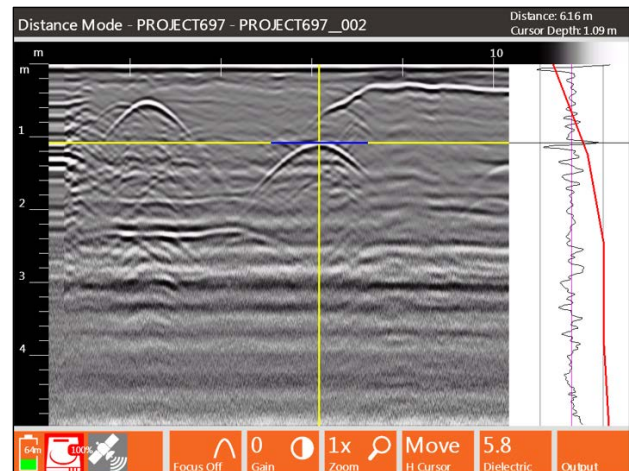
- The system defaults to 1x Zoom on initial startup and when data collection begins.
- This does not affect how the data are saved.



H Cursor

You can add a horizontal cursor to the screen during setup and data collection. The yellow line can be moved and toggled On or Off.

- To position H Cursor press the H Cursor control button to change the H Cursor to Move. Then use the Control Knob to adjust its position. Rotate the knob left (counter-clockwise) to move the cursor down the time range. Rotate the knob right (clockwise) to move the cursor up the time range.
- To set the H Cursor press the Control Knob or press Enter. The H Cursor control button will say On.
- To turn the H Cursor off press the H Cursor control button until it says Off.



Play Mode

If you click this button while in the Setup Collect Mode the system will prompt you for a file to open and playback from the current project folder. Use the Control Knob or arrow keys to select a saved file. You can select multiple files to playback in sequence.

Select All: Selects all files in the current project folder to playback in sequence.

Choose Path: Allows you to select a different project folder for playback.

Copy to USB: A way to transfer currently selected files to a USB drive. The files will only be copied; the original files will remain on the SIR 4000.

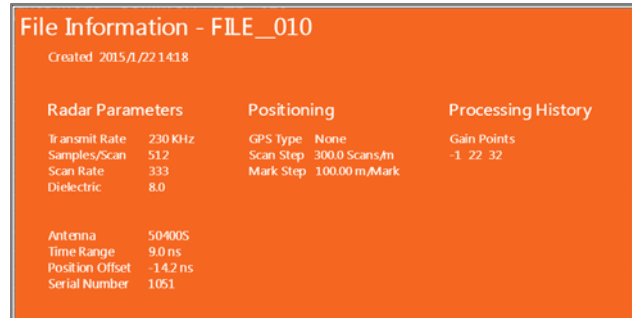
Move to USB: A way to transfer currently selected files to a USB drive. The files will be removed from the SIR 4000.



Delete Files: Deletes the currently selected files from the project folder. If all of the files are selected and deleted the SIR 4000 will still keep the project folder.

File Info

This control button opens a window showing the current settings including Radar Parameters, Positioning information, and Processing History.



In Setup Playback Mode

In Setup Playback Mode, the Toolbar will look like this:



Init(ialize)

This button initiates the auto gain, which will reset the gain curve based on the quality of the saved data.

Gain

This Gain option is identical to the option in Setup Collect Mode (see above).

Zoom

This Zoom option is identical to the option in Setup Collect Mode (see above).

Select File

Opens a list of files within the current project folder to open into Playback Mode. You can navigate through the list using either the Control Knob or the arrow keys. Select a file to open by pressing the Control Knob. Then open the file by pressing the Enter key. If two or more files are selected it will open the files in sequence from the lowest file number to the highest.

Select All: Selects all of the files in the current project folder to playback in sequence.

Choose Path: Allows you to select a different project folder for playback.

Copy to USB: A way to transfer the files currently selected to a USB drive. The files will be copied, maintaining a copy on the SIR 4000.



Move to Net: A way to transfer the files currently selected to a location on the network. The files will be removed from the SIR 4000. This option will be available in a future update.

Move to USB: A way to transfer the files currently selected to a USB drive. The files will be removed from the SIR 4000.

Delete Files: Deletes the currently selected files from the project folder. If all of the files are selected it maintains the project folder.

Collect Mode

Clicking the Collect control button will bring you back to Setup Collect Mode. You'll know which mode you're in by the text displayed in the top left corner of the screen.

Playback Mode: Playback Mode – [Folder] – [File name]

Collect Mode: Distance/Time/Point Mode – [Folder] – [File name]

File Info

This Command Key opens a window showing the current settings including Radar Parameters, Positioning information, and Processing History.

In Collect Mode

To begin Collect Mode press on the green Start button while in the Setup Collect Mode. After the Start button is pushed data will start to fill in from the left moving to the right at a rate dependent upon the type of collection mode chosen. In Collect Mode, the Command Bar will change based on the method of data collection; Distance, Time, or Point.



Distance Mode Control Buttons



Time Mode Control Buttons

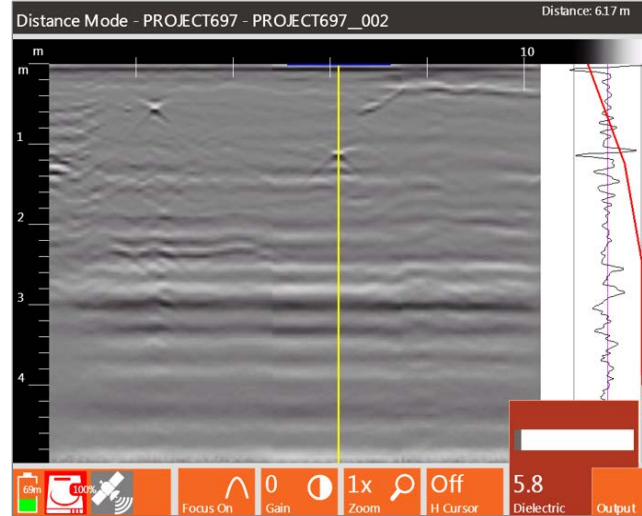


Point Mode Control Buttons

Focus On - Distance Mode Only

Focus On performs a migration, which is a processing procedure that reduces or eliminates hyperbolic diffraction patterns in the data. It removes the tails of hyperbolas to more accurately represent the center location of a target. This makes the identification of point reflectors much easier. Migration also uses the shape of the hyperbolas as a simple and accurate way of estimating the radar velocity (and thus dielectric) of the material your target is in.

- If the dielectric constant is too high when Focus is turned on, hyperbolic reflections will still appear as hyperbolas.
- If the dielectric constant is too low when Focus is turned on, hyperbolas will appear in a “U” shape.
- Adjusting the dielectric with the Dielectric control button will change how hyperbolic reflections appear during data collection. The goal is for all hyperbolic reflections to appear as dots.
- If you are on a homogenous material, like concrete, this calibration is good for all similar materials. If you are on soils, this is only an approximation because the Dielectric Constant can change greatly with depth and across an area.



Pause/Resume - Time Mode Only

Temporarily pauses data collection in Time Mode. Press once to Pause collection. When the system is paused, the Pause control button will become a Resume control button. Press Resume to continue data collection.

Next Point - Point Mode Only

This is the control button that allows you to collect multiple scans in one file when collecting data in Point Mode. When the Next Point control button is pressed a subsequent scan will be added to the data display starting from the left and progressing to the right.

Gain

This Gain option is also referred to as display gain (see section 2.4 above for screenshots). It increases the amplitude of your data by multiplying every sample throughout your scan by a constant value. The result is that you will be able to better see weaker reflections, but those already strong reflections may be over-gained. This function is useful for a quick viewing of data that is attenuated or otherwise under-gained to guarantee that it was not clipped.

- You can change Gain from -12 to 60, with negative values weakening the entire signal and positive values strengthening the signal by the value shown.
- To modify Gain press the Gain control button and use either the Control Knob or Right/Left Arrow keys to adjust the gain amount.
- Display Gain is only for display and is not saved with the data.

Zoom – Distance and Time Mode

This option modifies the horizontal scale by zooming in or out by factors of ½x, 1x, 2x, 4x, or 8x (see Section 2.4 above for screenshots).

- The system defaults to 1x Zoom on initial startup and when data collection begins.
- ***This does not affect how the data are saved.***

H Cursor

Adds a yellow horizontal line to the screen during data collection that can be moved or toggled On or Off.

- To position H Cursor press the H Cursor control button to change the H Cursor to Move. Then use the Control Knob to adjust its position. Rotate the knob left (counter-clockwise) to move the cursor down the time range. Rotate the knob right (clockwise) to move the cursor up the time range. As the H Cursor moves the Cursor Depth is updated in the upper right corner of the screen and in the Set Depth Control Button on the Command Bar (only visible if Show Hyperbola is turned off in the Output Menu).
- To set the H Cursor press the Control Knob or press Enter. The H Cursor control button will say On.
- To turn the H Cursor off press the H Cursor control button until it says Off.

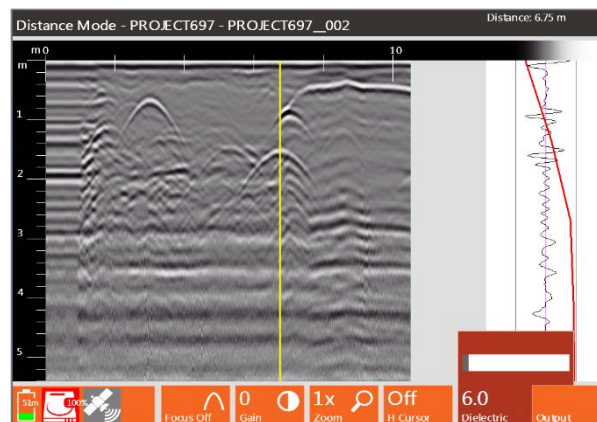


Dielectric

You can adjust the Dielectric Constant during data collection from a value of one (1) to eighty-one (81).

- Changing the Dielectric Constant will change the vertical scale if it is displayed in depth based on the Time Range selected during setup.

Distance Mode: Dielectric can be modified during distance-based collection when data are not actively being collected, as when the survey wheel is stopped or backing up. Adjust the Dielectric Constant by pressing the Dielectric control button and using the Control Knob or arrow keys to adjust the value. Save the selected Dielectric by pressing the control button again, the Control Knob, or the Enter button.



Time Mode: In this mode, Dielectric can only be adjusted when data collection is paused.

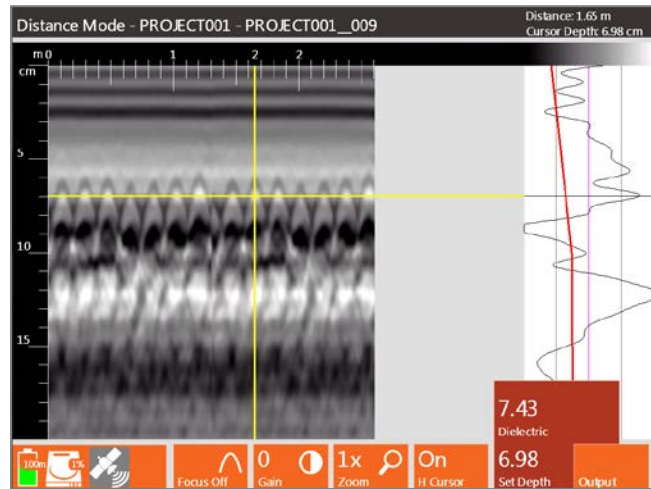
- Press the Pause control button to pause data collection. Then press the Dielectric control button. Use the Control Knob to adjust the Dielectric Constant between one (1) and eighty-one (81). The vertical scale will update as the Dielectric Constant is changed.
- Save the selected Dielectric by pressing the control button, the Control Knob, or the Enter button.

Point Mode: Dielectric can be modified at any time during Point Mode collection. Adjust the Dielectric Constant by pressing the Dielectric control button and using the Control Knob or arrow keys to adjust the value. Save the selected Dielectric by pressing the control button again, the Control Knob, or the Enter button.

Set Depth

This control button allows you to enter the depth of a known target and automatically adjust the Dielectric Constant. This option is only available when Show Hyperbola is turned off. This can either be done from Setup or while collecting through the Output control button.

- 1 Collect a file over a target with a known depth.
- 2 Back up so the vertical cursor is in line with the target.
- 3 Set Horizontal Cursor (H Cursor) to Move, and the Set Depth button appears. Position the H Cursor at the top of the known target.
- 4 Press the Set Depth control button and the depth value for the position of the H Cursor appears above Set Depth.
- 5 Adjust the depth value using either the Control knob or arrow keys to match the known value. The vertical scale and Dielectric will change as you adjust the depth value.



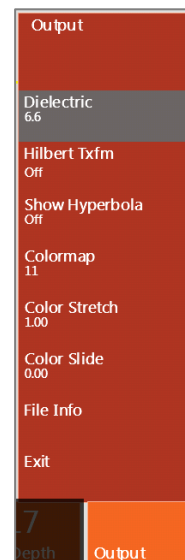
Output - Distance Mode

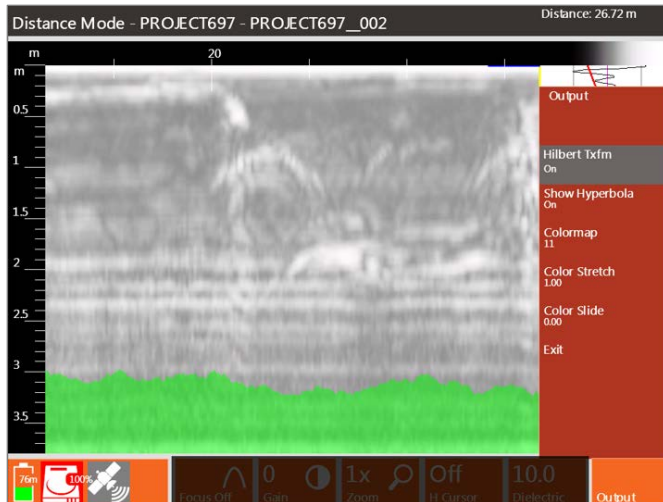
This control button opens a menu with options for modifying the data display during collection.

Dielectric: You can adjust the Dielectric Constant during data collection from a value of one (1) to eighty-one (81).

- Changing the Dielectric Constant will change the vertical scale if it is displayed in depth based on the Time Range selected during setup.

Hilbert Txfm: A Hilbert Transform is used to display subtle properties of the subsurface. Reflector amplitude and time are the primary types of information in GPR data used to make interpretations. Another way of defining the data is by transforming it into frequency and phase (positive or negative changes in the scan trace). This information is sometimes more sensitive to important subsurface (dielectric) changes in the amplitude or geometric information.



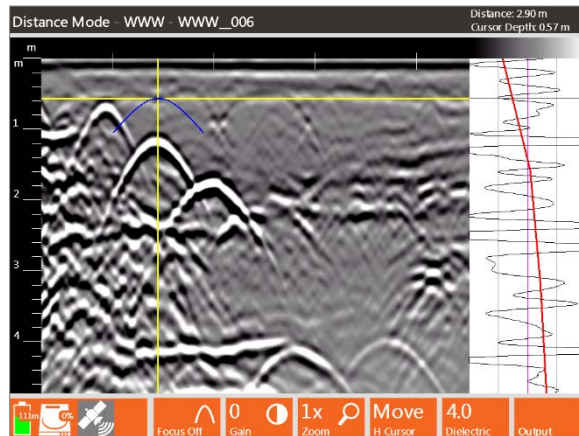


A Hilbert Transform will change a radar signal represented as a time series into its magnitude (via envelope detection) phase). The Hilbert Transform expresses the relationship between the phase and magnitude of the signal, or between its real and imaginary parts. It allows the phase of a signal to be reconstructed from its amplitude.

Toggle Hilbert Transform On or Off by pressing the Control Knob or the Enter key.

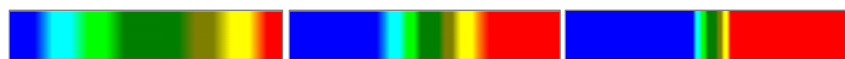
Show Hyperbola: Toggles a hyperbola On or Off while in setup or during collection. The hyperbola appears at the intersection of the vertical and horizontal cursor. By default the horizontal cursor is placed at the top of the data display.

- The hyperbola is used during data collection to do real-time hyperbola fitting. Hyperbola fitting measures the geometry of visible hyperbolas in the data to generate an estimated Dielectric Constant.
- During data collection you'll also have the option to turn the hyperbola On or Off.
- Toggle Show Hyperbola On or Off by pressing the Control Knob or the Enter key.



Colormap: This menu option offers 30 available Colormap options (i.e. color tables). Select the menu by pressing the Control Knob or Enter key and then scroll through Colormap #0-29. To preview the different Colormaps, if the O-Scope is not displayed during data collection, return to the Setup Screen->Output Menu.

Color Stretch: Selecting Color Stretch allows you to adjust how the selected Colormap is distributed over a scan's amplitude range. A Color Stretch greater than one (1) compresses the colors towards zero (0). A Color Stretch less than one (1) expands the colors towards the maximum negative and positive amplitudes. To preview Color Stretch, if the O-Scope is not displayed during data collection, return to the Setup Screen->Output Menu.



Left Color Stretch = 0; Middle Color Stretch = 1; Right Color Stretch = 3

Color Slide: Selecting Color Slide allows you to shift the center point of the selected Colormap over a scan's amplitude range. A negative number shifts towards the positive amplitudes and positive number shifts towards the negative amplitudes. To preview Color Slide, if the O-Scope is not displayed during data collection, return to the Setup Screen->Output Menu.

- Adjusting the Color Slide over a particular value range allows you to see more subtle variations in the data.



Left Color Slide = -0.20; Middle Color Slide = 0; Right Color Slide = 0.20

File Info: This opens a window showing the current settings including Radar Parameters, Positioning information, and Processing History.

Output - Time Mode

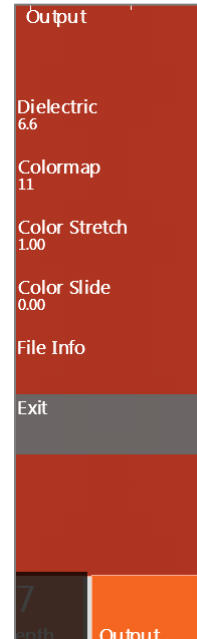
This control button opens a menu with options for modifying the data display during collection.

Dielectric: You can adjust the Dielectric Constant during data collection from a value of one (1) to eighty-one (81). (See Output – Distance Mode above for screenshots and other information).

Colormap: This menu option offers 30 available Colormap options. (See Output – Distance Mode above for screenshots and other information).

Color Stretch: Selecting Color Stretch allows you to adjust how the selected Colormap is distributed over a scan’s amplitude range. (See Output – Distance Mode above for screenshots and other information).

Color Slide: Selecting Color Slide allows you to shift the center point of the selected Colormap over a scan’s amplitude range. (See Output – Distance Mode above for screenshots and other information).



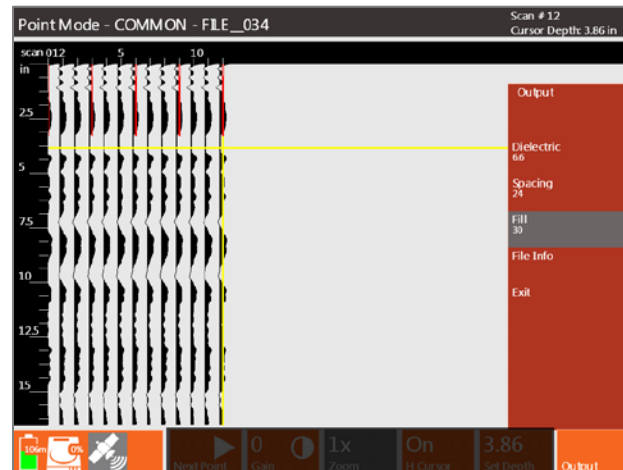
Output - Point Mode

This control button opens a menu with options for modifying the data display during collection.

Dielectric: You can adjust the Dielectric Constant during data collection from a value of one (1) to eighty-one (81). (See Output – Distance Mode above for screenshots and other information).

Spacing: This is the number of pixels displayed between each individual scan collected using Point Mode. Values range from 1-50. You can select different spacing using the Control Knob or the arrow keys. You can select different spacing using the Control Knob or the arrow keys.

Fill: This is the percent of the scan’s positive peaks that are filled in and will appear black during data collection.



File Info: This opens a window showing the current settings including Radar Parameters, Positioning information, and Processing History.

In Playback Mode

This is what the Toolbar will look like in Playback Mode. This mode is accessible from the Playback Setup screen by pressing the green Start button. After clicking Start button the data file will scroll to the end of the file and stop.



Pause/Resume

Pauses the data as it is being displayed on the SIR 4000. When the Pause control button is pressed once it stops playback and the control button changes to Resume. The Resume control button can then be pressed to continue playing back the selected data.

Gain

This Gain option is also referred to as display gain. It increases the amplitude of your data by multiplying every sample by a constant value. This will enhance weaker reflections, but those already strong reflections may be over-gained (See Output Distance Mode above for screenshots and additional information).

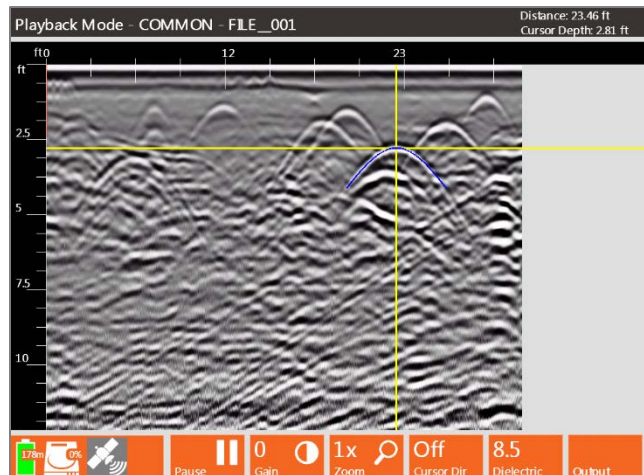
Zoom

This option allows you to modify the horizontal scale by zooming in or out by factors of ½x, 1x, 2x, 4x, or 8x (See Output Distance Mode above for screenshots and additional information).

Cursor Dir

You can move a horizontal and vertical cursor around the screen during data playback.

- Press the Cursor Dir control button to change the cursor to either Vert(ical) or Horiz(ontal). Then use the Control Knob to adjust its position.
- Rotate the knob left (counter-clockwise) to move vertical cursor to the left. Rotate the knob right (clockwise) to move the vertical cursor to the right.
- Rotate the knob left (counter-clockwise) to move the horizontal cursor down the time range. Rotate the knob clockwise to move the cursor up the time range.
- To turn the Cursor off press the Cursor Dir control button until it says Off. The Cursor Dir needs to be turned off in order to use the arrow keys for other functions.

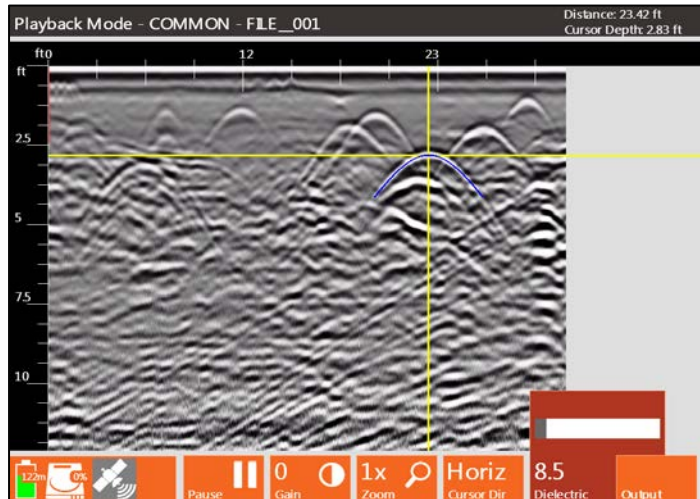


Dielectric

You can adjust the Dielectric Constant during playback from a value of one (1) to eighty-one (81).

- Changing the Dielectric Constant will change the vertical scale if it is displayed in depth based on the Time Range selected during setup.

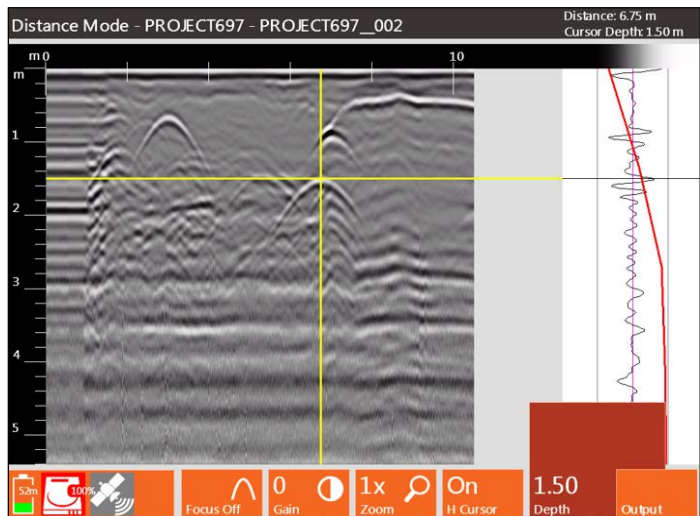
- If you turn on Show Hyperbola from the Output Menu, you can perform hyperbola fitting to get a better dielectric estimate.
 - Position the horizontal and vertical cursor at the top of a hyperbola.
 - With Show Hyperbola turned on, select the Dielectric control button and use the Control Knob or arrow keys to change the value. As the value changes, the shape of the hyperbola on the screen will update. Match the blue hyperbola with the one seen in the data to get a better dielectric estimate.



Set Depth

This control button allows you to enter the depth of a known target and automatically adjust the Dielectric Constant. This option is only available when Show Hyperbola is turned off. This can either be done from Setup or while data playback through the Output control button.

- 1** Set Horizontal Cursor (H Cursor) to Move, and the Set Depth button appears. Position the H Cursor at the top of the known target.
- 2** Press the Set Depth control button. The depth value for the position of the H Cursor appears above Set Depth.
- 3** Adjust the depth value using either the Control knob or arrow keys to match the known value. The vertical scale will change as you adjust the depth value and once the known depth is saved the Dielectric Constant is adjusted.



Output – Distance and Point Mode

This control button opens a menu with options for modifying the data display during playback.

Dielectric: Adjust the Dielectric Constant during data collection from one (1) to eighty-one (81).

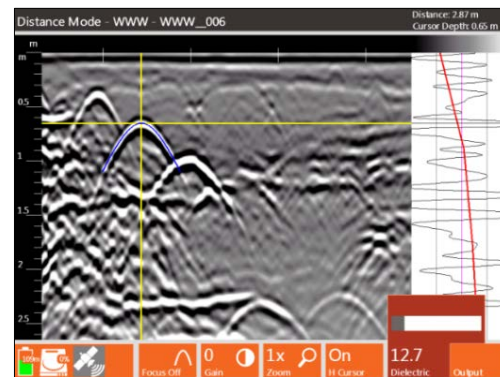
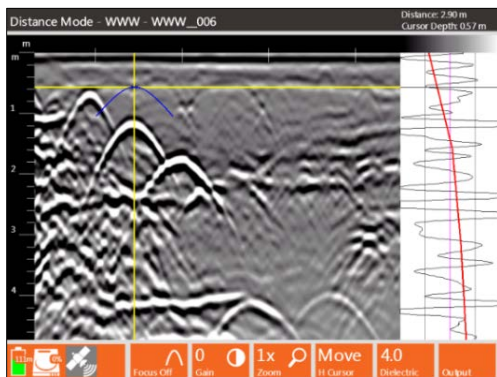
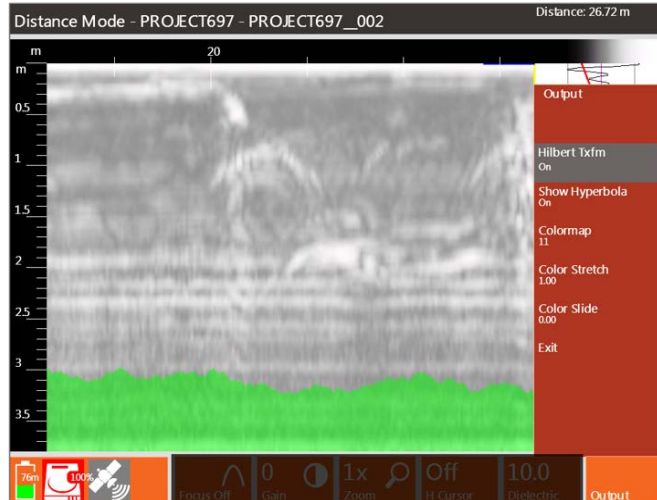
- Changing the Dielectric Constant will change the vertical scale if it is displayed in depth based on the Time Range selected during setup.

Hilbert Txfm: A Hilbert Transform is used to display subtle properties of the subsurface. Reflector amplitude and time are the primary types of information in GPR data used to make interpretations. Another way of defining the data is by transforming it into magnitude. This information is sometimes more sensitive to important subsurface (dielectric) changes in the amplitude or geometric information.

A Hilbert Transform will change a radar signal represented as a time series into its magnitude (via envelope detection) phase). Toggle Hilbert Transform On or Off by pressing the Control Knob or Enter key.

Show Hyperbola: Toggles a hyperbola On or Off while in setup or during playback. The hyperbola appears where the vertical and horizontal cursors meet. The horizontal cursor is placed at the top of the data display by default.

- The hyperbola is used during data collection to do real-time hyperbola fitting. Hyperbola fitting measures the geometry of visible hyperbolas in the data to generate an estimated Dielectric Constant.
- During data collection you can turn the hyperbola On or Off.
- Toggle Show Hyperbola On or Off by pressing the Control Knob or the Enter key.



Colormap: This menu option offers 30 available Colormap options (i.e. color tables). Select the menu by pressing the Control Knob or Enter key and then scroll through Colormap #0-29. To preview the different Colormaps, if the O-Scope is not displayed during data collection, return to the Setup Screen->Output Menu.

Color Stretch: Selecting Color Stretch allows you to adjust how the selected Colormap is distributed over a scan's amplitude range. (See Output Distance Mode above for screenshots and additional information).

Color Slide: Selecting Color Slide allows you to shift the center point (point of zero amplitude) of the selected Colormap over a scan's amplitude range. To preview Color Slide, if the O-Scope is not displayed during data collection, return to the Setup Screen->Output Menu. (See Output Distance Mode above for screenshots and additional information).

Output – Time Mode

This control button opens a menu with options for modifying the data display during playback.

Dielectric: You can adjust the Dielectric Constant during data collection from a value of one (1) to eighty-one (81).

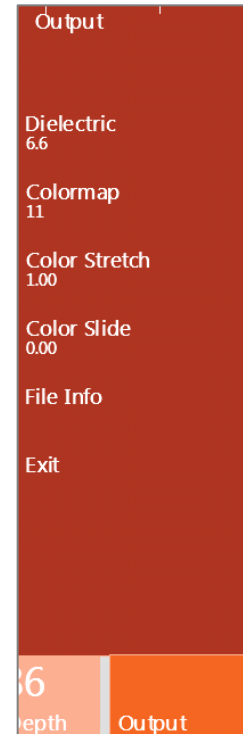
- Changing the Dielectric Constant will change the vertical scale if it is displayed in depth based on the Time Range selected during setup.

Colormap: This menu option offers 30 available Colormap options (i.e. color tables). Select the menu by pressing the Control Knob or Enter key and then scroll through Colormap #0-29. To preview the different Colormaps, if the O-Scope is not displayed during data collection, return to the Setup Screen->Output Menu.

Color Stretch: Selecting Color Stretch allows you to adjust how the selected Colormap is distributed over a scan's amplitude range. (See Output Distance Mode above for screenshots and additional information).

Color Slide: Selecting Color Slide allows you to shift the center point (point of zero amplitude) of the selected Colormap over a scan's amplitude range. (See Output Distance Mode above for screenshots and additional information).

File Info: This opens a window showing the current settings including Radar Parameters, Positioning information, and Processing History.



Chapter 3: Setting Up Your SIR 4000 for 2D Data Collection and Playback in Expert Mode

This chapter provides instructions for configuring your SIR 4000 to collect single 2D profiles of data. These profiles can be interpreted by themselves or stacked together in software to produce a 3D image. See Chapter 2: Getting Started and Export Mode Setup, for more information about each of the options and settings described below. The first section includes a step-by-step checklist to help set up your system. This refers to the software setup only. If you are using a survey cart, please see Appendix C for a hardware example, otherwise see section 2.1. The first two sections assume that you are collecting distance-based data with a survey wheel. If you are collecting data where the scan spacing is based on time (Time-based) see section 3.3. If you are collecting single Point data please see section 3.4.

3.1: Setting Up Distance Mode Data Collection

Step 1 - Introduction Screen

Press the green power button and wait for the SIR 4000 Introduction Screen to appear.

Expert Mode: Select Expert Mode from the rotating list at the top of the Introduction Screen.

General Settings: Once the Introduction Screen loads verify Language settings, Units of Measure, and Theme. These options are available in the Toolbar at the bottom of the screen.

Antenna: If not using an antenna with “Smart ID” choose from the list of available antenna frequencies.

GPS: Configure the GPS. Refer to Chapter 7: Using a GPS with your SIR 4000 for instructions.

New Project: Select New Project and enter a new Project Name. This will be the name of the folder where all of your files will be stored and the default name of the files as well. Once you provide a name and press Apply you will automatically leave the Introduction Screen and enter the Collect Setup Screen.

Step 2 – Expert Mode Setup

Once a new project is created you will see a split screen with the main data display window on the left, the O-Scope in the center, and the Setup menu on the right. The Setup Menu has four (4) main menus: **Radar, Process, Output, and System**. To collect data, you’ll need to check or adjust settings in all four (4) menus.

Recall Setup

If you’ve previously saved a setup that you want to use, recall it first before making any changes. Otherwise when you do recall the setup it will overwrite any of your changes with those that were saved. Setups can either be uniquely named or you can use one of the sixteen (16) available setup names.

1 Open the System Menu and select Recall Setup.

- 2 Select your saved setup from the list using either the Control knob or arrow keys. Once the desired setup is highlighted press either the Control knob or Enter button.

Note: If you recall a setup after configuring the GPS, the SIR 4000 will recall a baud rate of 4800. If this does not match your previously selected Baud Rate, return to the Introduction Screen and reset your Baud Rate in the GPS Configuration window.

Radar Menu

- 1 **Collect Mode:** Set to Distance.

- **Dielectric/Soil Type:** Choose a Dielectric Constant or Soil Type that best represents the area you are surveying (See Appendix D: Dielectric Values for Common Materials)

- 2 **Depth/Time Range:** There are two options for setting the depth or time range.

- **Full Range:** With the system in Collect Setup mode and data scrolling across the screen, move the antenna. As you do so, observe the scan trace displayed in the O-Scope window. When the scan trace gets to a depth/time where there is more noise/interference than signal strength, you'll see the scan trace jump from negative to positive and appear craggy. To setup the system so that you're collecting the maximum range of data possible you'll want to see some of that noise in the scan trace. If no noise is apparent then you should increase your depth or time range until about 25% of the scan trace consists of noise. The noise to signal ratio will change as you move across your survey area. Keeping some noise on the screen will help ensure that you always collect the full range of quality signal.
- **Target Specific:** With the system in Collect Setup Mode and data scrolling across the screen, move the antenna and find a target that you want to image. Note its position on the screen and at what time/depth it occurs. Ideally, it should be halfway down the screen so that you can image targets above and below it. If it is not properly located, change the depth or time range.

- 3 **Scans/Unit:** Generally you need a minimum of 10 scans to draw a recognizable hyperbola. The rule of thumb is to have 10 scans divided by the depth of the shallowest object. If you want to image a target 10 feet deep, $10 \text{ scans} / 10 \text{ feet} = 1 \text{ scan/foot}$. For 5 feet deep, $10 \text{ scans} / 5 \text{ feet} = 2 \text{ scans/foot}$.

- For locating structural features in concrete with the 1.5/1.6 GHz antenna, we usually recommend 90 scans/ft. For utility and tank location, we usually recommend 6-24 scans/ft. While this is more than the minimum rule of thumb, GSSI has found these densities work well in the widest variety of situations.

Process Menu

- 1 **Gain Mode and Edit Gain Curve:** In the O-Scope window the gain curve is the thin red line superimposed over the scan. The centerline of the scan is zero, to the left of it is negative (decreasing gain) and to the right is positive (increasing gain). To model signal loss, gain is applied in decibels (dB) along an exponential function. Your goal should be to have a gain curve that creates a scan trace with balanced amplitude changes from top to bottom.

- **Select Auto Gain Mode:** If Auto Gain Mode is already selected, press the Init control button at the bottom of the screen to apply an automatic gain curve to the current scan trace. This will re-initialize the system and add/subtract gain to produce a visible signal. Move the antenna and look

for evidence of clipping. If your data becomes clipped, leave the antenna in place and re-initialize by pressing the Init control button. This will decrease the gains so that the data will not clip.

- If you plan to collect multiple profiles and wish to compare them, it is usually best to set the gain to Manual Gain Mode once you find appropriate gain settings (you can see targets and the signal does not clip).
- If you are performing real-time locating, leaving the Gain Mode set to Auto will allow you to use Init when your signal quality changes between profiles.
- **Edit Gain Curve:** If portions of the signal are under- or over-gained after using Auto Gain Mode, try increasing or decreasing the number of gain points. Gain points are evenly distributed along the scan trace; adjusting the number of points can change where amplification occurs.
 - Select Edit Gain Curve.
 - Add or erase points to modify the gain curve.
 - Save and Exit to return to the Collect Setup screen.

Output Menu

- 1 Scale and Units:** Verify that you are using the appropriate vertical scale, vertical units, and horizontal units.
- 2 Colormap, Color Stretch, and Color Slide:** Check that you are using your preferred color scale settings.

System Menu

- 1 AutoSave:** With AutoSave turned on you'll automatically save every profile. Select this option to save all of the files you collect, rather than be selective.
 - If performing real-time locating AutoSave may be beneficial as it will decrease the number of selections required to clear your screen.
 - If collecting individual profiles to build into a 3D grid using software we recommend turning AutoSave Off. As you finish collecting one line this pauses data collection while you get in position to start the next line.
- 2 Save Setup:** Once you've made all of the modifications to the settings listed above, it's a good idea to save your setup. This way you can recall it later if you have to restart the system or if you know you'll use these settings on a regular basis.

3 Survey Wheel Calibration: If you're switching between different carts or moving from one type of terrain to another you should recalibrate the survey wheel in order to accurately track distance. To manually calibrate the antenna you will need to lay out a measured line on your survey surface.

- a) Select Survey Wheel Mode: Quadrature or Pulse.
- b) Select calibration distance – The default distance is 10 meters or feet. This distance can be changed, and a longer distance provides a more accurate calibration.
- c) Position Antenna on the Start mark – The antenna or system can be positioned anywhere at the start if you use the same point on the antenna or system when you stop.
- d) Press the Start button – This is the green Start button located on the keypad of the SIR 4000.
- e) Move antenna to the stop mark – This should match the same location on the antenna or system where you started.
- f) Press Stop button – This is the red Stop button located on the keypad of the SIR 4000.

If necessary, you can manually enter the calibration value:

- 1 Use either the Control Knob or Arrow keys to navigate to the New Calibration Value box.
- 2 Press the Control Knob of the Enter key to highlight the New Calibration Value box.
- 3 Rotate the Control Knob or use the up and down arrows to enter in the correct value.
- 4 Click the right arrow to save and exit.

Once the desired survey wheel calibration is achieved select Apply. The current value will be saved and the Calibrate SW menu will close. Press the Quit Toolbar key to return to the main Introduction Screen.

Step 3 – Data Collection

- 1 To begin data collection press the green Start button once.
- 2 At the end of your profile, press the red Stop button once or press and hold the green Start button. This halts the collection of the current data file; you won't be able to scroll across the profile or perform any of the functions on the command bar.
 - If AutoSave is set to On the file will automatically be saved. A new file will immediately begin using the same collection parameters as the previous file.
 - If AutoSave is set to Off a system prompt will pop up giving you the option to save or discard the file. Choose to save or discard using the Control knob or the Directional Keys.
- 3 To continue data collection after choosing to save or discard a file, position yourself at the beginning of your next profile. Then press the green Start button one time to begin the next data file. The previous data will be cleared and a new file opened. New files will be collected with the same collection parameters as the previous file.

- 4 To return to the Collect Setup screen if AutoSave is set to On, push and hold down the red Stop button for two seconds. The current file will automatically be saved and you will return to the Collect Setup screen. If AutoSave is set to Off, press the red Stop button one time. A system prompt will pop up giving you the option to save or discard the current file. Once an option has been selected push and hold down the red Stop button for two seconds and you will return to the Collect Setup screen.

3.2: Setup for Single Line 3D Collection in Expert Mode

Follow these instructions if you want to build a 3D area out of multiple individual survey profiles. You will save each profile as a different file and create the 3D project in RADAN's 3D Module. This method does not use the Quick3D mode on the SIR 4000. For instructions on how to use the control unit to aid in 3D data collection see Chapter 4: Using Quick3D Mode.

Step 1 – Distance Mode Setup

Follow all the above steps for 2D Distance Mode setup in order to set your SIR 4000 to local conditions and antenna choice. The following setup options are also recommended for single line 3D collection.

Position: Set Position to Manual under the Radar Menu. This will ensure that you do not accidentally auto-position over different ground surface conditions while collecting, which makes it impossible to compare depth or time between multiple profiles.

Gain: After you have set the gains so that you are not clipping, set Gain under the Process Menu to Manual. This will prevent auto-gain over a different area while collecting, which would produce a 'checkerboard' pattern. Gain differences will mask features and create edge-effects.

Select Datapath: GSSIs recommend creating separate datapaths when collecting a bi-directional 3D grid. Create new folders for files collected in the X-direction and for files in the Y-direction.

AutoSave: Set AutoSave to Off. This will pause the system between profiles allowing you to reposition the antenna to start the next profile.

Step 2 – Grid Setup

Arrange your survey grid so that you can cross your targets with at least three profiles; this will allow you to tell the difference between a point target and a linear target. For example, if you are looking for graves 2 meters in length your survey profiles should be spaced no more than 0.5 m apart. Try to orient your survey grid so that you cross the graves perpendicular to their long axis in order to have the greatest possibility of hitting them. If you have targets moving in multiple directions then you should plan to survey the grid twice; once in the X-direction and once in the Y-direction.

Your grid length should be evenly divisible by your line spacing. For example, for a 30 m by 30 m grid your lines in either the X- or Y-directions can be 0.5 m, 1 m, or 2 m apart, but they cannot be 4 m apart. Additionally, line spacing should not change during a gridded survey unless you begin collection on another grid.

Step 3 – Take Notes

In order for your data to be properly positioned in RADAN, you must be able to tell the software your survey grid origin, line direction, and line orientation. You may begin your survey in any corner of the grid and survey either in one direction, or zig-zig (i.e., back and forth). Be sure to keep accurate notes showing the location of each file in relation to other files and immovable objects. You will assemble the 3D project in RADAN with the 3D Module after downloading the data to a PC.

Step 4 – Data Collection

Collect each survey profile as a separate file.

- 1** Position the center of the antenna on the baseline of your grid. The antenna has black lines on it that mark the center. For 4-wheel carts there are lines on the black frame of the cart marking the center.
- 2** To begin data collection, press the green Start button one time.
- 3** At the end of each profile, press the red Stop button one time. You will be prompted to save the file. Before saving the file, reposition your antenna so that it is in place to begin collecting the next profile. Once the antenna is in position select Save.
- 4** Repeat steps 1-3 until finished with the first direction of the grid.
- 5** At the end of your last profile in each direction, push and hold down the red Stop button to stop data collection and return to the Collect Setup screen. The profile will be saved and can be viewed in Playback mode.
- 6** If collecting a bi-directional 3D grid, create a new datapath and then repeat steps 1-5 in the new direction.

3.3: Setting Up for Time Mode Data Collection

The scan spacing (horizontal resolution) of Time-based data profiles is a function of the speed that the system is collecting data (Scans/Second) and the rate the antenna is moving over the survey surface. Data density is improved with higher Scans/Second and slower antenna speed.

Time-based data has no real distance tag, so the software does not know how far you actually traveled. It is extremely important to move the antenna at a constant speed and to add user marks (by clicking the mark button) at consistent intervals. Time-based data requires additional processing in RADAN to create a 3D image. If 3D imaging is your goal, it is ideal to collect Distance-based data with a survey wheel.

Step 1 – Introduction Screen

Press the green power button and wait for the SIR 4000 Introduction Screen to appear.

Expert Mode: Select Expert Mode from the rotating list at the top of the Introduction Screen.

General Settings: Once the Introduction Screen loads, verify that you are using the appropriate Language, Units of Measure, and Theme. These options are available in the Toolbar at the bottom of the screen.

Antenna: If not using an antenna with “Smart ID” choose an antenna frequency from the list of available frequencies.

GPS: Configure the GPS. Refer to Chapter 7: Using a GPS with your SIR 4000 for instructions on how to configure the GPS.

New Project: Select New Project and enter in a new Project Name. This will be the name of the folder where all of your files will be stored and the default name of the files as well. Once you provide a name and press Apply you will automatically leave the Introduction Screen and enter the Collect Setup Screen.

Step 2 – Expert Mode Setup

Once a new project is created you will see a split screen with the main data display window on the left, the O-Scope window in the center, and the Setup menu on the right.

There are four (4) main menus in the Setup Menu: Radar, Process, Output, and System. To get started collecting data you'll need to check or adjust settings in all four (4) menus.

Recall Setup

If you've previously saved a setup you'd like to use, recall it first before making any changes. Otherwise when you do recall the setup it will overwrite any of your changes with those that were saved. Setups can either be uniquely named or you can use one of the sixteen (16) available setup names.

- 1 Open the System Menu and select Recall Setup.
- 2 Select your saved setup from the list using either the Control knob or arrow keys. Once the desired setup is highlighted press either the Control knob or Enter button.

Note: If you recall a setup after configuring the GPS, the SIR 4000 will recall a baud rate of 4800. If this does not match your previously selected Baud Rate, return to the Introduction Screen and reset your Baud Rate in the GPS Configuration window.

Radar Menu

- 1 **Collect Mode:** Set to Time.
- 2 **Dielectric/Soil Type:** Choose a Dielectric Constant or Soil Type that best represents your survey area. For a list of Dielectric Constants see Appendix D: Dielectric Values for Common Materials.
- 3 **Depth/Time Range:** There are two options for setting the depth or time range.
 - **Full Range:** With the system in Collect Setup mode and data scrolling across the screen, drag the antenna over the area. As you do so watch the scan trace displayed in the O-Scope window. When the scan trace gets to a depth/time where there is more noise, or interference, than signal strength, you'll see the scan trace jump from negative to positive and appear craggy. To setup the system so that you're collecting the maximum range of data possible you'll want to see some of that noise in the scan trace. If no noise is apparent then you should increase your depth or time range until about 25% of the scan trace consists of noise. The noise to signal ratio will change as you move across your survey area. So keeping some noise on the screen will help ensure that you always collect the full range of quality signal.
 - **Target Specific:** With the system in Collect Setup mode and data scrolling across the screen, drag the antenna over the area and find a target that you want to image. Note its position on the screen and at what time/depth it occurs. Ideally, it should be halfway down the screen so that you can image targets above and below it. If it is not properly located, change the depth or time range.
- 4 **Scans/Second:** Your data density depends on the rate you move the antenna over the survey surface. Typically this value is set much lower than the maximum.
- 5 **Units/Mark:** You can also set how many units (feet or meters) will be collected between system marks.

Process Menu

- 1 Gain Mode and Edit Gain Curve:** The thin, red line superimposed over the scan in the O-Scope window is the gain curve. The centerline of the scan is zero and to the left of it is negative (decreasing gain) and the right is positive (increasing gain). Gain is applied in dB along an exponential function to model signal loss. Your goal should be to have a gain curve that creates a scan trace with balanced amplitude changes from top to bottom.
 - **Select Auto Gain Mode:** If Auto Gain Mode is already selected you can press the Init control button at the bottom of the screen to apply an automatic gain curve to the current scan trace. This will cause the system to re-initialize and add/subtract gain to produce a visible signal. Drag the antenna over the area and look for evidence of clipping. If your data becomes clipped, leave the antenna over the area where it is occurring and re-initialize by pressing the Init control button. This will decrease the gains so that the data will not clip.
 - If you plan to collect multiple profiles and wish to compare them, it is usually best to set the gain to Manual Gain Mode, once you find gain settings which are workable (you can see targets and the signal does not clip).
 - If you are performing real-time locating, then leaving the Gain Mode set to Auto will allow you to use Init when your signal quality changes between profiles.
 - **Edit Gain Curve:** If portions of the signal are under- or over-gained after using Auto Gain Mode, you can try increasing or decreasing the number of gain points. The number of gain points selected are evenly distributed along the scan trace and changing the number of points can change where along the scan trace amplification is increased or decreased.
 - Select Edit Gain Curve.
 - Add or erase points to modify the gain curve.
 - Save and Exit to return to the Collect Setup screen.

Output Menu

- 1 Scale and Units:** Verify that you are using the appropriate vertical scale, vertical units, and horizontal units.
- 2 Colormap, Color Stretch, and Color Slide:** Check that you are using your preferred color scale settings.

System Menu

- 1 AutoSave:** How you set this is based upon whether or not you want to save all of the files you collect or be selective. With AutoSave turned on you'll automatically save every profile.
 - If performing real-time locating, turning this to On may be beneficial as it will decrease the number of selections you have to make to clear your screen.
 - If collecting individual profiles to build into a 3D grid using the software it is recommended to turn AutoSave Off. As you finish collecting one line this pauses data collection while you get in position to start the next line.
- 2 Save Setup:** Once you've made all of the modifications to the settings listed above it's a good idea to save your setup. This way you can recall it later if you have to restart the system or if you know you'll use these settings on a regular basis.

Step 3 – Data Collection

- 1** To begin data collection, press the green Start button one time. The SIR 4000 will instantly begin collecting scans at the rate specified during setup. Scans will fill the screen from left to right.
- 2** If adding user marks during collection to correct distance in RADAN, press the Mark button at the appropriate interval.
 - For example, if collecting single lines to build a 3D grid in RADAN, add a user mark when the antenna crosses the baselines to indicate the beginning and end of each line.
- 3** At the end of your profile, press the red Stop button one time or press and hold the green Start button. This halts the collection of the current data file; you now won't be able to scroll across the profile or perform any of the functions on the command bar.
 - If AutoSave is set to On the file will automatically be saved and a new file will immediately begin using the same collection parameters as the previous file.
 - If AutoSave is set to Off a system prompt will pop up giving you the option to save or discard the file. Choose to save or discard using the Control knob or the Directional Keys.
- 4** To return to the Collect Setup screen if AutoSave is set to On, push and hold down the red Stop button for two seconds. The current file will automatically be saved and you will return to the Collect Setup screen. If AutoSave is set to Off, press the red Stop button one time. A system prompt will pop up giving you the option to save or discard the current file. Once an option has been selected push and hold down the red Stop button for two seconds and you will return to the Collect Setup screen.

3.4: Setting Up for Point Mode Data Collection

The third data collection mode on the SIR 4000 is for Point mode data collection. This mode is most useful for deep geophysical investigations or data collection over difficult, broken terrain.

Point mode is for recording individual scans over an area. These scans are combined to produce a profile similar to the other collection modes. The scan spacing (horizontal resolution) of Point-based data profiles is a function of how far apart you set your collection points.

Step 1 – Introduction Screen

Press the green power button and wait for the SIR 4000 Introduction Screen to appear.

Expert Mode: Select Expert Mode from the rotating list at the top of the Introduction Screen.

General Settings: Once the Introduction Screen loads verify the appropriate Language, Units of Measure, and Theme. These options are available in the Toolbar at the bottom of the screen.

Antenna: If not using an antenna with “Smart ID” choose an antenna frequency from the list of available frequencies.

GPS: Configure the GPS. Refer to Chapter 7: Using a GPS with your SIR 4000 for instructions on how to configure the GPS.

New Project: Select New Project and enter in a new Project Name. This will be the name of the folder where all of your files will be stored and the default name of the files as well. Once you provide a name and press Apply you will automatically leave the Introduction Screen and enter the Collect Setup Screen.

Step 2 – Expert Mode Setup

Once a new project is created you will see a split screen with the main data display window on the left, the O-Scope window in the center, and the Setup menu on the right.

There are four (4) main menus in the Setup Menu: Radar, Process, Output, and System. To get started collecting data you'll need to check or adjust settings in the first three (3).

Recall Setup

If you've previously saved a setup you can recall it before making any changes. Otherwise when you do recall the setup it will overwrite any of your changes with those that were previously saved. Setups can either be uniquely named or you can use one of the sixteen (16) available setup names.

- 1 Open the System Menu and select Recall Setup.
- 2 Select your saved setup from the list using either the Control knob or arrow keys. Once the desired setup is highlighted press either the Control knob or Enter button.

Note: If you recall a setup after configuring the GPS, the SIR 4000 will recall a baud rate of 4800. If this does not match your previously selected Baud Rate, return to the Introduction Screen and reset your Baud Rate in the GPS Configuration window.

Radar Menu

- 1 **Collect Mode:** Set to Point.
- 2 **Dielectric/Soil Type:** Choose a Dielectric Constant or Soil Type that best represents the area you are surveying. For a list of Dielectric Constants see Appendix D: Dielectric Values for Common Materials.
- 3 **Depth/Time Range:** There are two options for setting the depth or time range.
 - **Full Range:** With the system in Collect Setup mode and data scrolling across the screen, drag the antenna over the area. As you do this watch the scan trace displayed in the O-Scope window. When the scan trace gets to a depth/time where there is more noise, or interference, than signal strength, you'll see the scan trace jump from negative to positive and appear craggy. To setup the system so that you're collecting the maximum range of data possible you'll want to see some of that noise in the scan trace. If no noise is apparent then you should increase your depth or time range until about 25% of the scan trace is made up of noise. The noise to signal ratio will change as you move across your survey area. Keeping some noise on the screen will help ensure that you always collect the full range of quality signal.
 - **Target Specific:** With the system in Collect Setup mode and data scrolling across the screen, drag the antenna over the area and find a target that you want to image. Note its position on the screen and at what time/depth it occurs. Ideally, it should be halfway down the screen so that you can image targets above and below it. If it is not properly located, change the range under the Scan menu.
- 4 **Scans/Unit:** This is the number of scans that will be collected every foot or meter. This number will affect how the horizontal scale is displayed during data collection.

Process Menu

- 1 Gain Mode and Edit Gain Curve:** The thin, red line superimposed over the scan in the O-Scope window is the gain curve. The centerline of the scan is zero and to the left of it is negative (decreasing gain) and the right is positive (increasing gain). Gain is applied in dB along an exponential function to model signal loss. Your goal should be to have a gain curve that creates a scan trace with balanced amplitude changes from top to bottom.
 - **Select Auto Gain Mode:** If Auto Gain Mode is already selected you can press the Init Command key at the bottom of the screen to apply an automatic gain curve to the current scan trace. This will cause the system to re-initialize and add/subtract gain to produce a visible signal. Drag the antenna over the area and look for evidence of clipping. If your data becomes clipped, leave the antenna over the area where it is occurring and re-initialize by pressing the Init Command key. This will decrease the gains so that the data will not clip.
 - If you plan to collect multiple profiles and wish to compare them, it is usually best to set the gain to Manual Gain Mode, once you find gain settings which are workable (you can see targets and the signal does not clip).
 - If you are performing real-time locating, then leaving the Gain Mode set to Auto will allow you to use Init when your signal quality changes between profiles.
 - **Edit Gain Curve:** If using Auto Gain Mode still leaves portions of the signal under-gained, you can try increasing or decreasing the number of gain points. The number of gain points selected are evenly distributed along the scan trace and changing the number of points can change where along the scan trace amplification is increased or decreased.
 - Set Gain Mode to Manual.
 - Select Edit Gain Curve.
 - Add or erase point to modify the gain curve.
 - Save and Exit to return to the Collect Setup screen.
- 2 Static Stacking:** Point data is typically collected with some static stacking. A good default value here is 64. The system will take 64 scans at each scan location and average them together to output a single scan. This is done to minimize high-frequency, random noise.

Output Menu

- 1 Scale and Units:** Verify that you are using the appropriate vertical scale and units. The horizontal scale will appear in number of scans during collection.
- 2 Spacing, Amplitude, and Fill:** Check that you are using your preferred display settings for Point Mode.

Step 3 – Data Collection

- 1** To begin data collection press the green Start button one time. The screen will appear with one scan trace on the left side of the data display screen and the rest of the data display will be blank.
- 2** Press the Next Point control button to collect subsequent scans. The Scan number will update in the Information Bar at the top of the screen as additional scans are added.
- 3** At the end of your profile, press and hold the red Stop button for two seconds. If AutoSave is set to On the profile will be saved and you will return to the Collect Setup menu. If AutoSave is set to Off a system prompt will give you the option to save or discard the current file. Once an option has been selected press and hold the red Stop button again and you will return to the Collect Setup screen.

3.5: Playing Back Collected Data

You can playback and review data collected in Distance, Time, or Point Mode. Playback can be accessed either from the Introduction Screen by selecting Playback or from the Collect Setup screen by pressing the Play Mode control button. Either method will open a list of files stored in the currently selected folder.

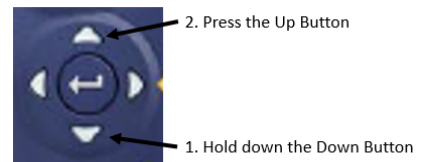
- 1** Use the Control Knob or Arrow keys to navigate through the list.
- 2** Select a file or files to Playback by pressing with the Control Knob. Once you've made your selections press the Enter key to open the selected files. The selected files will scroll across the screen in numerical order.
- 3** When the file scrolls across that you wish to view in full screen, press the green Start button. This will open the Playback Screen with only the current file displayed. The file will scroll across to the end and you can pause and resume the scroll using the Pause/Resume control buttons.

3.6: Saving an Image

The SIR4000 operating system includes a feature called Screen Capture. Screen Capture allows you to save a screenshot of the entire SIR 4000 screen and save that image automatically to the SIR4000 memory as a Portable Network Graphics (.PNG) file. A .PNG file is a "picture" file that you can email to the client or print off. You do not need RADAN to see a .PNG file; any PC or Mac computer can open it. Screen Capture is available in any mode and in Collect or Playback.

How to Use Screen Capture:

- 1 Button sequence:** Press and hold the Down arrow and then press the Up arrow once. Screen Capture works in either Collect or Playback mode. You will hear an audio indication that the SIR 4000 has saved the screen capture.



- 2 Screen Capture Image:** The SIR4000 screen capture feature will save the entirety of the image that is currently on the screen. This means that for longer data files, you must scroll left or right to capture images from an entire file. It is stored as the file name with a letter designator. For example, an image from FILE__036.DZT will be saved as FILE__036A.PNG. Multiple .PNG files can be captured from a single .DZT file.
- 3 Transfer the File:** Transfer the data file (DZT) file to your computer following the steps in the next section. The .PNG file(s) will transfer automatically along with the associated .DZT. There is no way to transfer the image without transferring the data.

Chapter 4: Using Quick3D Mode

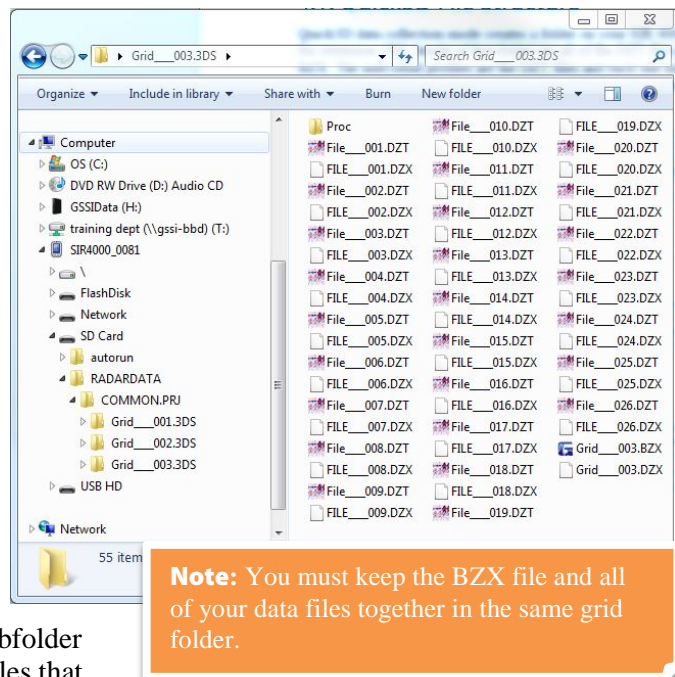
Quick3D mode is designed to help you easily collect 3D data on an area of any size and surface with some obstacles. By entering the grid size and profile spacing the SIR 4000 can show the current survey location and guide you through 3D data collection. During the survey each individual radar profile is saved as it is collected. At the end of the grid, the SIR 4000 creates a special folder and file which contain positioning information. This information is then used by RADAN to quickly build and display the 3D data. You can also view the 3D data on the SIR 4000 after collection and perform some processing functions such as applying FIR/IIR Filters or performing Hyperbola Fitting. Quick3D allows you to skip the 3D file creation process in RADAN and allows you to analyze your 3D data in the field.

The next section explains the file structure of a Quick3D file. The subsequent sections explain the field use and implementation of Quick3D files in RADAN.

4.1: Quick3D File Structure

Quick3D data collection mode creates a folder on your SIR 4000 with the name of the grid followed by the extension 3DS. Inside of that folder are all of the DZT files, DZX files, and a file with the extension BZX. The individual profiles are the DZT files and each one has a corresponding header file, the DZX. The BZX is a grid assembly file that tells RADAN how to assemble the individual files into a grid.

- In the screenshot, a 50 foot x 50 foot area was surveyed in one direction only with profiles spaced every 2 feet. This survey created 26 DZT and DZX files (1 every 2 feet including the line at 0) and 1 BZX file. The Grid was named GRID__003.3DS. The grid name was automatically generated by the SIR 4000 within the project folder, COMMON.PRJ.
- The BZX file is an information file which tells the RADAN software where each DZT file is positioned and directs the software to create a 3D file with the proper positioning information. Opening the grid in RADAN is as simple as opening the BZX file.
- The project folder will also contain a subfolder called Proc. This folder contains DZP files that are used to playback the 3D data on the SIR 4000. They are not necessary for 3D viewing or processing in RADAN.
- When transferring data from the SIR 4000 to a PC running RADAN, the entire Grid folder is transferred. In order for the BZX file to work all of the DZT and DZX files must be kept in the same folder as the BZX file.



In summary each grid is saved in a separate folder under the project folder. Inside each folder are all of the individual radar profiles (DZT and DZX files) and one BZX file. The BZX file tells RADAN where to put each profile to create a 3D grid.

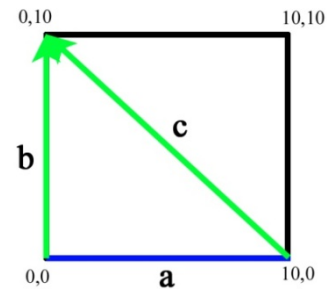
4.2: Setting Up a Physical 3D Grid

Collecting data for 3D processing and interpretation is easiest when following a physical guide grid. Grids can be laid out using chalk, paint, measuring tapes, ropes, or some other method. A grid can be any size, but data quality is better if the grid corners are square. The grid itself does not have to be a square, it can be a rectangle, or can be irregularly shaped.

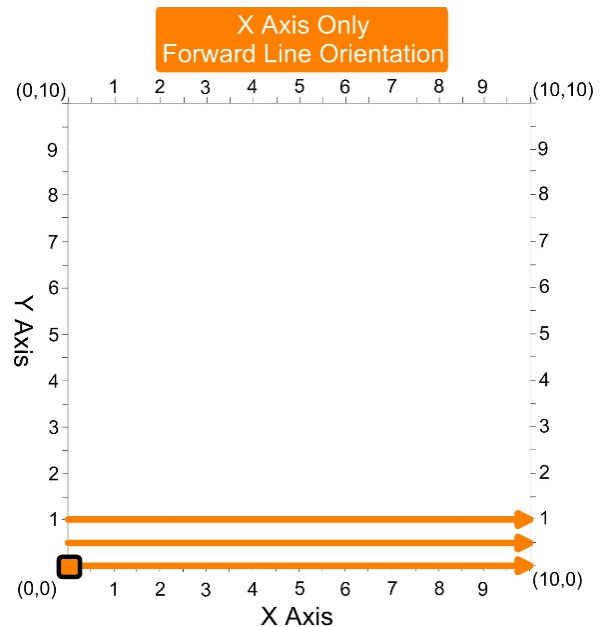
Follow the tips below to help ensure successful grid setup and data collection.

The graphic below illustrates how to put together a square, 10×10 grid. You can use the following method to setup grids of any size including rectangular grids. Make sure to assign the X and Y axis.

- 1** Locate the origin point (0,0) and pull a tape measure 10 units to find the point 10,0 (blue line a). This is your baseline.
- 2** Pull one tape measure 10 units from (0,0) (green line b) to (0,10).
- 3** Pull one tape measure from (10,0) to (0,10) (green line c).
- 4** Move both green tapes together so that 10 on line b connects to 14.14 on line c. The point that they connect is the grid corner. You will know that the corner at (0,0) is square because this method produces a right triangle.
- 5** Repeat for the corner (10,10).
- 6** Once the grid corners are set you'll need to mark the starting and ending point of each line you're going to collect. You could either leave the baselines on the ground or put markers, such as pin flags, along each baseline. In the example to the right you would put a flag at the beginning and the end of each orange arrow.



If:
 $a^2 + b^2 = c^2$
 $10^2 + 10^2 = c^2$
 so:
 $\sqrt{200} = c$
 so:
 $c = 14.14$



- 7** Photograph or make a sketch map of the grid. Notes to include in the sketch map:

- X and Y axis
- Starting corner
- Direction of the first and second line in each direction
- Obstacles located within the grid
- Location of trees inside and outside of the grid
- Features that are visible on the ground surface

4.3: Setting Up Quick3D Collection

Quick3D mode on the SIR 4000 has the same menus as Expert Mode described in Chapter 2, plus an additional menu to setup the size and collection parameters for a 3D grid.

Grid Menu

X/Y Start Value: These two items tell the system the coordinate of your origin point. Typically these will both be zero (0). If you are working on a pre-existing site grid and you want your survey grid origin to have that coordinate, you may add it here.

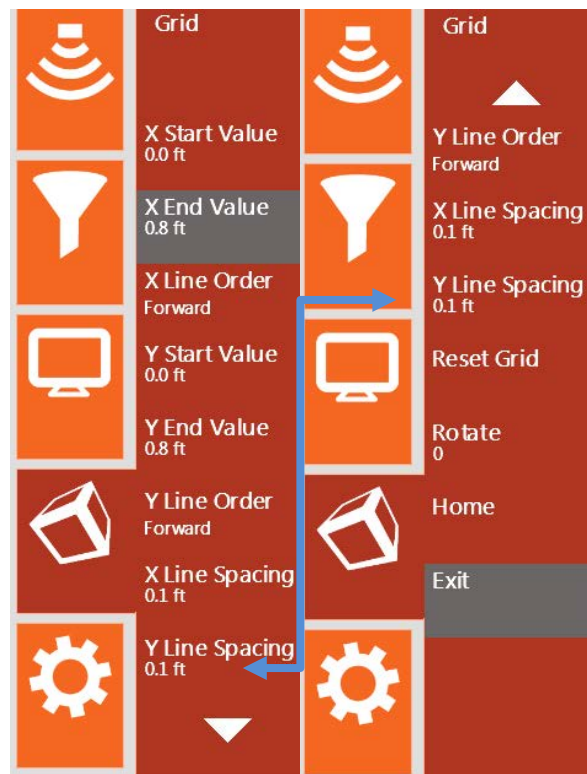
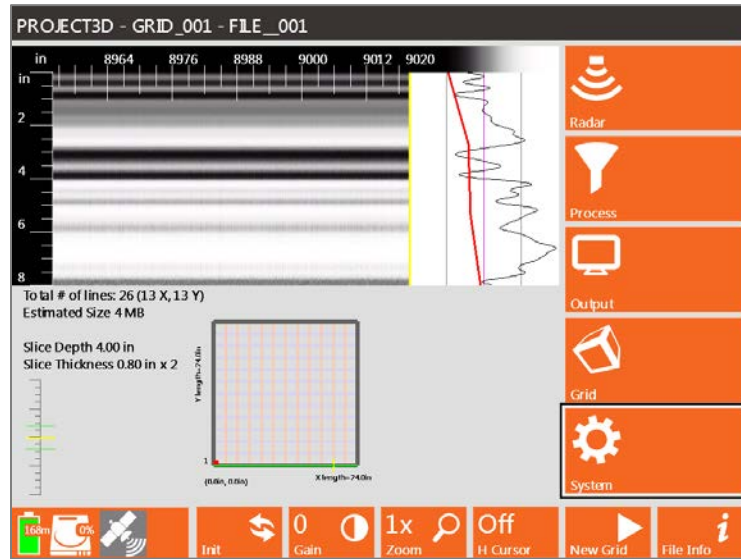
X/Y End Value: The SIR 4000 uses this coordinate to figure out the size of your grid. In the example menu, the numbers for both the X and Y are 10. This means that the X axis and the Y axis both end at 10, and since the origin is at (0,0) the grid is 10×10.

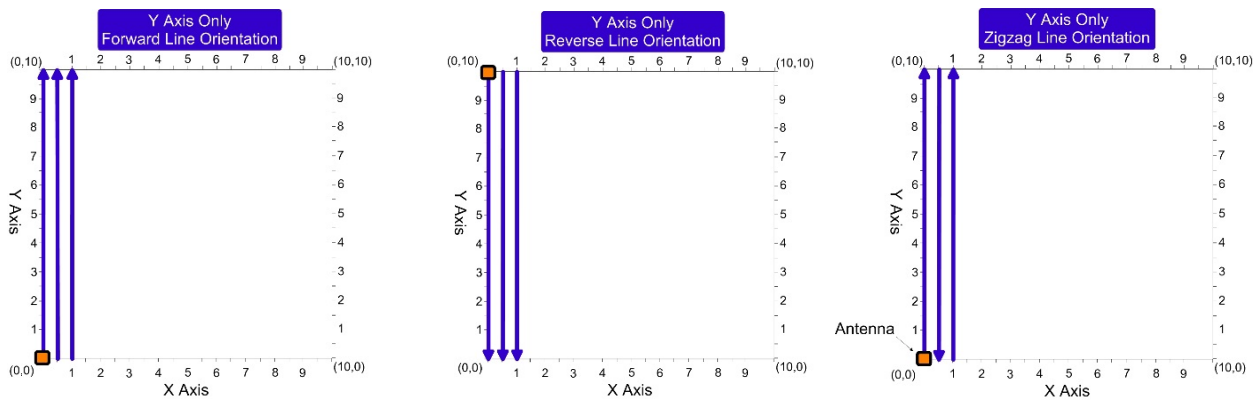
X/Y Line Spacing: This is the spacing between your survey lines. X lines are parallel to the X axis and Y lines are parallel to the Y axis. The X spacing can be different from the Y spacing, but the spacing must be regular. For example, you cannot start your grid at one interval and change halfway through to another. If you need to change the line spacing, you must start a new grid with the new parameters.

Survey Directions (X, Y, or both): 3D surveys are typically collected along both the X and Y grid axes. If you only want to collect on the X or the Y, you must also change the parameters for the unused grid direction. GSSI recommends changing the values of the unused axis to the overall grid dimensions.

X/Y Line Order: Controls the survey line direction.

- **Forward:** Profiles are surveyed in one direction from the starting baseline to the ending baseline. At the end of each profile, you must move the antenna back to the starting baseline before moving to the next line and collecting in the same direction.
- **Zigzag:** Allows you to collect data in both directions. At the end of a line, turn the system around and begin data collection in the opposite direction.
- **Reverse:** Profiles are surveyed in one direction from the ending baseline to the starting baseline. At the end of each profile, you must move the antenna back to the ending baseline before moving to the next line and collecting in the same direction.





Reset Grid: Changes the X/Y Start and End Values as well as the line spacing back to the system default (a 10m x 10m grid with 1.0m increment spacing in each direction).

Rotate: You can rotate the grid from 0-358° using the Control Knob. The rotation changes in increments of 2° and cycles continuously.

Home: Resets the Rotate to zero (0).

Note: The X/Y end numbers are coordinates, not line lengths. So if you have a 20x20 grid and X/Y START is 10x10, then X/Y END is 30x30.

4.4: Step By Step Quick3D Setup

Prior to starting a 3D grid you should perform a general survey of the area to determine the best settings to use during 3D data collection. You should already know which settings to adjust in the Radar and Process menu as well as how you'd like to change them.

Step 1: Start System

After system boot-up, select Quick3D from the modes listed at the top. Then select New Project to create a new project folder. After selecting Apply you will see the Setup screen with the menu on the right, O-scope in the upper middle, data preview in the upper left, and a grid preview in the bottom center of the screen.

Step 2: Setup

If you've previously saved a setup, or would like to start with a default setup, then you should recall it before making any changes. Otherwise when you do recall the setup it will overwrite any of your changes with those that were saved. Setups can either be uniquely named or you can use one of the available setups.

- 1** Open the System Menu and select Recall Setup.
- 2** Select your saved setup from the list using either the Control knob or arrow keys. Once the desired setup is highlighted press either the Control knob or Enter button.

Step 3: Survey Wheel Calibration

This is a critical step in 3D file collection because proper positioning of your data is essential for coherent 3D data. In order to accurately track distance when switching between different carts, or moving from one type of terrain to another, you should recalibrate the survey wheel. To manually calibrate the survey wheel, you will need to lay out a measured line on your survey surface. It can be of any length, but the longer the line, the more accurate the calibration.

- 1** Select Calibrate SW from the System Menu.
- 2** Begin by selecting Quadrature as the Survey Wheel Mode.
- 3** Select calibration distance – The default distance is 10 meters or feet. However this distance can be changed. The longer the calibration distance the more accurate the calibration.
- 4** Position Antenna on the Start mark – The antenna or system can be positioned anywhere at the start as long as you use the same point on the antenna or system when you stop.
- 5** Press the Start button – This is the green Start button located on the keypad of the SIR 4000.
- 6** Move antenna to the stop mark – This should match the same location on the antenna or system where you started.
- 7** Press Stop button – This is the red Stop button located on the keypad of the SIR 4000.
- 8** Repeat steps 3-6 at least twice to ensure that the calibration distance is consistent.

If necessary you can manually enter the calibration value:

- 1** Use either the Control Knob or Arrow keys to navigate to the New Calibration Value box.
- 2** Press the Control Knob of the Enter key to highlight the New Calibration Value box.
- 3** Rotate the Control Knob or use the up and down arrows to enter in the correct value.
- 4** Click the right arrow to save and exit.

Note: The SIR 4000 saves the survey wheel encoder calibration value in counts/meter no matter your selected units of measure. That means that if you are used to working in English (Imperial) units and are familiar with a Model 620 tow-behind wheel calibration value of ~127/ft, the new calibration value you will see will be ~417.

Step 4: Set Grid Limits

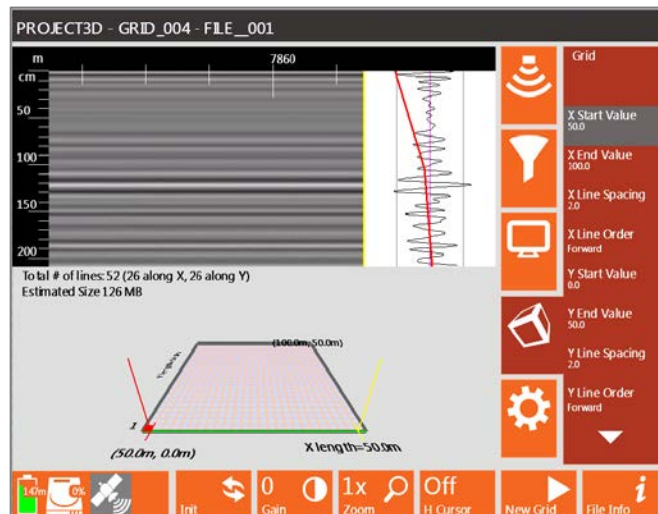
Under the Grid Menu, set your grid limits, line spacing, and orientation.

Start/End Values: Typically, the X Start Value and the Y Start Value should both be set to 0. If the grid does not start at (0,0) put in the coordinates of the origin point. This occurs when the grid is part of a larger site grid. If combining grids in RADAN using Super3D, you can just leave this number at (0,0) and add real coordinates later. Enter your X End Value and Y End Value coordinates and remember that these are not line lengths.

In the example below, the grid is part of a larger site and the grid measures 50x50. It's starting coordinates are X Start Value = 50 and Y Start Value = 0, therefore the X End Value = 100 and the Y End Value = 50.

Line Spacing: If collecting data in both the X and Y direction then include line spacing in each direction. If only collecting in one direction, set the line spacing of the unused direction to the value of the maximum grid dimension.

Line Order: Decide if you're going to collect the lines using Forward, Zigzag, or Reverse Line Order. Forward and Reverse will take longer to collect. However, these have potential for fewer offset errors created by uneven ground surface or a slightly misshapen grid. Potential offset errors created by collecting in Zigzag can be corrected in RADAN.



Step 5: Enter Collection Screen

Once you are satisfied with the grid and settings press the green Start button on the SIR 4000. This will open the 3D Collection Screen. There are four different ways to view the 2D profiles and 3D slice maps during collection and you can toggle through them by pressing the View Toggle control button.

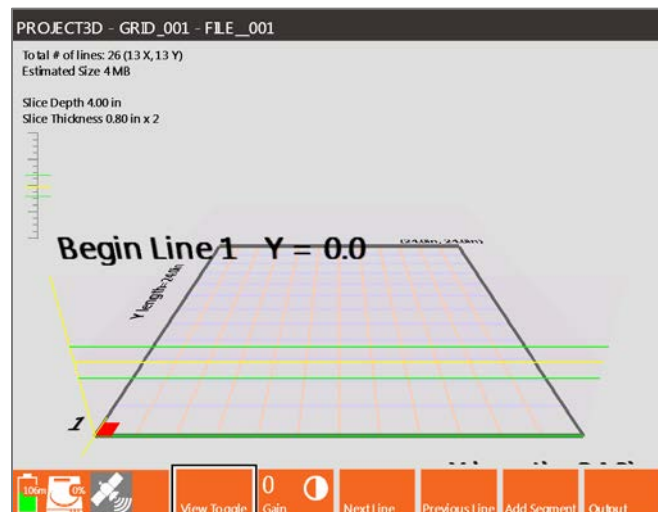
Grid Display: Shows the full 3D grid and your current location within the grid. There are three views in this display.

2D Profile: Shows just the 2D profile and can be used to perform a hyperbola fitting on the data. This view is only available from Line 1.

The grid coordinates are displayed at the bottom left and top right corners of the grid. The X and Y line lengths appear on the bottom and left side of the grid.

At the top of the screen the following information appears:

- Total number of lines
- Number in both the X and Y directions
- Estimated file size
- Current Slice Depth and Slice Thickness



4.5: Collecting 3D Data

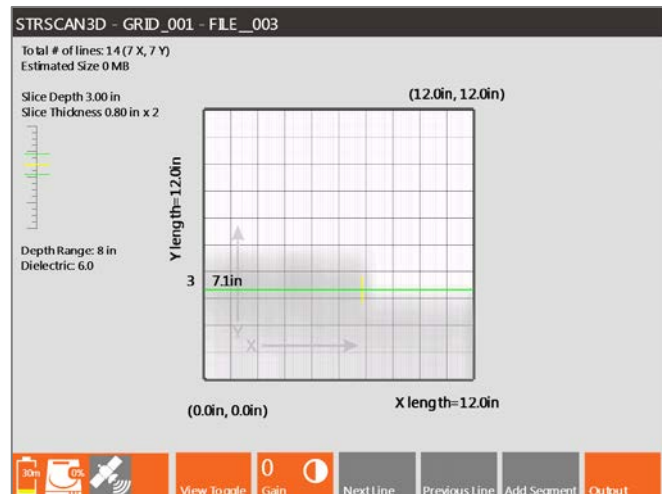
Step 1: Position Antenna

Once in the 3D Collection screen (after pressing the green Start button) you will see a grid layout in the center of the screen. The grid coordinates are displayed at the bottom left and top right corners of the grid. The X and Y line lengths appear on the bottom and left side of the grid. At the top of the screen the total number of lines is displayed along with the number in both the X and Y directions.

The estimated file size for the grid is also displayed at the top. A yellow line and red box appear at your starting coordinate. Position the center of the antenna over the starting coordinate for your grid. Typically that will be at (0,0), where the center of the antenna is centered over both the X and Y baseline at the same time.

Step 2: Begin Collection

Once the antenna is centered over the starting coordinate press the green Start button. This initiates data collection of Line 1. Nothing will happen until you begin to push or pull the survey wheel. Once the survey wheel starts moving in a forward direction (or whichever direction was used during SW calibration) you will start collecting data and see the yellow line progress across the screen.



After traveling the distance that you specified in 3D Setup, the SIR 4000 will automatically stop collecting data. The file will save and the system will automatically increment to the next line.

Orientation – Positioning the Next Line

Forward or Reverse Line Orders: Move your cart back to the baseline that you started from.

Zigzag Line Order: Turn your antenna around and position the center over the next line, but going in the opposite direction.

Start/Stop Buttons

The Start and Stop buttons offer different functions depending upon how long you press them.

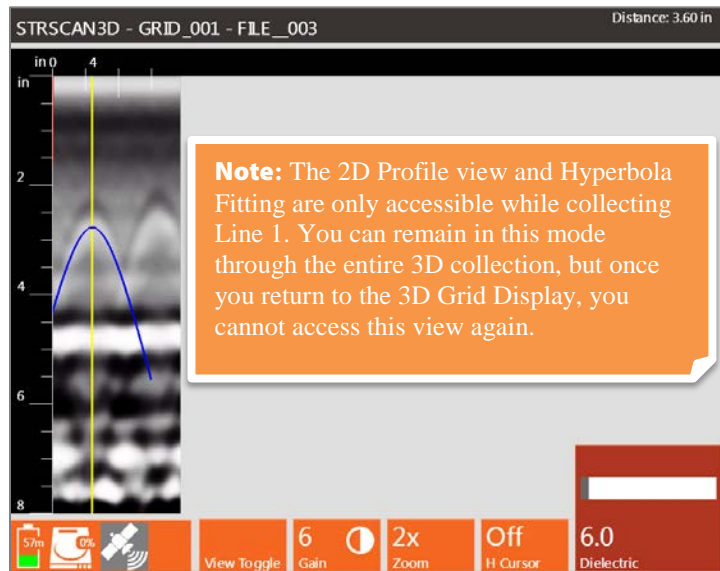
Green Start Button: Long and Short presses both start collection of a single line or continuation of a paused line when using Add Segment.

Red Stop Button: Short press ends data collection along a line. Long press saves the grid and exits data collection.

Estimating the Dielectric

By switching the view from the 3D grid to the 2D profile, you can perform a hyperbola fitting and get a better estimate of your Dielectric.

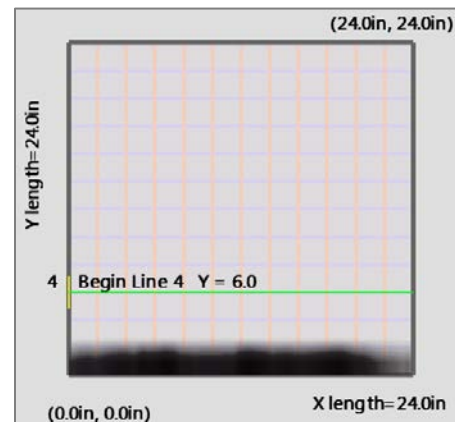
- 1** Begin collecting a line, but stop before you reach the end.
- 2** Back up so that the vertical yellow line is in the middle of a hyperbola.
- 3** Change H Cursor to Move and position the horizontal line at the top of the hyperbola.
- 4** Select Dielectric and adjust it until the hyperbola on the screen matches the shape of the one in your data.



Step 3: Recollecting or Skipping Lines

If you need to skip or redo a line, use Next Line or Previous Line to move around the grid. You will see the yellow line move to indicate your current position. Once the yellow line matches your current location press the green Start button to collect or recollect the line.

The new data file will be stored with the proper positioning info and any old data will be overwritten.

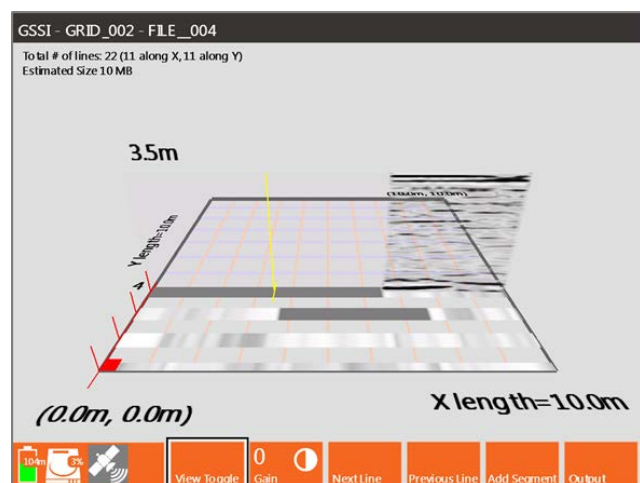


Step 4: Adding a Line Segment

You can collect portions of a line or stop and start collection along a line by using the Add Segment button. There are two ways to use this button.

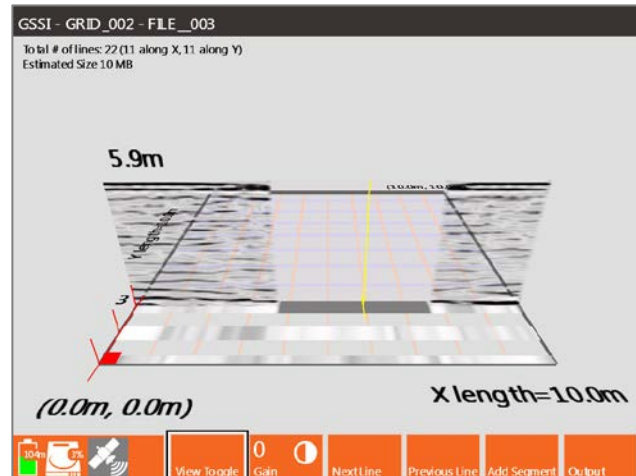
Offset the Starting Position: You can choose to start away from the baseline if needed.

- 1** Position the antenna along the line where you'd like to start.
- 2** Press Add Segment.
- 3** Move antenna to the end of the line and position the center of the antenna over the opposite baseline from where you started.
- 4** Press the red Stop button. This will end the line and shift it to line up with the opposite baseline.



Skipping a Section of the Line: You can skip a section in the middle of a line to avoid an obstacle.

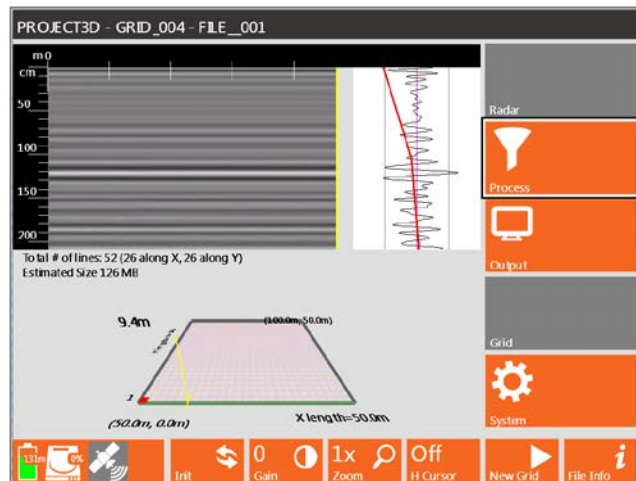
- 1 Begin data collection from the baseline as normal.
- 2 When you reach the section you want to skip press the red Stop button briefly.
- 3 Move the antenna to the opposite side of the area being skipped and line it up on the same path.
- 4 Press Add Segment to begin data collection again.
- 5 Move antenna to the end of the line and position the center of the antenna over the opposite baseline from where you started.
- 6 Press the red Stop button. This will end the line and shift it so that it lines up with the opposite baseline.



Step 5: Saving the Grid

When you are finished collecting in either the X-Direction, Y-Direction, or both press and hold the red Stop button. This will end collection of the 3D grid, save the grid, and return you to the 3D Setup Screen. You are now ready to start collecting the next sequential grid in the same project. Select New Grid from the Toolbar to enter the Quick3D Setup Screen with the next sequential grid selected.

To change to a different project press and hold the red Stop button a second time to return to the Introduction Screen.

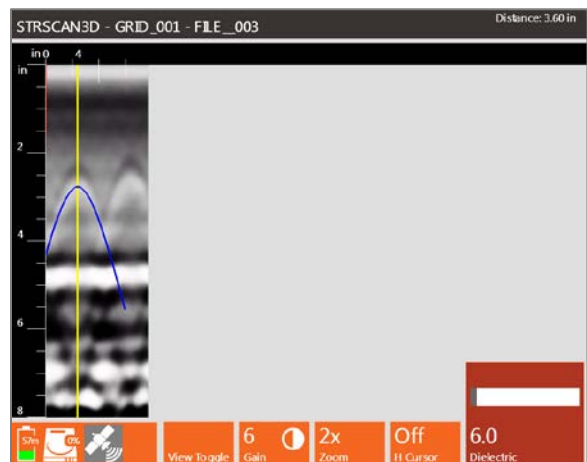
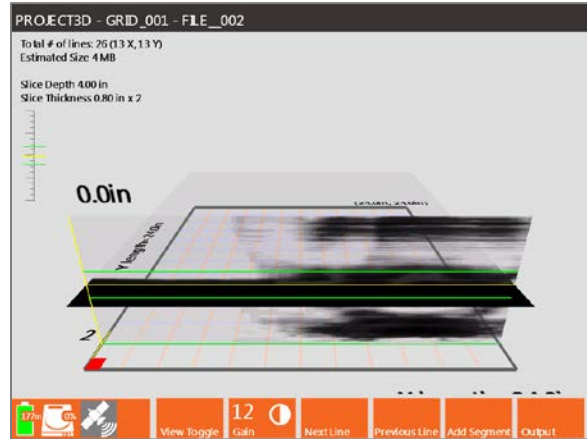
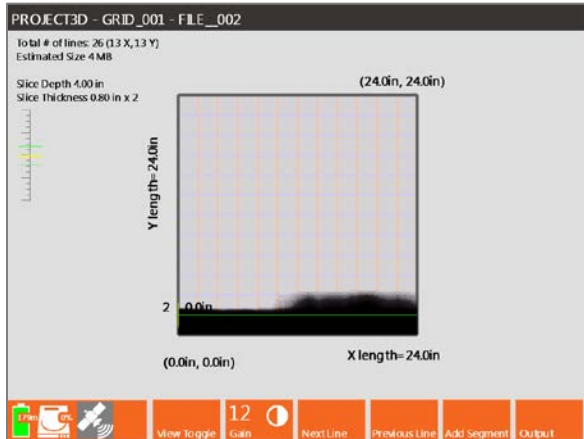


4.6 Modify the 3D Display during Collection

You can adjust how the data appear during data collection using the Toolbar soft keys and the Output menu available in the 3D Collection Screen.

View Toggle: Pressing this soft key toggles the 3D Collection Screen between a top down view of the grid and 3D view of the grid. You can further modify how the 3D grid appears through the Output Menu.

- **Grid Display:** Shows the full 3D grid and your current location within the grid. There are three views in this display.
- **2D Profile:** Shows just the 2D profile and can be used to perform a hyperbola fitting on the data.



Gain: Increase or decrease the Display Gain during data collection by a factor ranging from -12-60 dB. This can be used to adjust contrast for an entire profile by the same amount.

Output Menu

This menu provides options for modifying the appearance of your data during collection. The first six (6) options are the same for 3D collection as they are for 2D collection. None of these settings affect the raw data.

H Cursor: Changes the depth of the slice map in the Grid Display in half inch increments.

Slice Thickness: Adjusts the slice thickness from zero (0) inches to the maximum selected depth range in half inch increments. The slice is centered on the location of the H Cursor.

Dielectric: You can adjust the Dielectric Constant during data collection from a value of one (1) to eighty-one (81).

Colormap: This menu option offers 30 available Colormap options (i.e. color tables). Select the menu by pressing the Control Knob or Enter key and then scroll through Colormap #0-29.

Color Stretch: Selecting Color Stretch allows you to adjust how the selected Colormap is distributed over a scan's amplitude range. A Color Stretch greater than one (1)

Output

H Cursor
4.00 in

Slice Thickness
0.80 in

Dielectric
6.0

Colormap
11

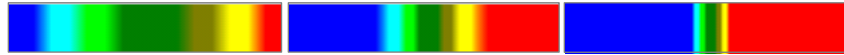
Color Stretch
1.00

Color Slide
0.00

Rotate
0

Viewpoint
0.00

compresses the colors towards zero (0). A Color Stretch less than one (1) expands the colors towards the maximum negative and positive amplitudes.



Left Color Stretch = 0; Middle Color Stretch = 1; Right Color Stretch = 3

Color Slide: Selecting Color Slide allows you to shift the center point of the selected Colormap over a scan’s amplitude range. A negative number shifts towards the positive amplitudes and positive number shifts towards the negative amplitudes.

- Adjusting the Color Slide over a particular value range allows you to see more subtle variations in the data.



Left Color Slide = -0.20; Middle Color Slide = 0; Right Color Slide = 0.20

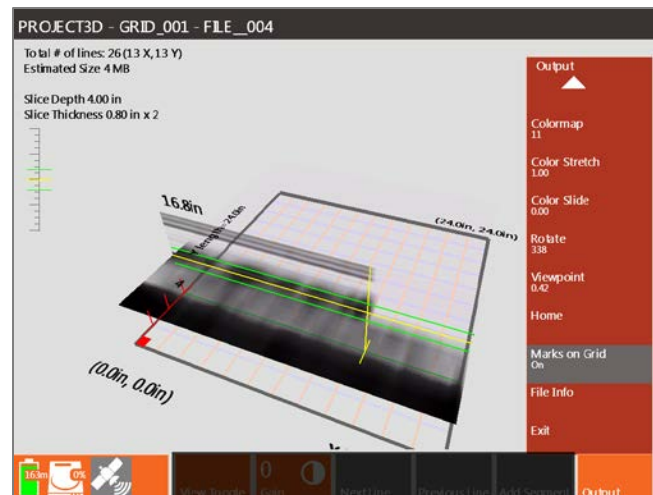
Rotate: You can rotate the grid from 0-358° using the Control Knob. The rotation changes in increments of 2° and you can start by moving up from zero or down from 358°. Combining Rotate with Viewpoint can create a 3D view of the data during collection.

Viewpoint: Viewpoint adjusts the perspective to view the grid. You can adjust the Viewpoint from -0.40 to 1, where -0.40 will provide almost a straight forward view of a 2D profile as you would see during 2D data collection. This will not preview through the Output menu unless Viewpoint Toggle was selected from the Toolbar.

Home: Resets Rotate and Viewpoint to zero (0).

Marks on Grid: This turns the grid marks on or off. Grid marks correspond with the location of the profiles in the grid. Only adds marks to the lines where data have already been collected.

File Info: This opens a window showing the current settings including Radar Parameters, Positioning information, and Processing History.



4.7 GPS Enabled 3D Collection

Connect a GPS unit to collect a georeferenced 3D grid on the SIR 4000.

Step 1: Connect and Configure GPS

Connect the GPS to your SIR 4000 using the serial connection on the top of the control unit. From the Introduction Screen select GPS from the Toolbar. Set the Baud Rate to match the GPS unit’s Baud Rate and choose the desired Format to view your location information.

Step 2: Begin 3D Collection

From the 3D Setup Screen you'll be able to see both your current coordinates on the top header bar and your HDOP (Horizontal Dilution of Precision) Status. An HDOP of two (2) or less will display a green satellite box, higher than two (2) a yellow satellite box, when there's no signal the box will appear red, and if GPS was never configured the box will remain grey.

Ensure you have a green satellite before starting data collection.

Step 3: Monitor GPS Quality

When you start collecting each 2D profile in your 3D grid, the SIR 4000 captures a GPS coordinate and place it in the file header. It will continue capturing positions every three (3) seconds until you end data collection as long as the HDOP is two (2) or less. Collected coordinates will be visible in the Tables Pane of RADAN 7.

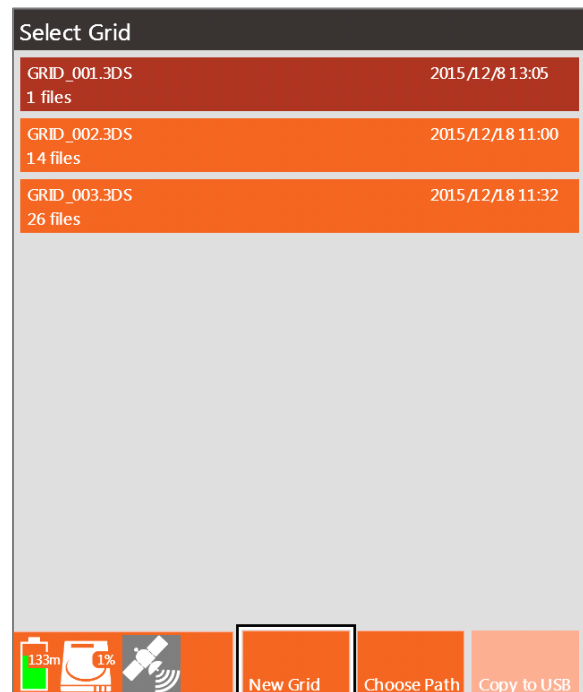
If the HDOP ever goes above two (2) the GPS Status icon will turn yellow and the system will stop collecting coordinates. If this occurs you can either pause data collection waiting until the satellite turns green again or continue collecting data knowing that this portion of the line is not georeferenced.

4.8 Quick3D Playback

Quick3D Playback allows the user to display previously collected 3D data as a grid or in 2D profiles, recollect data within a previously collected grid, and modify some settings used during the original data collection.

Select a 3D Grid for Playback

- 1** Select which units were used to collect the grid, Metric or English. Whichever units are selected will be used to playback the grid regardless of the units used during collection.
- 2** Access Quick3D Playback through the Introduction Screen by selecting Quick3D and then Playback. This will open a screen where you can select a grid from the current project folder or change the Data Path to select a grid from a previous project folder.
- 3** Choose the grid file you want to play back using the Control Knob and select it by pressing the Control Knob.
- 4** Press Enter to open the 3D grid.
- 5** A Loading Grid progress bar will appear on the screen to track the progress of opening the grid.
- 6** The 3D grid immediately opens in the Quick3D Playback Screen.



Quick3D Playback Options

The Playback Screen allows you to view individual 2D profiles in a grid format, rotate the grid to view data from different angles, apply filters, change colors, and do hyperbola fitting. If you're still in the field you also have the ability to recollect lines in the grid. These options are all available through the Toolbar located at the bottom of the screen.

View Toggle

Pressing the View Toggle button at the bottom of the screen switches the 3D grid displayed to either a top-down view of the data, a view of both the 2D profile and 3D slice, or the only individual 2D profiles. These options are available under the Output Menu in the Toolbar.

Gain

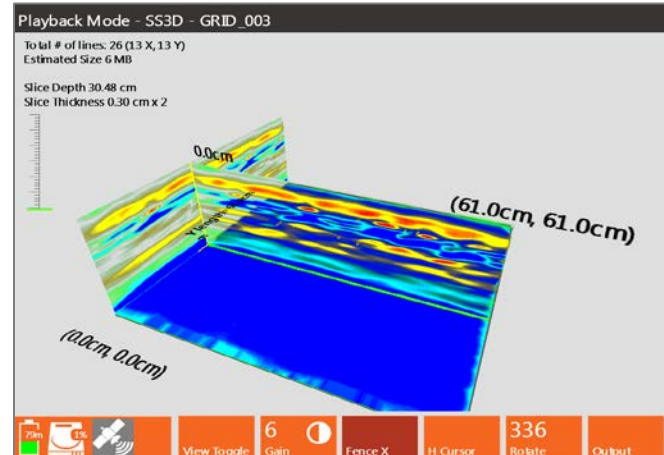
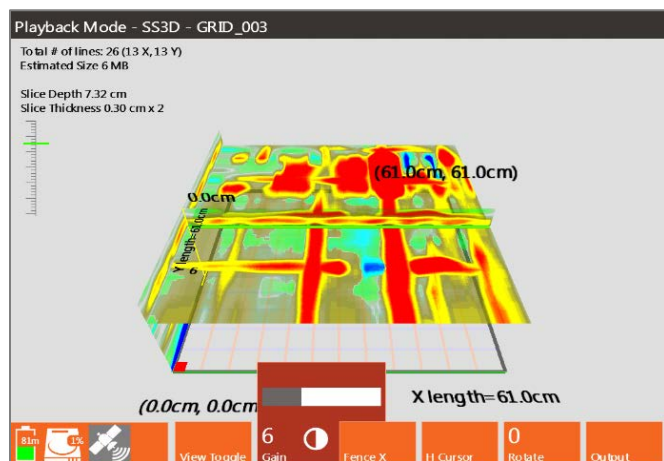
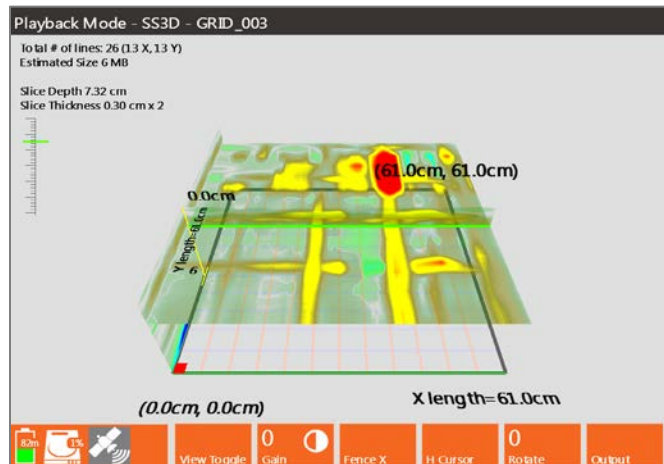
This Gain option is also referred to as display gain. It increases the amplitude of your data by multiplying every sample throughout your scan by a constant value. The result is that you will be able to better see weaker reflections, but those already strong reflections may be over-gained. This function is useful for a quick viewing of data that is attenuated or otherwise under-gained to guarantee that it was not clipped.

- You can change Gain from -12 to 60, with negative values weakening the entire signal and positive values strengthening the signal by the value shown.
- To modify Gain press the Gain control button and use either the Control Knob or Right/Left Arrow keys to adjust the gain amount.
- Display Gain is only for display and is not saved with the data.

Fence X and Y

Profiles that were collected in either the X or Y direction or both can be viewed during Playback.

- Press this soft key to select profiles to display.
- Use the Control Knob to view different profiles.

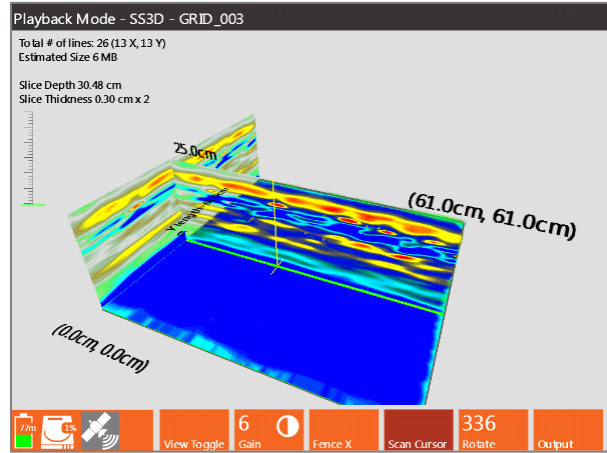


- If data were collected in both the X and Y directions, you can view profiles at the same time in both directions. This can help pinpoint the location of a reflection.

Scan Cursor

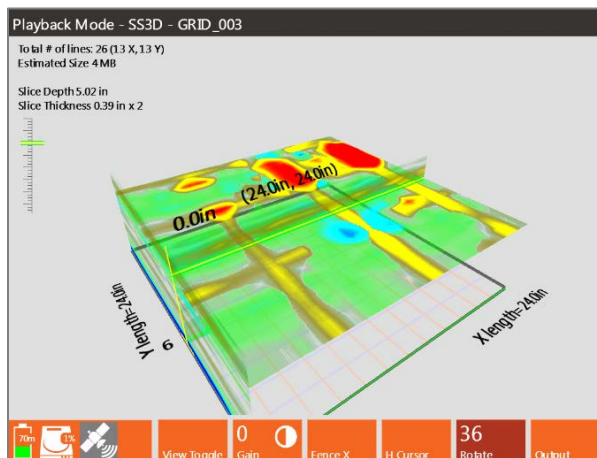
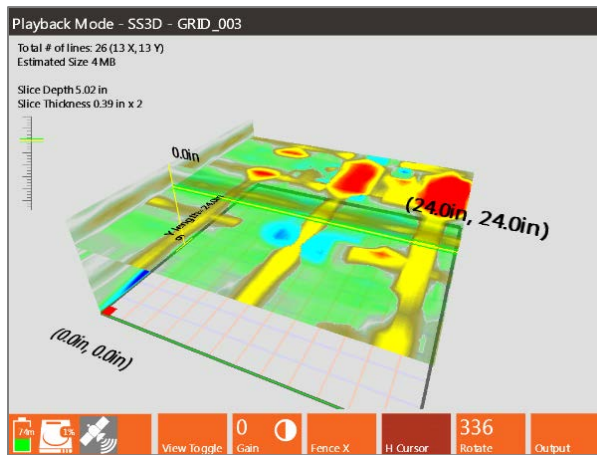
Selecting Scan Cursor allows you to place a Horizontal line on the currently selected profile and adjust the vertical location of that line. This can be used to acquire more accurate depth information.

- Press Scan Cursor until it shows H Cursor.
- Use the Control Knob to adjust the vertical location of the horizontal line.
- The location of the H Cursor is shown as the Slice Depth on the display and the thickness can be adjusted under the Output Menu.



Rotate

You can adjust the rotation of the 3D grid using either a soft key or from the Output Menu. To adjust simply press the Rotate soft key and use the Control Knob of rotate the grid on a 360° axis.



Output

This control button opens a menu with options for modifying the data display during playback.

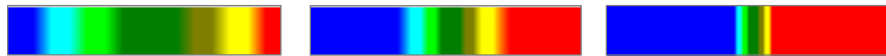
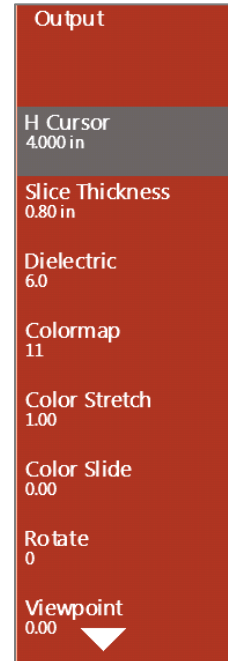
H Cursor: Changes the depth of the slice map in the Grid Display in half inch increments.

Slice Thickness: Adjusts the slice thickness from zero (0) inches to the maximum selected depth range in half inch increments. The slice is centered on the location of the H Cursor.

Dielectric: You can adjust the Dielectric Constant during data collection from a value of one (1) to eighty-one (81).

Colormap: This menu option offers 30 available Colormap options (i.e. color tables). Select the menu by pressing the Control Knob or Enter key and then scroll through Colormap #0-29.

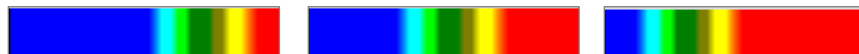
Color Stretch: Selecting Color Stretch allows you to adjust how the selected Colormap is distributed over a scan's amplitude range. A Color Stretch greater than one (1) compresses the colors towards zero (0). A Color Stretch less than one (1) expands the colors towards the maximum negative and positive amplitudes.



Left Color Stretch = 0 Middle Color Stretch = 1 Right Color Stretch = 3

Color Slide: Selecting Color Slide allows you to shift the center point of the selected Colormap over a scan's amplitude range. A negative number shifts towards the positive amplitudes and positive number shifts towards the negative amplitudes.

- o Adjusting the Color Slide may allow you to see more subtle variations in the data.



Left Color Slide = -0.20 Middle Color Slide = 0 Right Color Slide = 0.20

Rotate: You can rotate the grid from 0-358° using the Control Knob. The rotation changes in increments of 2° and you can start by moving up from zero or down from 358°. Combining Rotate with Viewpoint can create a 3D view of the data during collection.

Viewpoint: Viewpoint adjusts the perspective to view the grid. You can adjust the Viewpoint from -0.40 to 1, where -0.40 will provide almost a straight forward view of a 2D profile as you would see during 2D data collection. This will not preview through the Output menu unless Viewpoint Toggle was selected from the Toolbar.

Home: Resets Rotate and Viewpoint back to zero (0).

Marks on Grid: This turns the grid marks on or off. Grid marks correspond with the location of the profiles in the grid. Only adds marks to the lines where data were collected.

File Info: This opens a window showing the current settings including Radar Parameters, Positioning information, and Processing History.

Selecting a Different Quick3D Grid

To select a different 3D grid for playback press and hold the red Stop button to exit the Playback screen and return to the Introduction Screen. At this point you'll be able to select a different grid or data path by going into Playback Mode.

Chapter 5: Summary of Pre-Set Mode Parameters

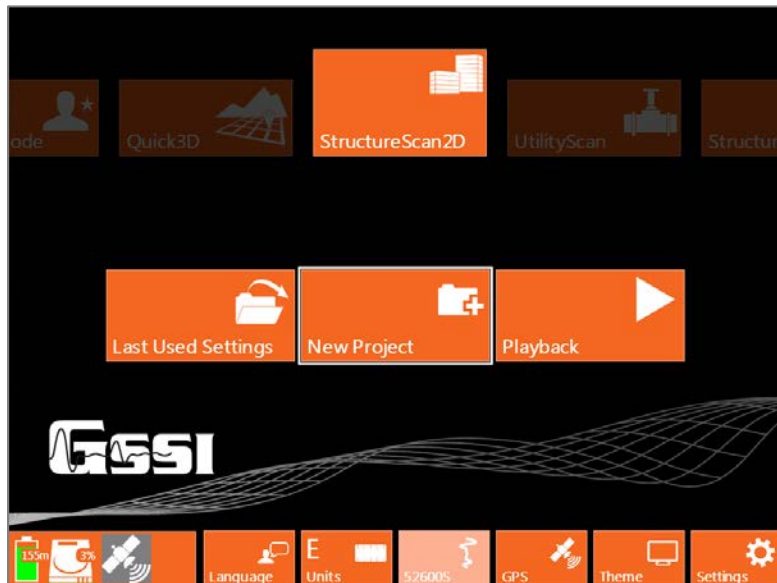
This section briefly describes the pre-set operation modes for the SIR 4000. These modes are more limited in their customization because they are meant for specific applications or to collect data for on-screen target location as opposed to post-processing. As noted earlier, Expert mode allows you full reign over all collection parameters. The Quick3D mode is similar to Expert mode in that it is fully customizable, but with the added feature of defining an easy 3D data collection project.

The additional modes are:

- StructureScan2D
- StructureScan3D
- UtilityScan (coming soon)
- UtilityScan DF (coming soon)

5.1: StructureScan2D

StructureScan2D is meant for a ‘quick and dirty’ scan of concrete. You would use this mode to locate shallow structural features in concrete and mark their location directly on the survey surface prior to any cutting, coring, or drilling. It works with the 2.6 GHz, 2 GHz Palm, 1.6 GHz, 1.5 GHz, and 1.0 GHz antennas.

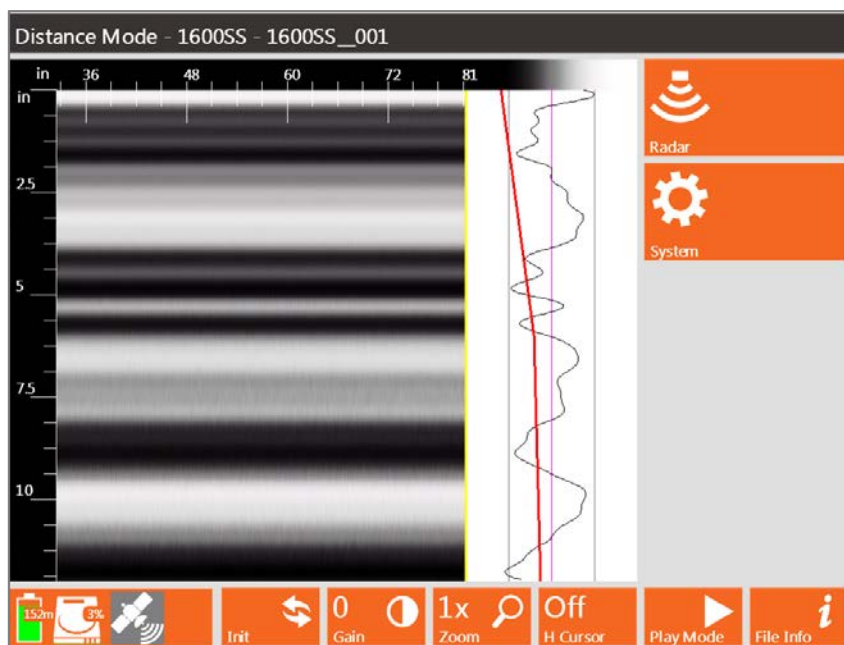


StructureScan2D Setup

- 1** Select StructureScan2D from the modes at the top of the Introduction screen.
- 2** If using a Smart Antenna, such as the 52600S, the correct antenna will be selected. However, if using an older antenna you'll need to select the correct frequency from the Antenna soft key at the bottom of the screen.
- 3** After verifying or selecting your antenna, select whether or not this is a New Project or if you're continuing a project with the Last Used Settings. You will then see the setup screen and, if an antenna is connected and the dead-man switch is engaged, it will initialize and data will start to scroll across.

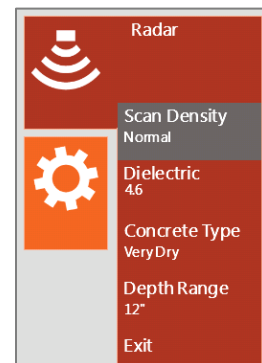
What You Can Customize

There are two setup menus in StructureScan2D: Radar and System.



Radar Menu: Change the settings in the Radar Menu in the order that they are listed.

- 1 Scan Density:** You can adjust the number of scans collected over the distance traveled. Below are the options for Scan Density. The higher the Scan Density the better chance you have of identifying small cables or distinguishing between two targets that are close together.
 - High: 20 scans/in (8 scans/cm)
 - Normal: 10 scans/in (4 scans/cm)
 - Low: 5 scans/in (2 scans/cm)
- 2 Dielectric:** You can adjust the Dielectric value of your concrete manually if you know it from a previous survey. Otherwise use Concrete Type to set the Dielectric.



3 Concrete Type: This sets the dielectric constant and gives you a more accurate depth calculation. You can adjust the Dielectric by setting a Concrete Type based on the conditions of the concrete you are scanning.

- Very Dry: 4.6 Dielectric
- Mod.(erately) Dry: 6.3 Dielectric
- Moist: 9 Dielectric
- Wet: 14 Dielectric



4 Depth Range: Select the Depth Range that is slightly greater than the thickness of concrete you are attempting to scan. For example, if you’re scanning a 10” slab, select the 12” Depth Range. Depths range from 4-24” in 4” differences (10-60 cm in 10 cm increments).

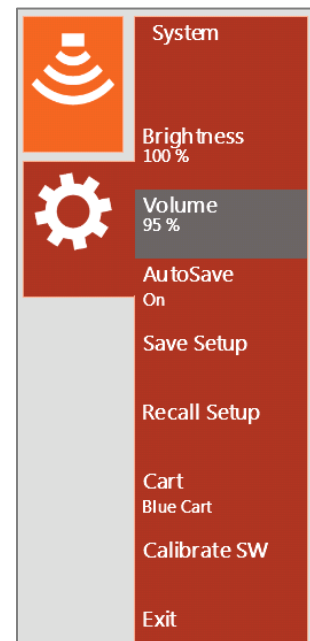
System Menu

1 Brightness: This controls screen brightness. The scale runs from 0-100% with 100% being the brightest. The screen will be black when set at zero (0). The screen consumes more power with increased brightness; the darker the screen is, the longer the battery will last.

2 Volume: This controls the volume of the control unit. The system makes noise at certain points during setup, data collection, and playback. The scale runs from 0-100% with 100% being the loudest. The sound is entirely turned off when set at zero (0).

3 AutoSave: Allows you to save all of the files you collect or to be selective. With AutoSave turned on you’ll automatically save every profile.

- If performing real-time locating turning this to On may be beneficial as it will decrease the number of selections you have to make to clear your screen.
- It is recommended to turn AutoSave Off if collecting individual profiles to build into a 3D grid using software. As you finish collecting one line this pausing data collection while you get in position to start the next line.



4 Save Setup: You can save all of the settings from the Radar menu to be recalled at a later date. When Save Setup is pressed using either the Control Knob or the Enter key a menu opens with sixteen (16) available setups, Setup01 – Setup16. You can select any of these numbered setups to save your current settings.

You can also create a New Setup from the control button at the bottom of the screen. Pressing this button opens the Edit Setup Menu where you can customize the name.

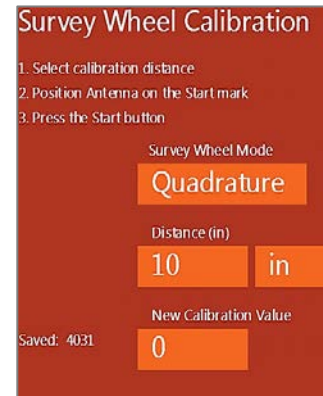
5 Recall Setup: You can also recall a setup that you previously saved. When Recall Setup is selected by either pressing the Control Knob or the Enter key, a list of available setups will appear.

6 Cart: Select which cart you are using with your antenna. This will recall a survey wheel calibration that matches your cart.

- Gray Cart
- Blue Cart
- Palm Antenna

7 Calibrate SW: If you are surveying over unfinished concrete or another rough surface it is recommended that you calibrate the survey wheel to adjust for the uneven surface.

- a) Select calibration distance – The default distance is 10 in.
- b) Position Antenna on the Start mark – The antenna can be positioned anywhere at the start as long as you use the same point on the antenna when you stop.
- c) Press the green Start button on the keypad of the SIR 4000.
- d) Move antenna to the stop mark – This should match the same location on the antenna where you started.
- e) Press the red Stop button on the keypad of the SIR 4000.
- f) Repeat Steps b)-e) at least twice to ensure that you get consistent calibration values.
- g) Select Apply to save the current calibration setting.



What is Preset

These are settings that you can customize in Expert Mode, but are preset in StructureScan2D.

- Samples/Scan: 512
- Scans/Second: 333
- Gain: 3 point Auto
- Filters (All)
- Offset position
- Surface position

The Dead-Man Switch

When using the blue cart or the Palm antenna with the SIR 4000 you'll need to hold the Dead-Man Switch on the cart or on the Palm antenna during setup and collection. If the Dead-Man Switch is not engaged the system will only record noise.

- If you see noise in Setup – Hold the Dead-Man Switch and press the Init control button. This will reinitialize the antenna and you will see a signal.
- If you see noise during Collection – Hold the Dead-Man Switch and try to collect more data. At this point you should start to see reflections; if you only see noise, return to the Setup screen, hold the Dead-Man Switch, and press the Init button. Then restart data collection.

Note: Before starting to collect data ensure that you have a signal and aren't seeing noise in the Setup screen.

StructureScan2D Data Collection

- 1** Hold the Dead-Man Switch, and press the green Start button. This will start data collection.
- 2** Continue to hold the Dead-Man Switch, and move the antenna forward over the line you're surveying.

3 At the end of your file, press the red Stop button one time. This halts the collection of the current data file; you now won't be able to scroll across the profile or perform any of the functions on the command bar.

- If AutoSave is set to On the file will automatically be saved. And a new file will immediately begin using the same collection parameters as the previous file.
- If AutoSave is set to Off a system prompt will pop up giving you the option to save or discard the file. Choose to save or discard using the Control knob or the Directional Keys.



4 To continue data collection after choosing to save or discard a file, position yourself at the beginning of your next profile. Then press the green Start button one time to begin the next data file. The previous data will be cleared and a new file opened. New files will be collected with the same collection parameters as the previous file.

5 To return to the Collect Setup screen if AutoSave is set to On, push and hold down the red Stop button for two seconds. The current file will automatically be saved and you will return to the Collect Setup screen. If AutoSave is set to Off, press the red Stop button one time. A system prompt will pop up giving you the option to save or discard the current file. Once an option has been selected push and hold down the red Stop button for two seconds and you will return to the Collect Setup screen.

Backup Cursor

StructureScan2D includes the backup cursor function. This allows you to back the antenna over the line you just surveyed and get an on-screen cursor that will help you relate the location of targets in the data back to the slab. The backup line in the data is the location of the midpoint of the antenna and shows the distance from the start of the line.



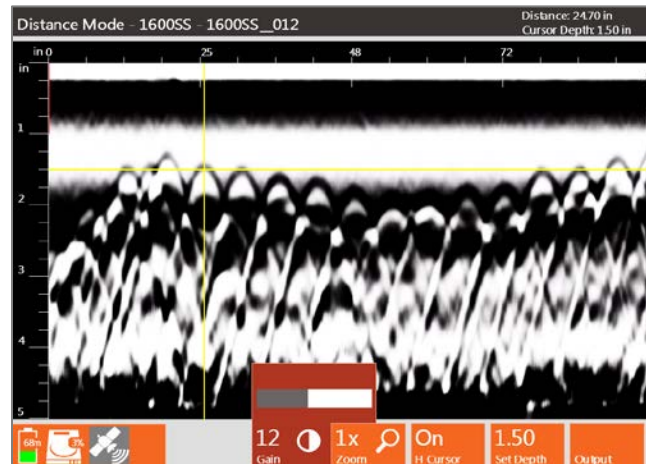
Options During Collection

As you collect a line along the slab you'll have several ways to calibrate the system and change the display.

Gain

This Gain option is also referred to as display gain. It increases the amplitude of your data by multiplying every sample throughout your scan by a constant value. The result is that you will be able to better see weaker reflections, but those already strong reflections may be over-gained. This function is useful for a quick viewing of data that is attenuated or otherwise under-gained to guarantee that it was not clipped.

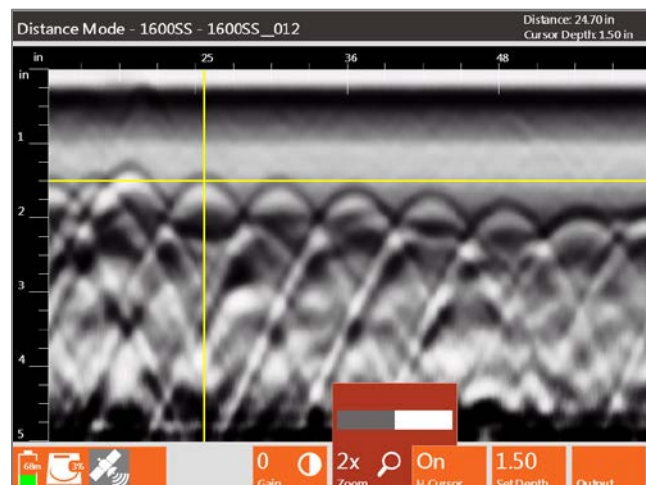
- You can change Gain from -12 to 60, with negative values weakening the entire signal and positive values strengthening the signal by the value shown.
- To modify Gain press the Gain control button and use either the Control Knob or Right/Left Arrow keys to adjust the gain amount.
- Display Gain is only for display and is not saved with the data.



Zoom

This option allows you to modify the horizontal scale by zooming in or out by factors of 1/2x, 1x, 2x, 4x, or 8x.

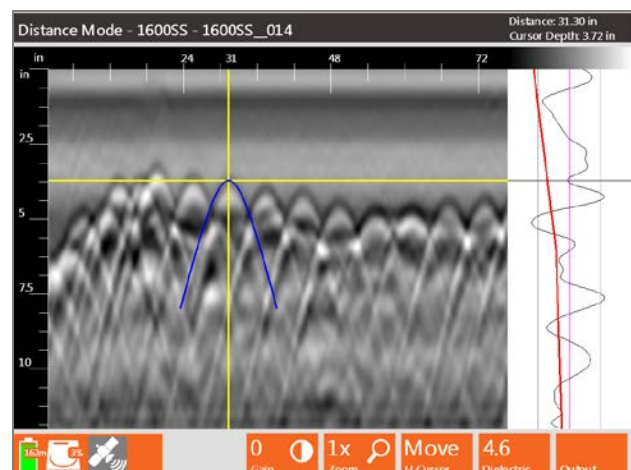
- The system defaults to 1x Zoom on initial startup and when data collection begins.
- This does not affect how the data are saved.



H Cursor

You can add a horizontal cursor to the screen during data collection. The yellow line can be toggled On or Off or moved.

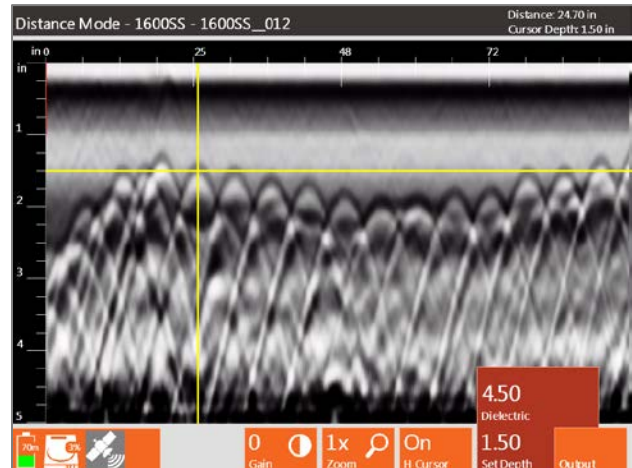
- To position H Cursor press the H Cursor control button to change the H Cursor to Move. Then use the Control Knob to adjust its position. Rotate the knob left (counter-clockwise) to move the cursor down the time range. Rotate the knob right (clockwise) to move the cursor up the time range.
- To set the H Cursor press the Control Knob or press Enter. The H Cursor control button will say On.
- To turn the H Cursor off press the H Cursor control button until it says Off.



Dielectric

You can adjust the Dielectric Constant during data collection from one (1) to eighty-one (81).

- 1 Turn Show Hyperbola On under the Output Menu.
- 2 Set the H Cursor at the top of a target in your slab.
- 3 Adjust the Dielectric so that the Hyperbola matches the shape of your target.



Changing the Dielectric Constant will change the vertical scale and give you a more accurate depth estimate for your targets.

Set Depth

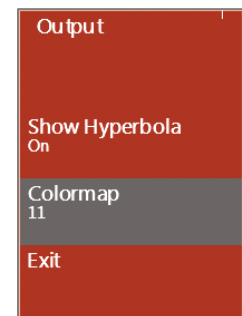
This control button allows you to enter the depth of a known target and automatically adjust the Dielectric Constant. This option is only available when Show Hyperbola is turned off from the Output menu.

- 1 Collect a file over a target with a known depth.
- 2 Back up so the vertical cursor is in line with the target.
- 3 Set Horizontal Cursor (H Cursor) to Move, and the Set Depth button appears. Position the H Cursor at the top of the known target.
- 4 Press the Set Depth control button and the depth of the H Cursor’s position appears above Set Depth.
- 5 Adjust the depth value using either the Control knob or arrow keys to match the known value. The vertical scale will change as you adjust the depth value and once the known depth is saved the Dielectric Constant is adjusted.

Output

This control button opens a menu with options for modifying the data display during collection. Below are the options for changing the display.

- **Show Hyperbola** - Toggles a hyperbola On or Off while in setup or during collection. The hyperbola appears at the intersection of the vertical and horizontal cursor. By default the horizontal cursor is placed at the top of the data display.
- **Colormap** - This menu option offers 30 available Colormap options (i.e. color tables). Select the menu by pressing the Control Knob or Enter key and then scroll through Colormap #0-29.



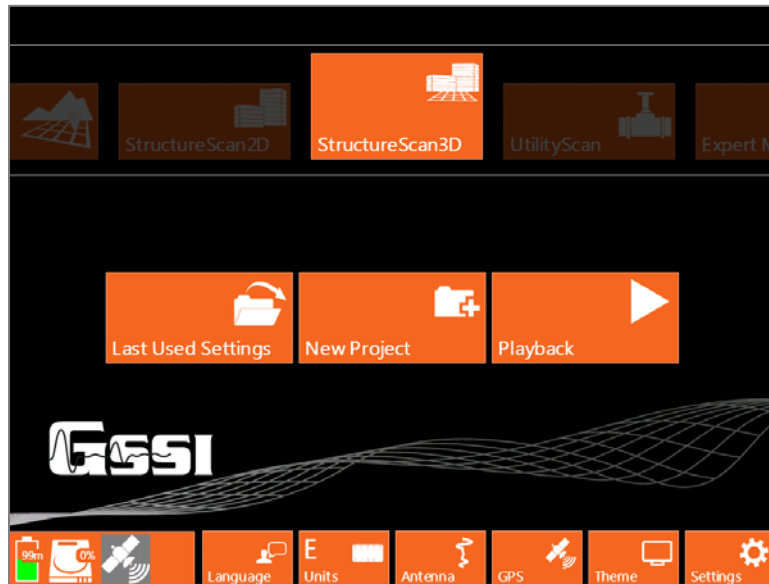
StructureScan2D Playback

After you've collected and saved data you can play it back on the SIR 4000.

- 1** From the Setup Screen press the Play Mode button at the bottom of the screen.
- 2** Select the file you want to play back from the list. Select it using the Control Knob and open it by pressing the Enter button.
- 3** Once the file opens in the Setup Screen, press the green Start button to play back the entire file.
- 4** From the Playback screen you'll have the following options for viewing or modifying the data. None of the changes made in Playback will save when you exit.
 - **Pause/Resume** - Pauses the data as it is being displayed on the SIR 4000. When the Pause control button is pressed once it stops playback and the control button changes to Resume. The Resume control button can then be pressed to continue playing back the selected data.
 - **Gain** - This Gain option is also referred to as display gain. It increases the amplitude of your data by multiplying every sample throughout your scan by a constant value. The result is that you will be able to better see weaker reflections, but those already strong reflections may be over-gained. This function is useful for a quick viewing of data that is attenuated or otherwise under-gained to guarantee that it was not clipped.
 - **Zoom** - This option allows you to modify the horizontal scale by zooming in or out by factors of ½x, 1x, 2x, 4x, or 8x.
 - **Cursor Dir** - You can move either the horizontal or vertical cursor on the screen during playback.
 - **Dielectric/Set Depth** - With Show Hyperbola turned On you can adjust the Dielectric Constant during playback from a value of one (1) to eighty-one (81). With Show Hyperbola turned Off you can set the depth of a known target.
 - **Output** - This control button opens a menu with options for modifying the data display during playback. Below are the options for changing the display.
 - **Dielectric:** Adjusts the Dielectric Constant used to calculate depth.
 - **Show Hyperbola:** Toggles a hyperbola On or Off while in setup or during collection. The hyperbola appears at the intersection of the vertical and horizontal cursor. By default the horizontal cursor is placed at the top of the data display.
 - **Colormap:** This menu option offers 30 available Colormap options (i.e. color tables). Select the menu by pressing the Control Knob or Enter key and then scroll through Colormap #0-29.
 - **File Info:** This opens a window showing the current settings including Radar Parameters, Positioning information, and Processing History.

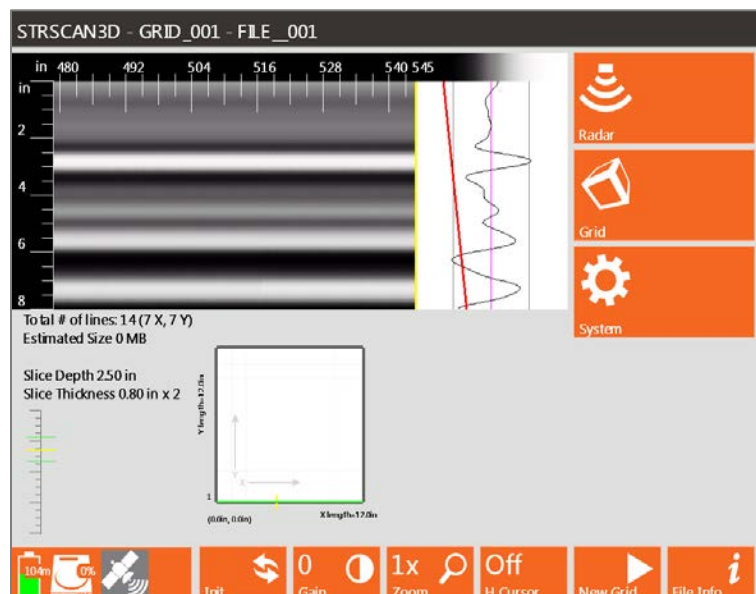
5.2: StructureScan3D

This mode is for collecting very high-resolution 3D data over a concrete slab or wall with a 2.6 GHz, 2 GHz Palm, 1.6 GHz, 1.5 GHz or 1.0 GHz antenna. This will produce a 3D cube of data that can be viewed in planview at differing depths so as to note clear locations for coring and cutting. You can also use the 3D data to quickly create graphics for reports that are more meaningful to your customers than 2D profiles.



StructureScan3D Setup

- 1** Select StructureScan3D from the modes at the top of the Introduction screen.
- 2** If using a Smart Antenna, such as the 52600S, the correct antenna will be selected. However, if using an older antenna you'll need to select the correct frequency from the Antenna soft key at the bottom of the screen.
- 3** After verifying or selecting your antenna, select whether this is a New Project or if you're continuing a project with the Last Used Settings. You will then see the setup screen and, if an antenna is connected and the dead-man switch is engaged, it will initialize and data will start to scroll across.
- 4** For instructions on how to configure the Radar and Systems menu refer to the StructureScan2D section in this chapter.



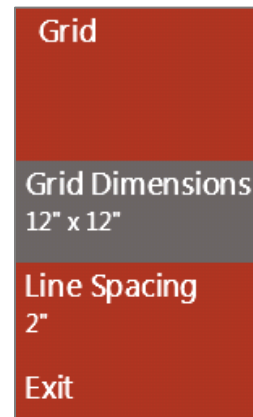
Setting up the 3D Grid on Concrete

There are two options for setting your grid up for StructureScan3D. You can either use a grid sheet that already has the lines printed on it or you can lay out your own grid using chalk or paint and a measuring tape. Grid pads are available in 12" x 12" (30 cm x 30 cm), 24" x 24" (60 cm x 60 cm), or 24" x 48" (60 cm x 120 cm) sizes. If you decide to setup your own grid ensure that it is a square or rectangle and matches one of the preset Grid Dimensions and Line Spacing options.

Grid Menu

Grid Dimensions: There are four possible grid sizes ranging from a 12" x 12" to a 48" x 48" grid (30 cm x 30 cm to 100 cm x 100 cm).

Line Spacing: This is the spacing between your survey lines and there are three options, 1", 2", or 4" spacing (2.5 cm, 5 cm, or 10 cm). The printed 3D grid sheets from GSSI have a 2" (5 cm) line spacing.



StructureScan3D File Structure

StructureScan3D mode creates a folder on your SIR 4000 with the name of the grid followed by the extension 3DS. Inside of that folder are all of the DZT files, DZX files, and a file with the extension BZX. The individual profiles are the DZT files and each one has a corresponding header file, the DZX. The BZX is a grid assembly file that tells RADAN how to assemble the individual files into a grid.

- The BZX file is an information file which tells the RADAN software where each DZT file is positioned and directs the software to create a 3D grid with the proper positioning information. Opening the grid in RADAN is as simple as opening the BZX file.
- The project folder will also contain a subfolder called Proc. This folder contains DZP files that are used to playback the 3D data on the SIR 4000. They are not necessary for 3D viewing or processing in RADAN.
- When transferring data from the SIR 4000 to a PC running RADAN, the entire Grid folder is transferred. In order for the BZX file to work all of the DZT and DZX files must be kept in the same folder as the BZX file.

Note: You must keep the BZX file and all of your data files together in the same grid folder.

In summary, each grid is saved in a separate folder under the project folder. Inside each folder are all of the individual radar profiles (DZT and DZX files) and one BZX file. The BZX file tells RADAN where to put each profile to create a 3D grid.

StructureScan3D Data Collection

Prior to starting a 3D grid you should perform a general survey of the area using StructureScan2D to determine the best settings to use during data collection and the ideal grid orientation. It will speed up data collection and interpretation if you already know which settings to adjust in the Radar menu as well as how you'd like to change them.

Step 1: Start System

After system boot-up, select the StructureScan3D mode. Then select New Project to create a new project folder. After naming the project and selecting Apply you will see the Setup screen with the menu on the right, o-scope in the upper middle, data preview in the upper left, and a grid preview in the bottom center of the screen.

Step 2: Setup Radar Menu

Under the Radar Menu select appropriate Scan Density and Concrete Type (or Dielectric is known).

Step 3: Set Grid Limits

Under the Grid Menu, set your grid dimensions and line spacing.

Grid Dimensions: StructureScan3D comes with four (4) grid size options. Select the size that best fits the area you're surveying.

Line Spacing: Next select the appropriate line spacing. If using one of the printed GSSI grid sheets, the line spacing is 2 inches (5 cm).

Step 4: Select Cart and Save Setup

Under the System Menu select which cart you're using with your concrete antenna. If you would like to use the same grid settings for a future survey you can save the setup through the System Menu.

Step 5: Enter Collection Screen

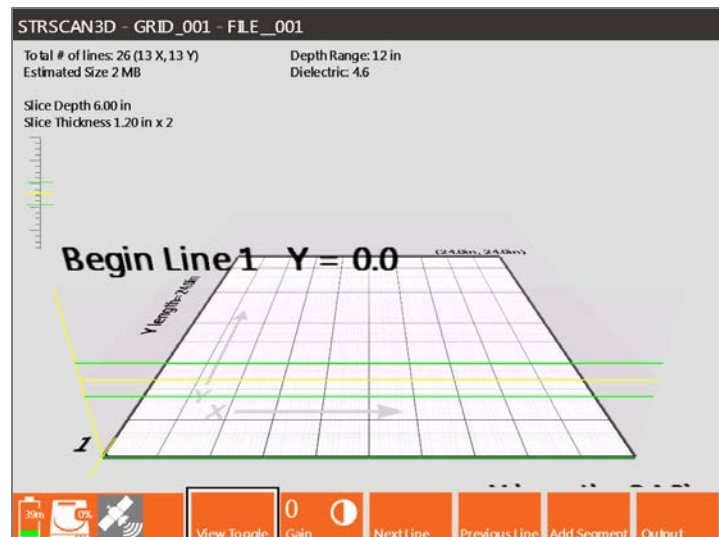
Once you are satisfied with the radar, grid, and system settings press the green Start button on the SIR 4000. This will open the 3D Collection Screen. There are four different ways to view the 2D profiles and 3D slice maps during collection and you toggle through them by pressing the View Toggle control button.

- **Grid Display:** Shows the full 3D grid and your current location within the grid. There are three views in this display.
- **2D Profile:** Shows just the 2D profile and can be used to perform a hyperbola fitting on the data. This view is only available from Line 1.

The grid coordinates are displayed at the bottom left and top right corners of the grid. The X and Y line lengths appear on the bottom and left side of the grid.

At the top of the screen the following information appears:

- Total number of lines
- Number in both the X and Y directions
- Estimated file size
- Total Depth Range
- Dielectric
- Current Slice Depth and Slice Thickness



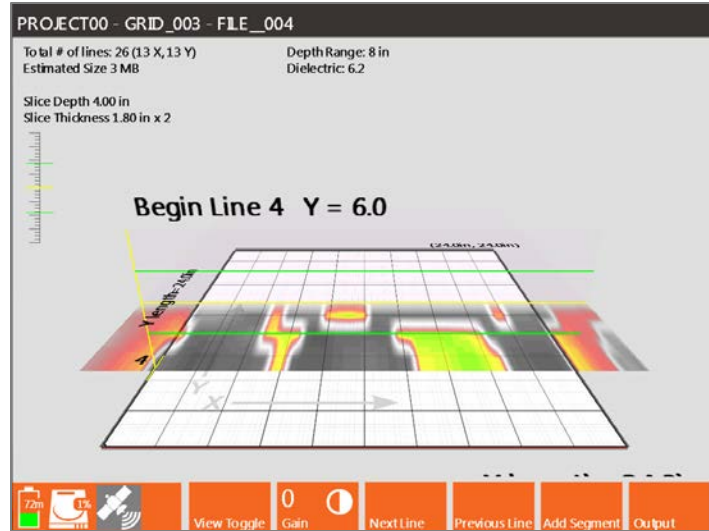
Step 6: Position Antenna

A yellow vertical line appears at your starting coordinate. Position the center of the antenna over the starting coordinate for your grid. That will be at (0,0) where the center of the antenna is centered over both the X and Y baseline at the same time.

Step 7: Begin Collection

Once the antenna is centered over the starting coordinate press the green Start button. This initiates data collection of Line 1. Nothing will happen until you begin to push the cart forward. Once the survey wheel starts moving forward you will begin collecting data and see the yellow line move across the screen.

After traveling the length of the grid, the SIR 4000 will automatically stop collecting data. The file will save and the system will automatically move to the next line.



Step 8: Continue Collection

Move the antenna to the beginning of Line 2 and center it over the baseline. Press the green Start button or the marker button on the cart (or antenna if using the 2 GHz Palm) to collect the next line. Repeat these steps until you've finished collecting lines in both the X and Y Directions.

Step 9: Saving the Grid

When you are finished collecting in both directions press and hold the red Stop button. This will end collection of the 3D grid, save the grid, and return you to the 3D Setup Screen. You are now ready to start collecting the next sequential grid in the same project. Select New Grid from the Toolbar to enter the StructureScan3D Setup Screen with the next sequential grid selected.

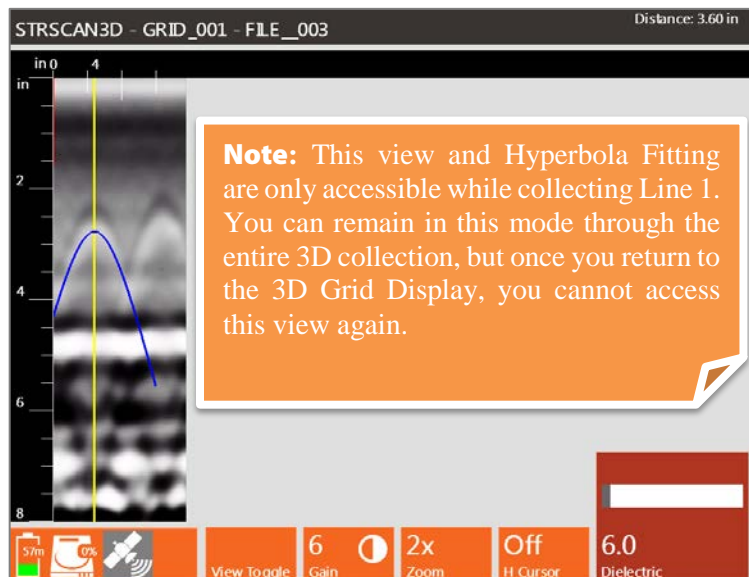
To change to a different project press and hold the red Stop button a second time to return to the Introduction Screen.

StructureScan3D Options during Data Collection

Estimating the Dielectric

By switching the view from the 3D grid to the 2D profile, you can perform a hyperbola fitting and get a better estimate of your Dielectric.

- 1** Begin collecting a line, but stop before you reach the end.
- 2** Back up so that the vertical yellow line is in the middle of a hyperbola.
- 3** Change H Cursor to Move and position the horizontal line at the top of the hyperbola.
- 4** Select Dielectric and adjust it until the hyperbola on the screen matches the shape of the one in your data.



Recollecting or Skipping Lines

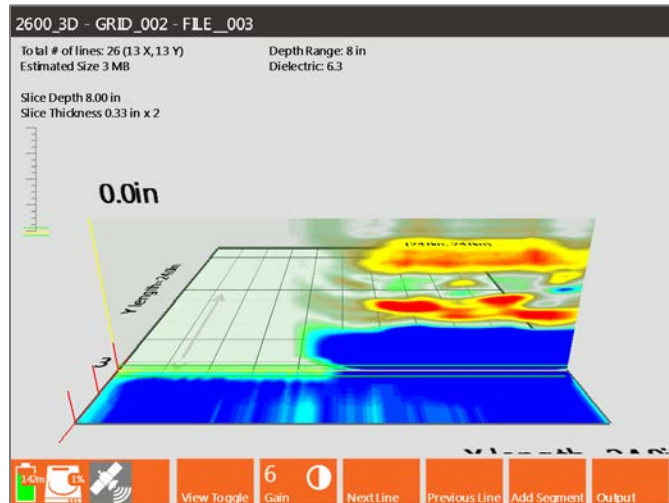
If you need to skip or redo a line, use Next Line or Previous Line in the Grid Display to move around the grid. You will see the yellow line move to indicate your current position. Once the yellow line matches your current location press the green Start button to collect or recollect the line. The new data file will be stored with the proper positioning info and any old data will be overwritten.

Adding a Line Segment

You can collect portions of a line or stop and start collection along a line by using the Add Segment button. There are two ways to use this button.

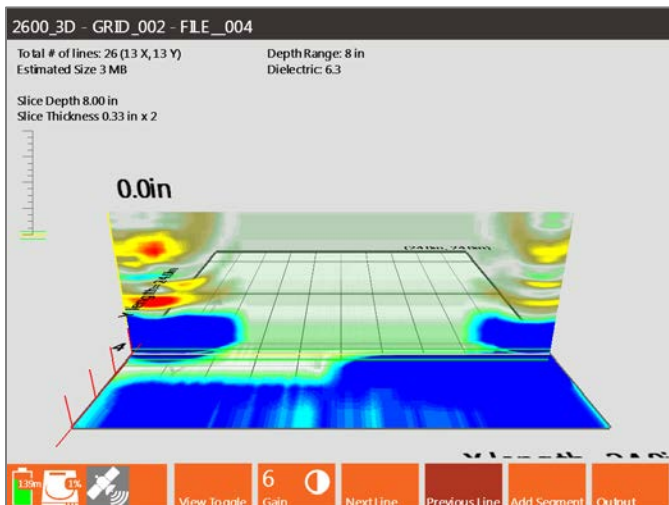
Offset the Starting Position: You can choose to start away from the baseline if needed.

- 1 Position the antenna along the line where you'd like to start.
- 2 Press Add Segment and then the green Start button.
- 3 Move antenna to the end of the line and position the center of the antenna over the opposite baseline from where you started.
- 4 Press the red Stop button. This will end the line and shift it so that it lines up with the opposite baseline.



Skipping a Section of the Line: You can skip a section in the middle of a line to avoid an obstacle. You can avoid one obstacle per line.

- 1 Begin data collection from the baseline as normal.
- 2 When you reach the section you want to skip press the red Stop button briefly.
- 3 Move the antenna to the opposite side of the area being skipped and line it up on the same path.
- 4 Press Add Segment to begin data collection again.
- 5 Move antenna to the end of the line and position the center of the antenna over the opposite baseline from where you started.
- 6 Press the red Stop button. This will end the line and shift it so that it lines up with the opposite baseline.



Modify the 3D Display during Collection

You can adjust how the data appear during data collection using the Toolbar soft keys and the Output menu available in the 3D Collection Screen.

View Toggle: Pressing this soft key toggles the 3D Collection Screen between a top down view of the grid, the 2D profiles and 3D view of the grid simultaneously, just the 2D profile, and the 2D profile view for hyperbola fitting. You can further modify the 3D grid appearance through the Output Menu.

Gain: Increase or decrease the Display Gain during data collection by a factor ranging from -12-60 dB. This can be used to adjust contrast for an entire profile by the same amount.

Output Menu

This menu provides options for modifying the appearance of your data during collection. The first six (6) options are the same for 3D collection and 2D collection. None of these settings affect raw data.

H Cursor: Changes the depth of the slice map in the Grid Display in half inch increments.

Slice Thickness: Adjusts the slice thickness from zero (0) inches to the maximum selected depth range in half inch increments. The slice is centered on the location of the H Cursor.

Dielectric: You can adjust the Dielectric Constant during data collection from a value of one (1) to eighty-one (81).

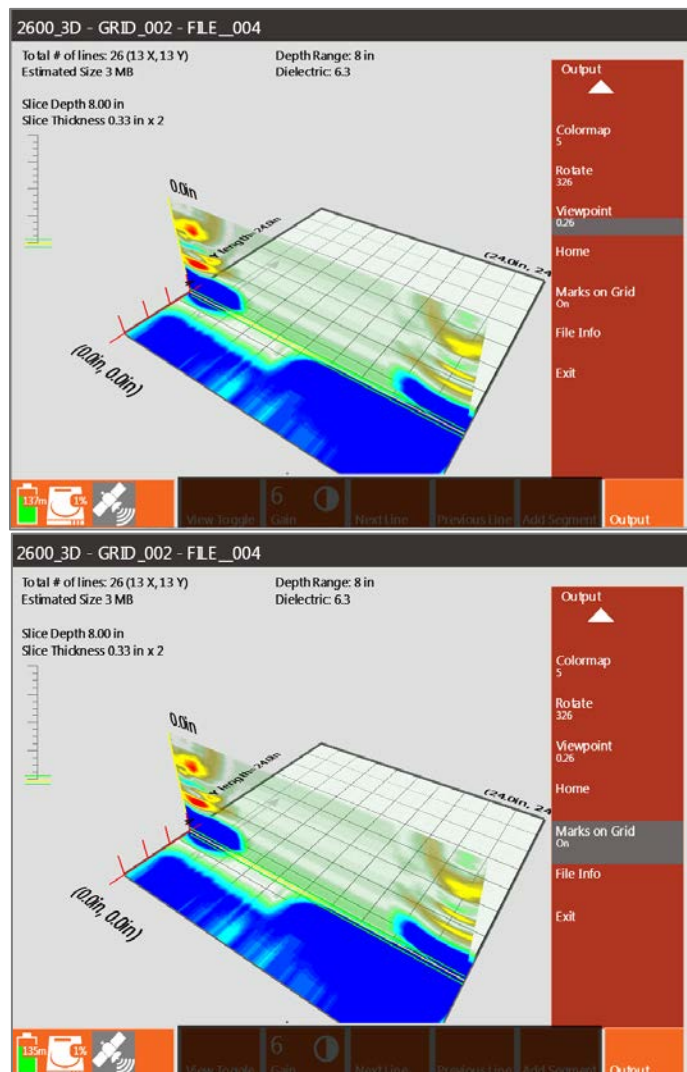
Colormap: This menu option offers 30 available Colormap options (i.e. color tables). Select the menu by pressing the Control Knob or Enter key and then scroll through Colormap #0-29.

Rotate: You can rotate the grid from 0-358° using the Control Knob. The rotation changes in increments of 2° and you can start by moving up from zero or down from 358°. Combining Rotate with Viewpoint can create a 3D view of the data during collection.

Viewpoint: Viewpoint adjusts the perspective to view the grid. You can adjust the Viewpoint from -0.40 to 1, where -0.40 will provide almost a straight forward view of a 2D profile as you would see during 2D data collection. This will not preview through the Output menu unless Viewpoint Toggle was selected from the Toolbar.

Home: Resets Rotate and Viewpoint back to zero (0).

Marks on Grid: This turns the grid marks on or off. Grid marks correspond with the location of the profiles in the grid. Only adds marks to the lines where data have already been collected.



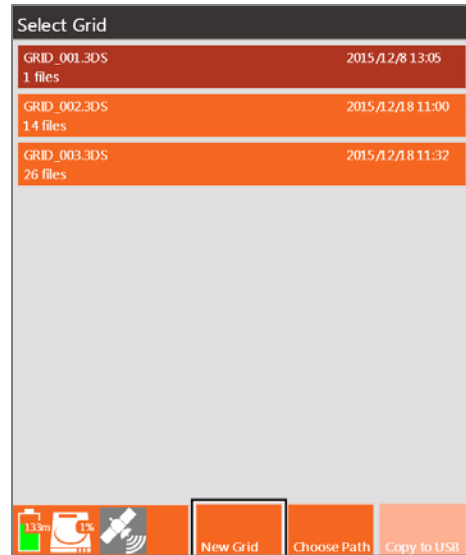
File Info: This opens a window showing the current settings including Radar Parameters, Positioning information, and Processing History.

StructureScan3D Playback

Quick3D Playback allows the user to display previously collected 3D data as a grid or in 2D profiles, recollect data within a previously collected grid, and modify some settings used during the original data collection.

Select a 3D Grid for Playback

- 1** Select which units were used to collect the grid, Metric or English. Whichever units are selected will be used to playback the grid regardless of the units used during collection.
- 2** Access StructureScan3D Playback through the Introduction Screen by selecting StructureScan3D and then Playback. This will open a screen where you can select a grid from the current project folder or press Choose Path to select a grid from a previous project folder.
- 3** Choose the grid file you want to play back using the Control Knob and select it by pressing the Control Knob.
- 4** Press Enter to open the 3D grid.
- 5** A Loading Grid progress bar will appear on the screen to track the progress of opening the grid.
- 6** The 3D grid immediately opens in the StructureScan3D Playback Screen.

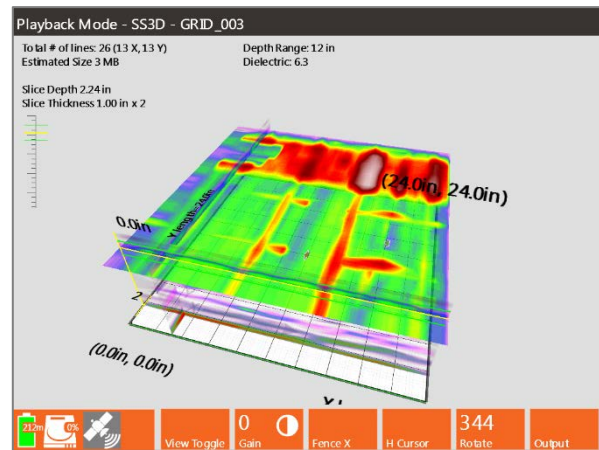
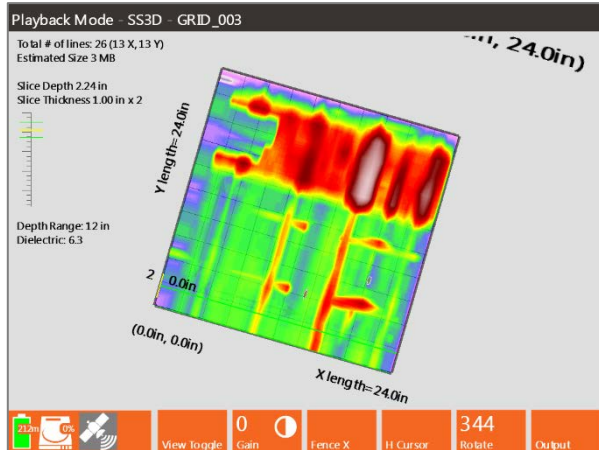


StructureScan3D Playback Options

The Playback Screen allows you to view individual 2D profiles in a grid format, rotate the grid to view data from different angles, change colors, and do hyperbola fitting. These options are all available through the Toolbar located at the bottom of the screen.

View Toggle

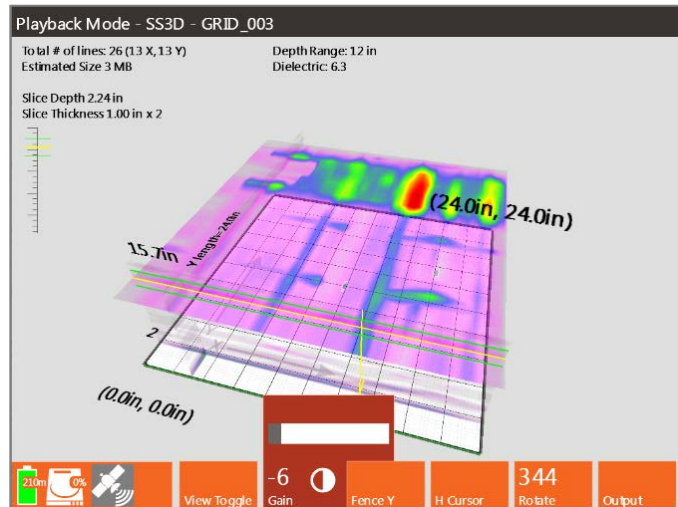
Pressing this soft key toggles the 3D Collection Screen between a top down view of the grid, askew angle showing the 2D profiles and 3D view of the grid simultaneously, just the 2D profile, and the 2D profile view for hyperbola fitting. You can further modify how the 3D grid appears through the Output Menu. The display reflects the applied Rotate and Viewpoint adjustments. These options are available under the Output Menu in the Toolbar.



Gain

This Gain option is also referred to as display gain. It increases the amplitude of your data by multiplying every sample throughout your scan by a constant value. The result is that you will be able to better see weaker reflections, but those already strong reflections may be over-gained. This function is useful for a quick viewing of data that is attenuated or otherwise under-gained to guarantee that it was not clipped.

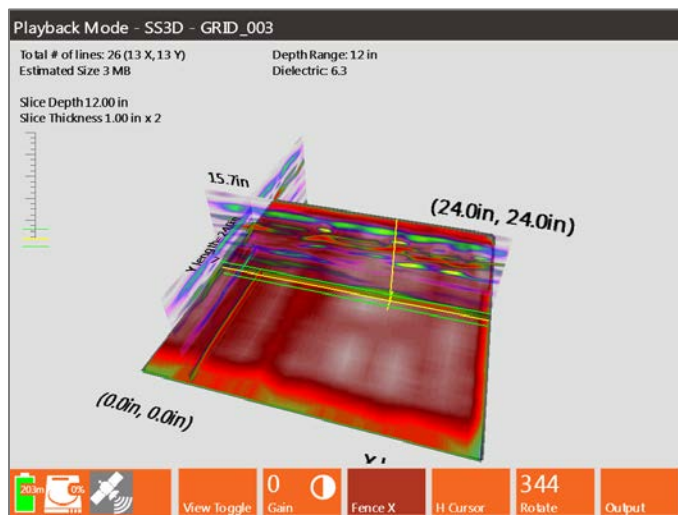
- You can change Gain from -12 to 60, with negative values weakening the entire signal and positive values strengthening the signal by the value shown.



Fence X and Y

Profiles that were collected in either the X or Y direction or both can be viewed during Playback.

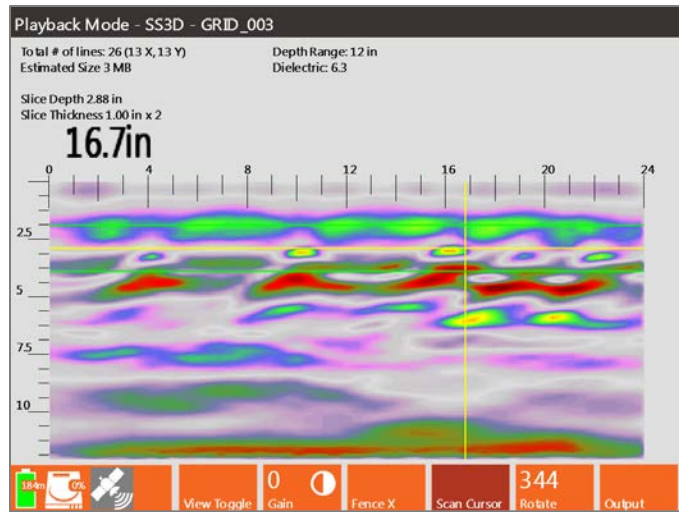
- Press this soft key to select which profiles to display.
- Once Fence X or Y is selected use the Control Knob to view different profilers.
- If data were collected in both the X and Y directions, you can view profiles at the same time in both directions. This can help pinpoint the location of a reflection.



Scan Cursor

Selecting Scan Cursor allows you to adjust the location of the Horizontal slice (H Cursor) in your grid or a Vertical line (Scan Cursor) along the currently selected profile. This can be used to acquire more accurate depth and distance information.

- Adjusting H Cursor:
 - Press Scan Cursor until it shows H Cursor.
 - Use the Control Knob to adjust the vertical location of the center horizontal line.
 - You can adjust the slice thickness in the Output Menu.

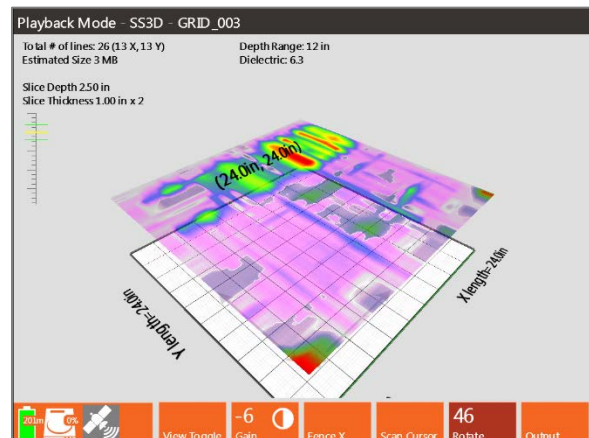


Rotate

You can adjust the rotation of the 3D grid using either a soft key or from the Output Menu. To adjust simply press the Rotate soft key and use the Control Knob of rotate the grid on a 360° axis.

Output Menu

This control button opens a menu with options for modifying the data display during playback.

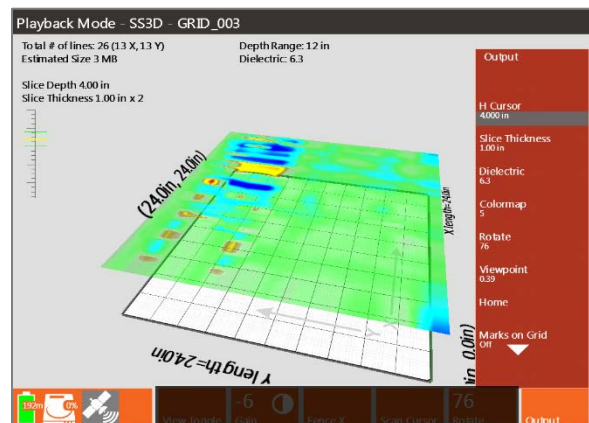


H Cursor: Changes the depth of the slice map in the Grid Display in half inch increments.

Slice Thickness: Adjusts the slice thickness from zero (0) inches to the maximum selected depth range in half inch increments. The slice is centered on the location of the H Cursor.

Dielectric: You can adjust the Dielectric Constant during data collection from a value of one (1) to eighty-one (81).

Colormap: This menu option offers 30 available Colormap options (i.e. color tables). Select the menu by pressing the Control Knob or Enter key and scroll through Colormap #0-29.



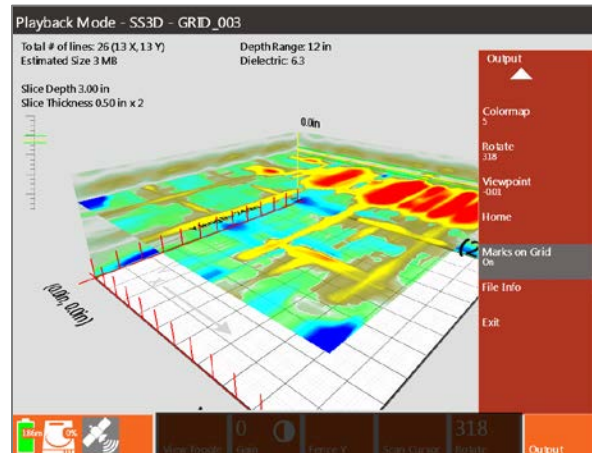
Rotate: You can rotate the grid from 0-358° using the Control Knob. The rotation changes in increments of 2° and you can start by moving up from zero or down from 358°. Combining Rotate with Viewpoint can create a 3D view of the data during collection.

Viewpoint: Viewpoint adjusts the perspective to view the grid. You can adjust the Viewpoint from -0.40 to 1, where -0.40 will provide almost a straight forward view of a 2D profile as you would see during 2D data collection. This will not preview through the Output menu unless Viewpoint Toggle was selected from the Toolbar.

Home: Resets Rotate and Viewpoint back to zero (0).

Marks on Grid: This turns the grid marks on or off. Grid marks correspond with the location of the profiles in the grid. Only adds marks to the lines where data were collected.

File Info: This opens a window showing the current settings including Radar Parameters, Positioning information, and Processing History.



Chapter 6: Setting Up Your SIR 4000 for | 2D Data Collection and Playback in Digital 2D Mode

This chapter provides instructions for configuring your SIR4000 to collect 2D profiles of data in with digital antennas in Digital 2D mode. These profiles can be interpreted by themselves or stacked together in software to produce a 3D image. See Chapter 7: Setting up your SIR4000 for Digital 3D data collection. The first section includes a step-by-step checklist to help set up your system. This refers to software setup only. The first two sections assume that you are collecting distance-based data with a survey wheel. If you are collecting data where the scan spacing is based on time (Time-based) see section 6.3. If you are collecting single Point data please see section 6.4. This chapter discusses all three collection modes. There is considerable overlap between Distance, Time, and Point collection settings, therefore specific differences are noted in each section. For most collection parameters refer to the section on Distance Mode Data Collection.

These instructions pertain to GSSI digital antennas only; for analog antennas see earlier chapters for Expert Mode. Digital antennas are equipped with a SmartID and the SIR4000 will automatically recognize them. Also discussed in this chapter are unique menu options for specific antennas; these antenna-specific functions will be noted where applicable.

6.1: Setting Up Distance Mode Data Collection

Step 1 - Introduction Screen

Press the green power button and wait for the SIR 4000 Introduction Screen to appear. The SIR4000 will automatically recognize the connected digital antenna (300/800 DF, 350HS). In Digital Mode there are two available options: Digital 2D and Digital 3D. Select Digital 2D using the Control Knob or the arrow keys, then press down on the control knob or press the enter button.

Digital 2D: Select Digital 2D from the rotating list at the top of the Introduction Screen.

General Settings: Once the Introduction Screen loads verify Language settings, Units of Measure, and Theme. These options are available in the Toolbar at the bottom of the screen.

Antenna: The SIR4000 will automatically recognize your digital antenna. You will not be able to select other antenna models.

GPS: Configure the GPS. Refer to Chapter 9: Using a GPS with your SIR 4000 for instructions.

New Project: Select New Project and enter a new Project Name. This will be the name of the folder where all of your files will be stored and the default name of the files as well. Once you provide a name and press Apply you will automatically leave the Introduction Screen and enter the Collect Setup Screen.

Note: From the Collect Setup Screen you can change your Project Folder by using the Output Menu and choosing Select Datapath.

Step 2 – Digital 2D Mode Setup

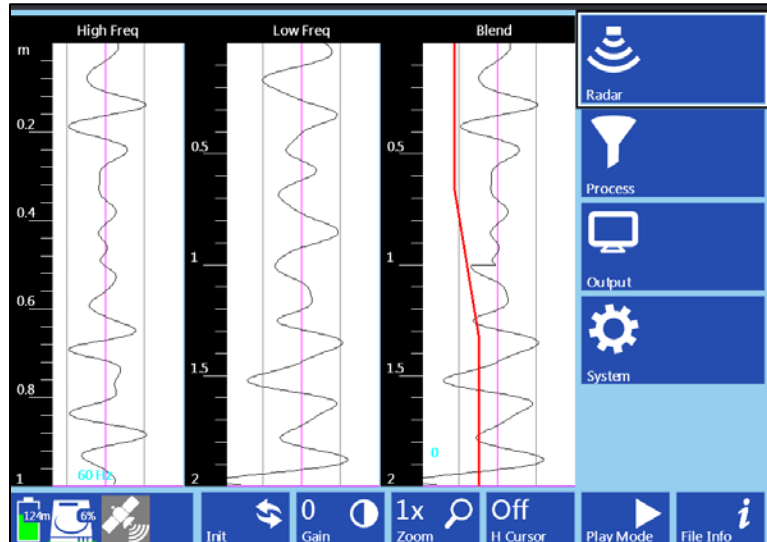
Once a new project is created you will see a new screen that will change depending on the antenna connected and previous display settings.

Setup/Collect Screen: 300/800 DF Antenna

300/800 MHz Dual Frequency

antenna: The Collect Setup screen will display either 1) Line Scan view with scrolling data, or 2) Wiggle mode showing O-Scopes for High Freq (-uency), Low Freq (-uency), or Blend. The High Freq O-Scope displays the 800MHz trace, the Low Freq O-Scope displays the 300MHz trace, and the Blend O-Scope shows the combined traces for 300MHz and 800MH. Note: both frequencies are being collected, regardless of the display setup.

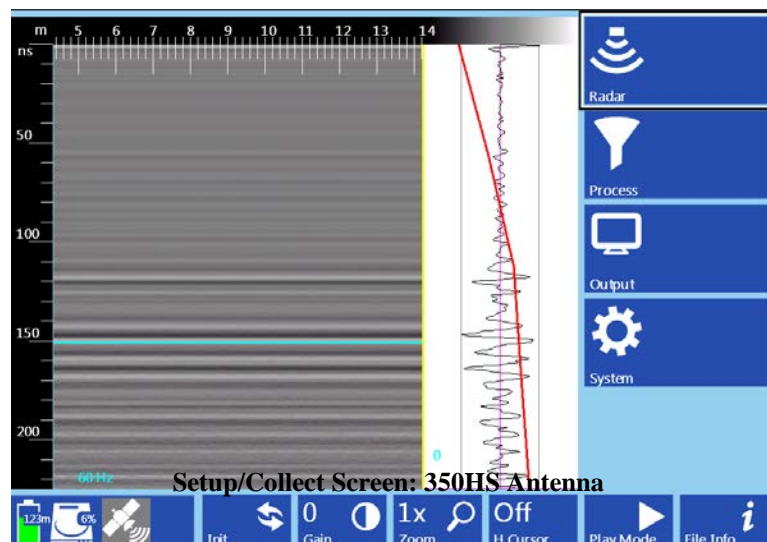
To change display type between Line Scan and Wiggle Mode, go to the Output Menu and scroll down to DF Display Type. Press down on the Control Knob or press the enter key to switch to Wiggle or Line Scan.



350HS antenna: The Collect Setup screen will display either 1) Line Scan view with scrolling data, 2) Line Scan view and O-Scope.

Setup Menu

Regardless of the digital antenna and display setup you will see a Setup Menu on the right-hand side of the screen. The Setup Menu has four (4) main menus: **Radar**, **Process**, **Output**, and **System**. To collect data, you'll need to check or adjust settings in all four (4) menus. The options for each Setup Menu will be different depending on the connected antenna. See below for antenna-specific Setup Menu options.



Recall Setup

If you've previously saved a setup that you want to use, recall it first before making any changes. Otherwise, when you do recall the setup it will overwrite any of your changes with those that were saved. Setups can either be uniquely named or you can use one of the sixteen (16) available setup names.

- 1 Open the System Menu and select Recall Setup. Select your saved setup from the list using either the Control knob or arrow keys. Once the desired setup is highlighted press either the Control knob or Enter button.

Note: If you recall a setup after configuring the GPS, the SIR 4000 will recall a baud rate of 4800. If this does not match your previously selected Baud Rate, return to the Introduction Screen and reset your Baud Rate in the GPS Configuration window.

Radar Menu: 300/800DF (Dual Frequency Antenna)

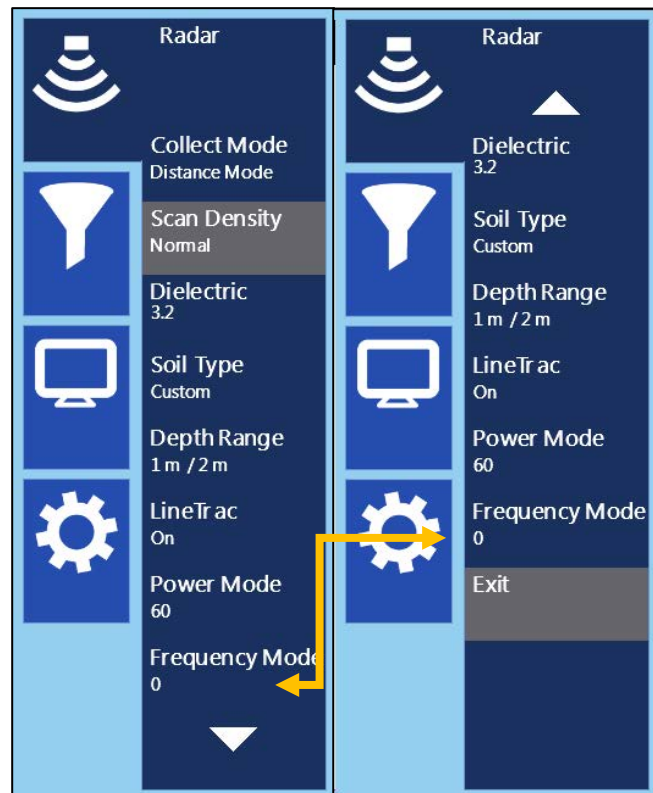
1 Collect Mode: Set to Distance.

2 Scan Density: Chose a Scan Density to set the number of scans collected per unit distance. This will adjust the number of scans collected over the distance traveled. The menu provides three Scan Densities: High, Normal, and Low. The higher the Scan Density the better chance you have of identifying small cables or distinguishing between two targets that are close together.

- High: 100 scans/m (30.5 scans/ft)
- Normal: 50 scans/m (15.25 scans/ft)
- Low: 25 scans/m (7.6 scans/ft)

3 Dielectric/Soil Type: Choose a Dielectric Constant or Soil Type that best represents your survey area (See Appendix D: Dielectric Values for Common Materials)

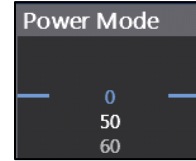
4 Depth Range: There are five depth ranges for the DF antenna. These are 0.5m/1.0m, 1m/2m, and 1m/3m, 2.0m/4.0m, and 3.0m/5.0m. These represent the depth range for each of the dual frequencies. For example, selecting a depth range of 2.0m/4.0m means that the high frequency depth range is 2.0m, and the low frequency depth range is 4.0m. Note that in Wiggle Mode as you change the depth range you will see the depths change for each frequency's O-Scope. Also note that the depth range of the low frequency will set the maximum depth of the Blend O-Scope.



Note: When adjusting time/depth range in Digital 2D mode, the following procedure is recommended. Before changing the dielectric or depth range, press the red Stop button to suspend communications with the antenna. Next, change dielectric or depth range. Finally, exit the Radar menu, and then press the Init button.

5 LineTrac: Set LineTrac On or Off. There are two settings that can be adjusted when LineTrac is turned On: Power Mode and Frequency Mode.

- Power Mode can be set to 0, 50 or 60.
 - Power Mode is a passive detection method that can locate the AC current of energized cables that are under load. These frequencies are typically 50Hz or 60Hz.
- Frequency Mode can be set to 1, 8, 16, or 33 KHz.
 - Frequency Mode is an active detection method used in combination with a user-supplied signal application device. Set the value of Frequency Mode to match the frequency of the applied signal.



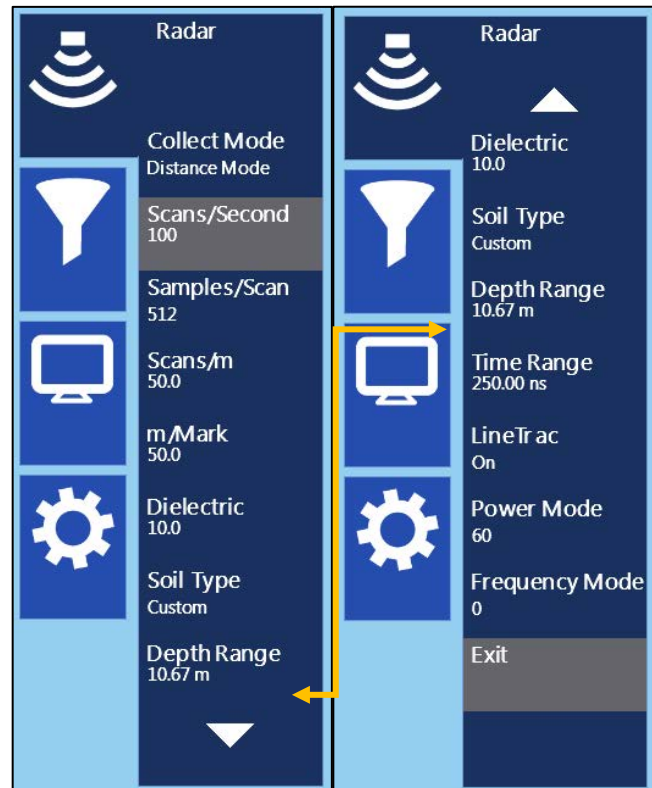
Radar Menu: 350HS (350MHz HyperStacking antenna)

1 Collect Mode: Set to Distance.

2 Scans/Second. The number of scans the system will collect per second. The SIR 4000 will collect minimum of 1 and maximum of 400 scans/second.

Samples/Scan If you are collecting distance-based data with a survey wheel, this number represents the maximum possible collect rate. If you exceed this maximum rate the over-speed beeps will sound. It is recommended that the scans/second be set lower as lower scan rates will auto stack and improve the signal to noise ratio.

For example: Scans/Second is set to 60 and you have configured the system to collect 60 scans a foot. If you move more than one foot per second the system will attempt to collect scans which are not available. Assuming your Antenna Transmit Rate is 200 KHz, the scans/second should be at least 240 whenever you are collecting with a survey wheel and are collecting a maximum of 512 Samples/Scan.



If you set Scans/Second higher than the selected transmit rate and the number of samples/scan, the SIR 4000 will lower it to the maximum possible. However, it is recommended that the scans/second be set lower than the maximum. This will allow the system to auto stack points thereby improving the signal to noise ratio.

3 Samples/Scan

Each scan curve is made up of individual data points, called Samples. More samples generate a smoother scan curve and improve vertical resolution. This also affects scan speed; more points collected means lower maximum scans/second.

- You can choose from a preset list of 256, 512, 1024, 2048, 4096, 8192, or 16384 samples/scan. Samples/Scan settings that are unavailable (due to conflicts with other settings) are greyed out. FIR filters should only be used with 256-2048 samples/scan.
- As sample number increases, max scan rate drops and file size increases.

- 4** GSSI recommends sampling at 512 or 1024 samples/scan for most applications. More samples will be required for deep geologic or polar ice thickness applications.

5 Scans/Unit

- Scans/Unit allows you to adjust the number of scans per unit of horizontal distance when you are collecting with a survey wheel. A unit of measure will appear based on the Units selected from the Introduction Screen and the Horizontal Units selected from the Output Menu.
- Smaller scan spacing produces higher resolution data, larger file sizes, and may require slower data collection. For example, if you see a 12 here and the system is set to English feet, rather than Metric units, you will collect 12 scans per foot, or 1 per inch.
- Scan spacing will vary based on application. For example, 5-10 scans/inch (60-120 scans/foot) is the optimal range for shallow structural features in concrete, but with lower frequency antennas a coarser scan density of 12-24 scans/foot is typical.

- 6 Scans/Mark:** Set how many units (i.e., feet or meters) will be collected between system marks. These marks will appear at the top of the data display along the horizontal scale.

- 7 Dielectric/Soil Type:** Choose a Dielectric Constant or Soil Type that best represents the area you are surveying (See Appendix D: Dielectric Values for Common Materials). Modifying the Dielectric will automatically adjust the Time Range, and vice versa.

- 8 Depth/Time Range:** There are two options for setting the depth or time range.

Depth Range: The vertical scale displayed in whichever units are selected under the Output -> Vertical Units menu.

- Depth Range can be set from 1cm to 10000cm (0.4-3900 in).

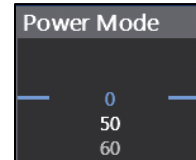
Time Range: The vertical scale in nanoseconds (ns) within which the SIR 4000 will record reflections. It is proportional to depth viewed because a higher Time Range will allow the energy to penetrate deeper and return deeper reflections.

- Time Range can be set from 1-20000 ns.
- It is important to remember that the Time Range is two-way travel time, so that a range of 50 ns means that the deepest possible reflector is at 25 ns.
- A very long range may require a greater number of samples to create enough data dots for the scan curve. Refer to the section above to determine the appropriate number of samples/scan.
- Please see Appendix D for a list of common ranges for individual antennas.
- Modifying Depth Range will automatically update the Time Range. Modifying Dielectric will also update the Time Range.

Note: When adjusting time/depth range in Digital 2D mode with the 350HS antenna, the following procedure is recommended. Before changing the time range, press the red Stop button to suspend communications with the antenna. Next, change time or depth range. Finally, exit the Radar menu, and then press the Init button.

- 9 LineTrac:** Set LineTrac On or Off. There are two settings that can be adjusted when LineTrac is turned On: Power Mode and Frequency Mode. When Power Mode is turned On a blue line will appear at the base of the LineScan. When Frequency Mode is On a yellow line will appear. If both Modes are turned on, a blue and a yellow line will appear.

- Power Mode can be set to 0, 50 or 60.
 - Power Mode is a passive detection method that can locate the AC current of energized cables that are under load. These frequencies are typically 50Hz or 60Hz.
- Frequency Mode can be set to a wide range of frequencies. Choose the option that matches your signal application device.
 - Frequency Mode is an active detection method used in combination with a user-supplied signal application device. Set the value of Frequency Mode to match the frequency of the applied signal.

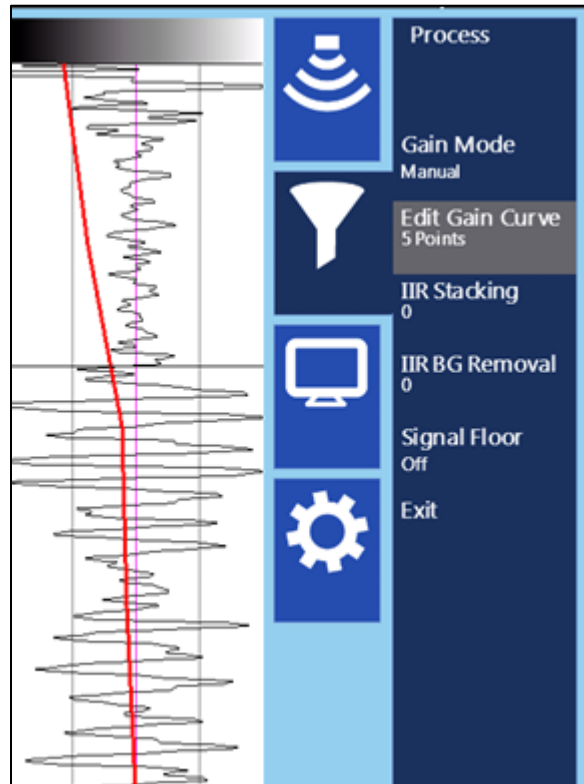


Process Menu: 350HS and 300/800DF

1 Gain Mode and Edit Gain Curve: In the O-Scope window the gain curve is the thin red line superimposed over the scan. The centerline of the scan is zero, to the left of it is negative (decreasing gain) and to the right is positive (increasing gain). To model signal loss, gain is applied in decibels (dB) along an exponential function. Your goal should be to have a gain curve that creates a scan trace with balanced amplitude changes from top to bottom.

2 Select Auto Gain Mode: If Auto Gain Mode is already selected, press the Init control button at the bottom of the screen to apply an automatic gain curve to the current scan trace. This will re-initialize the system and add/subtract gain to produce a visible signal. Move the antenna and look for evidence of clipping. If your data becomes clipped, leave the antenna in place and re-initialize by pressing the Init control button. This will decrease the gains so that the data will not clip.

- If you plan to collect multiple profiles and wish to compare them, it is usually best to set the gain to Manual Gain Mode once you find appropriate gain settings (you can see targets and the signal does not clip). This will set the gain levels and they will be consistent across your profiles. This may lead to signal clipping if you move to an area with different conditions.
- If you are performing real-time locating, leaving the Gain Mode set to Auto will allow you to use Init when your signal quality changes between profiles.

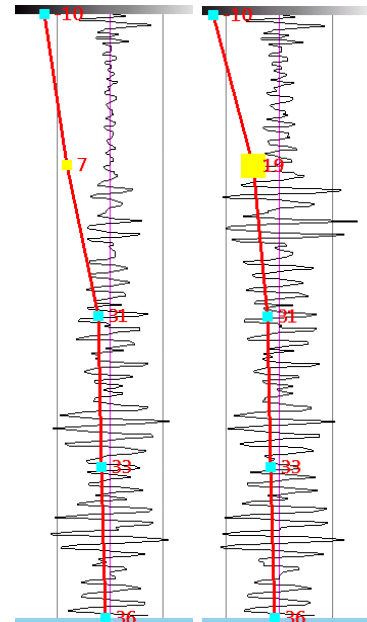


3 Edit Gain Curve: If portions of the signal are under- or over-gained after using Auto Gain Mode, try increasing or decreasing the number of gain points. Gain points are evenly distributed along the scan trace; adjusting the number of points can change where amplification occurs.

- Select Edit Gain Curve.
- Add or erase points to modify the gain curve.
- Save and Exit to return to the Collect Setup screen.

4 IIR Stacking: IIR Stacking is a high-frequency noise reduction filter operating in the horizontal direction. Each new scan has a $1/n$ influence in the data, so this filter has a tendency to smooth high frequency targets and accentuate low frequency horizontal features, such as layers. As the number of scans you stack (n) increases, the influence of each new scan drops.

- The IIR Stacking filter input is in number of scans. Pressing IIR Stacking with either the Control Knob or Enter button will allow you to select a number of scans.
- High frequency noise generally has a ‘snowy’ appearance. The larger the number you put in here, the smoother the data will be. It is possible to over-smooth and ‘smudge’ out real data. With larger numbers the system performs many extra calculations and this may reduce data collection speed. The maximum value is 1023 scans.



5 IIR BG Removal: This filter removes horizontal bands of noise. These bands are occasionally caused by ‘real’ horizontal reflectors, but they are also caused by low frequency noise such as antenna ringing. These layers can obscure other ‘real’ horizontal or point source reflectors.

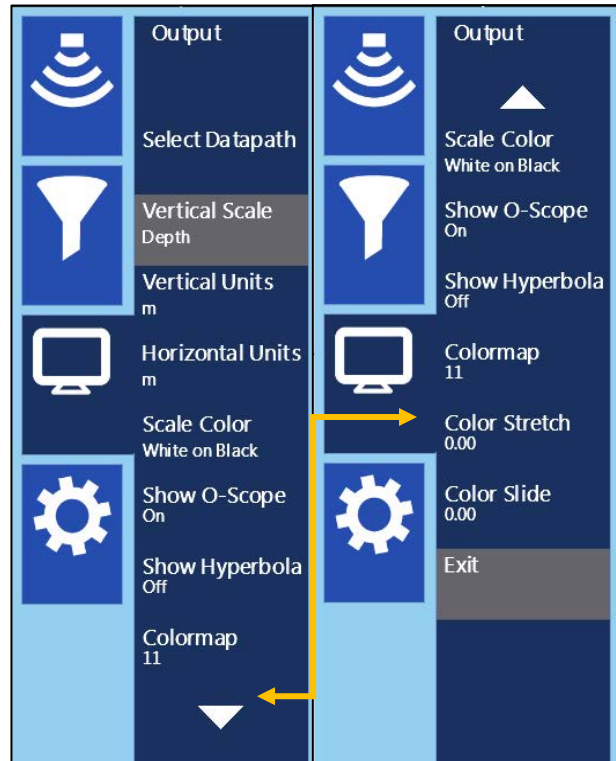
- Filter length should be set to the number of scans equal to the feature length to be removed. Be careful not to filter out desired reflectors.
- The IIR Background Removal filter input is in number of scans. Determine the length in scans of the feature or noise that you want to remove from the data and input that number. Features, or horizontal reflections, of this size or larger will be removed.
- The Background Removal filter maximum value is 1023 scans.
- It is recommended that this filter be set last. When Background Removal is turned on the previewed linescan data and individual scan will gradually be averaged out by the filter and only noise will be visible.

6 Signal Floor: When Signal Floor is turned on it overlays a green field on the Linescan display. This green field is an estimate of the effective depth of each scan based on an analysis of the noise to signal loss (attenuation). Real reflectors may still be located beneath the Signal Floor if they are strong enough.

- Press the Control Knob or Enter key to toggle Signal Floor On or Off.
- This process does not affect the data being collected. It is a visual indication only.

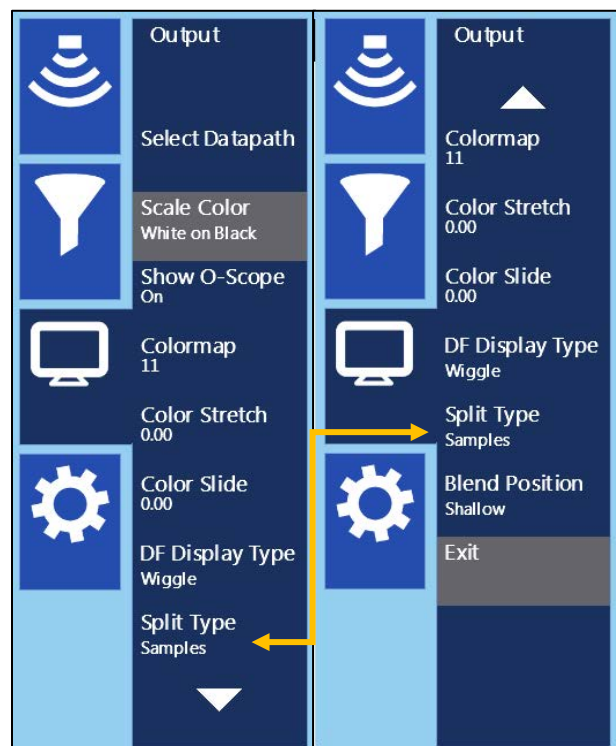
Output Menu: 350HS

- 1 Select Datapath:** Choose previously-created datapath or create a new datapath.
- 2 Scale and Units:** Verify that you are using the appropriate vertical scale, vertical units, and horizontal units.
- 3 Scale Color, Colormap, Color Stretch, and Color Slide:** Check that you are using your preferred color scale settings.
- 4 Show O-Scope:** Toggles the O-Scope display On or Off for use during data collection. Selecting Off will not turn off the O-Scope display in the Setup Screen.
- 5 Show Hyperbola:** Toggles a hyperbola On or Off while in setup or during collection. The hyperbola appears at the intersection of the vertical and horizontal cursor. By default the horizontal cursor is placed at the top of the data display. Toggle Show Hyperbola On or Off by pressing the Control Knob or the Enter key.



Output Menu: 300/800DF

- 1 Select Datapath:** Choose previously-created datapath or create a new datapath.
- 2 Scale and Units:** Verify that you are using the appropriate vertical scale, vertical units, and horizontal units.
- 3 Scale Color, Colormap, Color Stretch, and Color Slide:** Check that you are using your preferred color scale settings.
- 4 Show O-Scope:** Toggles the O-Scope display On or Off for use during data collection. Selecting Off will not turn off the O-Scope display in the Setup Screen. Toggle Show O-Scope On or Off by pressing the Control Knob or the Enter key.
- 5 DF Display Type:** Depending on your last used display settings you will see either 1) Line Scan view with scrolling data, or 2) Wiggle mode showing O-Scopes for High Freq(uecy), Low Freq(uecy), or Blend. The High Freq O-Scope is displaying the 800MHz trace, the



Low Freq O-Scope is displaying the 300MHz trace, and the Blend O-Scope show the combined traces for 300MHz and 800MHz.

- To change display type between Line Scan and Wiggle Mode, Go to the Output Menu and scroll down to DF Display Type. Press down on the Control Knob or press the enter key to switch to Wiggle or Line Scan
- **DF Display Type: Line Scan.** This Display Type shows Line Scan data, and is configured based on Split Type and Blend Position settings. With Line Scan selected, you can choose between four DF Display Styles: Split, Blend, High Freq., and Low Freq.
 - **Split:** Shows high frequency data at the top of the line scan, and low frequency data at the bottom. The suture point for the two frequencies is based on the selected Blend Position (see below).
 - **Blend:** Combines shallow high frequency data and deeper low frequency data without a noticeable suture line.
 - **High Freq.:** Displays only high frequency data
 - **Low Freq.:** Displays only low frequency data.
 - **DF Display Type: Wiggle**
- **DF Display Type: Wiggle.** This Display Type shows three O-Scopes that represent high frequency, low frequency, and a Blend of high and low frequencies. Note there is a difference in time/depth range for high and low frequency data, and the maximum depth of the Blend O-Scope is identical to the low frequency O-Scope.

6 Split Type: Choose to show high and low frequencies based on Time or Samples.

7 Blend Position: Choose between shallow, medium, and deep. This option controls the depth or time at which the high and low frequency data are blended. Use this option for viewing a greater or lesser range of each frequency. Note: this setting can help to optimize data viewing, especially when high frequency data are either attenuated with increasing depth/time, or you are seeing good high frequency data at greater depths.

System Menu: 350HS and 300/800DF

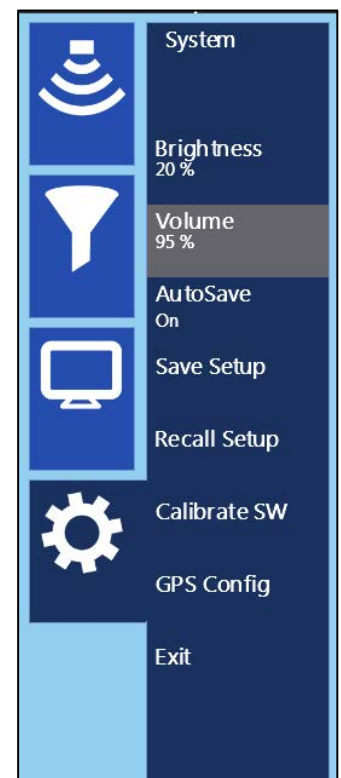
1 AutoSave: With AutoSave turned on you'll automatically save every profile. Select this option to save all of the files you collect, rather than be selective.

- If performing real-time locating AutoSave may be beneficial as it will decrease the number of selections required to clear your screen.
- If collecting individual profiles to build into a 3D grid using software, we recommend turning AutoSave Off. As you finish collecting one line this pauses data collection while you get in position to start the next line.

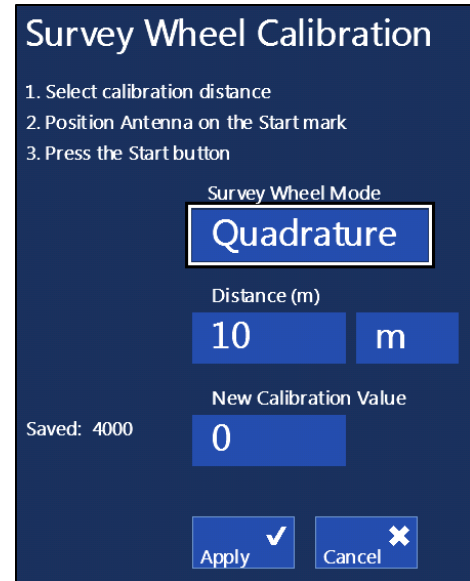
2 Save Setup: Once you've made all of the modifications to the settings listed above, it's a good idea to save your setup. This way you can recall it later if you have to restart the system or if you know you'll use these settings on a regular basis.

3 Survey Wheel Calibration: If you're switching between different carts or moving from one type of terrain to another you should recalibrate the survey wheel in order to accurately track distance. To manually calibrate the antenna you will need to lay out a measured line on your survey surface.

a) Select Survey Wheel Mode: Quadrature or Pulse.

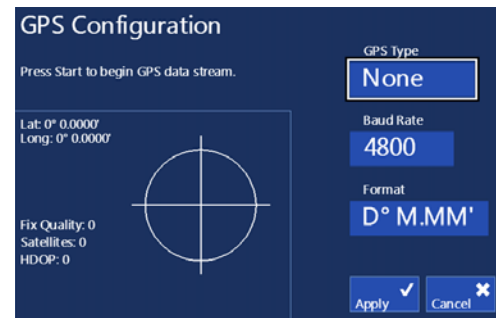


- b)** Select calibration distance – The default distance is 10 meters or feet. This distance can be changed, and a longer distance provides a more accurate calibration.
- c)** Position Antenna on the Start mark – The antenna or system can be positioned anywhere at the start if you use the same point on the antenna or system when you stop.
- d)** Press the Start button – This is the green Start button located on the keypad of the SIR 4000.
- e)** Move antenna to the stop mark – match to the same location on the antenna or system where you started.
- f)** Press Stop button – This is the red Stop button located on the keypad of the SIR 4000.



If necessary, you can manually enter the calibration value:

- 1** Use either the Control Knob or Arrow keys to navigate to the New Calibration Value box.
 - 2** Press the Control Knob of the Enter key to highlight the New Calibration Value box. Rotate the Control Knob or use the up and down arrows to enter in the correct value.
 - 3** Click the right arrow to save and exit.
 - 4** Once the desired survey wheel calibration is achieved select Apply. The current value will be saved and the Calibrate SW menu will close. Press the Quit Toolbar key to return to the main Introduction Screen.
- 5 GPS Config:** Enter GPS parameters based on the settings for your GPS. Press the green start button to begin GPS data collection. Once a GPS fix is acquired the GPS Configuration window will show the Fix Quality, Number of Satellites, and HDOP. Use the Control Knob to highlight Apply, and press down on the Control Knob.



Step 3 – Data Collection in Distance Mode

- 1** To begin data collection press the green Start button once.
- 2** At the end of your profile, press the red Stop button once or press and hold the green Start button. This halts the collection of the current data file; you won't be able to scroll across the profile or perform any of the functions on the command bar.
- 3** If AutoSave is set to On the file will automatically be saved. A new file will immediately begin using the same collection parameters as the previous file.
- 4** If AutoSave is set to Off a system prompt will pop up giving you the option to save or discard the file. Choose to save or discard using the Control knob or the Directional Keys.
- 5** To continue data collection after choosing to save or discard a file, position yourself at the beginning of your next profile. Then press the green Start button one time to begin the next data file. The

previous data will be cleared and a new file opened. New files will be collected with the same collection parameters as the previous file.

- 6** To return to the Collect Setup screen if AutoSave is set to On, push and hold down the red Stop button for two seconds. The current file will automatically be saved and you will return to the Collect Setup screen. If AutoSave is set to Off, press the red Stop button one time. A system prompt will pop up giving you the option to save or discard the current file. Once an option has been selected push and hold down the red Stop button for two seconds and you will return to the Collect Setup screen.

6.3: Setting Up for Time Mode Data Collection in Digital 2D

The scan spacing (horizontal resolution) of Time-based data profiles is a function of the speed that the system is collecting data (Scans/Second) and the rate the antenna is moving over the survey surface. Data density is improved with higher Scans/Second and slower antenna speed.

Time-based data has no real distance tag, so the software does not know how far you actually traveled. It is extremely important to move the antenna at a constant speed and to add user marks (by clicking the mark button) at consistent intervals. Time-based data requires additional processing in RADAN to create a 3D image. Note: If 3D imaging is your goal, it is ideal to collect Distance-based data with a survey wheel.

Most SIR-4000 system parameters are identical in Distance Mode and Time Mode. Listed below are the settings that pertain to Time Mode. For all other settings, refer to Distance Mode Data Collection in Digital 2D (see above).

Radar Menu

- 1 Collect Mode:** Set to Time.
- 2 Scans/Second:** Your data density depends on the rate you move the antenna over the survey surface. Typically this value is set much lower than the maximum.
- 3 Units/Mark:** You can also set how many units (feet or meters) will be collected between system marks.

Data Collection in Time Mode

- 1** To begin data collection, press the green Start button one time. The SIR 4000 will instantly begin collecting scans at the rate specified during setup. Scans will fill the screen from left to right.
- 2** If adding user marks during collection to correct distance in RADAN, press the Mark button at the appropriate interval.
 - For example, if collecting single lines to build a 3D grid in RADAN, add a user mark when the antenna crosses the baselines to indicate the beginning and end of each line.
- 3** At the end of your profile, press the red Stop button one time or press and hold the green Start button. This halts the collection of the current data file; you now won't be able to scroll across the profile or perform any of the functions on the command bar.
- 4** If AutoSave is set to On the file will automatically be saved and a new file will immediately begin using the same collection parameters as the previous file.

- 5** If AutoSave is set to Off a system prompt will pop up giving you the option to save or discard the file. Choose to save or discard using the Control knob or the Directional Keys.
- 6** To return to the Collect Setup screen if AutoSave is set to On, push and hold down the red Stop button for two seconds. The current file will automatically be saved and you will return to the Collect Setup screen. If AutoSave is set to Off, press the red Stop button one time. A system prompt will pop up giving you the option to save or discard the current file. Once an option has been selected push and hold down the red Stop button for two seconds and you will return to the Collect Setup screen.

6.4: Setting Up for Point Mode Data Collection in Digital 2D

The third data collection mode on the SIR 4000 is for Point mode data collection. This mode is most useful for deep geophysical investigations or data collection over difficult, broken terrain.

Point mode is for recording individual scans over an area. These scans are combined to produce a profile similar to the other collection modes. The scan spacing (horizontal resolution) of Point-based data profiles is a function of how far apart you set your collection points.

Radar Menu

- 1 Collect Mode:** Set to Point.
- 2 Depth/Time Range:** There are two options for setting the depth or time range.
- 3 Scans/Unit:** This is the number of scans that will be collected every foot or meter. This number will affect how the horizontal scale is displayed during data collection.

Process Menu

- 1 Static Stacking:** Point data is typically collected with some static stacking. A good default value here is 64. The system will take 64 scans at each scan location and average them together to output a single scan. This is done to minimize high-frequency, random noise.

Output Menu

- 1 Spacing, Amplitude, and Fill:** Check that you are using your preferred display settings for Point Mode.

Data Collection in Point Mode

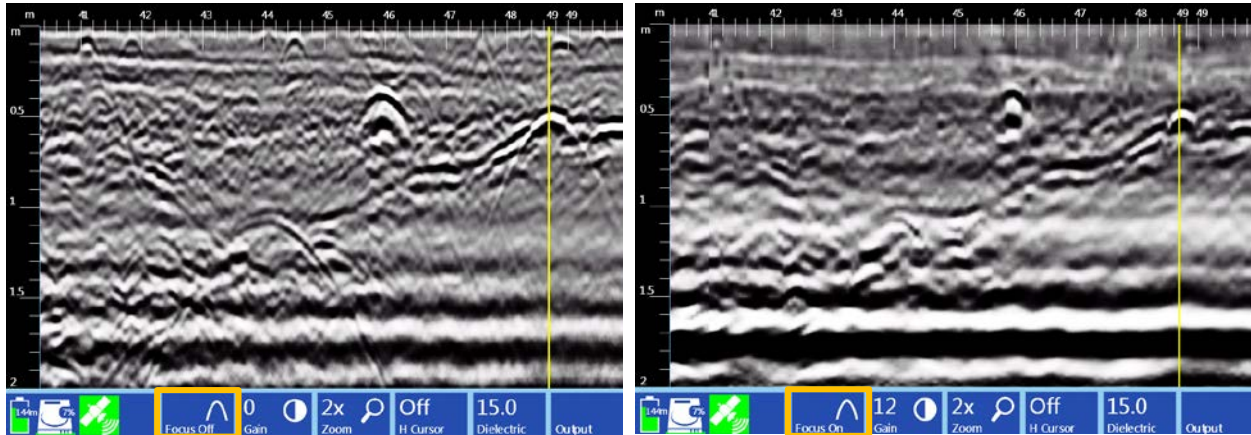
- 1** To begin data collection press the green Start button one time. The screen will appear with one scan trace on the left side of the data display screen and the rest of the data display will be blank.
- 2** Press the Next Point control button to collect subsequent scans. The Scan number will update in the Information Bar at the top of the screen as additional scans are added.

At the end of your profile, press and hold the red Stop button for two seconds. If AutoSave is set to On the profile will be saved and you will return to the Collect Setup menu. If AutoSave is set to Off a system prompt will give you the option to save or discard the current file. Once an option has been selected press and hold the red Stop button again and you will return to the Collect Setup screen.

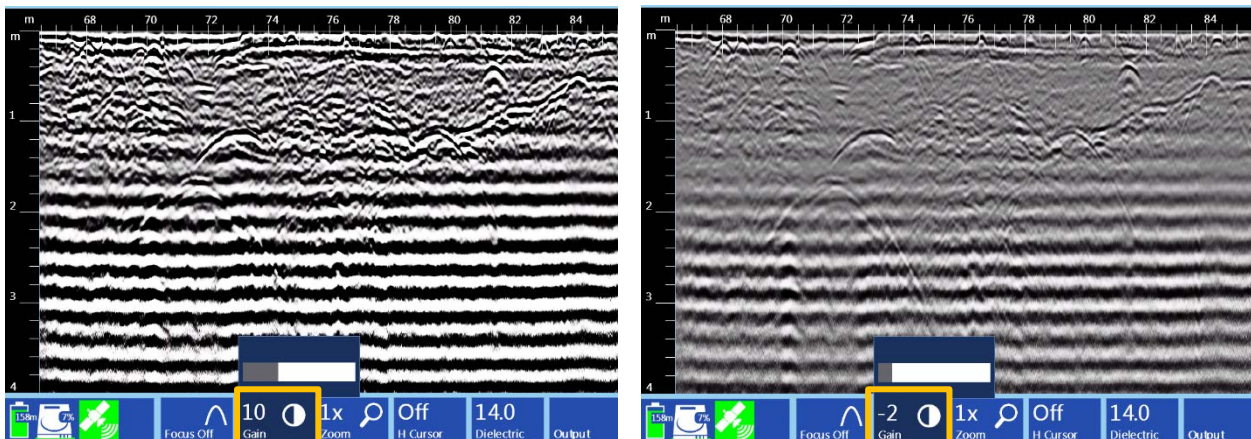
Data Collection Options During Playback

During data collection there are numerous options available for data display. There are 6 buttons at the bottom of the screen: Focus, Gain, Zoom, H Cursor, Dielectric, and Output. When the first five buttons are used in tandem with the Output Menu you have many options for customizing the appearance of data, determining the dielectric using a hyperbola in your data, changing gain levels, and zooming in or out to expand or condense the horizontal scale. Details for these options are listed below.

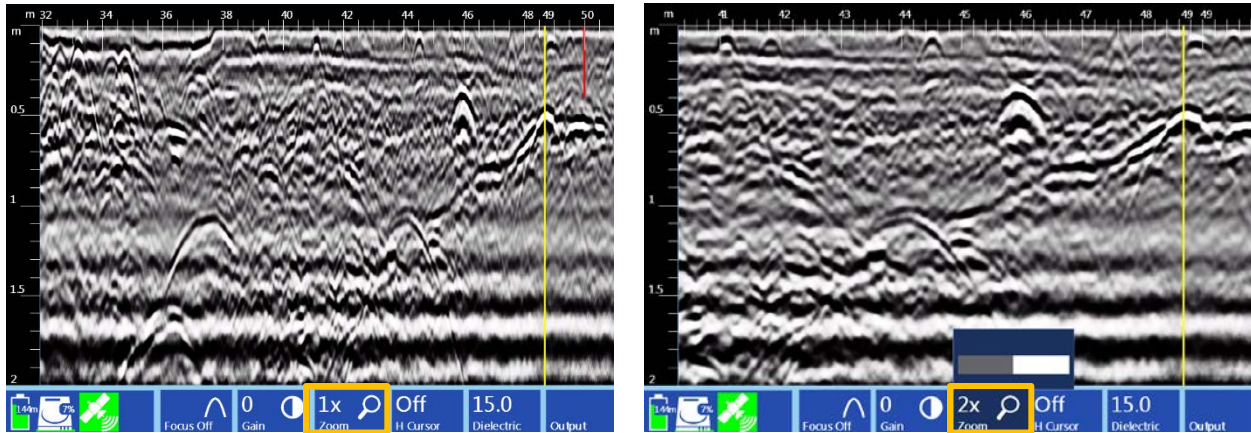
Focus: This option performs a real-time migration of the data by collapsing hyperbolas. This can help when trying to pinpoint a specific target during data collection.



Gain: Use this option to change the overall Gain during data collection. This is useful when crossing over areas with different subsurface conditions, or the Gain levels are too low or high along a given line. In the examples below, overgained data (left) are difficult to interpret because targets are obscured by high background amplitudes. In this case, reducing the Gains can greatly improve the visibility of targets against the background (right).

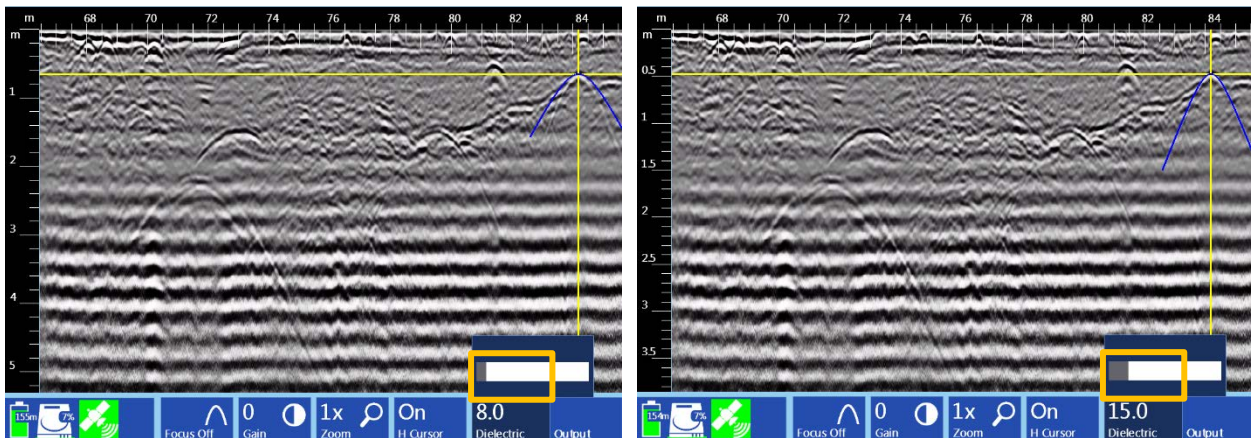


Zoom: Change the Zoom to expand or condense the horizontal scale. In the examples below, a Zoom of 1x (left) is compared with a Zoom of 2x (right). Note the stretching of targets in 2x Zoom.



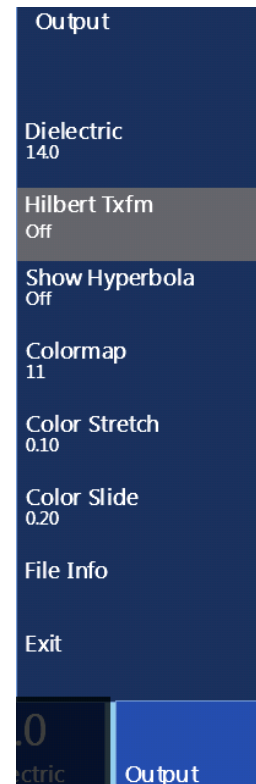
H Cursor: This button controls the visibility and position of the H Cursor. When H Cursor is On, a horizontal yellow line that runs parallel to the top of the profile. Roll the Control Knob to move the cursor up and down the profile. If you are using a survey wheel, the H Cursor will track the Backup Cursor as you move the antenna backwards/forwards. You can then position the Backup Cursor and H Cursor on a target of interest.

Dielectric: Use this option to change the Dielectric constant. As you change the Dielectric value the vertical scale will change as well. If you enable Show Hyperbola in the Output menu, changing the dielectric will change the shape of the hyperbola. Use this to calculate the dielectric in real-time during data collection. Note: in order to fit a hyperbolic curve to a hyperbolic reflector in your data, you must enable Show Hyperbola (Output Menu), and then pull the antenna backwards to move the vertical cursor to the desired location. In the examples below, an initial Dielectric of 8 was incorrect based on hyperbolic matching (left). The Dielectric was changed to 15 (right), which resulted in a better hyperbolic match and a more accurate depth correction.



Output Menu: Access the Output Menu by pressing the Output button on the bottom right side of the screen. This will provide additional options for displaying data and generating file information.

- **Dielectric:** Set the Dielectric constant. This value can also be set in the data collection window.
- **Hilbert Txfm:** Apply a Hilbert Transform to your data. A Hilbert Transform is used to display subtle properties of the subsurface, and will change a radar signal represented as a time series into its magnitude (via envelope detection) phase. The Hilbert Transform expresses the relationship between the phase and magnitude of the signal, or between its real and imaginary parts. It allows the phase of a signal to be reconstructed from its amplitude.
- **Show Hyperbola:** Use this option to display a Hyperbola in the data collection screen (see above examples for Dielectric). The hyperbola will move with the H Cursor, and its shape will change when you change the Dielectric. When you move an antenna backwards the hyperbola will move with the Backup Cursor. Move the H Cursor to move the hyperbola up and down the profile.
- **Colormap, Color Stretch, Color Slide:** These options allow you to change the color tables to your preferred settings.
- **File Info:** Displays a list of useful file information, such as Radar Parameters, Positioning, and Processing History.



6.5: Playing Back Collected Data in Digital 2D

You can playback and review data collected in Distance, Time, or Point Mode. Playback can be accessed either from the Introduction Screen by selecting Playback or from the Collect Setup screen by pressing the Play Mode control button. Either method will open a list of files stored in the currently selected folder.

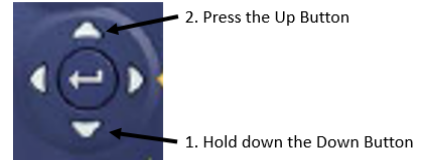
- 1 Use the Control Knob or Arrow keys to navigate through the list.
- 2 Select a file or files to Playback by pressing with the Control Knob. Once you've made your selections press the Enter key to open the selected files. The selected files will scroll across the screen in numerical order.
- 3 When the file scrolls across that you wish to view in full screen, press the green Start button. This will open the Playback Screen with only the current file displayed. The file will scroll across to the end and you can pause and resume the scroll using the Pause/Resume control buttons.

6.6: Saving an Image in Digital 2D

The SIR4000 operating system includes a feature called Screen Capture. Screen Capture allows you to save a screenshot of the entire SIR 4000 screen and save that image automatically to the SIR4000 memory as a Portable Network Graphics (.PNG) file. A .PNG file is a "picture" file that you can email to the client or print off. You do not need RADAN to see a .PNG file; any PC or Mac computer can open it. Screen Capture is available in any mode and in Collect or Playback.

How to Use Screen Capture:

1 Button sequence: Press and hold the Down arrow for at least 2 seconds, then release the Down arrow and press the Up arrow once. Screen Capture works in either Collect or Playback mode. You will hear an audio indication that the SIR 4000 has saved the screen capture.



2 Screen Capture Image: The SIR4000 screen capture feature will save the entirety of the image that is currently on the screen. This means that for longer data files, you must scroll left or right to capture images from an entire file. It is stored as the file name with a letter designator. For example, an image from FILE__036.DZT will be saved as FILE__036A.PNG. Multiple .PNG files can be captured from a single .DZT file.

3 Transfer the File: Transfer the data file (DZT) file to your computer following the steps in the next section. The .PNG file(s) will transfer automatically along with the associated .DZT. There is no way to transfer the image without transferring the data.

6.7: Setup for Single Line 3D Collection in Digital 2D

Follow these instructions if you want to build a 3D area out of multiple individual survey profiles. You will save each profile as a different file and create the 3D project in RADAN's 3D Module. This method does not use the Quick3D mode on the SIR 4000. For instructions on how to use the control unit to aid in 3D data collection in Digital 3D mode see Chapter 7.

Step 1 – Distance Mode Setup

To begin, follow the guide for 2D Distance Mode (see above). The following setup options are also recommended for single line 3D collection.

Position: Set Position to Manual under the Radar Menu. This will ensure that you do not accidentally auto-position over different ground surface conditions while collecting, which makes it impossible to compare depth or time between multiple profiles.

Gain: After you have set the gains so that you are not clipping, set Gain under the Process Menu to Manual. This will prevent auto-gain over a different area while collecting, which would produce a 'checkerboard' pattern. Gain differences will mask features and create edge-effects.

Select Datapath: For single-line 3D Collection, GSSIs recommend creating separate datapaths when collecting a bi-directional 3D grid. Create new folders for files collected in the X-direction and for files in the Y-direction. It is good practice to make a separate folder for unidirectional grid lines.

AutoSave: Set AutoSave to Off. This will pause the system between profiles allowing you to reposition the antenna to start the next profile.

Step 2 – Grid Setup

Arrange your survey grid so that you can cross your targets with at least three profiles; this will allow you to tell the difference between a point target and a linear target. For example, if you are looking for graves 2 meters in length your survey profiles should be spaced no more than 0.5 m apart. Try to orient your survey grid so that you cross the graves perpendicular to their long axis in order to have the greatest

possibility of hitting them. If you have targets moving in multiple directions then you should plan to survey the grid twice (bidirectional or “zig-zag”); once in the X-direction and once in the Y-direction.

Your grid length should be evenly divisible by your line spacing. For example, for a 30m by 30m grid your lines in either the X- or Y-directions can be 0.5 m, 1 m, or 2 m apart, but they cannot be 4 m apart. Additionally, line spacing should not change during a gridded survey unless you begin collection on another grid.

Step 3 – Take Notes

In order for your data to be properly positioned in RADAN, you must be able to tell the software your survey grid origin, line direction, and line orientation. You may begin your survey in any corner of the grid and survey either in one direction (unidirectional), or zig-zig (i.e., bidirectional or back and forth). Be sure to keep accurate notes showing the location of each file in relation to other files and immovable objects. You will assemble the 3D project in RADAN with the 3D Module after downloading the data to a PC. If an obstacle requires reversing the direction of a profile, such as a tree close to your baseline, make sure to note which profile was reversed. You can adjust the start and end positions of this line in RADAN.

Step 4 – Data Collection

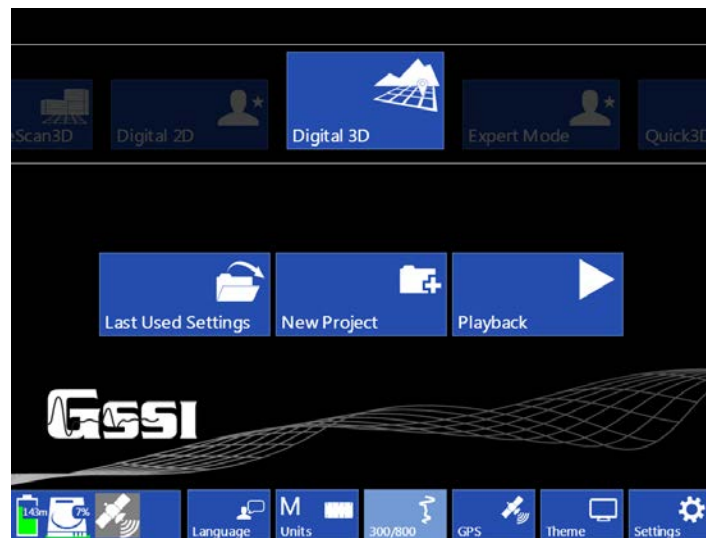
Collect each survey profile as a separate file.

- 1** Position the center of the antenna on the baseline of your grid. The antenna has black lines on it that mark the center. If there are no black lines, use the blue control plug as the center of the antenna. For 4-wheel carts there are lines on the black frame of the cart marking the center.
- 2** To begin data collection, press the green Start button one time.
- 3** At the end of each profile, press the red Stop button one time. Move the antenna to the next position on the grid, and then press the Green start button one time. Repeat steps 1-3 until finished with the first direction of the grid.
- 4** At the end of your last profile in each direction, push and hold down the red Stop button to stop data collection and return to the Collect Setup screen. Saved profiles can be viewed in Playback mode.
- 5** If collecting a bi-directional 3D grid, create a new datapath for the new grid axis and then repeat steps 1-5 in the new direction.
- 6** See the RADAN user manual for guidance on combining your profiles into a 3D grid.

Chapter 7: Setting Up Your SIR 4000 for 3D Data Collection and Playback in Digital 3D Mode

Digital 3D mode is designed to help you easily collect 3D data on an area of any size and surface with some obstacles. By entering the grid size and profile spacing the SIR 4000 can show the current survey location and guide you through 3D data collection. During the survey each individual radar profile is saved as it is collected. At the end of the grid, the SIR 4000 creates a special folder for profiles and a file containing positioning information. This information is then used by RADAN to quickly build and display the 3D data. You can also view the 3D data on the SIR 4000 after collection and perform some processing functions such as applying FIR/IIR Filters or performing Hyperbola Fitting. Digital 3D mode does not require the 3D file creation process in RADAN and allows you to analyze your 3D data in the field. If needed, you can also open and process Digital 3D data in RADAN.

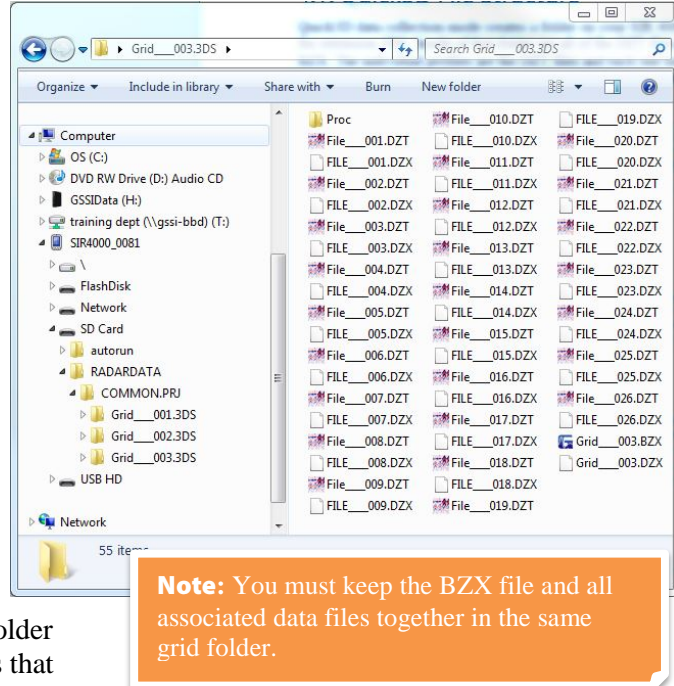
The next section explains the file structure of a Digital 3D file. The subsequent sections explain the field use and implementation of Digital 3D files in RADAN.



7.1: Digital 3D File Structure

Digital 3D data collection mode creates a folder on your SIR 4000 with the name of the grid followed by the extension 3DS. Inside of that folder are all of the DZT files, DZX files, and a file with the extension BZX. The individual profiles are the DZT files and each one has a corresponding header file, the DZX. The BZX is a grid assembly file that tells RADAN how to assemble the individual files into a grid.

- In the screenshot (right), a 50 foot x 50 foot area was surveyed in one direction only with profiles spaced every 2 feet. This survey created 26 DZT and DZX files (1 every 2 feet including the line at 0) and 1 BZX file. The Grid was named GRID__003.3DS. The grid name was automatically generated by the SIR 4000 within the project folder, COMMON.PRJ.
- The BZX file is an information file which tells the RADAN software where each DZT file is positioned and directs the software to create a 3D file with the proper positioning information. Opening the grid in RADAN is as simple as opening the BZX file.
- The project folder will also contain a subfolder called Proc. This folder contains DZP files that are used to playback the 3D data on the SIR 4000. They are not necessary for 3D viewing or processing in RADAN.
- When transferring data from the SIR 4000 to a PC running RADAN, the entire Grid folder is transferred. In order for the BZX file to work all of the DZT and DZX files must be kept in the same folder as the BZX file.



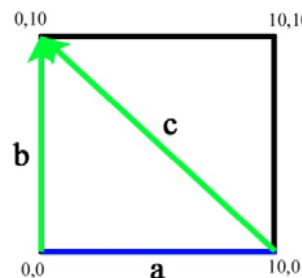
In summary: each grid is saved in a separate folder under the project folder. Inside each folder are all of the individual radar profiles (DZT and DZX files) and one BZX file. The BZX file tells RADAN where to put each profile to create a 3D grid.

7.2: Setting Up a Physical 3D Grid

Collecting data for 3D processing and interpretation is easiest when following a physical guide grid. Grids can be laid out using chalk, paint, measuring tapes, ropes, or some other method. A grid can be any size, but data quality is better if the grid corners are square. The grid itself does not have to be a square, it can be a rectangle, or can be irregularly shaped.

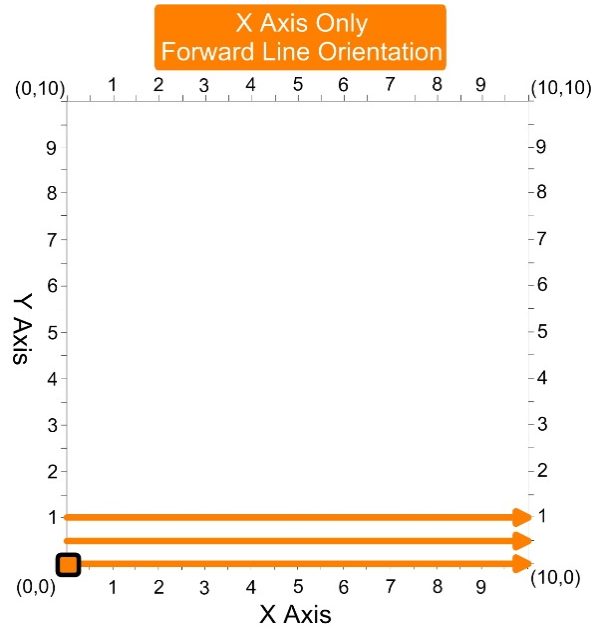
Follow the tips below to help ensure successful grid setup and data collection.

The graphic below illustrates how to put together a square, 10x10 grid. You can use the following method to setup grids of any size including rectangular grids. Make sure to assign the X and Y axis.



If:
 $a^2 + b^2 = c^2$
 $10^2 + 10^2 = c^2$
 so:
 $\sqrt{(200)} = c$
 so:
 $c = 14.14$

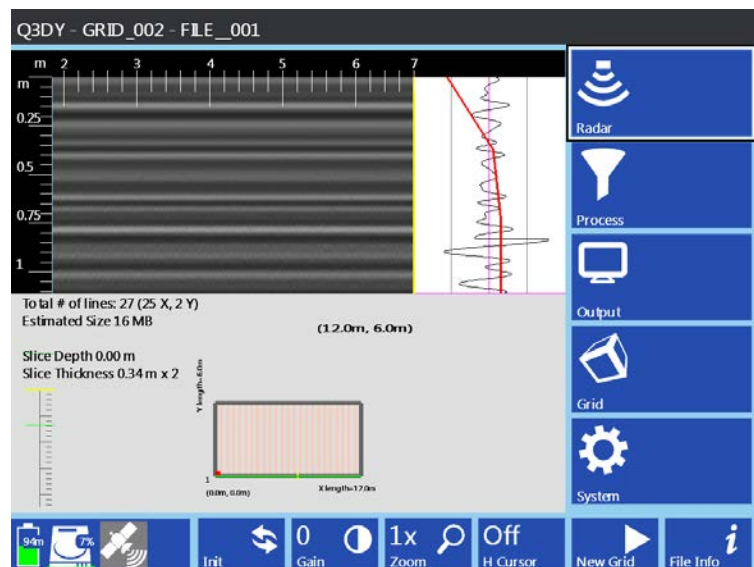
- 1** Locate the origin point (0,0) and pull a tape measure 10 units to find the point 10,0 (blue line a). This is your baseline.
- 2** Pull one tape measure 10 units from (0,0) (green line b) to (0,10).
- 3** Pull one tape measure from (10,0) to (0,10) (green line c).
- 4** Move both green tapes together so that 10 on line b connects to 14.14 on line c. The point that they connect is the grid corner. You will know that the corner at (0,0) is square because this method produces a right triangle.
- 5** Repeat for the corner (10,10).
- 6** Once the grid corners are set you'll need to mark the starting and ending point of each line you're going to collect. You could either leave the baselines on the ground or put markers, such as pin flags, along each baseline. In the example to the right you would put a flag at the beginning and the end of each orange arrow.



- 7** Photograph or make a sketch map of the grid.
Notes to include in the sketch map:
 - X and Y axis
 - Starting corner
 - Direction of the first and second line in each direction
 - Obstacles located within the grid
 - Location of trees inside and outside of the grid
 - Features that are visible on the ground surface

7.3: Setting Up Digital 3D Collection

Digital 3D mode on the SIR 4000 has the same menus as Digital 2D mode described in Chapter 5. However, the Digital 3D menus have additional options specific to digital antennas and LineTrac.

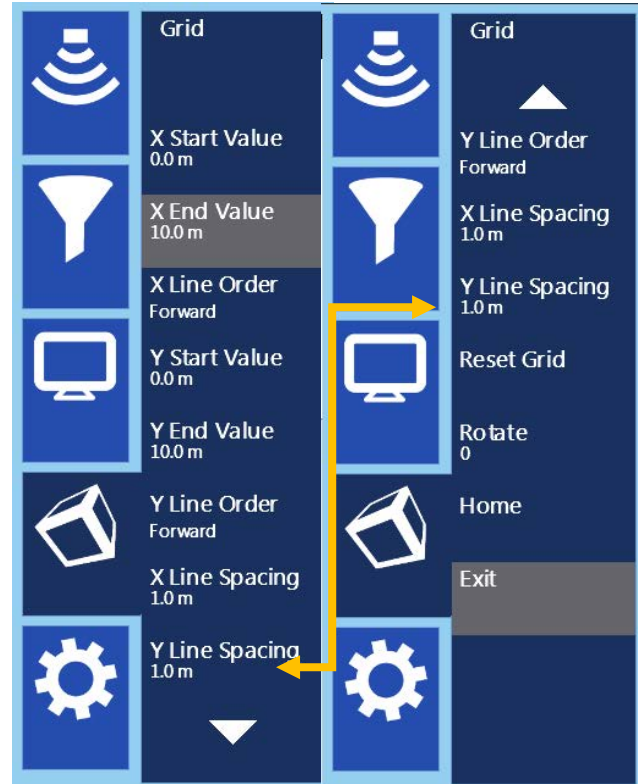


Grid Menu

X/Y Start Value: These two items tell the system the coordinate of your origin point. Typically these will both be zero (0). If you are working on a pre-existing site grid and you want your survey grid origin to have that coordinate, you may add it here.

X/Y End Value: The SIR 4000 uses this coordinate to figure out the size of your grid. In the example menu, the numbers for both the X and Y are 10. This means that the X axis and the Y axis both end at 10, and since the origin is at (0,0) the grid is 10×10.

X/Y Line Spacing: This is the spacing between your survey lines. X lines are parallel to the X axis and Y lines are parallel to the Y axis. The X spacing can be different from the Y spacing, but the spacing must be regular. For example, you cannot start your grid at one interval and change to another interval halfway through. If you need to change the line spacing, you must start a new grid with the new parameters.



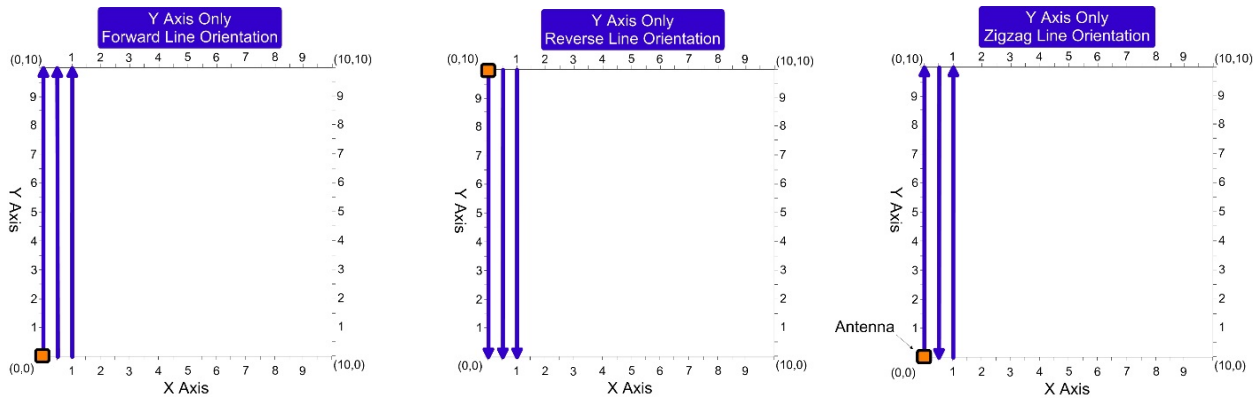
Note: These numbers are coordinates, not line length. For example, if you have a 20×20 grid and your grid origin is X0 Y0: the upper left corner is X0 Y20, and the upper right corner is X20 Y20.

Survey Directions (X, Y, or both): 3D surveys are typically collected along both the X and Y grid axes. If you only want to collect on the X or the Y, you must also change the parameters for the unused grid direction. GSSI recommends changing the values of the unused axis to the overall grid dimensions.

X/Y Line Order: This controls the survey line direction.

- **Forward:** Profiles are surveyed in one direction from the starting baseline to the ending baseline. At the end of each profile, you must move the antenna back to the starting baseline before moving to the next line and collecting in the same direction.
- **Zigzag:** Allows you to collect data in both directions. At the end of a line, turn the system around and begin data collection in the opposite direction.
- **Reverse:** Profiles are surveyed in one direction from the ending baseline to the starting baseline. At the end of each profile, you must move the antenna back to the ending baseline before moving to the next line and collecting in the same direction.





Reset Grid: Changes the X/Y Start and End Values as well as the line spacing back to the system default (a 10m x 10m grid with 1.0m increment spacing in each direction).

Rotate: You can rotate the grid from 0-358° using the Control Knob. The rotation changes in increments of 2° and cycles continuously.

Home: Resets the Rotate to zero (0).

7.4: Step-by-Step Digital 3D Setup

Prior to starting a Digital 3D grid you should perform a general survey of the area to determine the best settings to use during 3D data collection. You should already know which settings to adjust in the Radar and Process menu as well as how you'd like to change them.

Step 1: Start System

After system boot-up with a digital antenna, you will have two Mode options: Digital 2D and Digital 3D. Use the Control Knob to select Digital 3D. Then select New Project to create a new project folder. After selecting Apply you will see the Setup screen with the menu on the right, o-scope in the upper middle, data preview in the upper left, and a grid preview in the bottom center of the screen.

Step 2: Setup

If you've previously saved a setup, or would like to start with a default setup, then you should recall it before making any changes. Otherwise when you do recall the setup it will overwrite any of your changes with those that were saved. Setups can either be uniquely named or you can use one of the available setups by opening the System Menu and selecting Recall Setup. Select your saved setup from the list using either the Control knob or arrow keys. Once the desired setup is highlighted press either the Control knob or Enter button.

Calibrating your survey wheel is a critical step in 3D file collection because proper positioning of your data is essential for coherent 3D data. In order to accurately track distance when switching between different carts, or moving from one type of terrain to another, you should recalibrate the survey wheel. To manually calibrate, you will need to lay out a measured line on your survey surface. It can be of any length, but the longer the line, the more accurate the calibration.

- 1** Select Calibrate SW from the System Menu. Begin by selecting Quadrature as the Survey Wheel Mode.
- 2** Select calibration distance – The default distance is 10 meters or feet. This distance can be changed, but the longer the calibration distance the more accurate the calibration.
- 3** Position Antenna on the Start mark – The antenna or system can be positioned anywhere at the start as long as you use the same point on the antenna or system when you stop.
- 4** Press the Start button – This is the green Start button located on the keypad of the SIR 4000.
- 5** Move antenna to the stop mark – This should match the same location on the antenna or system where you started.
- 6** Press Stop button – This is the red Stop button located on the keypad of the SIR 4000.
- 7** Repeat steps 3-6 at least twice to ensure that the calibration distance is consistent.

If necessary, you can manually enter the calibration value:

- 1** Use either the Control Knob or Arrow keys to navigate to the New Calibration Value box.
- 2** Press the Control Knob or the Enter key to highlight the New Calibration Value box.
- 3** Rotate the Control Knob or use the up and down arrows to enter in the correct value.
- 4** Click the right arrow to save and exit.

Survey Wheel Calibration

1. Select calibration distance
2. Position Antenna on the Start mark
3. Press the Start button

Survey Wheel Mode
Quadrature

Distance (m)
10 m

New Calibration Value
0

Saved: 4000

Apply ✓ **Cancel** ✕

Step 4: Set Grid Limits

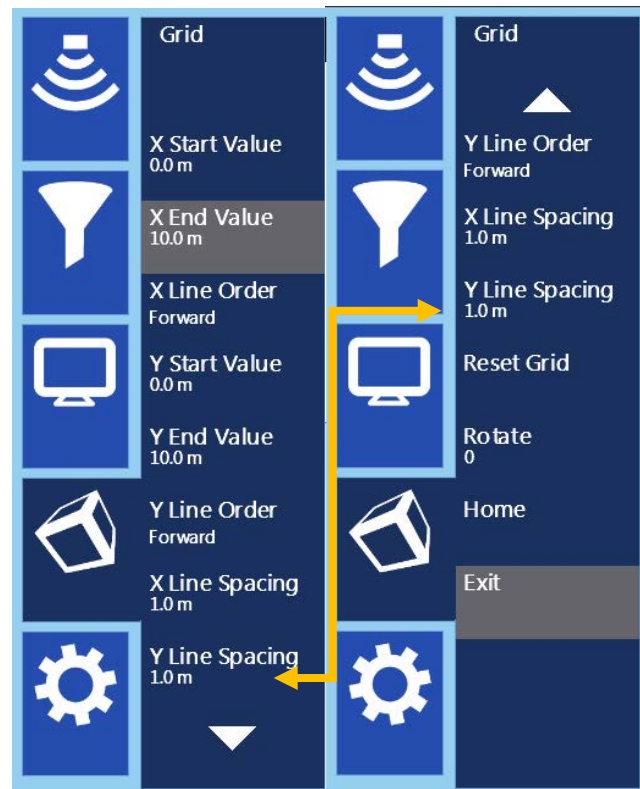
Under the Grid Menu, set your grid limits, line spacing, and orientation.

Start/End Values: Typically, the X Start Value and the Y Start Value should both be set to 0. If the grid does not start at (0,0) put in the coordinates of the origin point. This occurs when the grid is part of a larger site grid, or you are surveying along a previously-established grid. If combining grids in RADAN using Super3D, you can just leave this number at (0,0) and add real coordinates later. Enter your X End Value and Y End Value coordinates and remember that these are not line lengths.

In the example below, the grid measures 10m x 10m. Its starting coordinates are X Start Value = 0 and Y Start Value = 0, therefore the X End Value = 10 and the Y End Value = 10.

Line Spacing: If collecting data in both the X and Y directions then include line spacing in each direction. If only collecting in one direction then only include line spacing for the direction in which you're surveying and set the other to the maximum overall grid dimensions.

Line Order: Decide if you're going to collect the lines using Forward, Zigzag, or Reverse Line Order. Forward and Reverse will take longer to collect. However, these have potential for fewer offset errors created by an uneven ground surface or a slightly misshapen grid. Potential offset errors created by collecting in Zigzag can be corrected in RADAN.



Step 5: Enter Collection Screen

Once you are satisfied with the grid and settings press the green Start button on the SIR 4000. This will open the 3D Collection Screen. Once in the 3D Collection Screen you will have access to three menus: Process, Output, and System. These are explained below. There are also four different ways to view the 2D profiles and 3D slice maps during collection and you can toggle through them by pressing the View Toggle control button.

Grid Display: Shows the full 3D grid and your current grid location. There are three possible views.

2D Profile: Shows just the 2D profile and can be used to perform a hyperbola fitting on the data. This view is only available from Line 1.

The grid coordinates are displayed at the bottom left and top right corners of the grid. The X and Y line lengths appear on the bottom and left side of the grid. At the top of the screen the following appears:

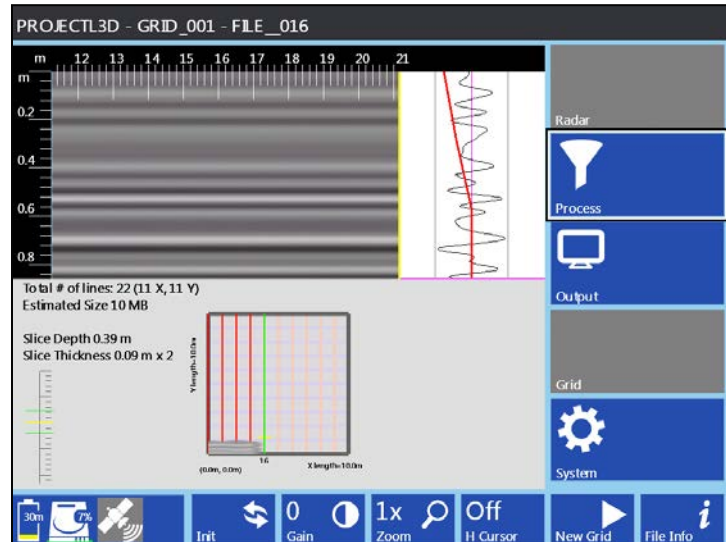
- Total number of lines
- Number in both the X and Y directions
- Estimated file size
- Current Slice Depth and Slice Thickness

7.5: Collecting Digital 3D Data

Step 1: Position Antenna

Once in the 3D Collection screen (after pressing the green Start button) you will see a grid layout in the center of the screen. The grid coordinates are displayed at the bottom left and top right corners of the grid. The X and Y line lengths appear on the bottom and left side of the grid. At the top of the screen the total number of lines is displayed along with the number in both the X and Y directions.

The estimated file size for the grid is also displayed at the top. A yellow line and red box appear at your starting coordinate. Position the center of the antenna over the starting coordinate for your grid. Typically that will be at (0,0), where the center of the antenna is centered over both the X and Y baseline at the same time.



Step 2: Adjusting Settings in the Process, Output, and System Menus

Process Menu: This menu allows you to adjust Gain settings and apply filters for data collection.

- **Gain Mode:** Choose between Auto and Manual Gain. Auto Gain Mode will automatically manage Gain settings based on the number of Gain Curve points.
- **Edit Gain Curve:** Opens a window where you can add or delete Gain Points, and increase or decrease the Gain for each point.
- **IIR Stacking:** IIR Stacking is a high-frequency noise reduction filter operating in the horizontal direction. This filter has a tendency to smooth high frequency targets and accentuate low frequency horizontal features, such as layers. As the number of scans you stack increases, the influence of each new scan drops.
 - The IIR Stacking filter input is in number of scans. Pressing IIR Stacking with either the Control Knob or Enter button will allow you to select a number of scans.
 - High frequency noise generally has a 'snowy' appearance. The larger the number you put in here, the smoother the data will be. It is possible to over-smooth and 'smudge' out real data. With larger numbers the system performs many extra calculations and this may reduce data collection speed. The maximum value is 1023 scans.
- **IIR BG Removal:** This filter removes horizontal bands of noise. These bands are occasionally caused by 'real' horizontal reflectors, but they are also caused by low frequency noise such as antenna ringing. These layers can obscure other 'real' horizontal or point source reflectors. Filter length should be set to the number of scans equal to the feature length to be removed. Be careful to not filter out desired reflectors.
 - The IIR Background Removal filter input is in number of scans, with a maximum value of 1023 scans. Determine the length in scans of the feature or noise that you want to remove from the data and input that number. Features, or horizontal reflections, of this size or larger will be removed.

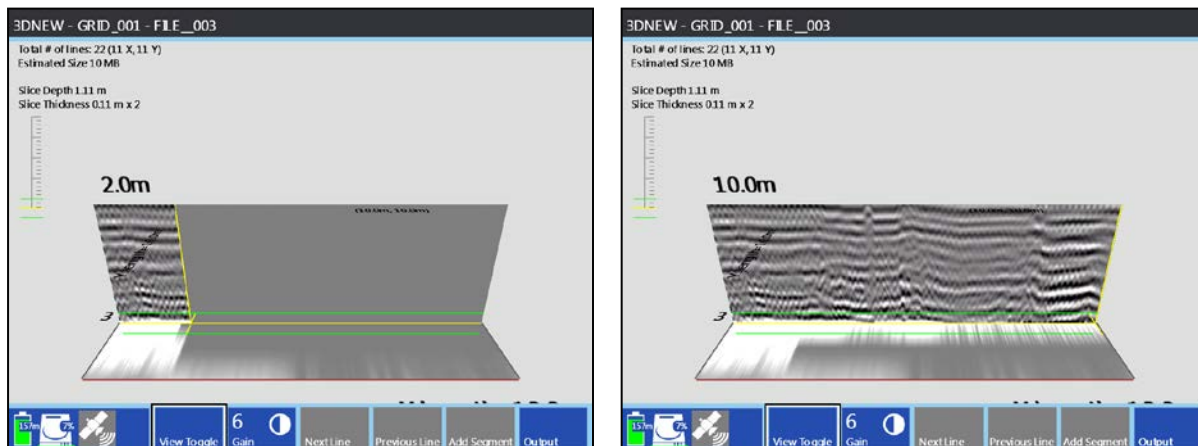
- It is recommended that this filter be set last. When Background Removal is turned on the previewed linescan data and individual scan will gradually be averaged out by the filter and only noise will be visible.

Output Menu: This menu is identical to the Output Menu in Digital 2D Mode. See the relevant section above for the digital antenna you are using.

System Menu: This menu is identical to the System Menu in Digital 2D Mode. See the relevant section above for the digital antenna you are using.

Step 2: Begin Collection

Once the antenna is centered over the starting coordinate press the green Start button. This initiates data collection of Line 1. Nothing will happen until you begin to push or pull the cart or survey wheel. Once the cart or survey wheel starts moving in a forward direction (or whichever direction was used during SW calibration) you will start collecting data and see the yellow line progress across the screen.



After traveling the distance that you specified in 3D Setup, the SIR 4000 will automatically stop collecting data. The file will save and the system will automatically increment to the next line.

Orientation – Positioning the Next Line

Forward or Reverse Line Orders: Move your cart back to the baseline that you started from.

Zigzag Line Order: Turn your antenna around and position the center over the next line, but going in the opposite direction.

Start/Stop Buttons

The Start and Stop buttons offer different functions depending upon how long you press them.

Green Start Button: Long and Short presses both start collection of a single line or continuation of a paused line when using Add Segment.

Red Stop Button: Short press ends data collection along a line. Long press saves the grid and exits data collection.

Estimating the Dielectric

By switching the view from the 3D grid to the 2D profile, you can perform a hyperbola fitting and get a better estimate of your Dielectric. Begin collecting a line, but stop before you reach the end. Back up so that the vertical yellow Backup Cursor is in the middle of a hyperbola.

Change H Cursor to Move and position the horizontal line at the top of the hyperbola.

Select Dielectric and adjust it until the hyperbola on the screen matches the shape of the one in your data.

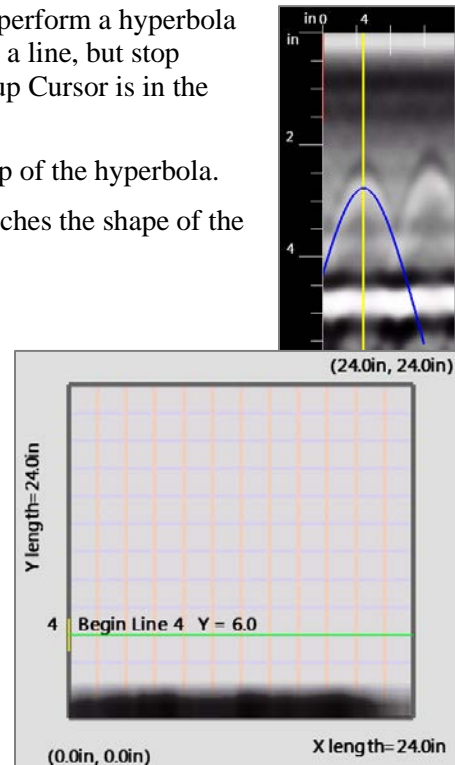
Step 3: Re-collecting or Skipping Lines

If you need to skip or redo a line, use Next Line or Previous Line to move around the grid. You will see the yellow line move to indicate your current position. Once the yellow line matches your current location press the green Start button to collect or recollect the line.

The new data file will be stored with the proper positioning info and any old data will be overwritten.

Step 4: Adding a Line Segment

You can collect portions of a line or stop and start collection along a line by using the Add Segment button. There are two ways to use this button.



Note: The 2D Profile view and Hyperbola Fitting are only accessible while collecting Line 1. You can remain in this mode through the entire 3D collection, but once you return to the 3D Grid Display, you cannot access this view again.

Offset the Starting Position: You can choose to start away from the baseline if needed. Position the antenna along the line where you'd like to start.

- Press Add Segment.
- Move antenna to the end of the line and position the center of the antenna over the opposite baseline from where you started.
- Press the red Stop button. This will end the line and shift it to line up with the opposite baseline.

Skipping a Section of the Line: You can skip a section in the middle of a line to avoid an obstacle.

- Begin data collection from the baseline as normal.
- When you reach the section you want to skip press the red Stop button briefly.
- Move the antenna to the opposite side of the area being skipped and line it up on the same path.
- Press Add Segment to begin data collection again.
- Move antenna to the end of the line and position the center of the antenna over the opposite baseline from where you started.
- Press the red Stop button. This will end the line and shift it so that it lines up with the opposite baseline.

Step 5: Saving the Grid

When you are finished collecting in either the X-Direction, Y-Direction, or both, press and hold the red Stop button. This will end collection of the 3D grid, save the grid, and return you to the 3D Setup Screen. You are now ready to start collecting the next sequential grid in the same project. Select New Grid from the Toolbar to enter the Quick3D Setup Screen with the next sequential grid selected.

To change to a different project press and hold the red Stop button a second time to return to the Introduction Screen.

7.6 Modify the 3D Display during Collection

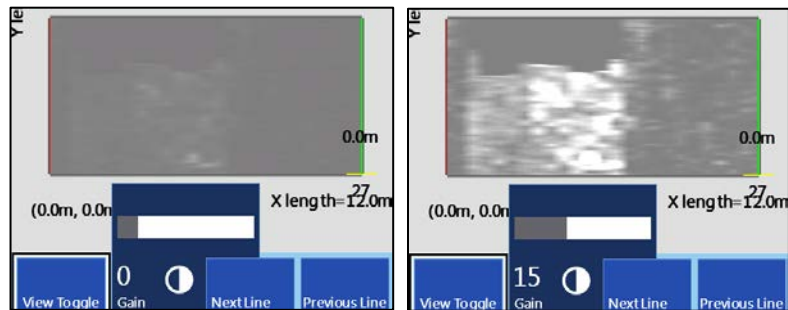
You can adjust how the data appear during data collection using the Toolbar soft keys and the Output menu available in the 3D Collection Screen.

View Toggle: Pressing this soft key toggles the 3D Collection Screen between a top down view of the grid, and 3D view of the grid and profiles, and a 2D profile view. You can further modify how the 3D grid appears through the Output Menu.

Grid Display: Shows the full 3D grid and your current location within the grid. There are three views in this display.

2D Profile: Shows just the 2D profile and can be used to perform a hyperbola fitting on the data.

Gain: Increase or decrease the Display Gain during data collection by a factor ranging from -12-60 dB. This can be used to adjust contrast for an entire profile or time slice by the same amount.



Output Menu

This menu appears along the bottom right of the Collection Screen while collecting data. It provides options for modifying the appearance of your data during collection. This does not affect raw data.

H Cursor: Changes the depth of the slice map in the Grid Display Window, in half inch increments. The H Cursor's position is displayed as a yellow horizontal line.

Slice Thickness: Adjusts the slice thickness from zero (0) inches to the maximum selected depth range in half inch increments. The slice is centered on the location of the H Cursor. The time/depth range of the slice shown as two green lines above and below the H Cursor line.

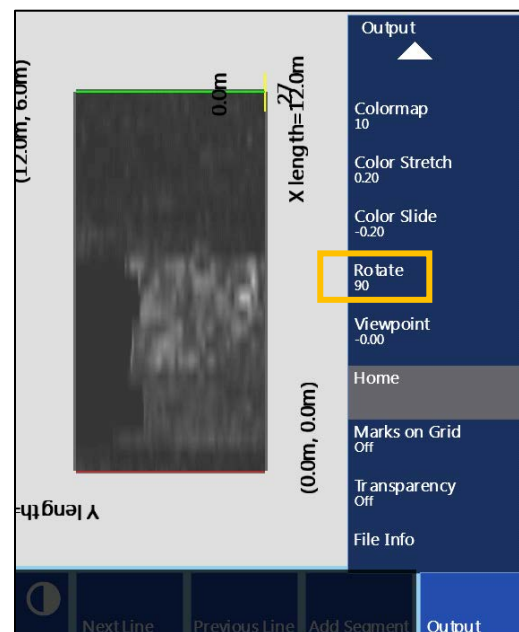
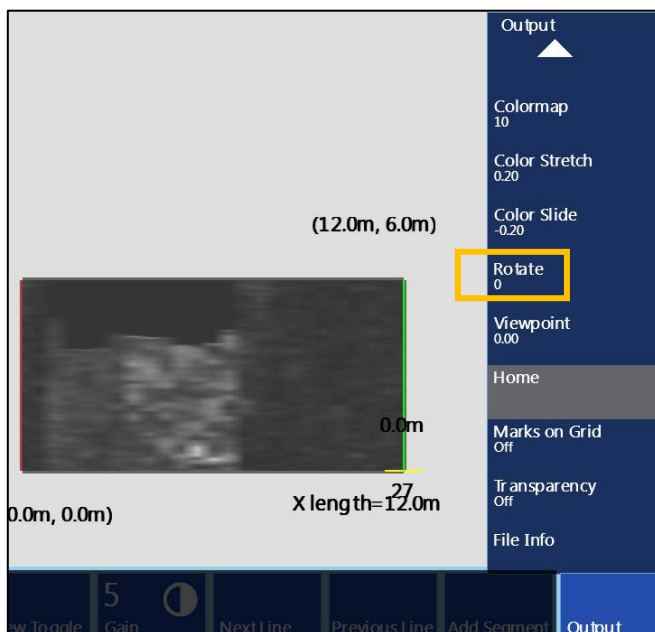
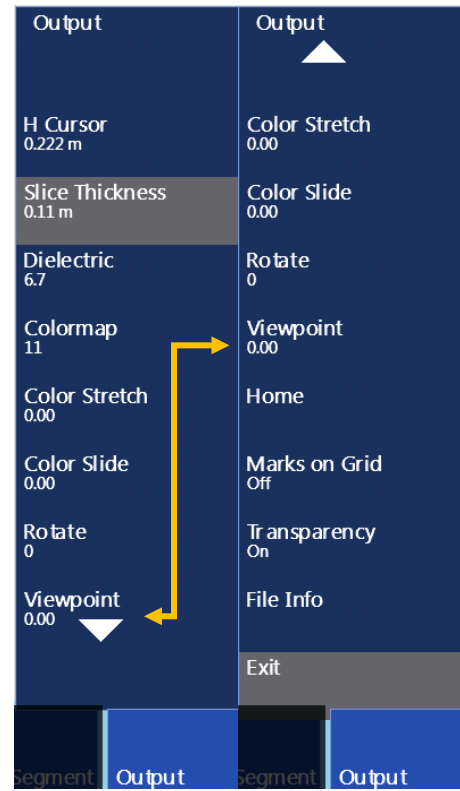
Dielectric: You can adjust the Dielectric Constant during data collection from a value of one (1) to eighty-one (81).

Scale Color, Colormap, Color Stretch, and Color Slide: Check that you are using your preferred color settings.

Rotate: You can rotate the grid from 0-358° using the Control Knob. The rotation changes in increments of 2° and you can start by moving up from zero or down from 358°. Combining Rotate with Viewpoint can create a 3D view of the data during collection.

Viewpoint: Viewpoint adjusts the perspective to view the grid. You can adjust the Viewpoint from -0.40 to 1, where -0.40 will provide almost a straight forward view of a 2D profile as you would see during 2D data collection. This will not preview through the Output menu unless Viewpoint Toggle was selected from the Toolbar.

Home: Resets Rotate and Viewpoint to zero (0).



Marks on Grid: This turns the grid marks on or off. Grid marks correspond with the location of the profiles in the grid. Only adds marks to the lines where data have already been collected.

File Info: This opens a window showing the current settings including Radar Parameters, Positioning information, and Processing History.

7.7 GPS Enabled 3D Collection

Connect a GPS unit to collect a georeferenced 3D grid on the SIR 4000.

Step 1: Connect and Configure GPS

Connect the GPS to your SIR 4000 using the serial port on the antenna. From the Introduction Screen select GPS from the Toolbar. Set the Baud Rate to match the GPS unit's Baud Rate and choose the desired Format to view your location information.

Step 2: Begin 3D Collection

From the 3D Setup Screen you'll be able to see both your current coordinates on the top header bar and your HDOP (Horizontal Dilution of Precision) Status. A HDOP of two (2) or less will display a green satellite box, and higher than two (2) a yellow satellite box. When there's no signal the box will appear red, and if GPS was never configured the box will remain grey. Ensure you have a green satellite box before starting data collection.

Step 3: Monitor GPS Quality

When you start collecting each 2D profile in your 3D grid, the SIR 4000 captures GPS coordinates and place them in the file header. It will continue capturing positions every three (3) seconds until you end data collection as long as the HDOP is two (2) or less. Collected coordinates will be visible in the Tables Pane of RADAN 7.

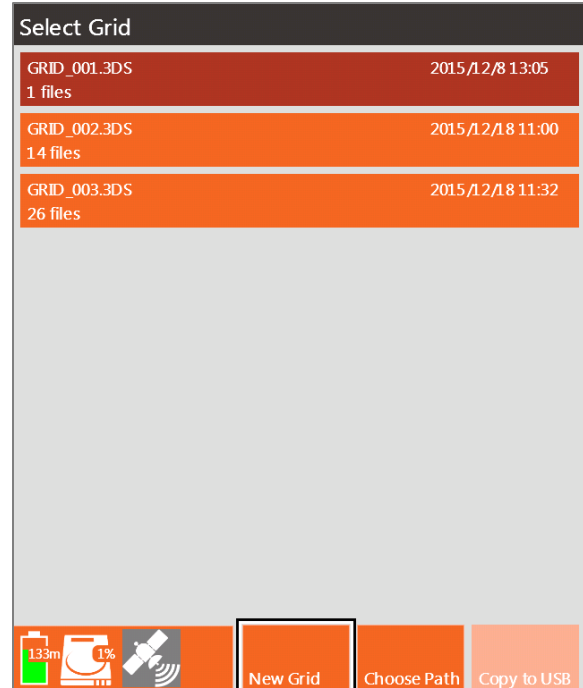
If the HDOP ever goes above two (2) the GPS Status icon will turn yellow and the system will stop collecting coordinates. If this occurs you can either pause data collection waiting until the satellite turns green again or continue collecting data knowing that this portion of the line is not georeferenced.

7.8 Digital 3D Playback

Digital 3D Playback allows the user to display previously collected 3D data as a grid or in 2D profiles, recollect data within a previously collected grid, and modify some settings used during the original data collection.

Select a 3D Grid for Playback

- 1** Select which units were used to collect the grid, Metric or English. Whichever units are selected will be used to playback the grid regardless of the units used during collection.
- 2** Access Digital 3D Playback through the Introduction Screen by selecting Digital 3D and then Playback. This will open a screen where you can select a grid from the current project folder or change the Data Path to select a grid from a previous project folder.
- 3** Choose the grid file you want to play back using the Control Knob and select it by pressing the Control Knob.
- 4** Press Enter to open the 3D grid.
- 5** A Loading Grid progress bar will appear on the screen to track the progress of opening the grid.
- 6** The 3D grid immediately opens in the Digital 3D Playback Screen.



Digital 3D Playback Options

The Playback Screen allows you to view individual 2D profiles in a grid format, rotate the grid to view data from different angles, apply filters, change colors, and do hyperbola fitting. If you're still in the field you also have the ability to recollect lines in the grid. These options are all available through the Toolbar located at the bottom of the screen.

View Toggle

Pressing the View Toggle button at the bottom of the screen switches the 3D grid displayed to either a top-down view of the data, a view of both the 2D profile and 3D slice, or the only individual 2D profiles. These options are available under the Output Menu in the Toolbar.

Gain

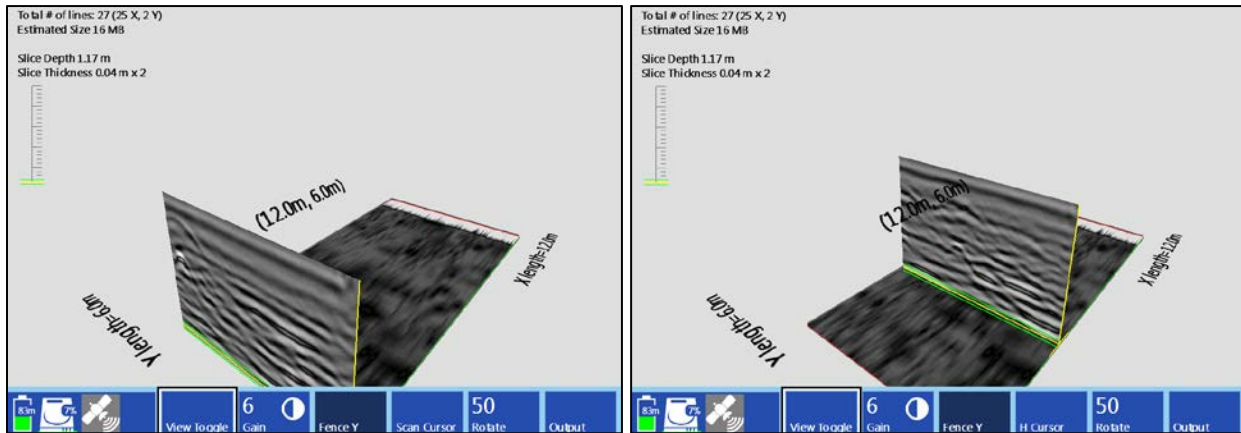
This option changes the Display Gain and increases the amplitude of your data by multiplying every sample throughout your scan by a constant value. Display Gain is not saved with the data.

Fence X and Y

Profiles that were collected in either the X or Y direction or both can be viewed during Playback.

- Press this soft key to select profiles to display.
- Use the Control Knob to view different profiles. A profile may not appear immediately after pushing Fence X or Fence Y. Use the Control Knob to scroll through profiles associated with the currently selected grid direction.

- If data were collected in both the X and Y directions, you can view profiles at the same time in both directions. This can help pinpoint the location of a reflection.



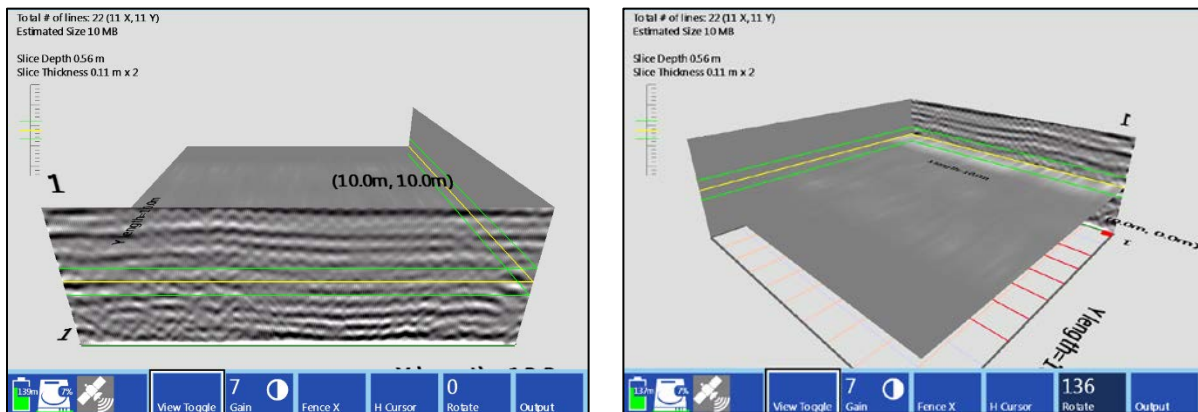
Scan Cursor and H Cursor

Selecting Scan Cursor allows you to place a Horizontal line on the currently selected profile and adjust the vertical location of that line. This can be used to acquire more accurate depth information.

- Press Scan Cursor until it shows H Cursor. Use the Control Knob to adjust the vertical location of the time slice data. The location of the H Cursor is shown as the Slice Depth on the display and the thickness can be adjusted under the Output Menu. You can also change the thickness of the time slice through the Output Menu. The yellow line corresponds to the H Cursor position, and the green lines show the upper and lower boundaries of the slice thickness.

Rotate

You can adjust the rotation of the 3D grid using either a soft key or from the Output Menu. To adjust simply press the Rotate soft key and use the Control Knob of rotate the grid on a 360° axis.



Output

This control button opens a menu with options for modifying the data display during playback. These Output options are identical to those in Digital 3D Collection Mode (see above).

Selecting a Different Digital 3D Grid

To select a different 3D grid for playback press and hold the red Stop button to exit the Playback screen and return to the Introduction Screen. At this point you'll be able to select a different grid or data path by going into Playback Mode.

Chapter 8: Data Transfer and File Maintenance

This section describes the transfer of data from the SIR 4000 to a PC for processing and interpretation, and also how to clear unwanted data from the system's memory. These functions are accomplished under the Play Mode control button.

8.1: Transfer to a PC via a USB Memory Stick

- 1** Turn on SIR 4000 or if already running stop all collection and playback functions prior to continuing.
- 2** Insert USB memory stick.
- 3** Select the mode you used to collect the data.
- 4** Select Playback from either the Introduction or Setup screens. This opens the last folder used during data collection. If your data are in a different folder press the Choose Path control button and select another project folder.
- 5** Select the files you wish to transfer by using the Control knob to navigate and pressing the Control Knob to select a file. You can select multiple files from the list.
- 6** To copy the files select the Copy to USB control button. This will copy the selected files to the USB memory stick and maintain a copy on the SIR 4000 internal memory. A progress bar will appear on the screen showing the status of the copied files.
- 7** To copy the files to the USB memory stick and remove them from the SIR 4000 press the Move to USB Command key. A progress bar will appear on the screen showing the status of the copied files.

8.2: Deleting Data from the System

It is advisable to keep the data on your system until you have transferred it (if desired) and checked the integrity of the data. However, the memory may fill up or you may simply want to do some 'housecleaning.'

Deleting Individual Files

- 1** To delete files you need to open up the file list. You can do this from three places:
 - a)** Select Playback from the Introduction Screen. This opens the last folder used during data collection. To choose a different datapath select Last Project and change the Datapath under the Output Menu.
 - b)** From the Collect Setup Screen select the Play Mode Command key. This opens the current folder and displays files available for playback or that you can delete.
 - c)** From the Playback Setup Screen choose Select File. This opens the current folder and displays files available for playback or that you can delete.
- 2** Select the files you wish to delete.
- 3** Press the Delete Files control button. A progress bar will show the status of the copied files.

Deleting Project Folders

- 1** From either the Collect or Playback Setup screen open Output->Select Datapath.
- 2** Select the data path you wish to delete.
- 3** Press the Delete Path control button. A progress bar will appear showing the status of the copied files.

Chapter 9: Using a GPS with your SIR 4000

Your SIR 4000 can assign GPS coordinates to individual data profiles. This will allow you to place your survey lines into a larger, real-world coordinate system provided that you have a GPS with sufficient accuracy for your application. RADAN will then be able to show coordinates with a GPR X, Y, and Z. Technical Notes are available on the GSSI Technical Support website at <http://support.geophysical.com>. These Notes contain specific GPS integration information.

The GPS you do choose must have the following:

1. Data output through a serial (RS232) port.
2. Output data at a baud rate ranging from 4800 to 230400.
3. Output the NMEA GGA data string.

East vs. West. The SIR 4000 is set to capture Latitude and Longitude coordinates rather than UTM. It does not however tag a North/South or East/West to those numbers. If you are west of the Prime Meridian, the Longitude will be negative and if you are south of the Equator, the Latitude will be negative.

9.1: Connecting a GPS

- 1** Turn on your GPS to determine if you are getting a good position and an adequate number of satellites.
- 2** Power up your SIR 4000 and connect the GPS to the serial port on the control unit.
- 3** From the Introduction Screen select GPS from the Toolbar and check the following settings.
 - **GPS Type:** Select Custom as the GPS Type.
 - **Baud Rate:** Choose a Baud Rate that matches the one set on the GPS unit.
 - **Start:** Press the green Start button on the right side of the control unit.
 - **Format:** Choose a format for viewing the data during collection and playback.

Once a GPS connection is verified Apply the settings.

- 4** When you start collecting a file, the SIR 4000 will capture a GPS coordinate and place it in the file header. It will do the same every three (3) seconds as long as you are collecting data and the HDOP (Horizontal Dilution of Precision) is two (2) or less. These coordinates will be visible in the Tables Pane in RADAN 7 software.

9.2: Understanding GPS

This section gives a quick GPS overview and then describes what you need to know in order to effectively use a GPS with the SIR 4000. GPS information is attached to the data as a *.DZG file. RADAN 7 incorporates GPS information automatically when the *.DZT file is opened.

What is GPS?

GPS is a satellite navigation system (provided free by the USDoD) designed to provide instantaneous position, velocity and time information almost anywhere on the globe at any time, and in any weather. It typically provides positioning accuracies ranging from 3 meters (costing \$150) to 1cm (\$15,000). Since it needs to see much of the sky, it works poorly indoors, in woods and in “concrete canyons” like Manhattan.

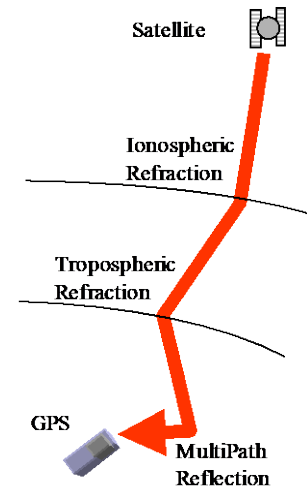


Why do I need it?

You probably don't! In fact for many Ground Penetration Radar applications you can just use a survey wheel to measure your distance and take simple notes about your start and stop locations. And since digging or drilling often requires more precision than 3 meters, knowing “sort of” where you are is not helpful. However, as surveys become larger and as technologies improve, GPS can be very helpful in telling you where you are on a map, or what road you turned onto, what section of the avalanche you have already covered, or even where you were in the middle of a lake. And of course if you actually need expensive survey-grade GPS accuracy, we want to give you the functionality to place RADAR data correctly. Increasingly GPS is claiming a legitimate place in the ever-increasing size and variety of GPR applications.

How does it work?

GPS works by triangulating the distance from satellites in space. Like our RADAR systems, these satellites transmit time very accurately and estimate the distance using the speed of light. The travel-time from three satellites is enough to know where you are on the earth, but the travel-time from 12 satellites greatly decreases the uncertainty of your position. Typically around buildings and trees you might “see” six satellites, plenty to know where you are to within 3 meters. The degree of precision depends on many things, like how well distributed the satellites are in the sky, or the travel path of the signal to your receiver.



Main sources of error

GPR and GPS share a lot in common. The travel times and paths are directly affected by the medium. For GPS, this means the signal from the satellites to your receiver can get slowed down and bent by changes in the Ionosphere, the Troposphere and even nearby objects. These sources of error can be reduced using expensive tricks like dual frequency, Klobuchar modeling and Real-Time Kinematic (RTK) solutions.

The least expensive way to correct for these errors is through Differential GPS (DGPS), where data from a second stationary “Base” GPS is subtracted from a Roving GPS. Compared to the distance from the satellite, distance between Base and Rover is insignificant. This means the travel paths through the ionosphere and troposphere are basically identical. So the difference between the two positions subtracts out atmospheric effects, leaving just the Rover position.

9.3 What is the DZG File?

The GPS file collected with the SIR 4000 is identified by the extension *.DZG and consists of multiple two-sentence blocks. First sentence (line) starting with \$GSSIS contains the DZT file scan (trace number) associated with the GPS location. Second sentence (line) starting with \$GPGGA contains the GPS-NMEA coordinate information.

Format:

```
$GSSIS,x,x
$GPGGA,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx*hh
```

Example:

```
$GSSIS,0,-1
```

\$GSSIS sentence structure

Name	Example	Description
Message ID	\$GSSIS	Fixed text identifier
File Scan #	0	File scan (trace) number, >=0
Scan Count*	-1	When Pulse Per Second (PPS) is used on the GPS unit, this number is the scan count at the specified scan rate from when the system was started, >=0 (missing value = -1)

*The value in field 2 is convertible into seconds by subtracting the number from the value associated with the \$GSSIS record at Scan 0, then dividing by the scans/sec in the DZT file header.

How to Calculate the Time

To calculate the time relative to the start of the file for each scan record, determine the scan rate from the DZT header, e.g., 473 scans per second. Following are three lines from a DZG file:

```
$GSSIS,0,1648470
$GPGGA,150523.00,4713.45783544,N,06817.11556267,W,2,10,1.0,185.873,M,-26.675,M,6.0,0138*76
```

```
$GSSIS,16,1648784
$GPGGA,150526.00,4713.46286086,N,06817.13084159,W,2,10,1.0,185.368,M,-26.675,M,3.0,0138*79
```

```
$GSSIS,42,1649257
$GPGGA,150527.00,4713.46473386,N,06817.13641152,W,2,10,1.0,185.206,M,-26.675,M,4.0,0138*7D
```

Scan Count at File Scan 0 = 1648470

Scan Count at File scan 16 = 1648784

Scan Count at File scan 42 = 1649257

Time at scan 16 relative to scan 0 = $(1648784 - 1648470)/473 = 0.66$ seconds

Time at scan 42 relative to scan 0 = $(1649257 - 1648470)/473 = 1.66$ seconds

\$GPGGA sentence structure

Name	Example	Description
Sentence Identifier	\$GPGGA	Global Positioning Fix Data
Time of Position	112921.00	11:29:21 UTC (Universal Time Coordinated)
Latitude N or S	4343.9993927,N	43d 43.9993927' N (negative N values indicate S)
Longitude E or W	00148.7984187,E	1d 48.7984187' E (negative E values indicate W)
Fix Quality 0 = Invalid 1 = GPS fix 2 = DGPS fix	2	Data is from a DGPS fix
Number of Satellites in Use	12	12 satellites used
Horizontal Dilution of Position (HDOP)	0.8	Relative accuracy of horizontal position
Antenna altitude above/below mean sea level (geoid), and units of altitude (i.e., antenna height)	192.470,M	192.470 meters
Geoidal separation (difference between WGS-84 ellipsoid and mean sea level (+/- above/below ellipsoid), and units of geoidal separation)	49.746,M	49.746 meters
Age in seconds since last update from differential reference station (i.e., DGPS update)	6.0	6.0 seconds
Differential reference station (DGPS) ID number	0136	(France)*
Checksum	*46	Used to check for transmission errors - refers to all bytes between the \$ and the * (not including delimiters) written in hexadecimal

9.4 What is WAAS?

The Wide Area Augmentation System (WAAS) is a form of differential GPS that uses geostationary satellites to transmit an error correction estimate back down to your receiver. The measured positions of ground reference stations, strategically positioned across the country, are sent up to the WAAS satellites. Your receiver reads the reference station closest to you.

“WAAS testing in September 2002 confirmed accuracy performance of 1 – 2 meters horizontal and 2 –3 meters vertical throughout the majority of the continental U.S. and portions of Alaska.”

(<http://gps.faa.gov/Programs/WAAS/waas.htm>) This is with a clear view of the sky. Typically WAAS can improve your error from less than 5 meters 95% of the time to less than 3 meters. WAAS is now available even in the less expensive GPS units and is recommended.

9.5 What is NMEA?

The National Marine Electronics Association ([NMEA](#), pronounced “NEE’ma”) has generated a standard set of messages for communicating GPS information. We use the NMEA 0183 version 2.1 protocol.

Appendix A: SIR 4000 System Specifications

A.1: System Hardware

Antennas: Compatible with all GSSI Antennas

Number of Channels: 1 (one)

Data Storage: Internal memory 32 GB

Processor: NVidia Tegra 3

Display: Enhanced 10.4" LED, 1024 by 768 resolution and 32-bit color

Linescan, Linescan plus O-Scope, and Wiggle trace display modes

Full 3D, 256 color bins are used to represent the amplitude and polarity of the signal

IP Rating: IP-65

GPS Support: Internal data logging

Video Output: HDMI

Input/Output:

- 19 pin analog antenna input (control cable)
- 13 pin digital antenna input (control cable)
- AC power adapter
- GPIO connector
- HDMI video out
- RS232 Serial I/O (GPS port)
- USB 2.0
- Micro USB
- RJ45 100BT Ethernet
- WiFi 802.11 B/G

Mechanical:

- Dimensions: 14x10x2.75 in (36x25x7 cm)
- Weight: 10 lbs (4.53 kg) with battery
- Relative Humidity: <95% non-condensing
- Storage Temperature: -40°C to 60°C external (-40°F to 140°F)

Operating:

- Temperature: -20°C to 40°C external (-4°F to 104°F)
- Charging Power Requirements: 19V DC, 3.42 amps
- Battery: 10.8V Lithium Ion rechargeable, Inspired Energy Ni2040ED
- Transmit Rate: Up to 800 KHz (International), US/Canada and CE rates depend on antenna model

A.2: Data Acquisition and Software

Data Format: RADAN™ (.dzt)

Output Data Format: 32 bit

Scan Rate: Maximum 400 scans/sec at 256 samples/scan

Scan Interval: User-selectable

Number Of Samples Per Scan: 256, 512, 1024, 2048, 4096, 8192, 16,384

Operating Modes: Time- (Continuous), Distance- (Survey Wheel), or Point-Based Collection

Time Range: 1-20,000 nanoseconds full scale, user selectable

Gain: Manual or automatic gain, 1-8 points, (-40 to +120 dB)

Standard Real-Time Filters:

- Vertical: FIR Low-Pass, FIR High-Pass, IIR Low-Pass, and IIR High-Pass
- Horizontal: FIR Stacking, FIR Background Removal, IIR Stacking, and IIR Background Removal

Advanced Real-Time Filters: Migration, Surface Position Tracking, Signal Noise Floor Tracking, and Hilbert Transform.

Automatic System Setups: Storage of an unlimited number of system setup files for different survey conditions and/or antenna deployment configurations.

Automatic Antenna Recognition: Automatic recognition of Smart Antennas to allow maximum compliant transmit rate.

A.3: System Includes

Digital Control Unit (DC-4000) with preloaded operating system (1)

Transit Case (1)

Batteries (2)

Charger (1)

Sunshade (1)

Operation Manual (1)

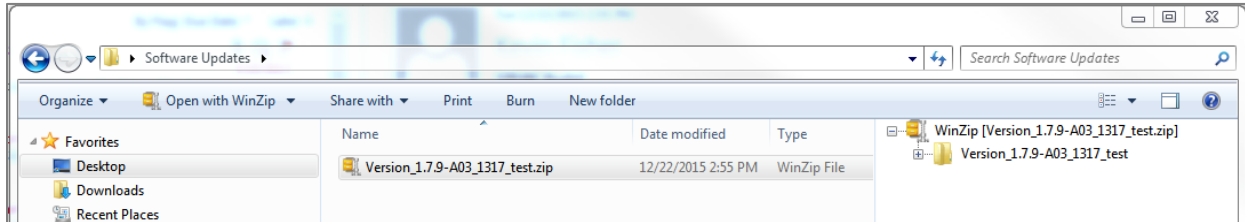
GSSI Manual CD (1)

Fully FCC , RSS-220, and CE Compliant.

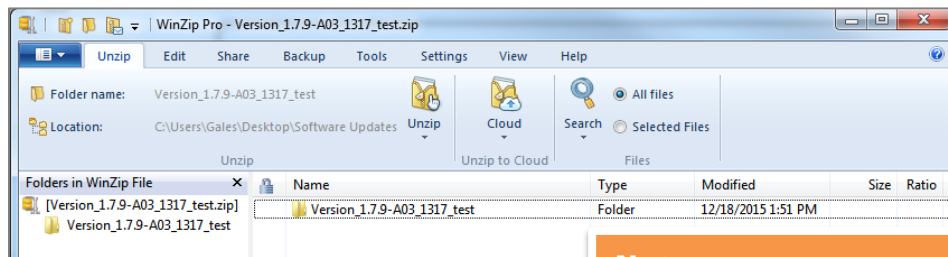
Appendix B: Updating the Software and Firmware

Software and Firmware Update

Download the latest version of software and instructions from the GSSI support website to your computer. <https://support.geophysical.com>.



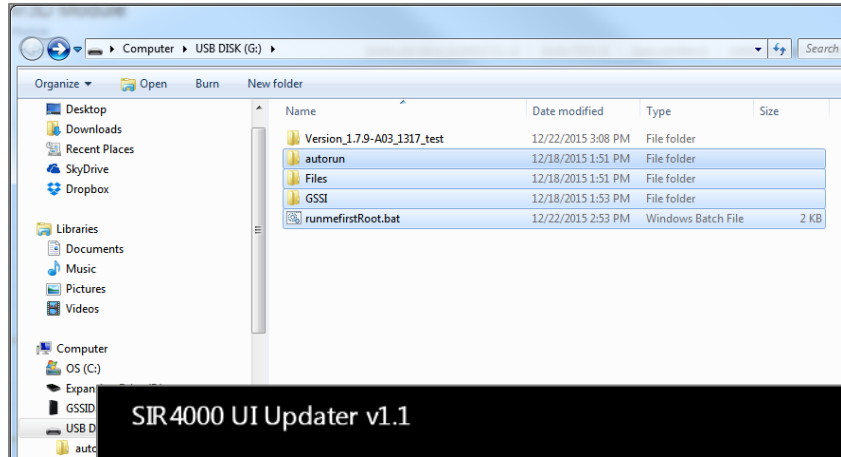
- 1 Unzip the folder to the GSSI 2GB USB drive supplied with your SIR 4000. By double-clicking on the *.zip file, Windows will automatically open whichever compression software you have installed.



Note: GSSI recommends using the provided USB as not all USB drives are formatted the same and some may interfere with the system's ability to do automatic updates.

- 2 Copy all of the subfolders and files to the main directory of your USB drive.

3 With the SIR 4000 powered on and on the Introduction Screen, plug the USB drive into your SIR 4000. The GSSI software will close and then automatically begin the upload. Once the file upload is complete the SIR 4000 will reboot.

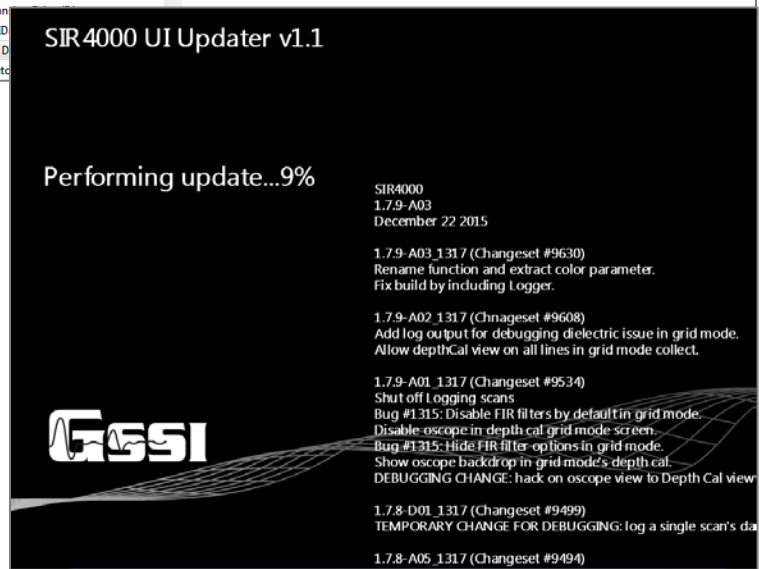


4 Once back on the Introduction Screen open the Firmware menu from the Settings toolbar.

5 Use the Control Knob or the arrow keys to navigate through the list of components.

6 Highlight GPR Control and then depress the Control Knob. You will now see the word “update” next to GPR Control.

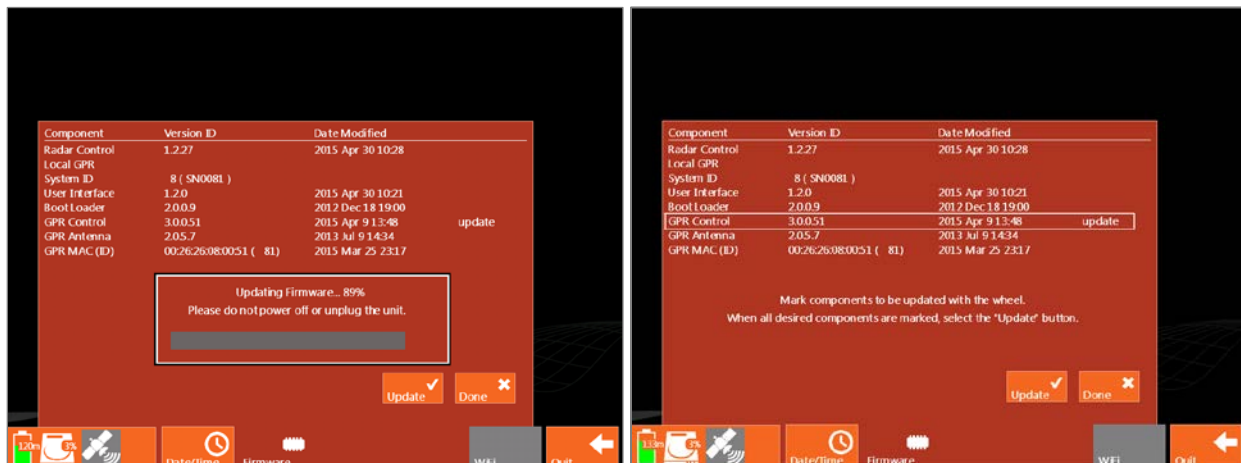
7 Once it reads Update next to the GPR Control, select Update at the bottom of the window.



8 An update status bar will appear. When the status bar reaches 100% and disappears, the firmware update is finished.

9 Reboot the SIR 4000 (Press and hold the green Power button for 3 seconds to turn the unit off, then press the Power button to turn the unit back on).

10 View the Firmware menu and verify that the updated components (Radar Control, Boot Loader, GPR Control, and GPR Antenna) match the versions listed for the SIR 4000 on the GSSI support website.



Appendix C: The How-To's of Field Survey

As the old saying goes: “Garbage in, Garbage out”. The accuracy of your data collection is the biggest single factor affecting data quality and your ability to make decisions based on it. This appendix has instructions and helpful hints to get you into the habit of collecting quality data from the beginning. While many of these points are only relevant to data collection over the ground, as opposed to concrete structures, you may find this section helpful regardless of your application.

C.1: Site Selection

Radar is not the proper technique for every situation. If you are unable to inspect the site, have prospective clients send a photograph of the area. As you gain experience, you will find it easy to judge an area's or an application's suitability. In the meantime, consider the four following issues before deciding whether you should conduct work at an area:

- Topography
- Ground Cover
- Subsurface Conditions
- Site Accessibility

Topography

Topography is one of the first things you should consider about a new survey area. In the first place, you need to be able to physically move the antenna over the ground surface in a fairly smooth fashion. Areas that are full of trenches or extreme slopes are not ideal. You can still survey an area of broken terrain, but it may require collecting point data rather than continuous data profiles. Radar energy travels into the ground perpendicular to the surface. This means that if the antenna is flat on the ground, and level, you are reading right under the antenna. This forward-scanning of the antenna could lead to serious position errors.

Ground Cover

If your antenna is floating on top of thick grass or a layer of gravel, you may get errors in your data because the signal is taking too long to couple (penetrate) with the ground. When this happens, more of the signal than was intended bounces off of the ground surface instead of going into the ground. Always try to keep your antenna flat on the ground surface. The systems will have no problem penetrating carpeting or low grass. A good rule of thumb for the 1500 MHz is no thicker than low carpet, and for the 400 MHz, no more than 1 inch. NEVER survey through standing water, no matter how shallow the puddle.

Subsurface Conditions

If you are working with concrete, try to make sure that the concrete has had some curing time. Three months is usually adequate for a standard slab on grade, while a suspended slab may cure faster. The best solution is to practice on slabs of different ages so that you have a first-hand feel of the way they will look. Concrete that is not well cured will be difficult to see into.

Try and find out some information about the area's soil and water content. Generally speaking, clay and water cause attenuation and impede penetration. Finding out the soil grain size (sand, silt, clay) will help you to guess the dielectric constant of the material to help you set up survey parameters and make time-

to-depth estimations. If you have never worked with soils before, you should consult the US Department of Agriculture soils website at <http://soils.usda.gov/>. The site has a number of free and low cost resources including soil maps of most of the United States and guides to help you understand soils.

Site Accessibility

Simply put, can you feasibly work in the proposed area? Is the site in the middle of a dense thicket of trees, or is it the outside of a tall building, or a tight elevator shaft? Remember that GPR and geophysics depends on your ability to see contrasts in the data. The area has to be large enough for you to collect enough data to be able to make an interpretation. For example, if you need to survey an area in advance of an 18” utility trench, you want to make sure that you have some coverage over areas outside of that trench so you can see normal conditions. Always give yourself some elbow room.

C.2: Targets

The type of targets you are trying to find will govern your choice of antennas, setup parameters, or even the feasibility of radar for the application. There are two main criteria to consider:

- Target Size
- Target Composition

Target Size

All things being equal, antenna choice determines how deeply you are able to penetrate and the minimum size of the targets that you are able to see. Lower frequency antennas see deep, but the minimum target size that they can see is larger. Rather than focus on what each antenna can see, the table below lists the appropriate antenna by application and depth range.

Frequency	Sample Applications	Typical Max Depth Feet (meters)	Typical Range (ns)
2.6 GHz	Structural Concrete, Roadways, Bridge Decks	1 (0.3)	10
1.6 GHz	Structural Concrete, Roadways, Bridge Decks	1.5 (0.5)	10-15
900 MHz	Concrete, Shallow Soils, Archaeology	3 (1)	10-20
400 MHz	Shallow Geology, Utility, Environmental, Archaeology	9 (3)	20-100
200 MHz	Geology, Environmental	25 (8)	70-300
100 MHz	Geology, Environmental	60 (20)	300-500

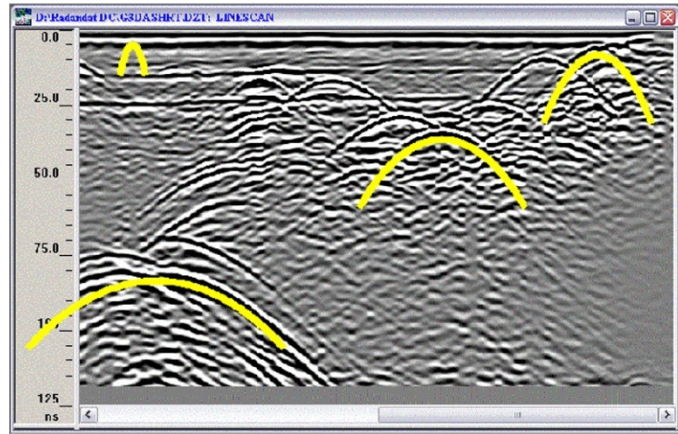
Antennas by Application

Radar is also not a continuous measurement along a survey line. The system takes readings (scans) at a set spacing. If your scan spacing is too wide, you risk not hitting your target with enough scans to draw a recognizable hyperbola, or worse, missing the target altogether. Generally, you need a minimum of 10 scans to draw a recognizable hyperbola.

The rule of thumb is to have 10 scans divided by the depth of the shallowest object. So if you want to image something 10 feet deep, 10 scans / 10 feet = 1 scan/foot. For 5 feet, 10 scans / 5 feet = 2 scans/foot.

For locating structural features in concrete with the 1.6 GHz antenna, we usually recommend 60-90/ft. For utility and tank location, we usually recommend 6-24/ft. While this is more than the minimum rule of thumb, GSSI has found these densities to work well in the widest variety of situations.

The image above shows hyperbolas from objects of similar size. The hyperbolas vary in size because, due to the spreading of the radar signal, a deeper target shows reflections in more scans than a shallow one.



Lower frequency antennas, like the 200 MHz and 400 MHz, will sometimes not image targets close to the surface very well. While not strictly a ‘dead zone’ you should be aware that it may be difficult (but not impossible!) to see targets in this area. As a general rule of thumb, this zone is equal to the spacing between the transmitter and receiver dipoles, but this can vary with soil composition. See the chart at right for a general idea. If your application requires you to see deep and shallow, consider surveying the area with two different antennas.

Frequency	“Hazy” Zone Inches (cm)
2.6 GHz	0.5 (1)
1.6 GHz	1 (2.5)
900 MHz	4 (10)
400 MHz	6 (15.25)
200 MHz	12 (30.5)

Target Composition

Your ability to see a target depends on the contrast between the dielectric values of the target’s material and the material that the radar energy was traveling through just before it hit the target. The greater the contrast between the dielectric values, the more visible the target is. For applications which involve finding metal targets like rebar, pipes, and drums, this is not a great issue because there will always be a great contrast. The dielectric of metals is so high that the actual number is meaningless. You will always have a visible contrast where metals are concerned.

Composition can affect your ability to see things in different ways. For example, the contact between a dry sand (3-6) and a water table (water being 81) will be easy to image, while the contact between sandstone (6) and limestone (7-8) will be much more difficult. Also remember that it is the electrical property of the material that most governs dielectric. Even though concrete and grade are qualitatively very different, they are made of similar materials and react to radar energy similarly. It is usually extremely difficult to tell the top of grade from the bottom of the slab. You should practice trying to image different materials so that you can build up a body of experience. See Appendix D for a chart of the dielectric constants of different materials.

C.3: Data Collection Methods: 2D vs. 3D

Time is money. Whether you are a university-based researcher working off a grant or performing NDT work for pay, the faster you can get the survey done the better off you will be. Those charging by the hour understand the fine balance between a price that reflects a realistic estimate of how long it will take to get the job done, and padding the cost with unnecessary work. The point of this discussion is to get you to think about how much information you really need to make a decision.

2D

Two-dimensional data collection means that you will be collecting and interpreting single profiles of data. This is useful for quickly following a pipe by scanning over an area, noting the location of the pipe hyperbola on the ground, then moving some distance away and scanning again for the pipe. The real benefit of 2D data collection is speed and ease of use. Processing is certainly possible on 2D data to clean up the image, but most clients will only use it for visually noting the presence/absence of targets in the field. 2D data collection is also useful for geologic applications such as bedrock and water table mapping.

3D

Collecting data for 3D imaging obviously takes more time than 2D collection. While the SIR(R) 4000 makes it faster and easier than it has ever been before, it can still add significant time (and cost) to a job. It also requires some software processing to produce an interpretable image. These two issues may frighten some users away from 3D data collection, but like GPR in general, it only requires some practice to gain confidence.

Three-dimensional data can be a great aid in interpretation. The question many people ask is “When do I use 3D?” Aside from producing a 3D map for its own sake, there are really only three main reasons: a complicated area, prospecting, or dangerous targets in the subsurface. A complicated area might be a city street with many different types of pipes running in different directions. In a situation like that, the best option is usually to do 3D data collection so that you are able to visually track targets as they twist and turn around other targets. Prospecting is mainly what those doing Archaeology will face. In this case, you don’t have any concrete information about the subsurface so you will need to do 3D over the area and look for human-made patterns that could be targets. An example of the final reason would be coring or cutting into an area that has live high-voltage in the floor. When the safety of your crew is at stake, the more information, the better.

Appendix D: Dielectric Values For Common Materials

Material	Dielectric Constant	Material	Dielectric Constant
Air	1	Wet Granite	6.5
Snow Firn	1.5	Travertine	8
Dry Loamy/Clayey Soils	2.5	Wet Limestone	8
Dry Clay	4	Wet Basalt	8.5
Dry Sands	4	Tills	11
Ice	4	Wet Concrete	12.5
Coal	4.5	Volcanic Ash	13
Asphalt	5	Wet Sands	15
Dry Granite	5	Wet Sandy Soils	23.5
Frozen Sand & Gravel	5	Dry Bauxite	25
Dry Concrete	5.5	Saturated Sands	25
Dry Limestone	5.5	Wet Clay	27
Dry Sand & Gravel	5.5	Peats (saturated)	61.5
Potash Ore	5.5	Organic Soils (saturated)	64
Dry Mineral/Sandy Soils	6	Sea Water	81
Dry Salt	6	Water	81
Frozen Soil/Permafrost	6		
Syenite Porphyry	6		
Wet Sandstone	6		

Meter to English conversion factor: 2.54 cm in 1 inch.

Table of Dielectric values adapted from: Reynolds, John M., 1997
An Introduction to Applied and Environmental Geophysics, John Wiley & Sons, New York.

Appendix E: Listing of Antenna Parameters

The SIR 4000 comes with preloaded setups to fit the system's data collection parameters and filters to the most commonly used, currently available GSSI antennas. Settings for additional antennae are also provided below to assist you in creating a setup for an older or specialized antenna. Please note that these are only generalized setups, and it may be necessary to alter these to your particular situation. For example, deeper penetration can be set by increasing the range in the Radar menu during setup. Please note that this is not an exhaustive list and you should consult the antenna documentation saved on the Manual CD Compendium or on the GSSI Support Website: www.support.geophysical.com.

E.1. Preloaded Setups in Digital 2D Mode (Digital Antennas)

350MHz HyperStacking Antenna (Model 350HS)

350MHz ground coupled digital antenna. Depth of viewing window is approximately 12m (40ft) assuming a dielectric constant of 5.

Range: 58 ns
Samples per Scan: 512
Resolution: 32 Bits
Number of Gain Points: 5
IIR Low Pass: 1000 MHz
IIR High Pass: 50 MHz
FIR Low Pass Filter: 0
Scan Rate: 60
Transmit Rate: 200 KHz

300/800 Dual Frequency Antenna (Model 50300/800)

300 MHz / 800 MHz Dual Frequency ground coupled digital antenna. Depth of viewing window approximately 7m (21ft) with 300 MHz frequency assuming a dielectric constant of 5.

Range: 18 ns
Samples per Scan: 512
Resolution: 32 Bits
Number of Gain Points: 4
IIR Low Pass: 2000 MHz
IIR High Pass: 500 MHz
FIR Low Pass Filter: 0
Scan Rate: 100
Transmit Rate: 200 KHz

E.2: Preloaded Setups in Expert Mode

2.6 GHz (Model 52600S)

2.6 GHz ground coupled antenna. Depth of viewing window is approximately 10 inches in concrete. Setting is optimized for scanning of structural features in concrete.

Range: 8 ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 4
Vertical High Pass Filter: 500 MHz
Vertical Low Pass Filter: 4000 MHz
Scans per second: 100
Vertical IIR High Pass $N=2F=10$ MHz
Transmit Rate: 100 KHz

2 GHz Palm (Model 62000)

2 GHz ground coupled antenna. Depth of viewing window is approximately 10 inches in concrete. Setting is optimized for scanning of structural features in concrete.

Range: 8 ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 2
Vertical High Pass Filter: 400 MHz
Vertical Low Pass Filter: 5000 MHz
Scans per second: 100
Vertical IIR High Pass $N=2F=10$ MHz
Transmit Rate: 100 KHz

1.5/1.6 GHz (Model 5100S)

1.5 GHz ground coupled antenna. Depth of viewing window is approximately 18 inches in concrete. Setting is optimized for scanning of structural features in concrete.

Range: 12 ns
 Samples per Scan: 512
 Resolution: 32 bits
 Number of gain points: 5
 Vertical High Pass Filter: 250 MHz
 Vertical Low Pass Filter: 3000 MHz
 Scans per second: 100
 Vertical IIR High Pass $N=2F=10$ MHz
 Transmit Rate: 100 KHz

900 MHz (Model 3101A)

900 MHz ground coupled antenna. Depth of viewing window is approximately 1 m assuming a dielectric constant of 5.

Range: 15 ns
 Samples per Scan: 512
 Resolution: 32 bits
 Number of gain points: 2
 Vertical High Pass Filter: 225 MHz
 Vertical Low Pass Filter: 2500 MHz
 Scans per second: 120
 Transmit Rate: 100 KHz

400 MHz (Model 50400S)

400 MHz ground coupled antenna. Depth of viewing window is approximately 3m assuming a dielectric constant of 5.

Range: 50 ns
 Samples per Scan: 512
 Resolution: 32 bits
 Number of gain points: 3
 Vertical High Pass Filter: 100 MHz
 Vertical Low Pass Filter: 800 MHz
 Scans per second: 120
 Transmit Rate: 100 KHz

270 MHz (Model 50270S)

270 MHz ground coupled antenna. Depth of viewing window is approximately 4m assuming a dielectric constant of 5.

Range: 75 ns
 Samples per Scan: 512
 Resolution: 32 bits
 Number of gain points: 3
 Vertical High Pass Filter: 75 MHz
 Vertical Low Pass Filter: 700 MHz
 Scans per second: 120
 Transmit Rate: 100 KHz

200 MHz (Model 5106)

200 MHz ground coupled antenna. Lower frequency antenna optimized for mid-range profiling.

Range: 100ns
 Samples per Scan: 512
 Resolution: 32 bits
 Number of gain points: 5
 Vertical High Pass Filter: 50 MHz
 Vertical Low Pass Filter: 600 MHz
 Scans per second: 64
 Transmit Rate: 100 KHz

100 MHz (Model 3207)

100 MHz ground coupled antenna. Low frequency for deeper profiling.

Range: 500ns
 Samples per Scan: 512
 Resolution: 32 bits
 Number of gain points: 5
 Vertical High Pass Filter: 25 MHz
 Vertical Low Pass Filter: 300 MHz
 Scans per second: 16
 Transmit Rate: 50 KHz

E.3: Parameter Listing for Older/Specialty Antennae

The following list of antenna setups is provided to assist you in using the SIR(R) 4000 with additional antennae. To use this list, you must enter the correct parameters. You may wish to save any special parameters in a separate setup (under the System menu) to help you easily recall them. Some of these are no longer commercially available, but the system does function with all older antennas. They are designated by their center frequency, and in some cases a D or S which noted whether that setup is for Deep or Shallow prospecting. Please note that many of these antennae have a different listed transmit rate than the default one on the SIR 4000. The transmit rate listed here is the rate that the antenna was tested and rated at. It may function correctly at a higher transmit rate and allow you to collect data faster, but you must pay careful attention to your data to decide if the antenna is functioning correctly at the different rate.

If your system is beeping, it indicates that your T_RATE is too high for this antenna.

500-MHz (Model 3102)

500 MHz antenna. Not Model 3102 HP or 3102 DP

Data Collection Mode: Continuous
Range: 60ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 3
Vertical High Pass Filter: 125 MHz
Vertical Low Pass Filter: 1000 MHz
Scans per second: 120
Transmit Rate: 100 KHz

300-Deep

Old 300 MHz antenna.

Data Collection Mode: Continuous
Range: 300ns
Samples per Scan: 1024
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 100 MHz
Vertical Low Pass Filter: 1000 MHz
Scans per second: 32
Horizontal Smoothing: 5 scans
Transmit Rate: 50 KHz

300-Shallow

Old 300 MHz antenna.

Data Collection Mode: Continuous
Range: 150ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 100 MHz
Vertical Low Pass Filter: 1000 MHz
Scans per second: 32
Horizontal Smoothing: 5 scans
Transmit Rate: 50 KHz

120-Deep-Unshielded

120 MHz standard antenna.

Data Collection Mode: Continuous
Range: 400ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 30 MHz
Vertical Low Pass Filter: 240 MHz
Scans per second: 32
Horizontal Smoothing: 5 scans
Transmit Rate: 50 KHz

120-Shallow-Unshielded

120 MHz standard antenna.

Data Collection Mode: Continuous
Range: 200ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 30 MHz
Vertical Low Pass Filter: 240 MHz
Scans per second: 32
Horizontal Smoothing: 5 scans
Transmit Rate: 50KHz

100 High Power

100 MHz antenna with high power transmitter.

Data Collection Mode: Continuous
Range: 500ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 25 MHz
Vertical Low Pass Filter: 200 MHz
Scans per second: 16
Horizontal Smoothing: 5 scans
Transmit Rate: 12 KHz

100 Very High Power

100 MHz antenna with very high power transmitter.

Data Collection Mode: *Continuous*
Range: 500ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 25 MHz
Vertical Low Pass Filter: 200 MHz
Scans per second: 16
Horizontal Smoothing: 5 scans
Transmit Rate: 6 KHz

80 MHz

80 MHz folded bow-tie antenna.

Note: The 80 MHz antenna is unshielded.

Data Collection Mode: Continuous
Range: 500ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 25 MHz
Vertical Low Pass Filter: 200 MHz
Scans per second: 32
Stacking: 32 scans
Transmit Rate: 50 KHz

MLF 120 cm

Low Frequency antenna 1.2m length.

Note: The MLF antennas are unshielded.

Data Collection Mode: Point
Range: 250ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 30 MHz
Vertical Low Pass Filter: 160 MHz
Scans per second: 32
Stacking: 32 scans
Transmit Rate: 12 KHz

MLF 240 cm

Low Frequency antenna length 2.4m

Data Collection Mode: Point
Range: 500ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 15 MHz
Vertical Low Pass Filter: 90 MHz
Scans per second: 32
Stacking: 32 scans
Transmit Rate: 12 KHz

MLF 360 cm

Low Frequency antenna length 3.6m

Data Collection Mode: Point
Range: 750ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 10
Vertical Low Pass Filter: 60
Scans per second: 32
Stacking: 32 scans
Transmit Rate: 12 KHz

MLF 480 cm

Low Frequency antenna set to a length of 4.8m

Data Collection Mode: Point
Range: 1000ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 6
Vertical Low Pass Filter: 40
Scans per second: 32
Stacking: 32 scans
Transmit Rate: 12KHz

MLF 600 cm

Low Frequency antenna set to a length of 6.0m

Data Collection Mode: Point
Range: 1000ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 1
Vertical Low Pass Filter: 50
Scans per second: 32
Stacking: 32 scans
Transmit Rate: 12 KHz

Borehole 120 MHz

Borehole antenna frequency 120 MHz. Note:
The borehole antennas are unshielded.

Data Collection Mode: Point
Range: 500ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 30 MHz
Vertical Low Pass Filter: 240 MHz
Scans per second: 32
Stacking: 32 scans
Transmit Rate: 64 KHz

Borehole 300 MHz

Borehole antenna frequency 300 MHz.

Data Collection Mode: Point
Range: 300ns
Samples per Scan: 512
Resolution: 32 bits
Number of gain points: 5
Vertical High Pass Filter: 38 MHz
Vertical Low Pass Filter: 600 MHz
Scans per second: 32
Stacking: 32 scans
Transmit Rate: 64 KHz

Appendix F: Basic LineTrac Setup and Interpreting Field Data

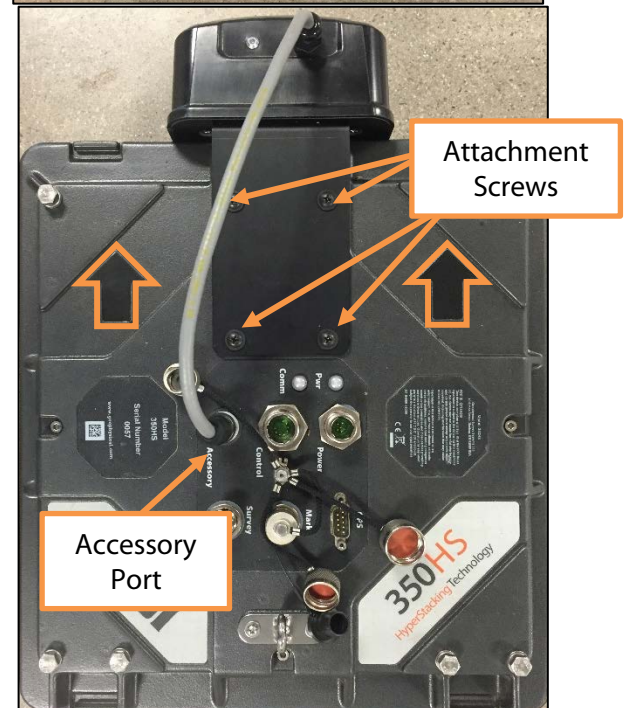
GSSI's LineTrac is an optional accessory for digital GPR antennas. LineTrac is a sensitive and versatile locating device that measures the AC current of powered utilities and induced frequencies in non-powered utilities. Two modes are available: Power Mode, a passive detection mode that tracks AC current in energized lines; and Frequency Mode, where the device tracks a specific frequency that has been user-induced into a utility line.

The LineTrac is installed on a digital antenna via four screws near the front of the antenna. The device is then plugged directly into the digital antenna via the integrated accessory port. When the SIR 4000 is powered on, you will see a Green Indicator Light on the top of the LineTrac. To begin using the LineTrac you must configure settings in the Collect/Setup screen. Select the Radar Menu, and scroll to the bottom using the Control Knob. Turn LineTrac On.

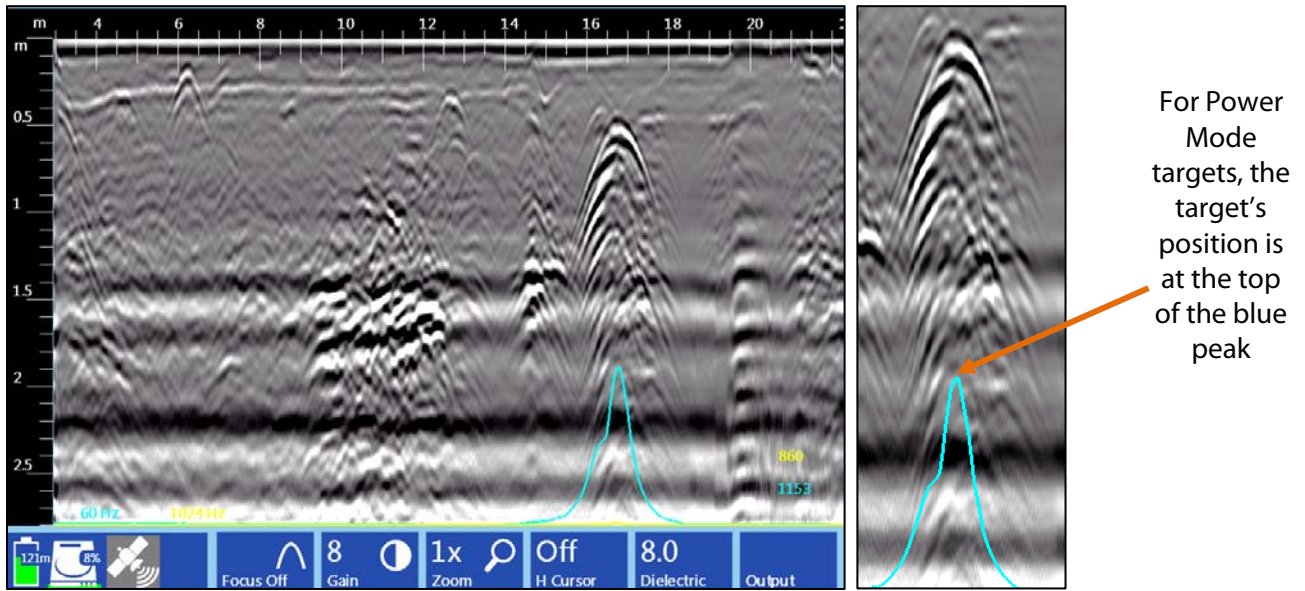
Next, select either Power Mode, Frequency Mode, or both, and choose the appropriate settings for your survey.

- Power Mode can be set to 0, 50 or 60.
 - Power Mode is a passive detection method that can locate the AC current of energized cables that are under load. These frequencies are typically 50Hz or 60Hz.
- Frequency Mode can be set to 1, 8, 16, or 33 KHz.
 - Frequency Mode is an active detection method used in combination with a user-supplied signal application device. Set the value of Frequency Mode to match the frequency of the applied signal.

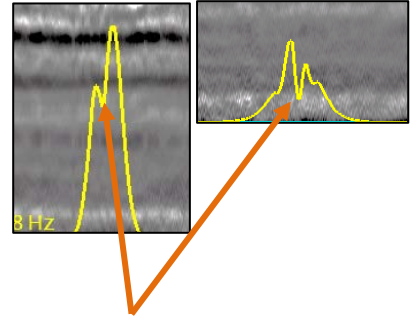
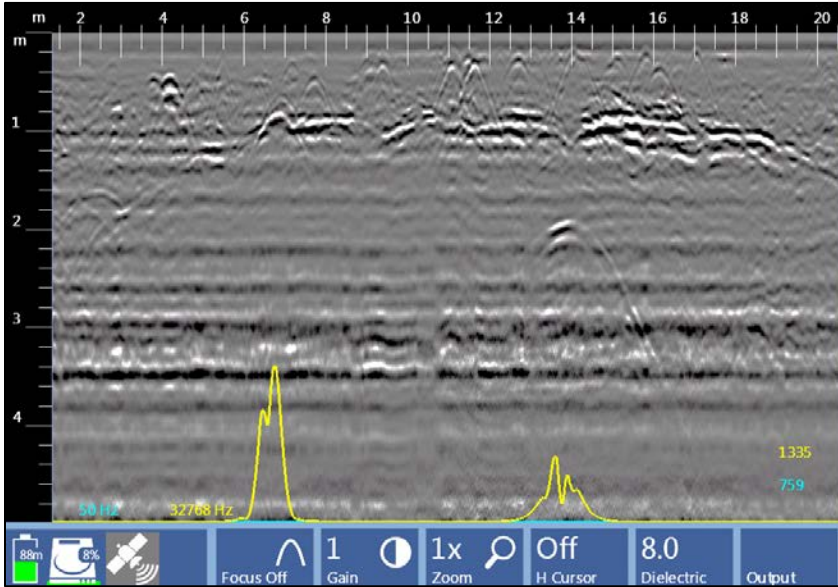
Once the LineTrac settings are configured, enter the Collection Screen by pressing the Green Start Button on the SIR 4000. As you move the antenna, LineTrac data will scroll across the screen with the GPR data. Power Mode data will appear as a blue line and Frequency Mode data will be yellow. You will notice many small data peaks in the absence of a large Power or Frequency target. When you approach a real target the small spikes will be minimized and a large Power or Frequency spike will appear. As you pass over the energized target the spike will build to a peak (Power Mode) or two peaks with a trough between them (Frequency Mode). As you move beyond the target the LineTrac readings will decrease. You can then pull the antenna backwards and center the Backup Cursor on the target based on the GPR data, Power Mode peak, or the



Frequency Mode trough between two peaks. **Note:** The LineTrac sensor is approximately six inches in front of the antenna; take this into consideration when delineating target locations based solely on Power or Frequency data.



Example of LineTrac peaks in Power Mode.
The blue lines and blue text show Power Mode information.



For Frequency Mode targets,
the target's position is the
trough between two peaks

Example of LineTrac peaks in Frequency Mode.
The yellow lines and yellow text show
Frequency Mode information.

Appendix G: Glossary of Terms and Suggestions for Further Reading

Antenna: a paired transmitter and receiver that sends electromagnetic energy into a material and receives any reflections of that energy from materials in the ground. Also called a transducer. Antennae are commonly referred to by their center frequency value (i.e. 400 MHz, 1.5 GHz). This frequency determines the depth of penetration and the size of the objects or layers visible.

Attenuation: the weakening of a radar pulse as it travels through different materials.

Center Frequency: the median transmit frequency of an antenna. The antenna will also transmit energy at a frequency range of 0.5-2 times its center value. For example, a 400 MHz antenna may actually transmit at a range from 200-800 MHz.

Clipping: occurs when the amplitude of a reflection is greater than the maximum recordable value. The system disregards the true value of the reflection and writes in the maximum allowable value. Clipping appears in the O-Scope as signal that “goes off the scale” at the sides of the window.

Dielectric permittivity: the capacity of a material to hold and pass an electromagnetic charge. Varies with a material’s composition, moisture, physical properties, porosity, and temperature. Used to calculate depth in GPR work.

EM: Acronym for electro-magnetic.

FCC: Acronym for Federal Communications Commission. The United States governmental body that oversees the UWB industry of which GPR is a part.

Gain: amplifying the signal to certain section of a radar pulse in order to counteract the effects of attenuation and make features more visible.

GHz: Acronym for Gigahertz. A measurement of frequency equal to one billion cycles per second.

GPR: Acronym for Ground Penetrating Radar.

Ground-coupling: the initial entry of a radar pulse into the ground.

Hyperbola: an inverted “U.” The image produced in a vertical linescan profile as the antenna is moved over a discrete target. The top of the target is at the peak of the first positive (white in a grayscale color table) wavelet.

Interface: the surface separating materials with differing dielectric constants or conductivity values.

KHz: Acronym for Kilohertz. A measurement of frequency equal to one thousand cycles per second.

Linescan: commonly used method of depicting a radar profile. Linescans are produced by placing adjacent scans next to each other and assigning a color scheme to their amplitude values.

Macro: a preset list of processing options that may be applied to perform repetitive functions on an entire dataset. Macros may be created and edited to include different functions (see RADAN manual for addition information).

Mark: point inserted along a survey line manually by the operator or at preset intervals.

MHz: Acronym for Megahertz. A measurement of frequency equal to one million cycles per second.

Migration: mathematical calculation used to remove outlying tails of a hyperbola and to accurately fix the position of a target.

Nano-second: unit of measurement for recording the time delay between transmission of a radar pulse and reception of that pulse's reflections. Equal to one one-billionth of a second.

Noise: unwanted background interference that can obscure true data.

nS: see Nano-Second.

Oscilloscope: device used to view and measure the strength and shape of energy waves. Common term in GPR industry for a method of data display showing actual radar wave anatomy.

Passband: the frequency range at which the antenna is emitting energy. It is roughly equivalent to 0.5-2 times the center frequency.

RAM: Acronym for random access memory. Temporary memory in which a computer stores information used with a running program, or temporarily stored data before it is written to a hard drive.

Range: the total length of time (in nanoseconds) for which the control unit will record reflections. Note: indicates two-way travel time.

RF: Acronym for radio frequency.

Sample: a radar data point with two attributes: time and reflection amplitude. A third attribute, position, is assigned by the user. Under-sampling will produce a scan wave that does not contain enough information to draw a smooth curve. It may miss features. Over-sampling will produce a larger data file.

Samples/Scan: the number of samples recorded from an individual radar scan. Commonly set to 512.

Scan: one complete reflected wave from transmission to reception, sometimes called a trace.

Signal Noise floor: time depth at which the noise makes target identification impossible.

Survey wheel: wheel attached to an antenna and calibrated to record precise distances. Necessary for accurate data collection.

Time-slice: a horizontal planview of amplitude values drawn from adjacent vertical profiles. The time-slice is produced for a particular time-depth and is vital for understanding the horizontal positions of features in a survey area.

Time window: the amount of time, in nano-seconds, that the control unit will count reflections from a particular pulse. Set by the operator.

Transect: a line of survey data. An area is systematically surveyed by recording transects of data at a constant interval. The transects are then placed in their correct position relative to each other in a computer and horizontal time-slices are produced.

UWB: Acronym for Ultra-Wide Band. Refers to the wide frequency band of emissions put out by a GPR device.

Wiggle trace: method of GPR data display showing oscilloscope trace scans placed next to each other to form a profile view. Commonly used method in seismic studies.

Further Reading

Butler Dwain, K., Ed.

2005 *Near-Surface Geophysics*. Society of Exploration Geophysicists, Tulsa, OK.

Daniels, David J.

2004 *Ground Penetrating Radar, Second Edition*. The Institution of Electrical Engineers, London, United Kingdom.

Conyers, Lawrence B.

2004 *Ground-Penetrating Radar for Archaeology, Third Edition*, Altamira Press, Boulder, CO.

Conyers, Lawrence B

2012 *Interpreting Ground-Penetrating Radar for Archaeology*, Left Coast Press, Walnut Creek, CA.

Jackson, J.D.

1975 *Classical Electrodynamics*. Wiley & Sons, Hoboken, NJ.

Jol, Harry M.

2001 *Ground Penetrating Radar in Sediments*. The Geological Society of London, London, United Kingdom.

Oppenheim, Alan, V., and Schafer, Ronald W.

1975 *Digital Signal Processing*. Prentice Hall, Englewood Cliffs, NJ.

Oppenheim, Willsky and Young

1983 *Signal and Systems*. Prentice Hall, Englewood Cliffs, NJ.

Reynolds, John M.

1997 *An Introduction to Applied and Environmental Geophysics*. Wiley and Sons, Hoboken, NJ.

Telford, W.M., Geldart, L.P., Sheriff, R.E.

Applied Geophysics. Cambridge Univ. Press, MA, p. 291.

Wait, J.R.

1982 *Geo-Electromagnetism*. Academic Press, New York.

Witten, Alan J.

2006 *Handbook of Geophysics and Archaeology*. Equinox Publishing, Ltd.

Yilmaz, Oz

Seismic Data Analysis: Processing, Inversion, and Interpretation of Seismic Data. Investigations in Geophysics No. 10, Society of Exploration Geophysicists, Tulsa, OK.

Useful Websites:

- 1** Geophysical Survey Systems, Inc.:
www.geophysical.com
- 2** United States Department of Agriculture Soils Website:
<http://soils.usda.gov/>
- 3** USDA-Natural Resources Conservation Service, Ground Penetrating Radar Program:
<http://nesoil.com/gpr/>
- 4** USDA – Natural Resources Conservation Service, GPR Soil Suitability
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/maps/?cid=nrcs142p2_053622
- 5** USDA-Natural Resources Conservation Service, Web Soil Survey
<http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>
- 6** North American Database of Archaeological Geophysics:
www.cast.uark.edu/nadag