


ConquestTM SL

by Sensors & Software Inc.

User's Guide

© Copyright 2012 Sensors & Software Inc.

Drawing Number: 2012-00034-03

s u b s u r f a c e i m a g i n g s o l u t i o n s

Sensors & Software Inc.
1040 Stacey Court
Mississauga, ON L4W 2X8 Canada

Tel: (905) 624-8909
Fax: (905) 624-9365

E-mail: sales@senssoft.ca
Website: www.senssoft.ca



Sensors & Software

1040 Stacey Court
Mississauga, ON, L4W 2X8
CANADA
Tel: 905-624-8909 Fax: 905-624-9365
sales@sensoft.ca, www.sensoft.ca



**Sensors &
Software**

1040 Stacey Court
Mississauga, ON, L4W 2X8
CANADA
Tel: 905-624-8909 Fax: 905-624-9365
sales@sensoft.ca, www.sensoft.ca

Warranty Confirmation

Return this card within 60 days of purchase to confirm your warranty. Mail to the address above,
Fax to 905-624-9365 or **Register your product online at** www.sensoft.ca/product-registration.

Name: _____ Company Name: _____

Address: _____

City: _____ State (Province): _____ Zip Code: _____

Country: _____ e-mail: _____

Phone: _____ Fax: _____

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

| | | | |
|-------------|----------------|-------------|----------------|
| Comp: _____ | Serial # _____ | Comp: _____ | Serial # _____ |
|-------------|----------------|-------------|----------------|

| | | | |
|-------------|----------------|-------------|----------------|
| Comp: _____ | Serial # _____ | Comp: _____ | Serial # _____ |
|-------------|----------------|-------------|----------------|

| | | | |
|-------------|----------------|-------------|----------------|
| Comp: _____ | Serial # _____ | Comp: _____ | Serial # _____ |
|-------------|----------------|-------------|----------------|

| | | | |
|-------------|----------------|-------------|----------------|
| Comp: _____ | Serial # _____ | Comp: _____ | Serial # _____ |
|-------------|----------------|-------------|----------------|

| | | | |
|-------------|----------------|-------------|----------------|
| Comp: _____ | Serial # _____ | Comp: _____ | Serial # _____ |
|-------------|----------------|-------------|----------------|

Name of vendor: _____ Date Received: _____

SENSORS & SOFTWARE INC. PRODUCT LICENSE, COPYRIGHT, LIABILITY AND WARRANTY INFORMATION

Important

Please read this document carefully before using the *SOFTWARE PRODUCT* or assembling the *HARDWARE PRODUCT*. By using the storage media or assembling the hardware, you are agreeing to be bound by the terms of this agreement. If you do not agree to the terms of this agreement, promptly contact Sensors & Software, Inc. at the address indicated at the end of this document.

Definition

The word *PRODUCT* as used herein defines any item sold by Sensors & Software, Inc. and may be comprised of *HARDWARE PRODUCT* which consists of physical objects and *SOFTWARE PRODUCT* which means computer programs, codes and related support materials.

Software Product License Agreement

In order to preserve and protect its rights under the applicable laws, Sensors & Software, Inc. (hereafter SSI) does not sell any rights to its Software products. Rather, SSI grants the right to use its software, diskettes (or other storage media) and documentation (hereafter collectively called *SOFTWARE PRODUCT*) by means of a *SOFTWARE PRODUCT* license. You acknowledge and agree that SSI retains worldwide title and rights to all its software and that the *SOFTWARE PRODUCT* contains proprietary materials protected under copyright, trademark and trade secret laws.

Grant of Software Product License

In consideration of payment of the license fee which is the price you pay for the *SOFTWARE PRODUCT* and your agreement to abide by the terms and conditions of this License Agreement, SSI grants to you, the Licensee, a non-exclusive right to use the *SOFTWARE PRODUCT* under the following conditions:

You may:

- use the *SOFTWARE PRODUCT* on a single workstation owned, leased or otherwise controlled by you;
- copy the *SOFTWARE PRODUCT* for backup purposes in support of your use of the product on a single workstation.

You may not:

- copy, distribute or sell copies of the *SOFTWARE PRODUCT* or accompanying written materials, including modified or merged *SOFTWARE PRODUCT* to others;
- sell, license, sublicense, assign or otherwise transfer this license to anyone without the prior written consent of SSI;
- modify, adapt, translate, decompile, disassemble or create derivative works based on the *SOFTWARE PRODUCT*.

Termination

This license is effective until terminated. You may terminate the license at any time by returning the *SOFTWARE PRODUCT* and all copies to SSI. The license will automatically terminate without notice by SSI if you fail to comply with any terms or conditions of this agreement. Upon termination, you agree to return all copies of the *SOFTWARE PRODUCT* to SSI.

Update Policy

SSI may create, from time to time, updated versions of its *SOFTWARE PRODUCT*. At its option, SSI will make such updates available to licensees who have paid the update fee.

Product Warranty, Limited Remedy and Limited Liability

SSI warrants the *PRODUCT* to be free from defect in material and workmanship under normal use for a period of one year (365 days) from the date of shipment. Any third party computer systems or other items not manufactured directly by SSI purchased with any *PRODUCT* or independently from SSI are subject to the original manufacturer's warranty and are not the responsibility of SSI.

SSI makes no other warranties including, but not limited to, any implied warranty of merchantability or fitness for a particular purpose. If this product is defective within the warranty period stated above, your exclusive remedy shall be, at SSI's option to replace or repair the SSI product or refund the purchase price of the SSI product. Except where prohibited by law, SSI will not be liable for any loss or damage arising from this SSI product, whether direct, indirect, special, incidental or consequential regardless of the legal theory asserted.

All statements, technical information, and recommendations related to SSI products are based on information believed to be reliable, but the accuracy or completeness is not guaranteed. Before using this product, you must evaluate it and determine if it is suitable for your intended application. You assume all risks and liability associated with such use. Any statements related to the product, which are not contained in SSI current publications, or any contrary statements contained on your purchase order shall have no force or effect unless expressly agreed upon, in writing, by an authorized officer of SSI.

SSI warrants the diskettes or other storage media on which the *SOFTWARE PRODUCT* is furnished to be free from defects in material and workmanship under normal use for a period of ninety (90) days from the date of purchase as evidenced by a copy of your invoice.

Except as specified above, any *SOFTWARE PRODUCT* is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, the use or result of use of the product in terms of correctness, accuracy, reliability, currentness or otherwise. The entire risk as to the results and performance of the *PRODUCT* is assumed by you. If the *PRODUCT* is defective or used improperly, you, and not SSI or its dealers, distributors, agents, or employees, assume the entire cost of all necessary servicing, repair or correction.

SSI's entire liability and your exclusive remedy for *SOFTWARE PRODUCT* shall be, at SSI's option, either:

- the replacement of any diskette or hardware components which do not meet SSI's Limited Warranty and which are returned to SSI postage prepaid with a copy of the receipt, or
- if SSI is unable to deliver a replacement diskette which is free of defects in material or workmanship, Licensee may terminate this agreement and have the license fee refunded by returning all copies of the *SOFTWARE PRODUCT* postage prepaid with a copy of the receipt.

If failure of any *PRODUCT* resulted from accident, abuse or misapplication, SSI shall have no responsibility to replace the *SOFTWARE PRODUCT*, refund the license fee, or replace or repair the *HARDWARE PRODUCT*.

Do not tamper with any *PRODUCT*. *PRODUCT* contains no user serviceable parts. If tampering is evident in SSI's opinion, warranty is void and null.

No oral or written information or advice given by SSI, its dealers, distributors, agents or employees shall create a warranty or in any way increase the scope of this warranty and you may not rely on any such information or advice.

Neither SSI nor anyone else who has been involved in the creation, production or delivery of the *PRODUCT* shall be liable for any direct, indirect, special, exemplary, incidental or consequential damages,

claims or actions including lost information, lost profits, or other damages arising out of the use or inability to use this *PRODUCT* even if SSI has been advised of the possibility of such damages.

This warranty gives you specific rights. You may have other rights which vary from province to province, territory to territory and certain limitations contained in this limited warranty may not apply to you.

General

No right, license, or interest to any SSI trademarks is granted hereunder with the purchase of the *PRODUCT* or the *SOFTWARE PRODUCT* license.

Governing Law

In the event of any conflict between any provision in this license agreement and limited warranty and any applicable provincial legislation, the applicable provincial legislation takes precedence over the contravening provision. This agreement shall be governed and construed in accordance with the laws of the Province of Ontario, Canada.

Serviceability

Should any term of this agreement be declared void or not enforceable by any court of competent jurisdiction, the remaining terms shall remain in full effect.

Waiver

Failure of either party to enforce any of its rights in this agreement or take action against any other party in the event of a breach of this agreement shall not be considered a waiver of the right to subsequent enforcement of its rights or actions in the event of subsequent breaches by the other party.

Acknowledgement

You acknowledge that you have read this agreement, understand it and agree to be bound by its terms and conditions. You further agree that this agreement is the complete and exclusive statement of agreement between the parties and supersedes all proposals or prior agreements oral or written between the parties relating to the subject matter of this agreement.

Should you have any questions concerning this agreement, please contact in writing:

Sensors & Software Inc.

1040 Stacey Court
Mississauga, Ontario
Canada L4W 2X8
Tel:(905) 614-1789
Toll Free: 1 877 614-1789
Fax:(905) 624-9365
E-mail: radar@sensoft.ca

pulseEKKO, Noggin, SpiView, SnowScan, Conquest, SmartCart, SmartHandle, RoadMap, Conquest for Windows, ConquestView, Win_EKKO, EKKO_Mapper, EKKO_3D and EKKO_POINTER ARE TRADEMARKS OF SENSORS & SOFTWARE INC.

Table of Contents

| | | |
|----------|---|-----------|
| 1 | OVERVIEW | 1 |
| 2 | PRINCIPLES OF OPERATION | 3 |
| 2.1 | LINE SCANS CROSSING TARGETS PERPENDICULARLY | 4 |
| 2.2 | CONCRETE TYPE | 5 |
| 2.3 | LINE SCANS RUNNING PARALLEL TO TARGETS | 6 |
| 2.4 | GRID SCAN COLLECTION | 7 |
| 2.5 | LIMITATIONS | 8 |
| 2.5.1 | <i>New Concrete</i> | 8 |
| 2.5.2 | <i>Concrete Covered by Metal</i> | 8 |
| 2.5.3 | <i>Penetration Depth</i> | 9 |
| 2.6 | POWER CABLE DETECTION (PCD) PRINCIPLES | 10 |
| 3 | ASSEMBLING CONQUEST | 15 |
| 3.1 | BASIC ASSEMBLY | 15 |
| 3.2 | OPTIONAL ACCESSORIES | 21 |
| 3.2.1 | <i>Battery</i> | 21 |
| 3.2.2 | <i>Handle</i> | 22 |
| 3.2.3 | <i>DVL Carrier</i> | 23 |
| 3.3 | DIGITAL VIDEO LOGGER (DVL) | 24 |
| 3.3.1 | <i>Menu Buttons</i> | 24 |
| 3.3.2 | <i>Screen</i> | 24 |
| 3.3.3 | <i>Brightness</i> | 24 |
| 3.3.4 | <i>Contrast</i> | 24 |
| 3.3.5 | <i>Compact Flash Card</i> | 24 |
| 3.3.6 | <i>DVL Temperatures</i> | 25 |
| 3.4 | POWERING UP CONQUEST | 26 |
| 4 | MENU NAVIGATION | 27 |
| 4.1 | DVL BUTTONS | 27 |
| 4.1.1 | <i>Horizontal Menus</i> | 27 |
| 4.1.2 | <i>Vertical Menus</i> | 28 |
| 4.1.3 | <i>A and B Buttons</i> | 28 |
| 4.1.4 | <i>Exiting a Sub-Menu</i> | 28 |
| 4.2 | SENSOR HEAD BUTTONS | 29 |
| 4.2.1 | <i>Horizontal Menus</i> | 29 |
| 4.2.2 | <i>Vertical Menus</i> | 29 |
| 4.2.3 | <i>Enter Button</i> | 30 |
| 4.2.4 | <i>Star (*) Button</i> | 30 |
| 4.2.5 | <i>Exiting a Sub-Menu</i> | 30 |
| 5 | MAIN SCREEN | 31 |
| 5.1.1 | <i>Powering Off Conquest</i> | 31 |
| 6 | LINE SCAN | 33 |
| 6.1 | DEPTH AND POSITION SCALES | 34 |
| 6.2 | DYNAQ INDEX BAR | 34 |

| | | |
|----------|--|-----------|
| 6.3 | BACK-UP INDICATOR | 35 |
| 6.4 | ADDING FIDUCIAL MARKERS..... | 36 |
| 6.5 | PCD (POWER CABLE DETECTOR) RESPONSE..... | 37 |
| 6.6 | STOPPING LINE SCAN | 37 |
| 6.7 | LINE SCAN RE-DISPLAY MENU | 38 |
| 6.7.1 | <i>Saving Line Scan Data</i> | 38 |
| 6.7.2 | <i>Gain</i> | 38 |
| 6.7.3 | <i>Stretch</i> | 39 |
| 6.7.4 | <i>Depth and Cross Hairs</i> | 40 |
| 6.7.5 | <i>Color</i> | 41 |
| 6.7.6 | <i>Concrete Type</i> | 41 |
| 6.7.7 | <i>Line #</i> | 42 |
| 6.7.8 | <i>Exit</i> | 42 |
| 7 | GRID SCAN | 43 |
| 7.1 | DEFINE AREA OF INTEREST | 43 |
| 7.2 | PLACE GRID MAT | 43 |
| 7.2.1 | <i>Standard Grids</i> | 44 |
| 7.2.2 | <i>Larger Grids</i> | 45 |
| 7.3 | GRID SCAN PARAMETERS | 45 |
| 7.3.1 | <i>Scan Number</i> | 46 |
| 7.3.2 | <i>Grid Size</i> | 46 |
| 7.3.3 | <i>Scan Depth</i> | 47 |
| 7.3.4 | <i>Grid Resolution</i> | 47 |
| 7.3.5 | <i>Delete</i> | 47 |
| 7.3.6 | <i>Exit</i> | 47 |
| 7.4 | SURVEYING THE GRID..... | 47 |
| 7.4.1 | <i>Positioning the Sensor</i> | 48 |
| 7.4.2 | <i>Collecting Grid Lines</i> | 49 |
| 7.4.3 | <i>Progress and DynaQ Bar</i> | 49 |
| 7.4.4 | <i>Finishing a Line</i> | 50 |
| 7.4.5 | <i>Modifying Line Display</i> | 50 |
| 7.4.6 | <i>PCD (Power Cable Detector) Response</i> | 54 |
| 7.4.7 | <i>Reviewing and Rescanning Grid Lines</i> | 54 |
| 7.5 | SLICE VIEW IMAGE COMPUTATION..... | 54 |
| 7.5.1 | <i>Concrete Type</i> | 55 |
| 8 | SLICE VIEW..... | 57 |
| 8.1 | SLICE VIEW SCREEN..... | 58 |
| 8.2 | GRID NUMBER..... | 58 |
| 8.3 | DEPTH SLICE | 59 |
| 8.3.1 | <i>Conquest Resolution</i> | 59 |
| 8.3.2 | <i>PCD Image</i> | 60 |
| 8.4 | DATA DISPLAY TYPES..... | 61 |
| 8.4.1 | <i>Multi-Slice</i> | 61 |
| 8.4.2 | <i>3D View</i> | 62 |
| 8.5 | COLOR..... | 64 |
| 8.5.1 | <i>Grid</i> | 65 |
| 8.5.2 | <i>Sensitivity</i> | 65 |

| | | |
|-----------|---|-----------|
| 8.6 | SLICE TYPE..... | 67 |
| 8.7 | RE-PROCESSING THE GRID SCAN WITH A DIFFERENT SCAN DEPTH | 68 |
| 9 | TOOLS..... | 69 |
| 9.1 | EXPORT | 69 |
| 9.2 | UNITS | 70 |
| 9.3 | DELETE LINES/GRIDS | 70 |
| 9.4 | DATE/TIME | 71 |
| 9.5 | MORE TOOLS | 72 |
| 9.5.1 | System Test | 72 |
| 9.5.2 | Odometer Wheel Calibration..... | 74 |
| 9.5.3 | PCD Frequency..... | 75 |
| 9.5.4 | Image Enhancement Processing (IEP)..... | 75 |
| 10 | TRANSFERRING DATA TO A PC (OPTIONAL)..... | 77 |
| 10.1 | PC SOFTWARE..... | 77 |
| 10.2 | CONQUEST GRID PARAMETER (.CV2) FILE DEFINITION | 77 |
| 11 | EXAMPLES & INTERPRETATION | 79 |
| 12 | HELPFUL HINTS..... | 85 |
| 12.1 | MARKING THE SITE | 85 |
| 12.2 | SCAN SPEED AND DATA QUALITY | 85 |
| 12.3 | SENSOR HEAD POSITIONING | 86 |
| 12.4 | COLLECTING A SHORT LINE OR PARTIAL GRID | 87 |
| 12.5 | LINE SCAN DATA FILE LENGTH..... | 87 |
| 12.6 | EXTENDING THE DEPTH AFTER COLLECTING DATA | 87 |
| 13 | TROUBLESHOOTING..... | 89 |
| 13.1 | RESTART THE SYSTEM..... | 89 |
| 13.2 | POWER SUPPLY | 89 |
| 13.3 | WARNING BEEP IN LINE SCAN MODE | 89 |
| 13.4 | WARNING BEEP AND FLASHING IN GRID SCAN MODE | 90 |
| 13.5 | SENSOR HEAD KEY PAD DOESN'T RESPOND | 90 |
| 13.6 | SYSTEM DOES NOT START WITH THE SENSOR HEAD..... | 90 |
| 13.7 | POWER LIGHT ON DVL NOT ILLUMINATED..... | 90 |
| 13.8 | EXPORT MENU ITEM NOT ACCESSIBLE | 91 |
| 13.9 | CONSTANT PROMPT TO PERFORM SYSTEM TEST | 91 |
| 13.10 | CREATING A TEST LINE FOR DATA QUALITY | 91 |
| 13.11 | CONTACTING SENSORS & SOFTWARE INC. | 92 |
| 14 | CARE AND MAINTENANCE..... | 93 |
| 14.1 | CABLE CARE | 93 |
| 14.2 | CONQUEST SENSOR HEAD WEAR PAD | 93 |
| 14.3 | STORAGE CASES..... | 93 |
| 14.4 | SPARE PARTS | 93 |

| | |
|---|----------|
| APPENDIX A: HEALTH & SAFETY CERTIFICATION | 1 |
| APPENDIX B: GPR EMISSIONS, INTERFERENCE AND REGULATIONS..... | 1 |
| B-1 FCC REGULATIONS | 1 |
| B-2 ETSI REGULATIONS FOR THE EC (EUROPEAN COMMUNITY) | 6 |
| B-3A INDUSTRY CANADA REGULATIONS - ENGLISH | 7 |
| B-3B RÈGLEMENT D'INDUSTRIE CANADA - FRANÇAIS | 8 |
| APPENDIX C: INSTRUMENT INTERFERENCE | 1 |
| APPENDIX D: SAFETY AROUND EXPLOSIVE DEVICES | 1 |

1 Overview

Conquest is an integrated ground penetrating radar (GPR) data acquisition platform specifically designed to meet the needs of the concrete inspection industry. The system consists of the Digital Video Logger (DVL), control module, sensor head, cable, survey grids and AC power supply connections. Optional items include a battery, charger, handle for the sensor head and a software kit that includes a removable Compact Flash card, card reader, and PC software for Conquest data display and image export for reports.

Conquest provides quick, easy surveying with integrated analysis and 3D imaging.

The PCD (Power Cable Detector) feature uses an additional sensor built into the Conquest sensor head to detect and image current-carrying cables inside or beneath the concrete. The PCD data are collected at the same time as the GPR data so there is no additional effort required by the operator.



Figure 1-1: Conquest SL system in operation.

2 Principles of Operation

The Conquest system uses ground penetrating radar (GPR) technology to image concrete and other similar materials (soil, rock, asphalt, etc.). GPR systems emit a high frequency radio wave pulse and detect the echoes that return from objects within the material. The concept is shown in Figure 2-1.

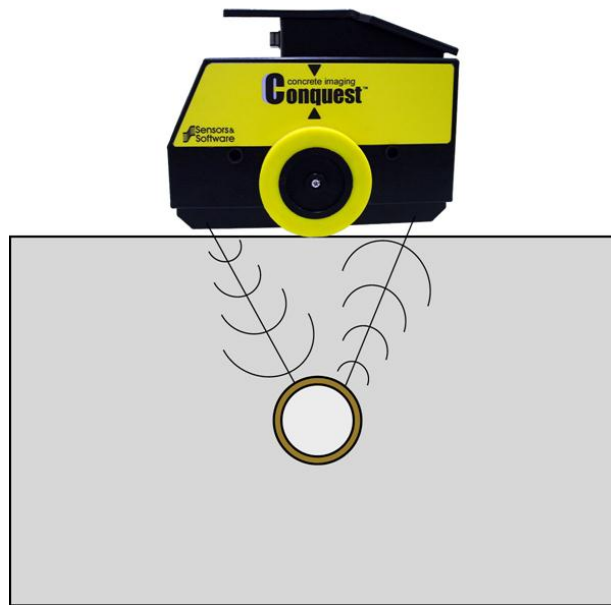


Figure 2-1: The Conquest sensor head transmits GPR signals into concrete and collects the signals that reflect from rebar, conduits and other targets embedded inside.

The GPR display shows signal amplitude versus depth (time) and sensor position along a line. This is called a “Line Scan”. The echo sounder and fish finder used on boats operate in an analogous fashion as indicated in Figure 2-2.

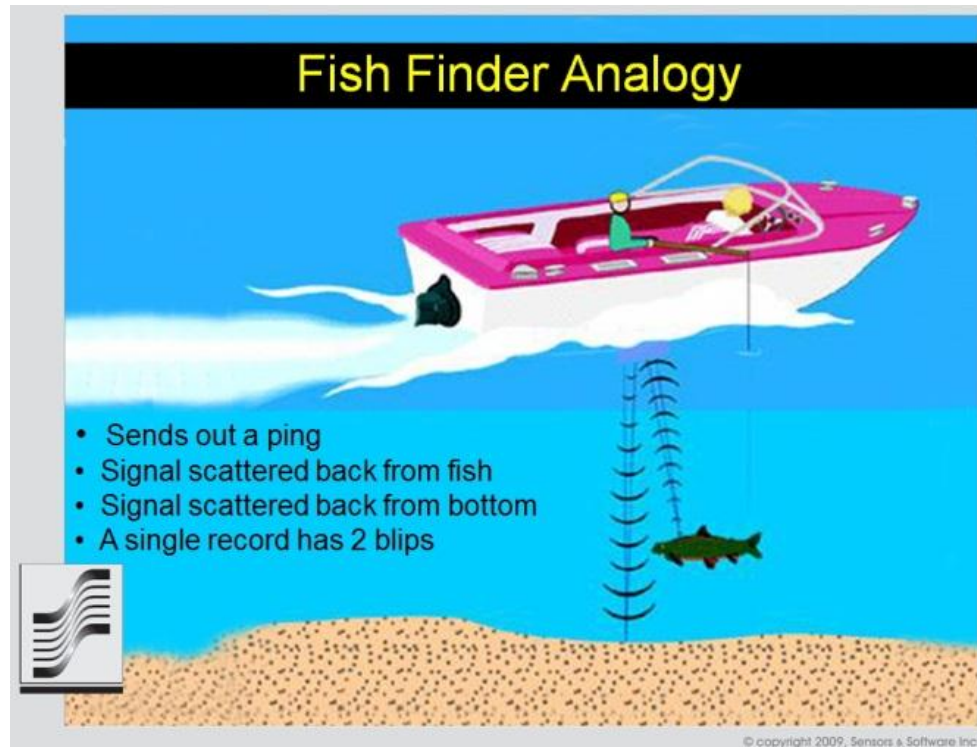


Figure 2-2: GPR is conceptually similar to a fish finder.

2.1 Line Scans Crossing Targets Perpendicularly

Conquest detects rebar and conduits which are generally rod-like in shape. The sensor should cross perpendicular to the long axis of the feature, i.e. it should cross the feature at 90° (Figure 2-3 left). When the sensor crosses a target, the result is the typical “hyperbolic” or inverted “V” response from the target, as shown in Figure 2-3 right.

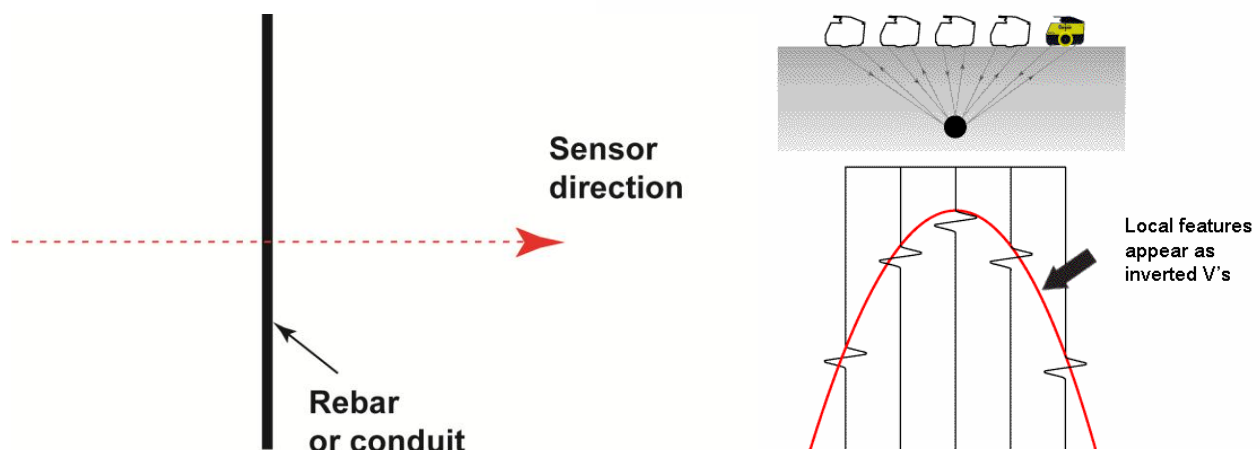


Figure 2-3: The arrow represents the path of the sensor, crossing the rebar or conduit at 90° (left). This produces an inverted “V” or hyperbola in the cross-section image (right).

A real data image is shown in Figure 2-4.

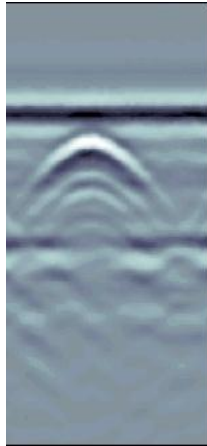


Figure 2-4: Data image of a hyperbola produced by crossing a piece of rebar perpendicularly with the Conquest sensor head.

The point (apex) of the inverted V gives the position and depth of the feature (Figure 2-5).

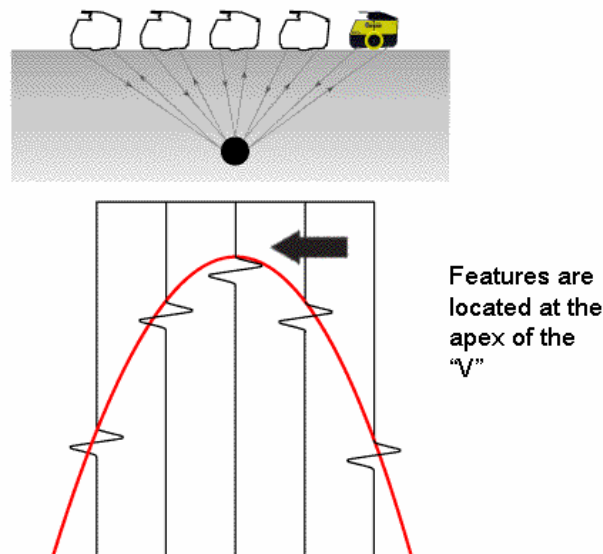


Figure 2-5: The actual location of a target corresponds to the top or apex of the hyperbola.

2.2 Concrete Type

The "Concrete Type" property is a measure of the velocity with which the Conquest signals travel through the concrete. The Concrete Type can be determined by measuring the shape of hyperbolas (Figure 2-3 and Figure 2-4). An accurate Concrete Type is required for reliable

depth estimates and depth slice images, the user must calibrate the unit on each site to determine the Concrete Type.

The Concrete Type can be determined from the data by calibrating after collecting a cross-section data image like Figure 2-4. Crossing the target perpendicularly is important to ensure an accurate Concrete Type calibration value.

2.3 Line Scans Running Parallel to Targets

Moving parallel to (or directly on top of) the subsurface feature (Figure 2-6) results in a constant flat line in the data image (Figure 2-7). Other features such as layers and the bottom of concrete will also appear as flat responses.

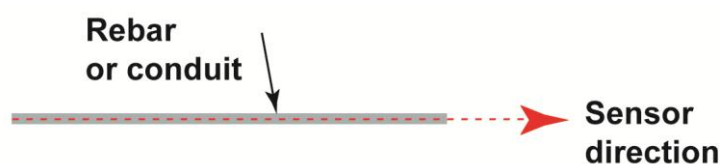


Figure 2-6: The arrow represents the path of the sensor, running on top of a rebar or conduit.

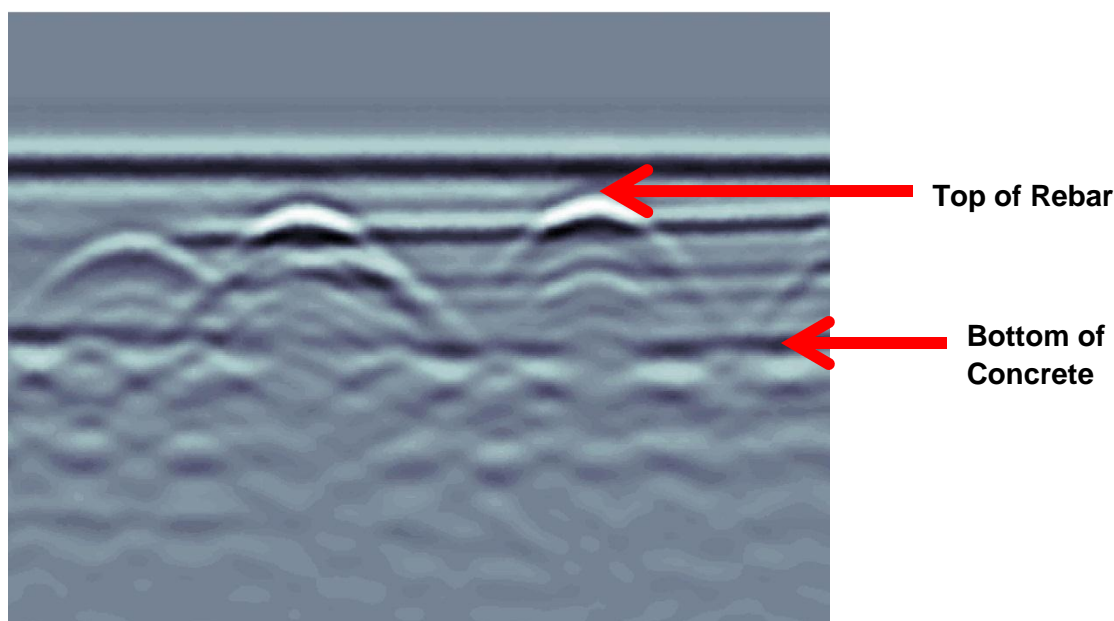


Figure 2-7: Data image of hyperbolas produced by a line scan crossing 3 rebars perpendicularly. The image also shows flat lines generated by the reflection from the bottom of the concrete. Ensure that the Filter option is OFF or flat-lying features are removed from the image.

Be aware that Conquest has the option of applying a background subtraction filter to the data to remove flat-lying features in the data image. The filter option is available on the **Color** button in **Line Scan**, **Grid Scan** (Figure 7-6) or **Slice View**. The filter is used to enhance the hyperbolas from targets like rebar, and so if the item of interest is a flat-lying feature like the bottom of concrete, make sure that the Filter is OFF.

2.4 Grid Scan Collection

A Conquest **Grid Scan** consists of collecting a series of parallel line scans in two directions perpendicular to one another (Figure 2-8). The lines labeled 1 – 7 are called “Numeric” lines, and lines labeled A – G are called “Alpha” lines.

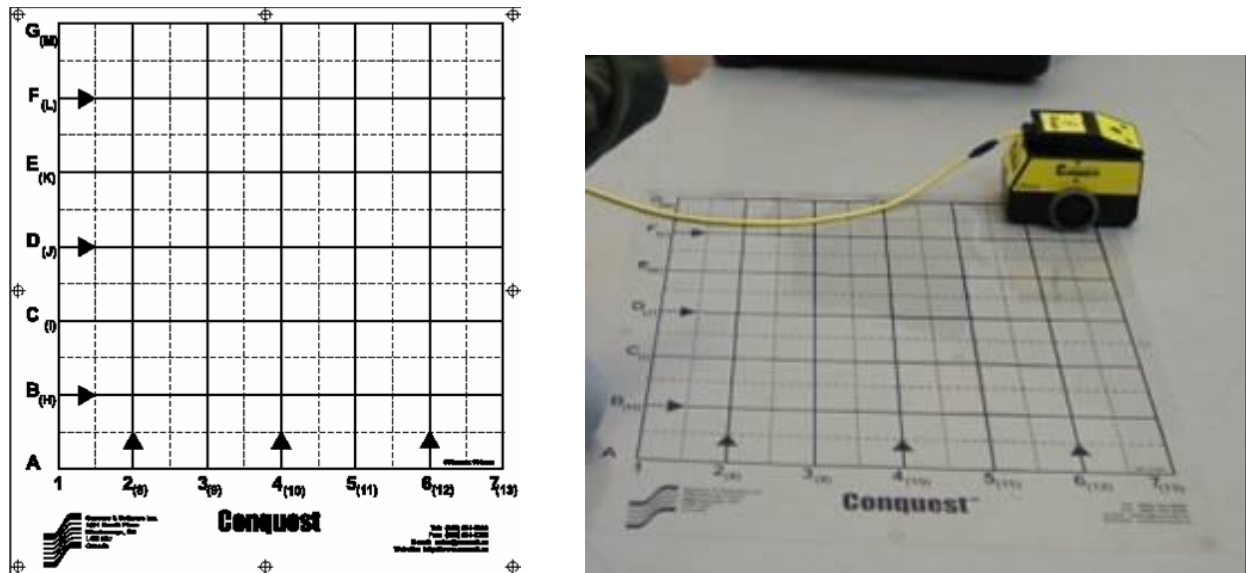


Figure 2-8: Grid Scans are based on collecting multiple line scans in two directions on a grid.

Together, these line scans sample a 3D volume or cube of concrete. This is shown conceptually in Figure 2-9a. Processing the data results in a solid data volume, again, conceptually shown in Figure 2-9b.

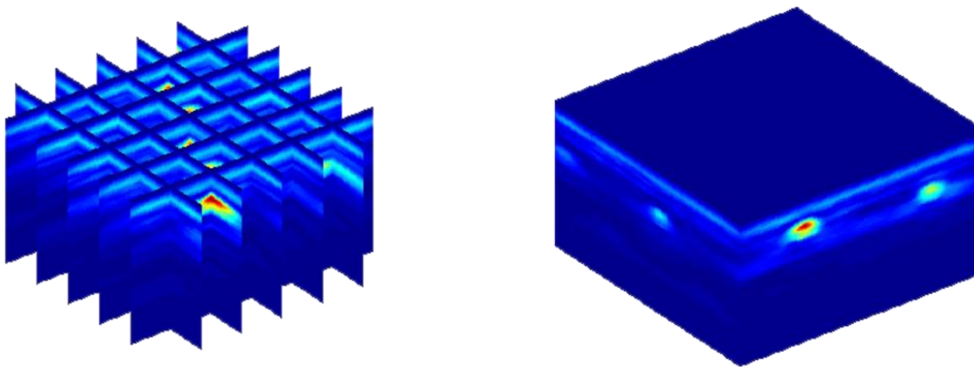


Figure 2-9: (a) A series of line scans on a grid cover a volume. (b) Processing interpolates data into the gaps between lines to produce a solid volume.

The data volume can then be visualized as a number of “slabs” or depth slices. Conquest displays a series of 2.5 cm (1 inch) thick depth slice images moving through the data volume from top to bottom (Figure 2-10).

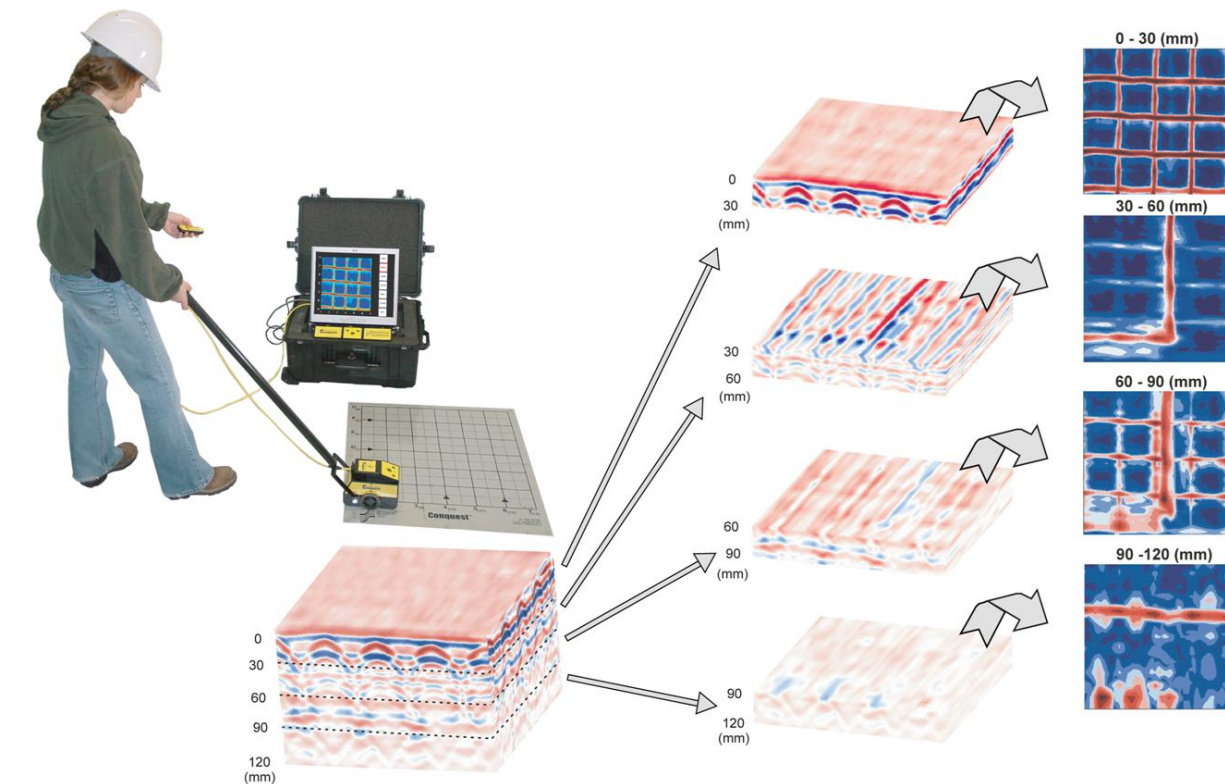


Figure 2-10: The concept of grid scanning with Conquest. Collecting a grid of data results in a data cube or 3D volume that is visualized as a series of 25mm (1 inch) thick depth slices.

2.5 Limitations

Before using the Conquest system, keep in mind that Conquest will not solve every problem that you will face.

2.5.1 New Concrete

Most importantly, Conquest will not work effectively on very new concrete. When concrete is very fresh, it is extremely conductive and absorbs the signals that the Conquest system emits and does not allow penetration to substantial depths. Depending on the concrete mix and local conditions, curing can take days to weeks. As a result, the use of Conquest in the early stages of concrete construction has to be considered experimental until the concrete is adequately cured.

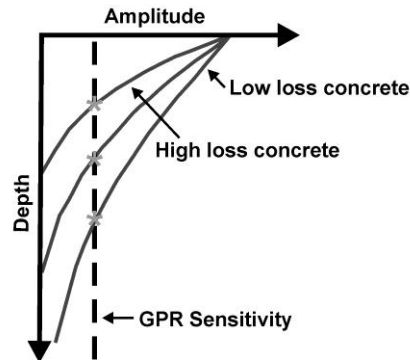
2.5.2 Concrete Covered by Metal

In some situations, concrete may be covered by metal or contain a very fine screen mesh. This can happen in a plastered wall or in a terrazzo floor. In these cases the metal screen acts like a perfect mirror for the radio signals emitted by the Conquest sensor. All the signals are reflected back and nothing will penetrate into the subsurface. At such sites, Conquest will not be effective for subsurface imaging.

2.5.3 Penetration Depth

GPR uses radio waves to image the subsurface. These waves are strongly absorbed by the material being scanned. The material type and pore water salinity dictate how deep signals will penetrate. Concrete can be highly variable depending on the original mix and state of wetting. Figure 2-11 shows how the depth of penetration can vary with concrete type.

Exploration Depth is Concrete Type Specific



1. Concrete absorbs radio waves
2. Different concrete mixes exhibit different absorption
3. Saline pore water makes concrete very high loss

Figure 2-11: Concrete absorbs GPR signals and generally limits penetration to about 18" (0.5 m).

There is a finite limit on the concrete thickness that can be detected. Experience indicates that approximately 18" (0.5 m) of concrete is the limit of exploration. In some situations where concrete is very dry and optimally mixed to hydrate all cement, penetration can reach 24" to 36" (0.6 to 1 m), but this is not common.

2.6 Power Cable Detection (PCD) Principles

The PCD sensor maps the location of current-carrying cables by detecting the magnetic field created by AC current flowing at 50 Hz or 60 Hz.

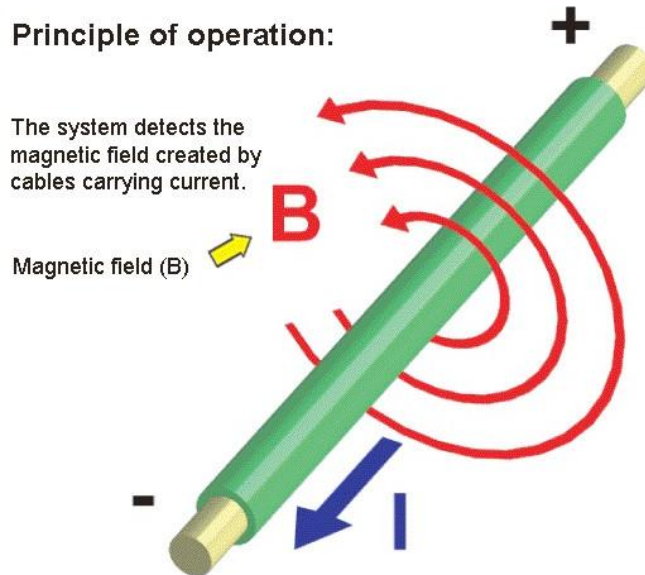


Figure 2-12: Depiction of the magnetic field created by AC current flowing in a wire.

Principle of operation:

The Conquest sensor head with PCD detects the magnetic fields versus position.

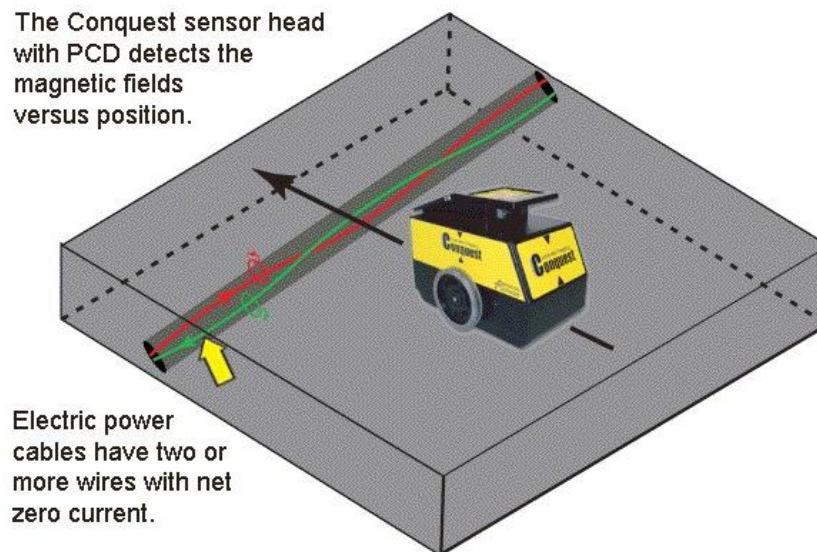


Figure 2-13: Conquest detects the current-carrying cable best when crossing it perpendicularly.

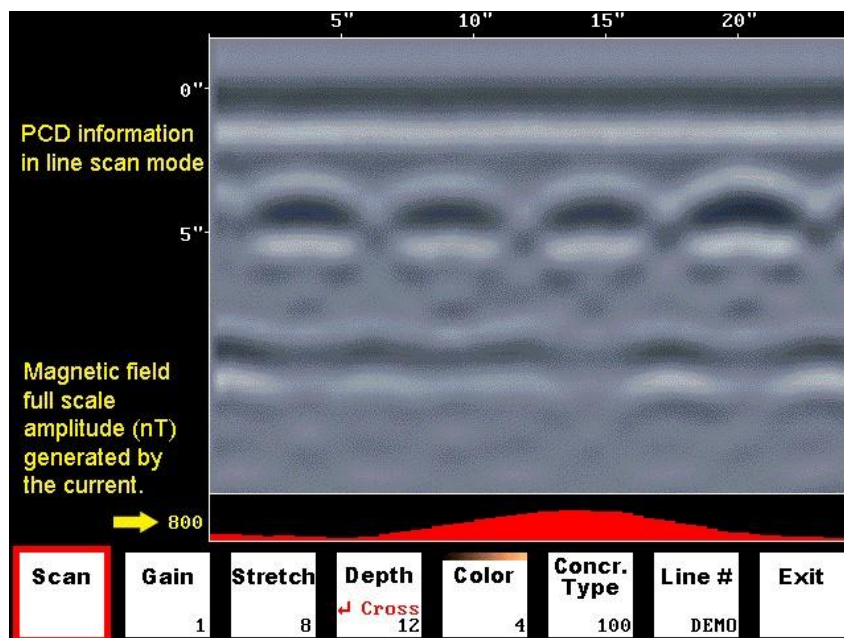


Figure 2-14: In Line Scan mode, the PCD profile appears under the GPR cross-section image. The PCD profile also appears after collecting each line in a Grid Scan.

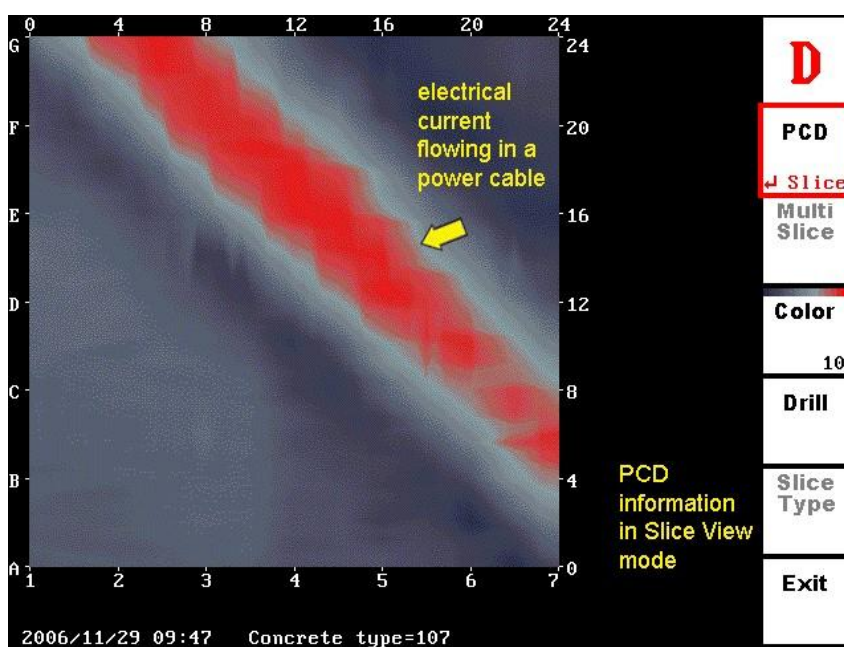


Figure 2-15: After Grid Scan data have been processed into depth slice images, the PCD image can also be displayed.

The magnetic field generated by current flowing in wires can be simple or highly contorted depending on how the wires are oriented. Examples of simple and twisted wires are shown in Figure 2-16.

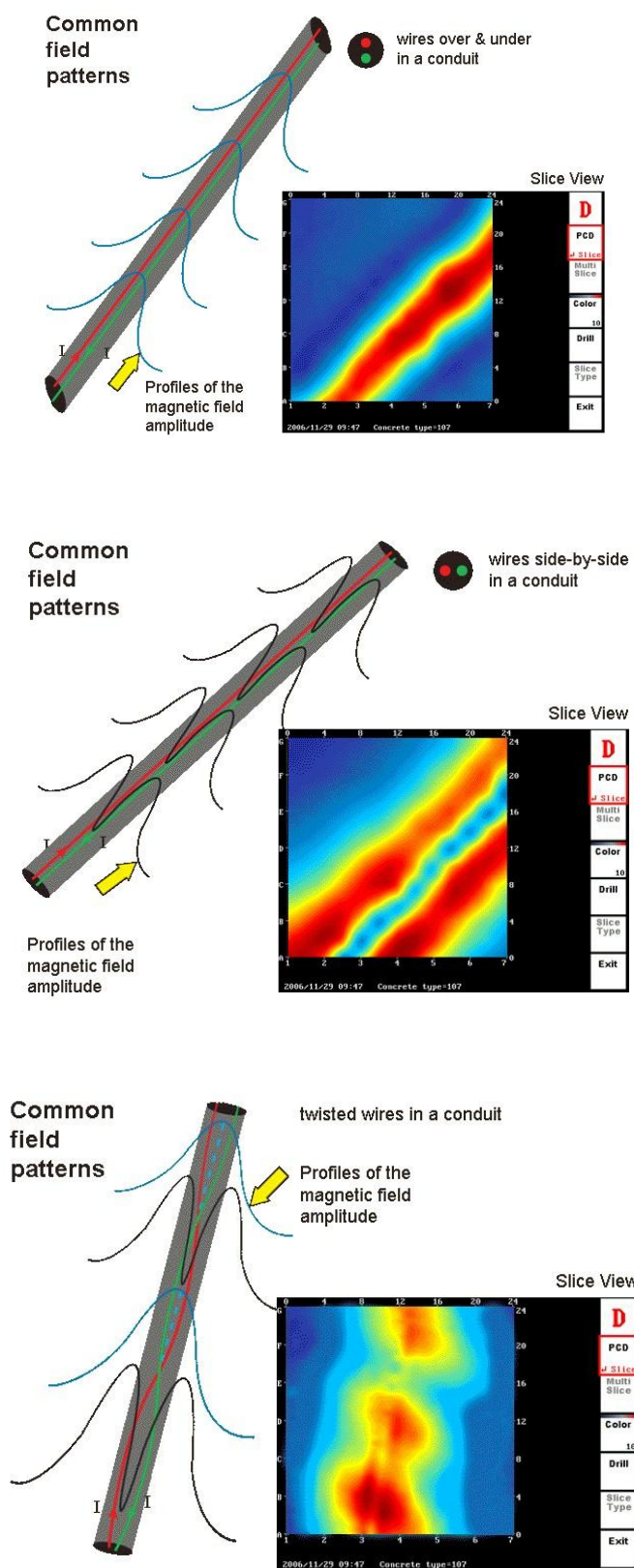


Figure 2-16: The shape of the magnetic field generated can be simple or complex depending on whether the wires are straight, vertically or horizontally oriented, their spacing and the degree of twist.

The amplitude of the PCD responses depends on the amount of current, cable depth, wire separation distance and degree of twist. The PCD response can vary over a wide range, typically from double digits to 10,000 or more (Figure 2-17).

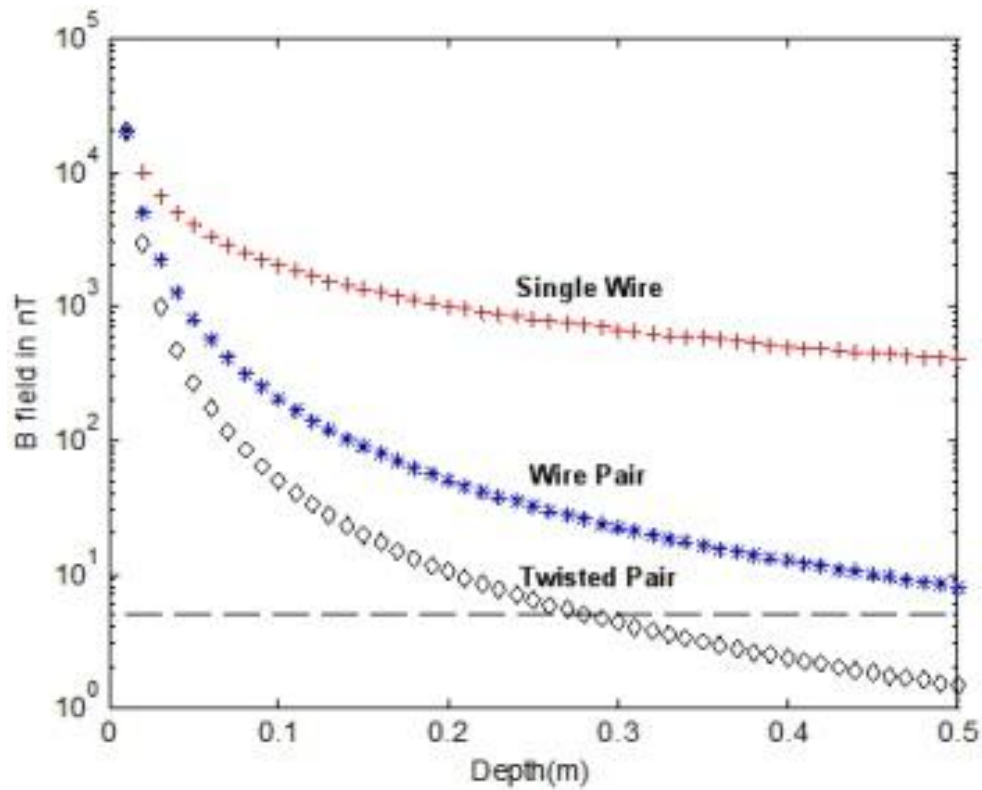


Figure 2-17: The strength of the magnetic field generated depends on the nature of the wire: single wire, pair or twisted pair and the spacing. It also depends on the depth of the wire and amount of current flowing in the wire. PCD values can vary over a wide range depending on these factors.

3 Assembling Conquest

3.1 Basic Assembly

Follow the steps below to assemble the Conquest SL unit:

1. Open the plastic case:



Figure 3-1: Conquest SL components in its carrying case.

2. Remove all the system components.

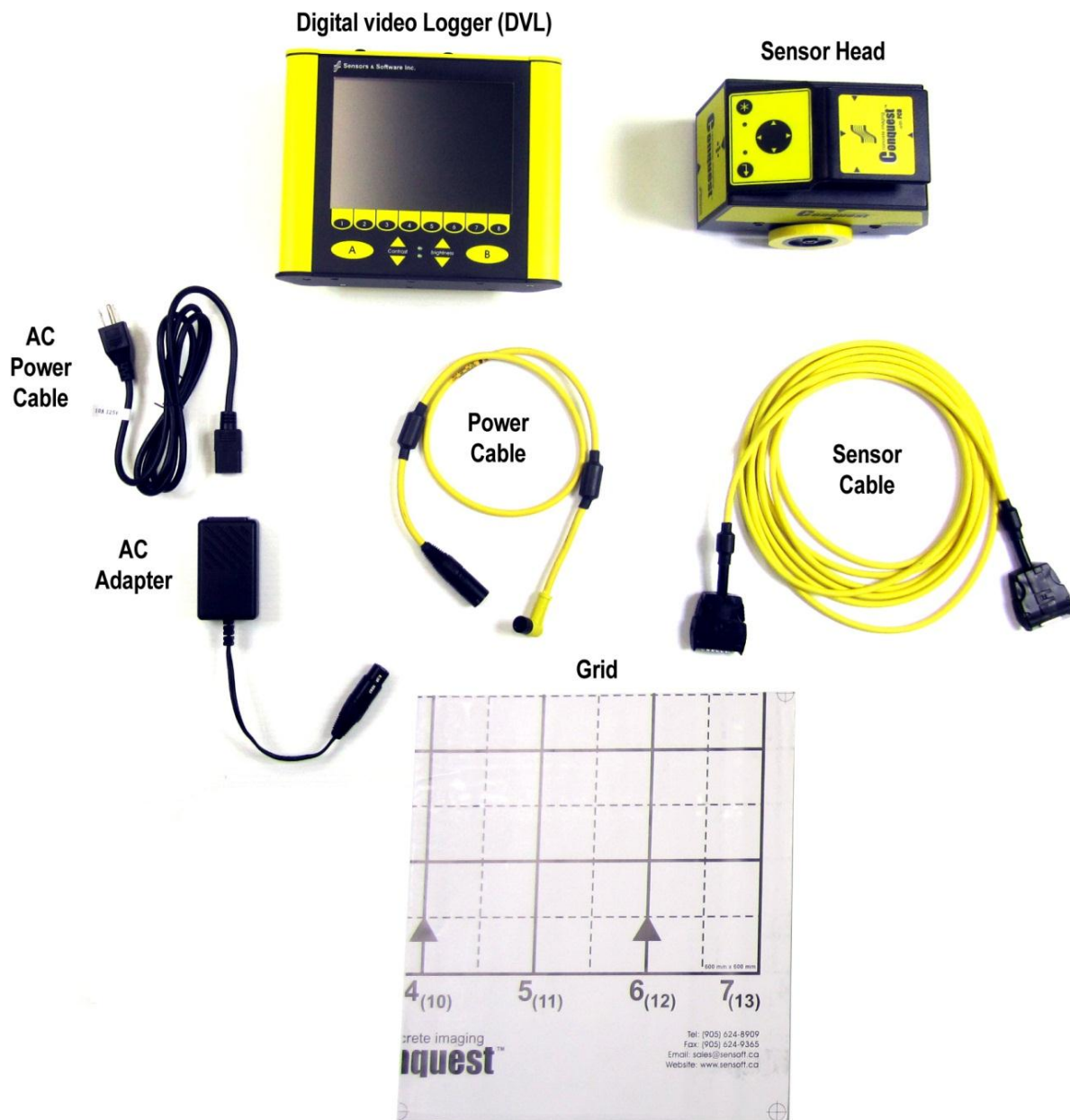


Figure 3-2: Conquest SL system components

3. The DVL comes with the Control Module already attached to the back. Note that if the DVL is used with other GPR systems, like Noggins, the Control Module can be detached by removing the 6 mounting screws. Contact Sensors & Software (Section 13.11) for detailed instructions on removing the Control Module and switching the embedded software on the DVL.



Figure 3-3: Conquest SL Control Module on the back of a DVL. Cable connections are indicated. If the DVL is used with other Sensors & Software GPR systems, detach the Control Module by removing the 6 labeled screws.

4. Connect the male end of the yellow sensor cable to the control module on the back of the DVL. Ensure that the connection “clicks” into place so it cannot be disconnected without squeezing the clips on either side of the connector.

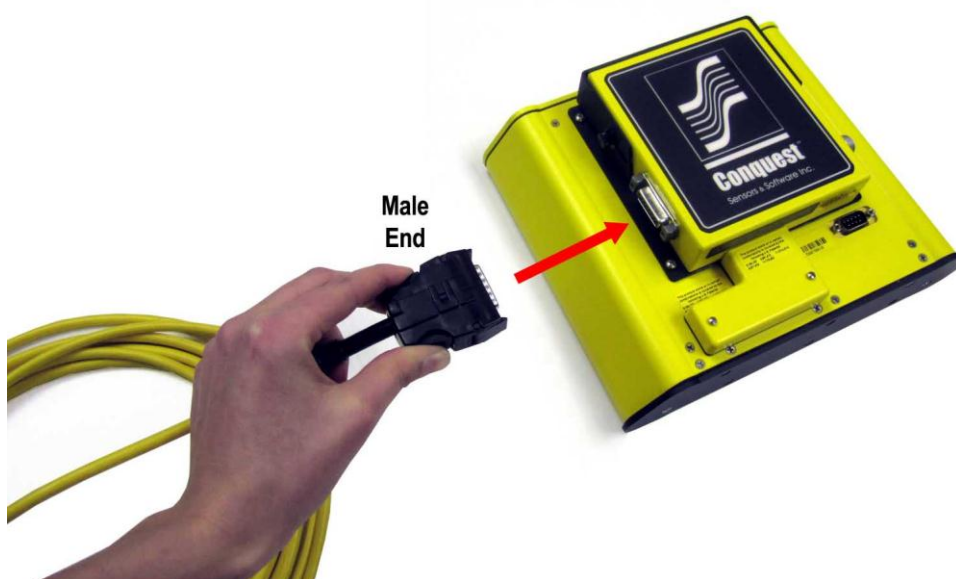


Figure 3-4: Sensor cable connection to Control Module.

5. Connect the other (female) end of the yellow sensor cable to the sensor head in a similar manner. Note that the receptacle is under the handle.



Figure 3-5: Sensor cable connection to Sensor Head

- The system power cable connects from the 4-pin receptacle on the Control Module to the XLR connector on the AC Adapter (Figure 3-6).



Figure 3-6: Fully assembled Conquest SL showing cable connections.

7. The DVL rests on a Support Stand to hold it at an angle for easier viewing (Figure 3-7).

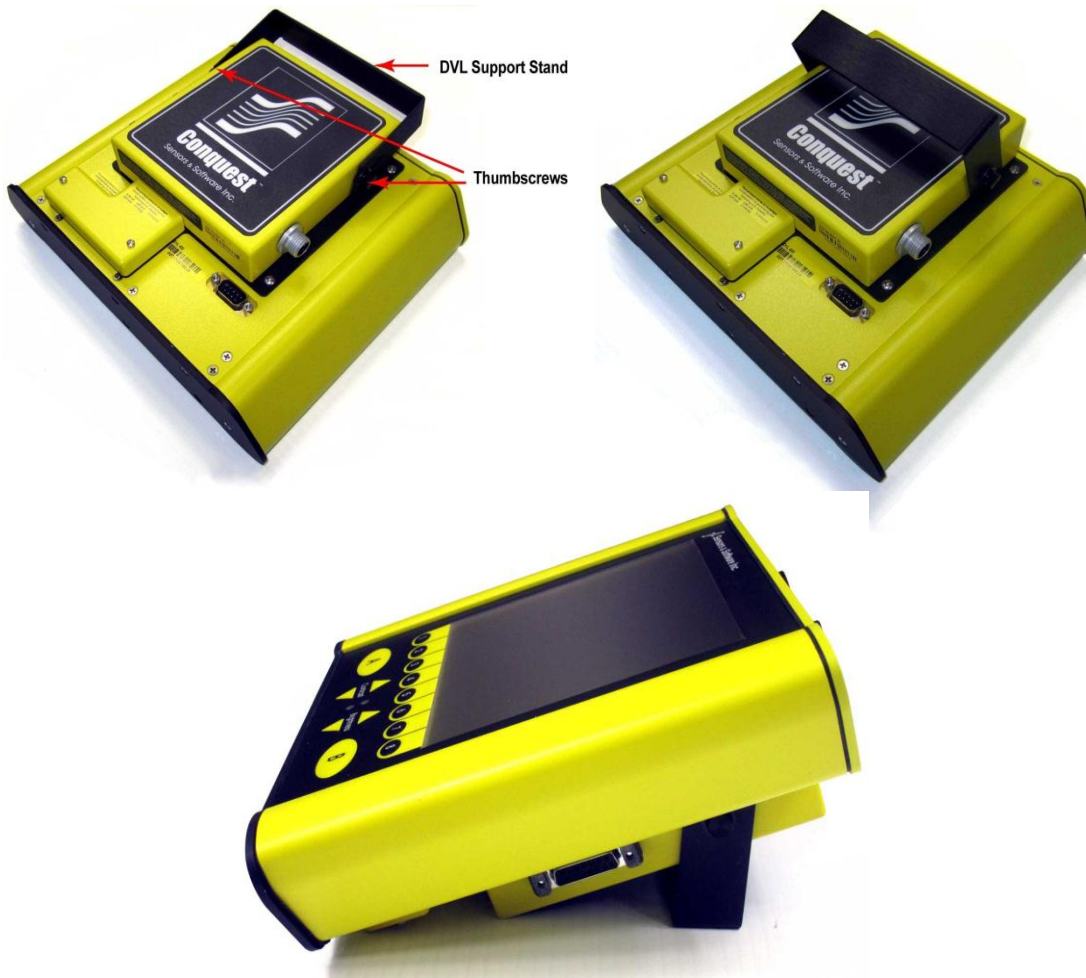


Figure 3-7: Loosen the thumbscrews on the Control Module, rotate the Support Stand into position and re-tighten the screws. The Support Stand angles the DVL for easier viewing.

3.2 Optional Accessories



Figure 3-8: Available optional items for Conquest SL include a 12 Volt battery, handle and DVL Carrier.

3.2.1 Battery

Conquest SL can be powered by the optional 12 Volt rechargeable battery. Connect the round 4-pin cable on the system power cable to the receptacle on the side of the battery (Figure 3-9).



Figure 3-9: Optional battery connection to power cable.

3.2.2 Handle

The optional handle allows the operator to stand up during data collection on floors.

Retract the spring-loaded knobs on the end of the handle, align with the two holes at the back of the Sensor Head and release them to lock into position.



Figure 3-10: Connecting the optional handle to the Sensor Head allows data collection to be performed from a standing position.

There is an additional set of handle mounting holes which can be used under unique circumstances such as scanning a vertical surface, or in confined spaces when pulling the sensor head towards the user may be preferable to pushing it.



Figure 3-11: The optional handle can also be attached to the Sensor Head using the holes in the front. This mounting position can make it easier to scan walls or complete surveys in situations where pulling the Sensor Head is preferable to pushing it.

3.2.3 DVL Carrier

For convenience during data acquisition, especially when using the handle, the DVL can be carried using the optional DVL Carrier shown in Figure 3-12.

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



Figure 3-12: The DVL can be attached to the optional DVL Carrier for hands-free operation. The DVL can be adjusted to optimize the view angle.

3.3 Digital Video Logger (DVL)

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

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

3.3.1 Menu Buttons

The yellow buttons labeled 1 to 8 correspond to numbered menu choices that appear on the screen or along the bottom of the screen when the DVL is turned on.

In addition, there are two general-purpose buttons labeled A and B. All buttons are DVL application-dependent and roles change based on the currently displayed menu. The function of each button will be self-explanatory from the display screen.

3.3.2 Screen

The DVL screen is a color LCD with adjustable brightness and contrast controls.

3.3.3 Brightness

The yellow Brightness control arrows are used to increase and decrease the screen brightness. For example, increasing the Brightness setting may improve the visibility of the screen when in a dark area. Note, however, that increasing the screen brightness also increases power consumption.

3.3.4 Contrast

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

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

3.3.5 Compact Flash Card

The DVL saves data to internal memory but also has a slot in the top for a removable compact flash card. The user can purchase a compact flash card to transfer data from the DVL to a computer. While normal flash cards may work, it is best to purchase an industrial grade compact flash card with higher transfer rates and temperature ranges. SanDisk, PSI-APRO, SimpleTech, Kingston, Viking, and Pretech are a few manufacturers of compact flash cards.

A card reader is also necessary to transfer data from the compact flash card to a PC.

Both compact flash cards and card readers are widely available in consumer electronics stores.



Figure 3-13: The DVL has a removable compact flash drive for data storage.

The removable compact flash drive is accessible by opening the door on the top of the DVL.

Ensure the DVL is powered down before removing or inserting the compact flash card. The card can become corrupted or irreversibly damaged and data can be lost if the card is removed while the DVL is powered up.

Loosen the two thumbscrews on the top of the DVL slightly to allow the door to rotate and insert the card into the card slot.

When a removable card is present, the data can be copied to the removable card using the **Export** function accessible from the **Tools** menu (Section 9.1).

3.3.6 DVL Temperatures

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

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

3.4 Powering Up Conquest

After the system is completely assembled, power it up by plugging the AC Adapter cable into a 110-240 volt AC power source or connecting to the optional 12 Volt battery. If the system is powered properly, a red LED on the front of the DVL will illuminate.

Turn on the system by pressing any button on the DVL keypad. Note that this **MUST** be done on the DVL Keypad and not the Sensor Head Keypad. After the system is powered on, the second red LED on the DVL should illuminate.

If the battery voltage is low, the light will flash for about 30 seconds and go out. If the light flashes or does not appear, check the AC adapter or battery connections. If using a battery, make sure it is fully charged.

Once the main menu is displayed on the DVL screen (Figure 5-1), you are ready to begin scanning with Conquest SL!

4 Menu Navigation

Conquest is controlled using menus. To navigate through the menus, select and modify settings, use the buttons on the DVL or the Sensor Head Keypad.

4.1 DVL Buttons

4.1.1 Horizontal Menus



Figure 4-1: Example of a screen with a horizontal menu.

Press the numbered DVL button (1–8) under the menu option on a horizontal menu. Selecting a menu option with a sub-menu will display the sub-menu. For example, pressing the 4 button under the **Tools** option on the main menu brings up the Tools sub-menu (Figure 4-1).

For horizontal menu options that do not have a sub-menu, a red box appears around the button when initially pressed to indicate that it has been selected. Once an item on a horizontal menu is selected (red), change the setting by pressing the button underneath the menu item again. This will toggle through all the available settings for that option. For example, the **Units** option changes from **Imperial** to **Metric** as the button underneath is pressed. If you continue to press the button, the options wrap around to the beginning.

4.1.2 Vertical Menus



Figure 4-2: Example of a screen with a vertical menu.

Press the numbered DVL button that corresponds with the number beside the vertical menu item. A red box appears around the currently selected item.

Once an item on a vertical menu is selected (red), change the setting by pressing the same numbered button again. This will toggle through all the available settings for that option. If you continue to press the button, the options wrap around to the beginning.

4.1.3 A and B Buttons

Pressing the **A** and **B** buttons provides special functionality for some menu items. For example, pressing **B** when the **Scan #** button is selected, increments the scan number by 10.

4.1.4 Exiting a Sub-Menu

To exit from a sub-menu and move up a menu, select the **Exit** button.

4.2 Sensor Head Buttons

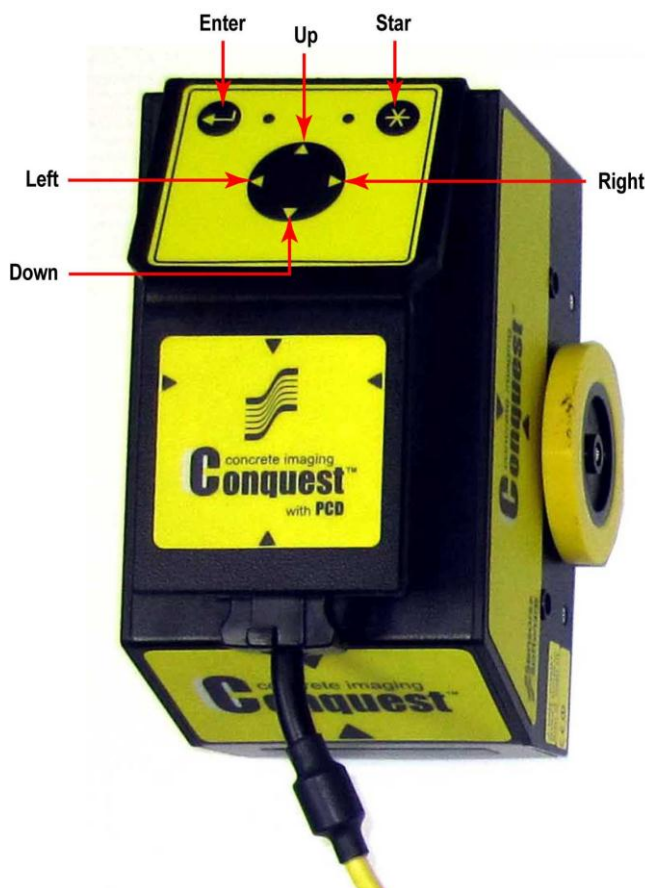


Figure 4-3: Navigate through the menus using the buttons on the Sensor Head keypad.

4.2.1 Horizontal Menus

Use the Left and Right arrow buttons to move between menu options on a horizontal menu. A red box appears around the currently selected item.

Once an item on a horizontal menu is selected (red), change the setting using the Up and Down arrows.

4.2.2 Vertical Menus

Use the Up and Down arrow buttons to move between menu options on a vertical menu. A red box appears around the currently selected item.

Once an item on a vertical menu is selected (red), change the setting using the Left and Right arrows.

4.2.3 Enter Button

Pressing the **Enter** button (Figure 4-3) selects the current menu item to move into a sub-menu or change the setting for that option. For example, pressing **Enter** while the **Tools** button is selected moves into the **Tools** sub-menu while pressing **Enter** on the **PCD Tools** option toggles the value from 50 to 60 Hz.

4.2.4 Star (*) Button

Pressing the **Star (*)** button (Figure 4-3) provides special functionality for some menu items. For example, pressing **Star (*)** when the **Color** button is selected turns the **Filter** on and off.

4.2.5 Exiting a Sub-Menu

To exit from a sub-menu and move up a menu, select the **Exit** button and press **Enter**.

5 Main Screen

The main screen is shown in Figure 5-1.



Figure 5-1: The Conquest SL main menu.

The following sections provide details on each main menu option.

The main screen also provides the following information:

Date/Time – changed under **Tools** (Section 9.4).

Power Supply Voltage – Conquest requires a minimum of 11.0 Volts to properly run. The system will shut down when the battery voltage reaches about 10.2 Volts. If using a battery, the voltage indicator can be helpful for identifying when the battery needs to be recharged.

DVL-embedded software version – This indicates the current revision of the Conquest SL embedded software. New versions are installed by copying an installation to a Compact Flash card, inserting it into the DVL, and powering it on. Contact Sensors & Software for details.

5.1.1 Powering Off Conquest

To power off the Conquest system, select the **Power Off** button on the main menu (Figure 5-1).

6 Line Scan

Line Scan mode is useful for reconnaissance surveys to get an idea of what lies inside the concrete before starting a grid survey. **Line Scan** allows the operator to acquire data along a straight line and examine it as a cross-section image.

In **Line Scan** mode, the objectives are:

- a) to confirm if the system is “seeing” into the concrete;
- b) to obtain a sense of the site structure;
- c) to assess the orientation of any rebar mats;
- d) to get an idea of the depth of exploration.

Line Scan mode can be used to identify the alignment of subsurface features. This makes it possible to select the optimum orientation for positioning the survey grid mat for detailed **Grid Scan** imaging.

Simple Line Scans do not always provide a good sense of the spatial distribution of the features at complex sites. Grid Scans permit you to create images to clearly define where objects are in relation to one another, allowing for more efficient planning of cutting and drilling sites.

To collect a Line Scan, select **Line Scan** from the main menu (Figure 5-1). A cross-section image of the last saved data line will be displayed. If no data has been saved, a screen with demonstration data and the menu will be shown (Figure 6-1).

Position the Sensor Head at the start of the line, understanding that data is collected based on the center of the Sensor Head (Figure 7-5).

Select **Scan** to begin data collection. The screen should go blank except for a depth scale visible on the right edge of the screen. As the Sensor Head is pushed along a straight line, the cross-section image scrolls onto the screen from the right and moves to the left. The data will scroll as fast as you move. It is best to go at a uniform slow speed because irregular motion may reduce data quality.

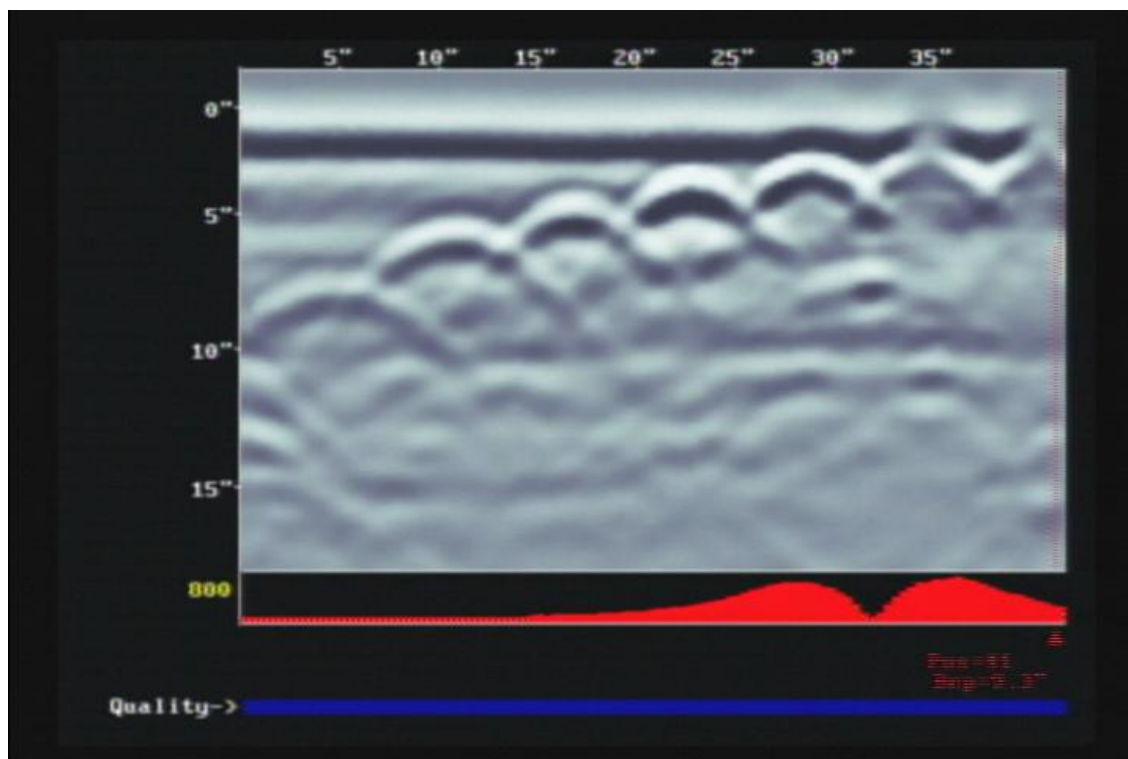


Figure 6-1: The Line Scan screen. The Line Scan image is displayed with a position scale along the top, and a depth scale based on the current Concrete Type on the left. The PCD response is plotted as a red graph underneath with the maximum scale value (in nT) displayed as a yellow number on the left.

From the Principles of Operation (Section 2), you will have a sense of the information that you will see on the screen. Flat boundaries such as the bottom of the concrete will appear as flat bands and localized features such as rebar and conduits will appear as inverted V's.

Any length of Line Scan can be collected, however, only the last 6.4 m (21 ft) can be saved (Section 6.7.1). When a Line Scan exceeds this length, the Sensor Head will beep.

6.1 Depth and Position Scales

The depth scale along the side of the cross-section image and the position scale along the top of the image are set to Metric or Imperial units based on the setting in the **Tools** menu (Section 9.2).

6.2 DynaQ Index Bar

Conquest uses DynaQ, an advanced patented technology that adjusts data quality as the Sensor Head movement speed varies. In most situations, moving the Sensor Head at a comfortable speed generates data of good quality. In situations where target resolution or maximum penetration depth is critical, moving slower increases data quality.

As the Line Scan data scrolls on the screen, the DynaQ Index Bar is displayed along the bottom of the screen (Figure 6-1). The color of the bar indicates the quality of the data at that point along the line:

White = No Data (too fast!)
Yellow = normal quality
Light blue = better quality
Dark Blue = highest quality

In general, avoid collecting data at extremely high rates of speed. The system senses if the Sensor Head is moved too quickly and will beep twice to indicate that a data quality issue has been detected.

6.3 Back-up Indicator

Line Scan mode incorporates a unique back-up feature. Move the Sensor Head backwards and cross-hairs will appear over the collected data and keep moving to the left on the screen as long as you are moving backwards (Figure 6-2).

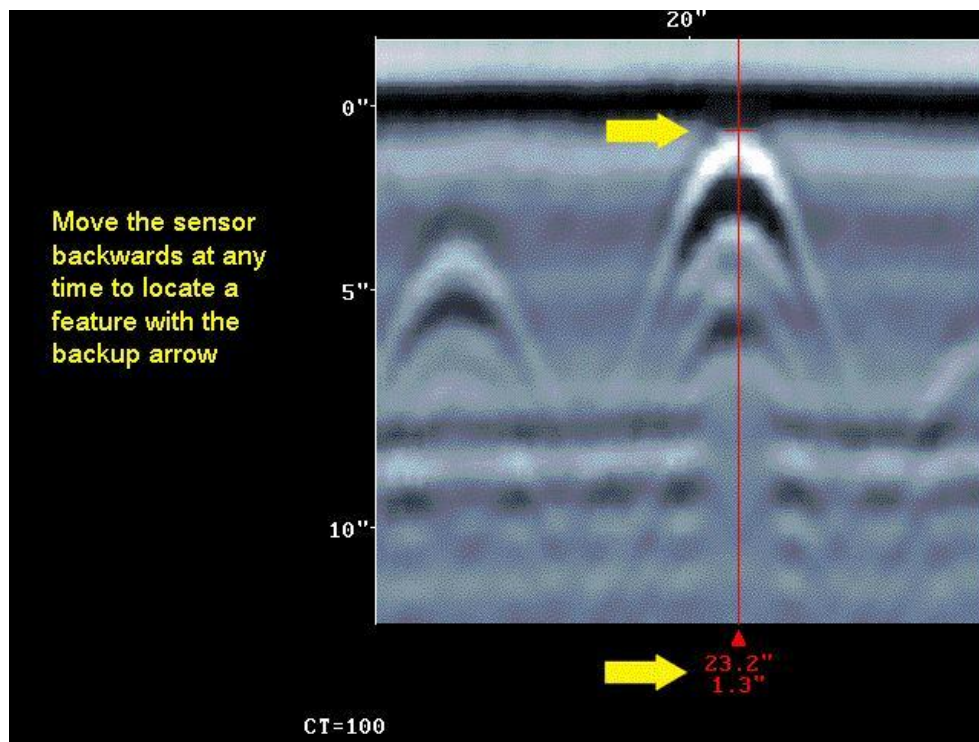


Figure 6-2: Line Scan mode data display. Moving the Sensor Head backwards during data collection displays a Back-up indicator, used to pinpoint the position and approximate depth of an object (depending on the accuracy of the Concrete Type value).

For example, if you pass an object in the concrete, simply roll the Sensor Head back along the same path until the red line appears exactly over it. The object is located at the center of the Sensor Head. You can mark the position of the object on the surface and continue data collection.

The position along the line and the depth of the horizontal cross-hair is displayed under the image (Figure 6-2). To determine the depth of an object, move the horizontal cross-hair up using the **Up** arrow key or DVL **1** button or move the horizontal cross-hair down using the **Down** arrow key or DVL **2** button until it lines up with the top of the highest band in the response from the object.

Move the Sensor Head forward again and the arrow moves to the right. New data will not be collected until you reach the point where you stopped and backed up.

6.4 Adding Fiducial Markers

Fiducial Markers can be added to the Line Scan image by pressing the **Star (*)** key or DVL **B** button during data collection.

Fiducial Markers are used to indicate significant positions on the line, for example, when crossing an object that is visible on the surface or the change from one surface material to a different one.

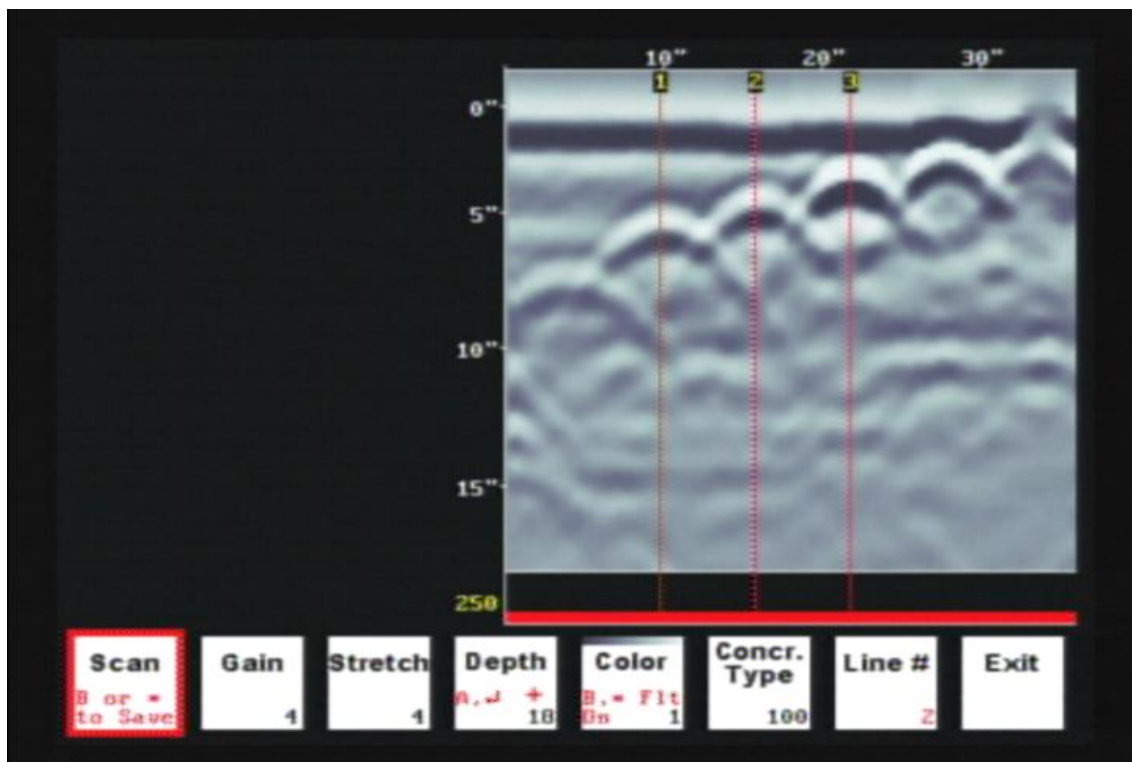


Figure 6-3: Fiducial Markers are added to the Line Scan image to indicate significant positions or objects.

Fiducial Markers can be added when the Sensor Head is actively collecting data while being pushed forward or when using the Back-up Indicator.

6.5 PCD (Power Cable Detector) Response

The PCD response is displayed as a red graph under the Line Scan image (Figure 6-1). The PCD graph indicates the strength of the magnetic field produced by AC current flowing near the sensor (Section 2.6). Strong peaks may indicate the presence of a cable with flowing AC current.

The PCD scale is plotted in nanoteslas (nT) and defaults to 250. If the magnetic field exceeds 250 nT during collection, data above 250 nT is clipped off. When the Line Scan is stopped, the PCD data are re-plotted at a vertical scale adjusted for the peak response with the maximum scale value displayed as a yellow number on left (Figure 6-3).

6.6 Stopping Line Scan

Stop the current Line Scan by pressing the **Enter** key or DVL **A** button. The data GPR and PCD data are re-displayed and a menu appears along the bottom of the screen that allows the user to modify the current image (Figure 6-4).

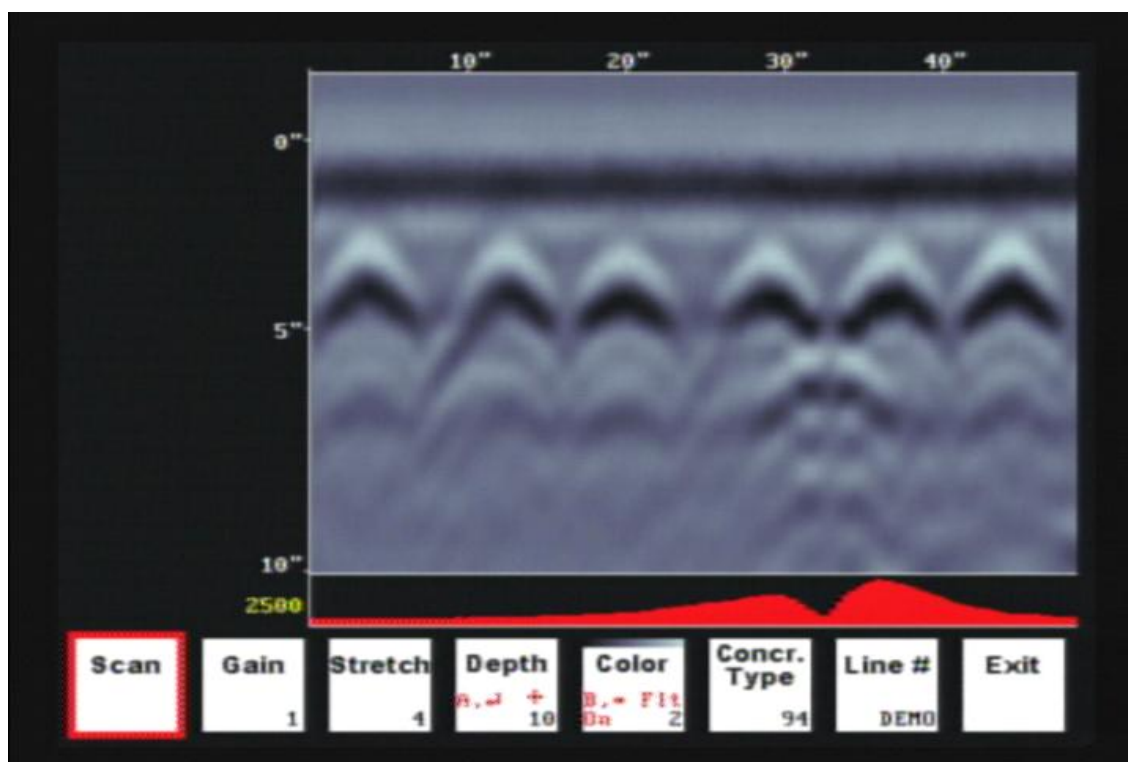


Figure 6-4: Stopping the Line Scan opens a menu to modify the Line Scan image.

6.7 Line Scan Re-Display Menu

When a Line Scan is ended by pressing the **Enter** key or DVL **A** button, the data is re-displayed and a menu appears along the bottom of the screen that allows the user to modify the current image.

6.7.1 Saving Line Scan Data

Line Scan data are saved by pressing the **Star (*)** key or DVL **B** button when the red selector box is located on the **Scan** button. The number on the **Line #** button turns from red to black and the Save option on the **Scan** button disappears to indicate that the line is saved.

Once a line has been saved, the delete (Del) option appears on the **Line #** button. Any saved line can be deleted by selecting the **Line #** button, using the **Up** and **Down** arrows or DVL **7** button to change the line number to the desired one and then pressing the **Enter** key or DVL **A** button.

Line Scan data are saved to a maximum line length of approximately 6.4 m (21 feet). If a Line Scan is longer than this length, only the last 6.4 m (21 feet) is saved.

6.7.2 Gain

Gain is used to amplify the signal strength to enhance weak features in the data image.

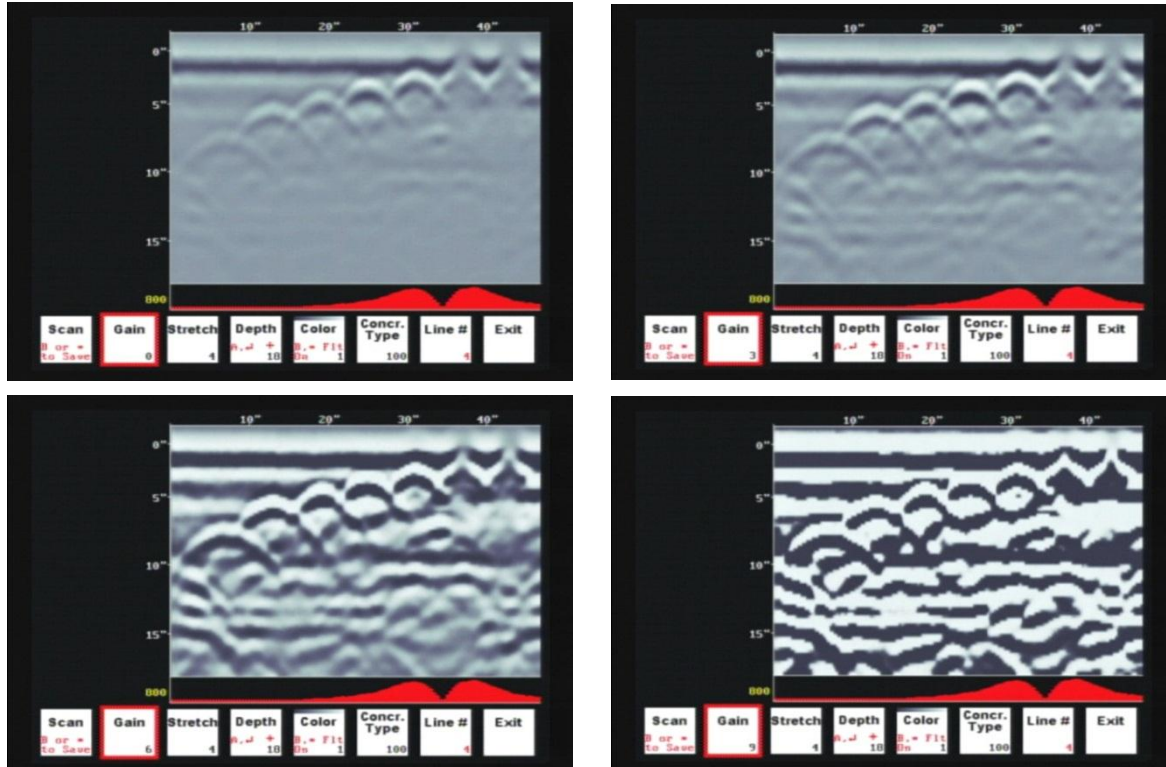


Figure 6-5: Gain is used to amplify the signal to enhance the weaker targets. Cross-section images with gain values of 0, 3, 6, and 9 are shown.

Gain values vary from 0 to 9 with 0 meaning that no amplification has been applied and 9 meaning that maximum amplification has been applied. The current gain is displayed in the lower right corner of the **Gain** button. Use the **Up** and **Down** arrow keys or DVL 2 button to change the **Gain** value.

Avoid over-gaining the data as it can make interpretation difficult.

6.7.3 Stretch

Stretch is used to expand or compress the horizontal scale. It varies from 1 to 8, the number indicating the width, in pixels, of each vertical data strip (trace).

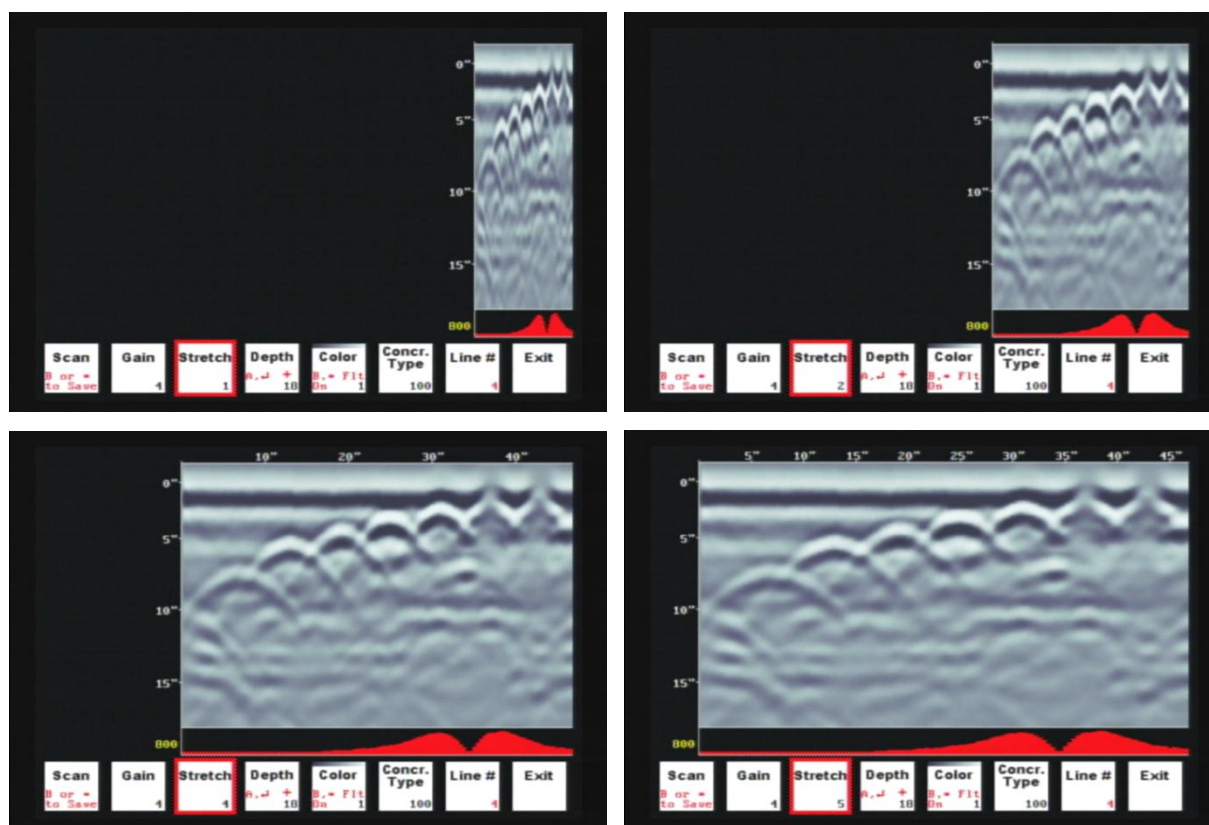


Figure 6-6: Cross-section images shown with Stretch values of 1, 2, 4, and 5.

A **Stretch** of 1 means that each GPR trace is plotted 1 pixel wide, so a total of 640 traces or 6.4m (21 feet) of data can be displayed on the screen at once. A Stretch of 1 is useful for showing the “big picture” to look for features that appear every few feet or the bottom of concrete.

A **Stretch** of 8 means that each trace is plotted 8 pixels wide, so a total of 80 traces or 0.8 m (2.6 feet) of data can be displayed on the screen at once. A high Stretch value “zooms in” on the data.

The current **Stretch** is displayed in the lower right corner of the **Stretch** button. Use the **Up** and **Down** arrow keys or DVL 3 button to increase or decrease the **Stretch** number.

6.7.4 Depth and Cross Hairs

The **Depth** button controls the maximum depth of GPR data displayed. Conquest always collects about 1000 mm (40 inches) of data, but the **Depth** value determines the maximum depth that is displayed on the cross-section image. **Depth** button values vary from 150 mm to 1000 mm in 50 mm increments (or 6 to 38 inches in 2 inch increments).

The current **Depth** value is displayed in the lower right corner of the **Depth** button. Use the **Up** and **Down** arrow keys or the DVL 4 button to change the value.

Pressing the **Enter** key or DVL A button displays cross-hairs on the cross-section image. The cross-hairs can be used to determine the position and depth of objects in the image. Use the Sensor Head **Left** and **Right** arrows (DVL 1 - 2 keys) to change the position and the **Up** and **Down** arrows (DVL 3 - 4 keys) to change the depth. The Position and Depth values at the location of the cross-hairs are displayed.

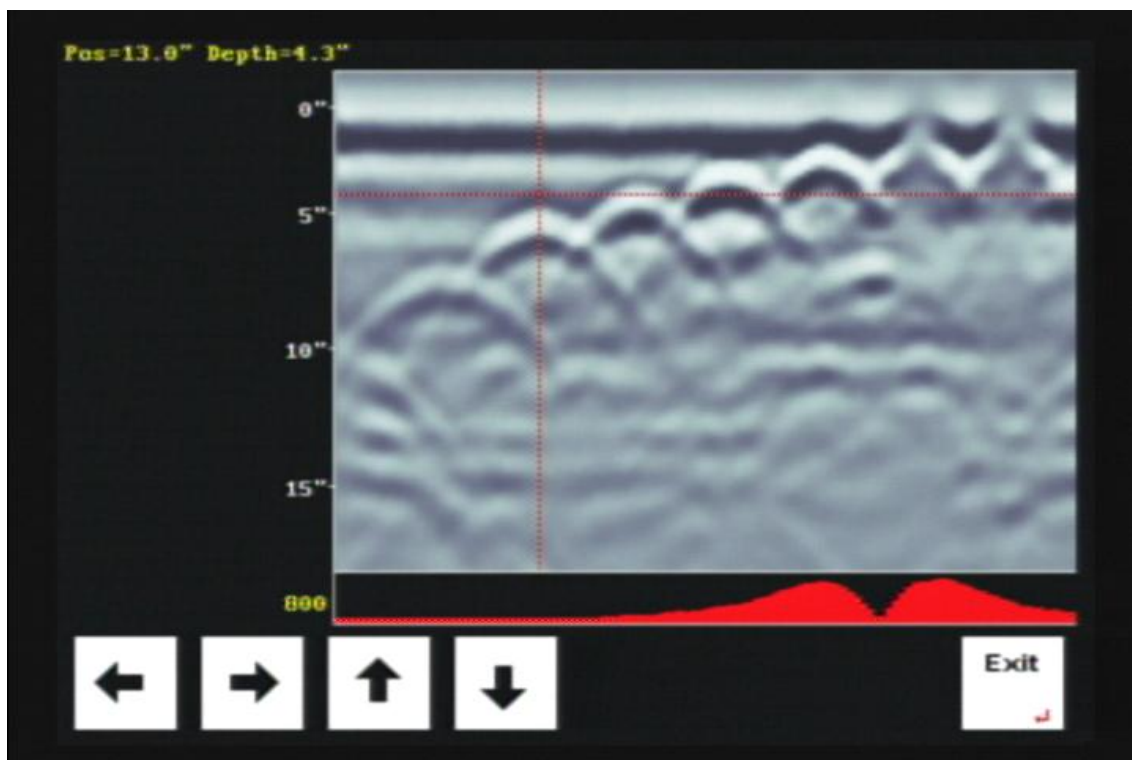


Figure 6-7: Cross-section image showing cross-hairs.

Turn the cross-hairs off by pressing **Enter** or the DVL 8 button.

6.7.5 Color

Color is used to change the color palette for the cross-section display. Conquest has 11 different color palette options.

The current color palette number is displayed in the lower right corner of the **Color** button. Use the **Up** and **Down** arrow keys or DVL **5** button to change the number. The image is automatically re-displayed as the color palette changes.

6.7.5.1 Filter

Pressing **Star (*)** or the DVL **B** button while the **Color** button is highlighted turns the **Filter** on and off.

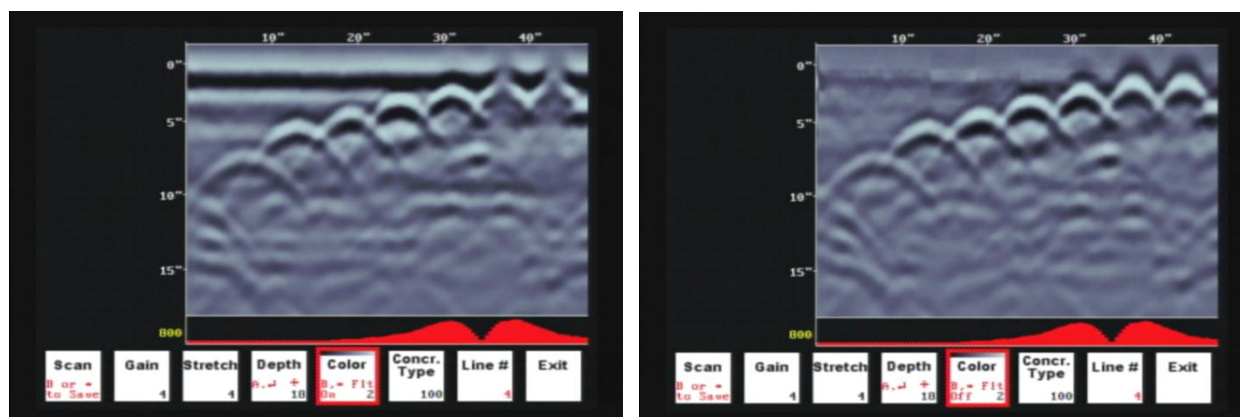


Figure 6-8: Cross-section images with no filter (left) and with the filter applied (right). The Filter removes flat-lying reflections and is especially useful for removing the strong surface reflection at the top of the data image to better reveal shallow objects.

When the filter is on, flat-lying responses in the data (like the surface reflection) are filtered out so that hyperbolic responses from objects like rebar and conduits are enhanced. The filter is especially useful for identifying the top of hyperbolic responses from shallow objects that are masked by the strong surface reflection. Avoid using the filter when looking for flat-lying features in the cross-section images such as the bottom of concrete.

6.7.6 Concrete Type

An accurate Concrete Type is critical for determining the depth of an object in the subsurface (Section 2.2).

The current Concrete Type is displayed on the **Concr. Type** button. The Concrete Type can be determined automatically or manually. First, select the **Concr. Type** button to open the Concrete Type sub-menu.

Manual: In the sub-menu, use the Sensor Head **Up** and **Down** arrow keys (DVL **1 – 2** buttons) to increase or decrease the Concrete Type number.

Automatic: In the sub-menu, press **Star (*)** or the DVL **3** button under **Auto**. The system processes the Line Scan data to determine the Concrete Type. The most accurate Concrete Type is determined from data with clearly defined hyperbolic responses.

As the Concrete Type changes, the image is re-displayed with a new depth scale. To accept the Concrete Type value, press the **Enter** key or the DVL **8** button.

Lines should NOT be used for the Concrete Type calculation if they have any of the following features:

1. Very shallow targets.
2. Targets that are not crossed at a 90° angle; crossing at an angle changes the shape of the hyperbola, resulting in a calibration value that is too high.
3. Data with no targets.
4. Complex data with multiple targets close together.

In these cases, the user should collect more lines to find a suitable one for determining the Concrete Type and then manually apply that value to other Line Scans in the same area.

6.7.7 Line

The **Line #** button is used to display saved Line Scan data. With the **Line #** button selected, use the **Up** and **Down** arrow keys or DVL **7** button to change the line number. The corresponding saved line is automatically displayed.

6.7.7.1 Delete Line

Once a line has been saved, the delete (Del) option appears on the **Line #** button. Any saved line can be deleted by selecting the **Line #** button, using the **Up** and **Down** arrows to change the line number, and then pressing the **Enter** key or DVL **A** button.

6.7.8 Exit

Select the **Exit** button to exit from Line Scan mode and return to the main menu screen.

7 Grid Scan

Grid Scans make images of concrete structures at various depths. Embedded features are revealed as deeper layers (or depth slices) of concrete are viewed.

The following is a simplified step-by-step approach that can be used to investigate a site using your Conquest system.

7.1 Define Area of Interest

The area of interest can be where you need to drill, cut, or where general information is desired for a variety of purposes. To make plan map / depth slice images, Conquest must acquire data in a grid pattern. The standard grids can be either metric or imperial units.

The five grid sizes available are:

| Imperial | Metric |
|-----------|-------------------|
| 24" x 24" | 600 mm x 600 mm |
| 48" x 48" | 1200 mm x 1200 mm |
| 24" x 48" | 600 mm x 1200 mm |
| 96" x 96" | 2400 mm x 2400 mm |
| 24" x 96" | 600 mm x 2400 mm |

Your specific site will dictate what is practical and where you can operate. In tight corners and spaces it may not always be possible to lay out a grid, which could limit the utility of Conquest in very confined spaces. In this case you may have to collect a partial grid (Section 12.4) or use **Line Scan** mode only (Section 6).

Before starting any work, you should obtain information about any construction practice that can help in your interpretation of the Conquest results. Remember that construction plans and drawings are just that: design plans! In construction, the implementation can deviate from the plan. Do not be surprised when your Conquest results show some differences from your expectations. This is a common occurrence.

7.2 Place Grid Mat

Use **Line Scan** (Section 6) to determine the optimum orientation for grids. For the best resolution of targets, the survey grid should be aligned perpendicular to any embedded objects in the concrete. If there are features which run at oblique angles, select the predominant orientation of the rebar for aligning the grid.

When positioning the grid mat, pick a reference point and then place the grid mat A1 corner on that mark. The best way to do that is to put a chalk mark, pin, or other indicator on the surface and then place the grid mat over top of it. This reference point should be fixed and documented so that you can locate the exact site after you have removed the grid mat.

The grid mat should be taped to the structure with duct tape to prevent it from moving during the grid scan.

7.2.1 Standard Grids

Conquest comes with a standard 24" x 24" grid mat or the metric equivalent (600 mm x 600 mm). This is the minimum suggested survey size for local area investigations.

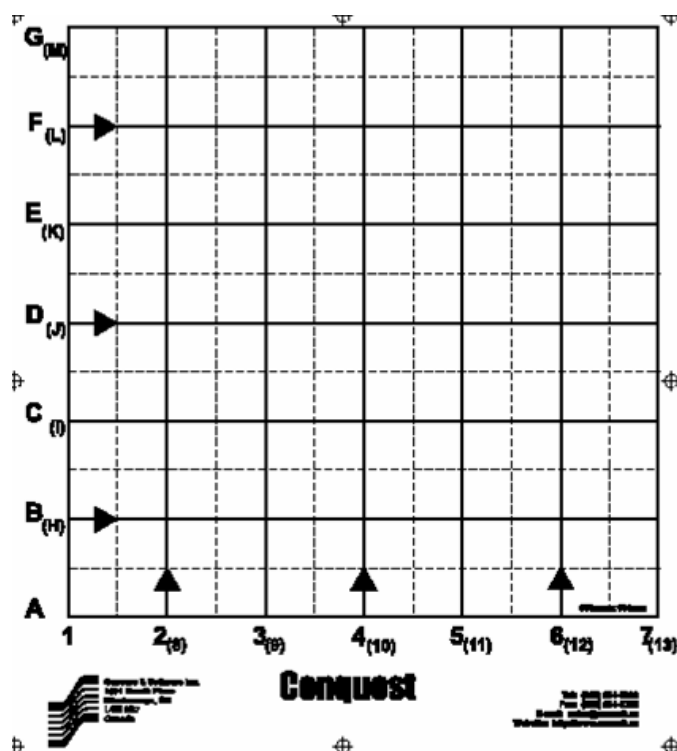


Figure 7-1: Grids are 24" x 24" or 600 x 600 mm. Alpha lines are labeled A, B, C etc. and Numeric lines are labeled 1, 2, 3 etc. and spaced 4 inches (or 100 mm) apart. High resolution lines are dotted and spaced every 2 inches (or 50 mm). Grids can be attached to make 48" x 24" (1200 x 600 mm), 48" x 48" (1200 x 1200 mm) and 96" x 24" (2400 x 600 mm) grids. The line names in brackets (8, 9, 10 etc. and H, I, J etc.) are used for larger grids.

The grid mats are labeled with numbers and letters. Survey lines which run up and down the sheet are labeled 1 through 7, and lines which run horizontally on the sheet are labeled A through G. These solid lines are spaced 4 inches or 100 mm apart and are used for normal resolution surveys. Dotted lines are shown halfway between these lines and are used in addition to the solid lines in high resolution surveys.

The lettering (Alpha lines) and numbering (Numeric lines) provides a grid coordinate system. This same coordinate system shows up on the images created by Conquest for easy reference back to the grid.

7.2.2 Larger Grids

Larger areas can be surveyed by taping multiple grid mats together to produce 48" x 24" (1200 x 600 mm), 48" x 48" (1200 x 1200 mm) or 96" x 24" (2400 x 600 mm) grids. 96" x 96" (2400 x 2400 mm) grids can also be collected, but the user must measure and mark this grid out.

On Conquest grid sheets, the line numbers past the edge of the first grid sheet are indicated on the second grid sheet mat in brackets. When joining multiple sheets, make sure they overlap such that the sheet edges won't catch the bottom of the sensor (Figure 7-2) and that the sequential numbers / letters are aligned.

Where possible, it is recommended that 48" x 48" (1200 x 1200 mm) size Grid Scans are completed to provide a better understanding of the concrete's internal features.

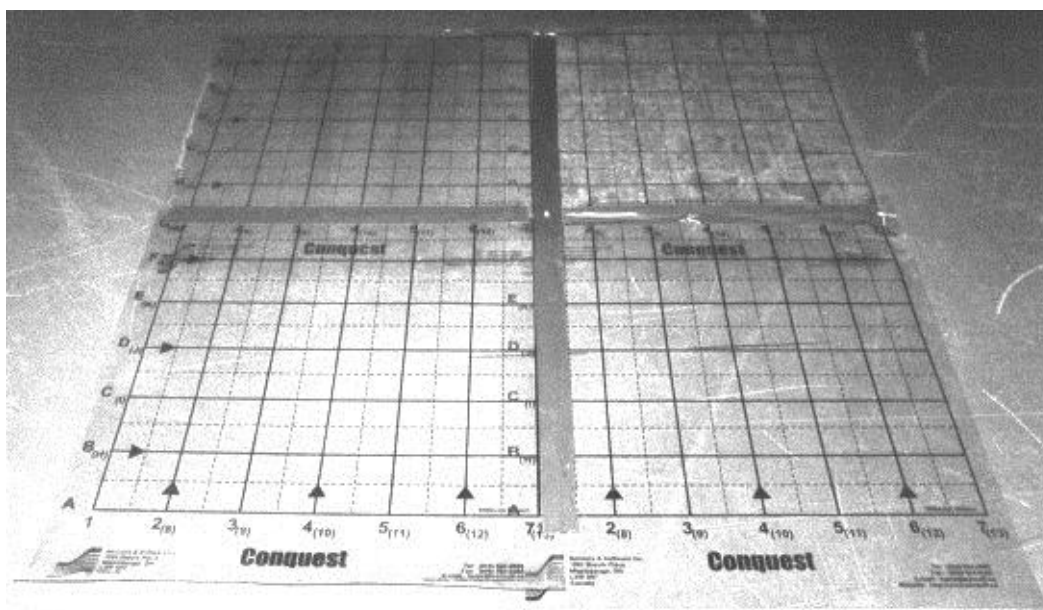


Figure 7-2: 4 Conquest Sheets taped down to make a 48" x 48" (1200 x 1200 mm) grid.

7.3 Grid Scan Parameters

Once you have your grid mat in place, you are now ready to acquire Grid Scan data.

Select the **Tools** option from the main menu screen to ensure that the desired units (Metric or Imperial) are selected (Section 9.2) and that the PCD option is set to the frequency appropriate for the geographic location, i.e. 60 Hz for North America and 50 Hz for Europe and Australia (Section 9.5.3).

Exit from the Tools menu back to the main menu.

From the main menu (Figure 5-1), select **Grid Scan**. The grid parameter screen is displayed (Figure 7-3).

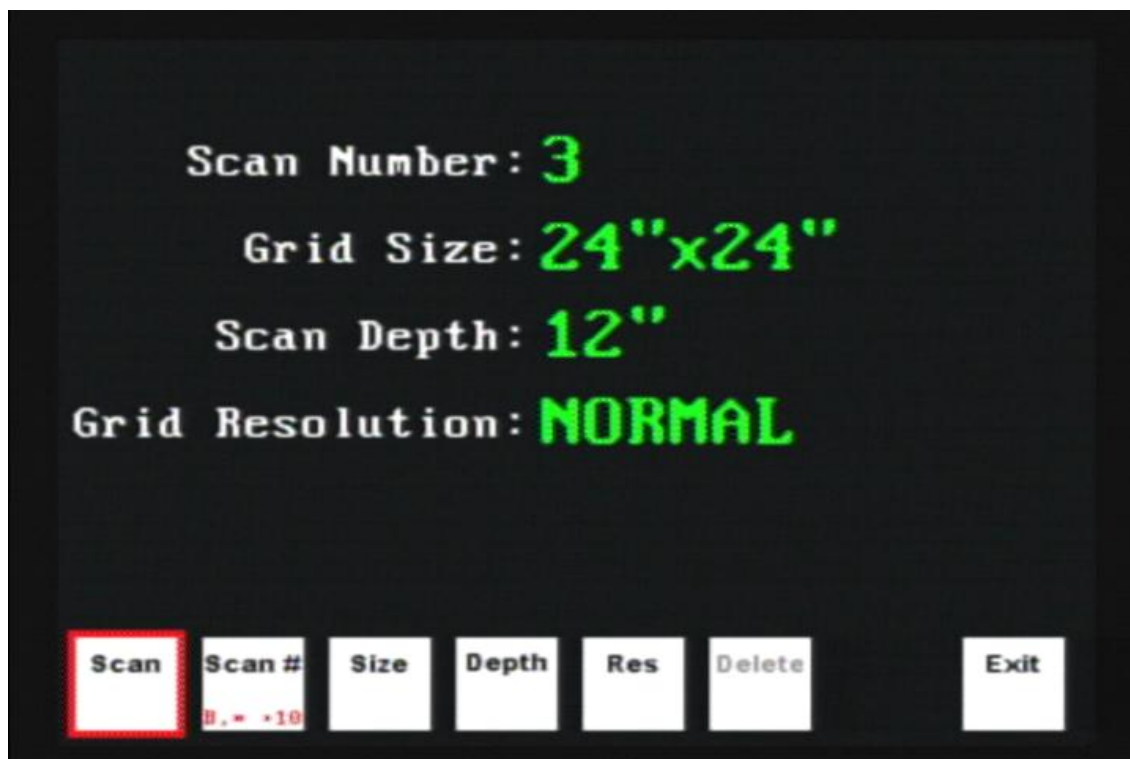


Figure 7-3: Grid Scan Parameters menu

7.3.1 Scan Number

Grid Scans are numbered from 1 to 99. Scroll through the Scan Numbers by selecting the **Scan #** button and then using the **Up** and **Down** arrows or DVL **2** button to change the number. You can move through the scan numbers more quickly by pressing the **Star (*)** button or DVL **B** key to increment by 10's.

If the Grid Scan parameters are displayed in green, the scan number is available for a new grid. If the parameters are displayed in red, the grid has already been collected and has data in it. Selecting a grid with red parameters allows data collection to continue on an interrupted grid or the collected data to be modified by re-collecting one or more lines.

7.3.2 Grid Size

Conquest allows 5 different grid sizes:

| Imperial | Metric |
|-----------|-------------------|
| 24" x 24" | 600 mm x 600 mm |
| 48" x 48" | 1200 mm x 1200 mm |
| 24" x 48" | 1200 mm x 600 mm |
| 96" x 96" | 2400 mm x 2400 mm |
| 24" x 96" | 2400 mm x 600 mm |

Change the grid size by selecting the **Size** button and then using the **Up** and **Down** arrows or the DVL **3** button.

7.3.3 Scan Depth

Scan Depth controls the maximum depth of data displayed. Conquest always collects about 1000 mm (40 inches) of data, but the Scan Depth value determines the maximum depth that is displayed in the Slice View (Section 8). Note that Scan Depth can be changed even after the grid has been collected in case the operator wants to view more data.

Scan Depth varies from 150 mm to 1000 mm in 50 mm increments (or 6 to 38 inches in 2 inch increments).

Change the Scan Depth using the **Up** and **Down** arrow keys or the DVL **4** button.

7.3.4 Grid Resolution

Grid resolution options are **Normal** and **High**. Normal resolution grids acquire data on the solid grid mat lines labeled 1, 2, 3 etc. and A, B, C etc. spaced 100 mm (4 inches) apart (Figure 7-1). High resolution grids also acquire data on the dashed lines in-between. These lines are called 1h, 2h, 3h etc. and Ah, Bh, Ch etc.

Change the grid resolution using the **Up** and **Down** arrow keys or the DVL **5** button.

High resolution grids are recommended for complex situations where there are many objects in the survey grid or when objects are curving or changing direction. Note that it is possible to collect a grid at Normal resolution and later change it to High resolution and collect the High resolution lines.

7.3.5 Delete

To delete the current Grid Scan, select the **Delete** button.

7.3.6 Exit

To exit from grid scanning and return to the main menu, select the **Exit** button.

7.4 Surveying the Grid

Once you have established the parameters for the Grid Scan, you are ready to acquire data on the survey grid mat.

To start a Grid Scan, select the **Scan** or **Scan #** button from the Grid Scan Parameters screen (Figure 7-3) and press **Enter**. This opens the Grid Scan screen (Figure 7-4).

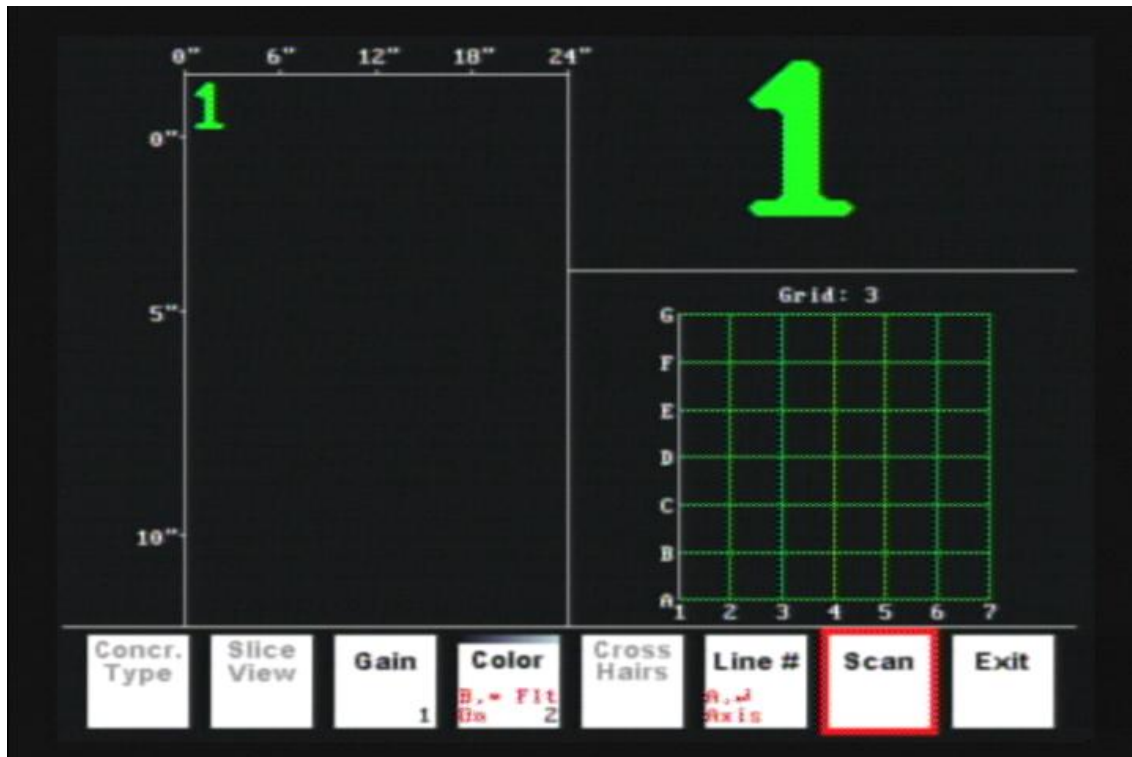


Figure 7-4: Grid Scan screen

The Grid Scan screen guides the user through proper data collection with 3 windows:

1. Top Right: Next line number to collect.
2. Bottom Right: Grid indicating the size of the grid, the lines that need to be collected (in green), the current line (in white) and the lines that have already been collected (in red).
3. Left: Cross-section display and number of the last line collected.

7.4.1 Positioning the Sensor

At the start of every grid line, it is important the sensor be properly positioned before pressing the Scan button. Measurements are based on the center of the sensor moving along the line.

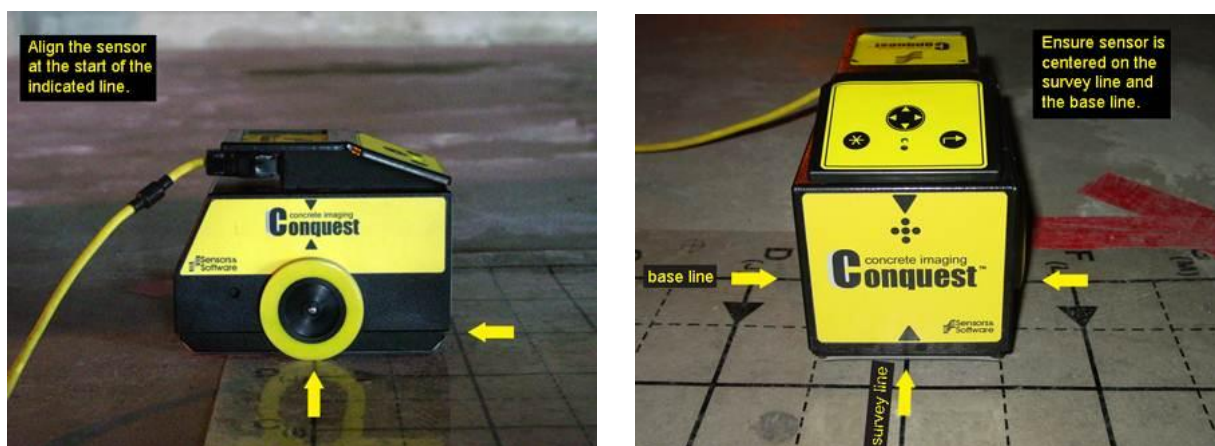


Figure 7-5: Properly position the Sensor Head on a grid line before scanning.

Position the center of the Sensor Head at the start of the line number indicated in green, using the arrows on the sides and top to center it on the base line and the arrows on the top and ends to center it on the line to be collected (Figure 7-5).

Always collect lines in the direction indicated by the arrows on the grid mat (Figure 7-1).

7.4.2 Collecting Grid Lines

Select **Scan**. The system will beep once when ready to collect the line. If the system beeps twice, it is not ready; try pressing **Scan** again with a lighter touch. Move the sensor along the survey line to the end. Move the sensor at a steady pace, keeping it centered on the grid line.

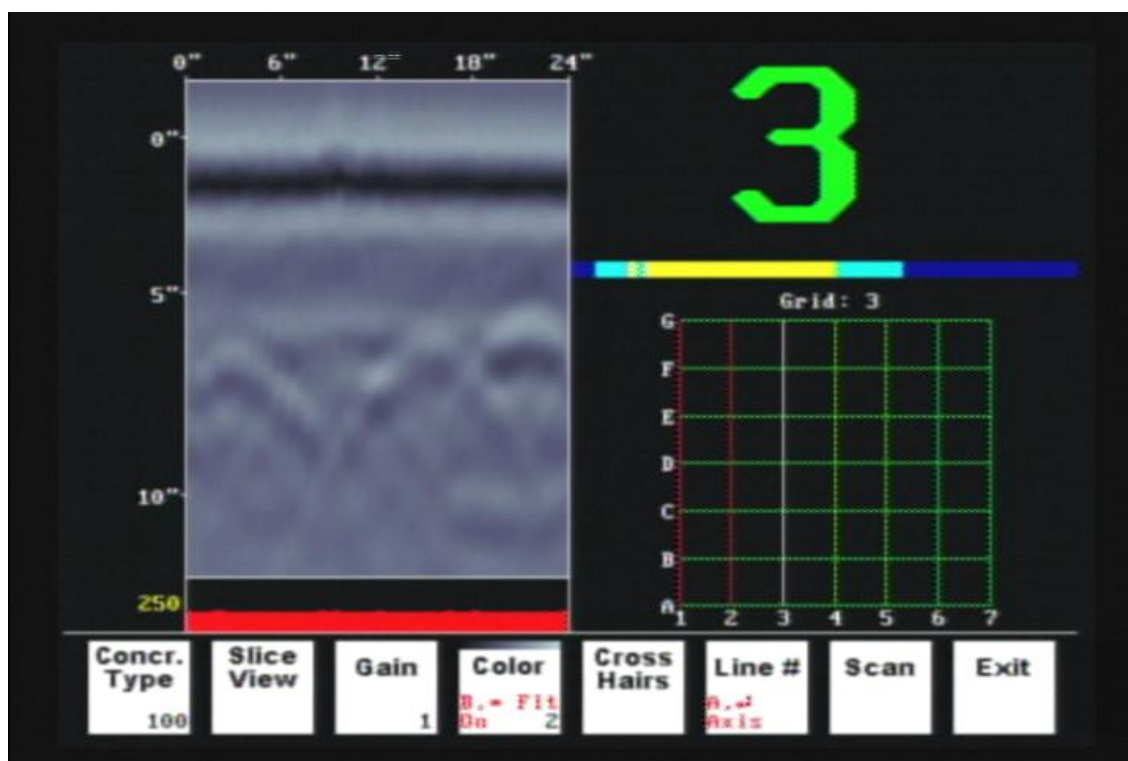


Figure 7-6: Grid Scan screen after finishing Line 2. Line 2 cross-section is displayed and Line 3 is next to collect. Completed lines are displayed in red on the grid image. The DynaQ Bar shows the quality of the data depending on the color. Higher quality data is dark blue.

7.4.3 Progress and DynaQ Bar

As a grid line is collected, a progress bar is displayed on the screen, indicating how much of the line still needs to be collected.

The progress bar is colored based on the DynaQ index (Figure 7-6). Conquest uses DynaQ: an advanced patented technology that adjusts data quality as the Sensor Head movement speed varies. In most situations, moving the Sensor Head at a comfortable speed generates data of good quality. In situations where target resolution or maximum penetration depth is critical, moving slower increases data quality.

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

White = No Data (too fast!)
Yellow = normal quality
Light blue = better quality
Dark Blue = highest quality

In general, avoid collecting data at extremely high rates of speed. The system will beep twice to indicate that a data quality issue has been detected. The survey line number will then flash in red, indicating that the line should be recollected.

7.4.4 Finishing a Line

The system will beep twice and line collection will end automatically once the end of the line is reached. If it does not end within a short distance of the end of the line, calibrate the odometer wheel to improve accuracy (Section 9.5.2).

In situations where the line must be stopped before the end of the grid is reached, either because the grid is smaller than the selected grid size or if there is an obstruction in the grid, press **Enter** or the DVL **A** key.

When a line has been completed, the cross-section is displayed on the left side of the screen along with the line number (now displayed in red because the line is complete).

The grid on the lower right now displays the completed line in red.

The next line number to collect is indicated in green on the screen. Continue collecting all lines until the grid is complete with all grid lines displayed in red.

7.4.5 Modifying Line Display

7.4.5.1 Concrete Type

An accurate Concrete Type is critical for determining the depth of an object in the subsurface (Section 2.2).

The current Concrete Type is displayed on the **Concr. Type** button. The Concrete Type can be determined automatically or manually. First, select the **Concr. Type** button to open the Concrete Type sub-menu.

Manual: In the sub-menu, use the **Up** and **Down** arrow keys or the DVL **1 – 2** keys to increase or decrease the Concrete Type number.

Automatic: In the sub-menu, press **Star (*)** or the DVL **3** button under **Auto**. The system processes the current Grid Scan line data to determine the Concrete Type. The most accurate Concrete Type is determined from data with good hyperbolic responses.

As the Concrete Type changes, the image re-displays with a new depth scale. To accept the Concrete Type value, press the **Enter** key or the DVL **8** button.

Lines should NOT be used for the Concrete Type calculation if they have any of the following features:

1. Very shallow targets.
2. Targets that are not crossed at a 90° angle; crossing at an angle will change the shape of the hyperbola, resulting in a calibration value that is too high.
3. Data with no targets.
4. Complex data with multiple targets close together.

In these cases the user should collect more Line Scans to find a suitable one for determining the Concrete Type and then manually apply that value to other Grid Scans in the same area.

7.4.5.2 Gain

Gain is used to amplify the signal strength to enhance weak features in the data image.

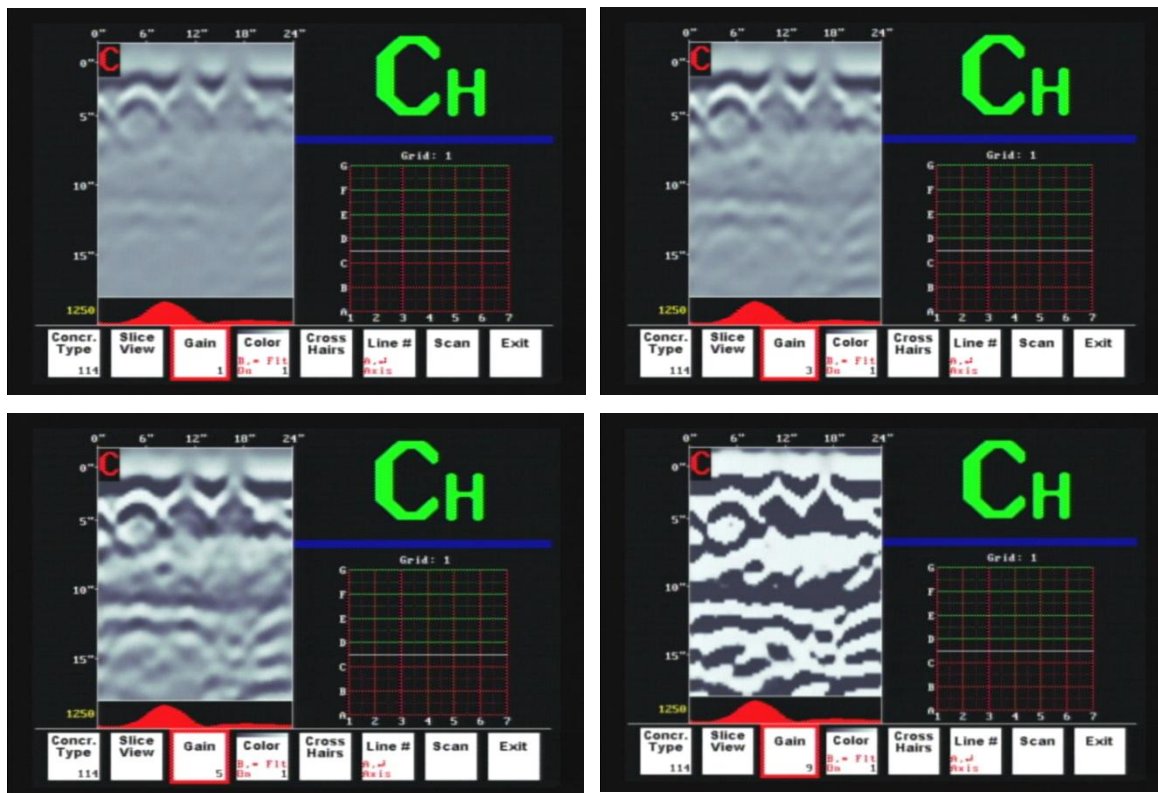


Figure 7-7: Grid Scan screen showing cross-section images with Gain values of 1, 3, 5 and 9.

Gain varies from 0 to 9 with 0 meaning that no amplification has been applied and 9 meaning that maximum amplification has been applied. The current gain is displayed in the lower right corner of the **Gain** button. Use the **Up** and **Down** arrow keys or the DVL **3** button to increase or decrease the gain number.

Avoid over-gaining the data as it can make interpretation difficult.

7.4.5.3 Color

Color is used to change the color palette for the data display. Conquest has 11 different color palette options.

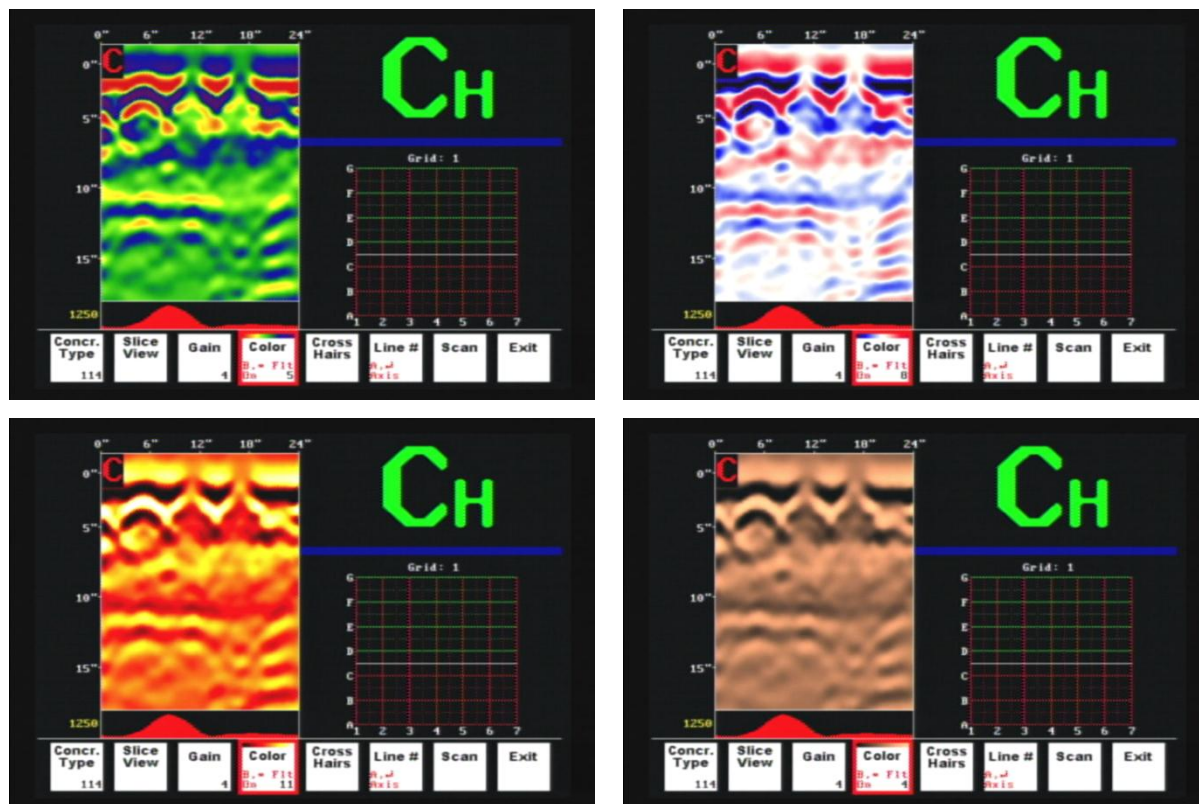


Figure 7-8: Grid Scan screen showing cross-section images with different color palettes.

The current color palette number is displayed in the lower right corner of the **Color** button. Use the **Up** and **Down** arrow keys or the DVL **4** button to change the number. The cross-section image is redrawn automatically as the color palette changes.

7.4.5.4 Filter

Pressing the **Star (*)** or DVL **B** turns the **Filter** on and off.

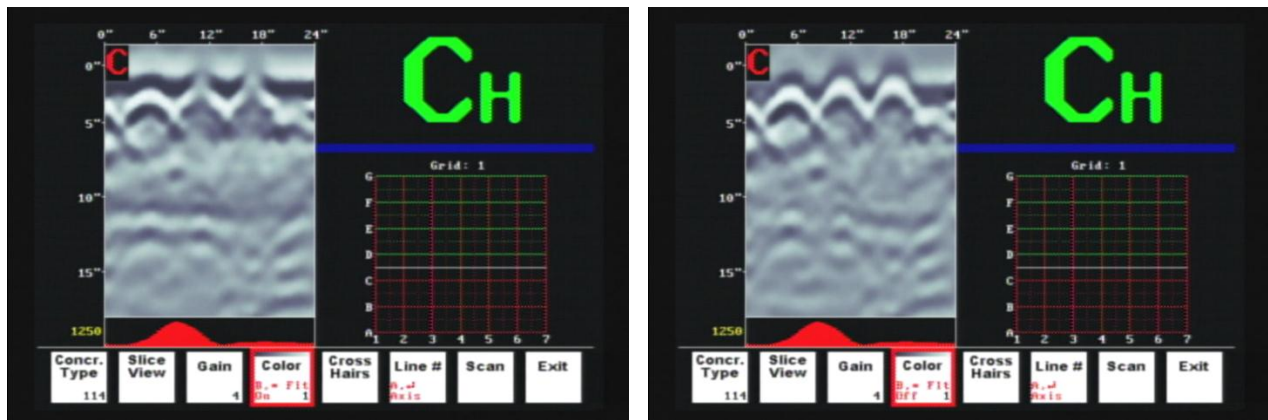


Figure 7-9: Grid Scan screen showing cross-section images with the no Filter (left) and with the Filter applied (right).

When the filter is on, flat-lying responses in the data (like the surface reflection) are filtered out so that hyperbolic responses from objects like rebar and conduits are enhanced. The filter is especially useful for identifying the top of hyperbolic responses from shallow objects that would otherwise be blocked by the strong surface reflection. Avoid using the filter when looking for the flat-lying features like the bottom of concrete in the cross-section images.

7.4.5.5 Cross Hairs

Selecting **Cross Hairs** displays cross-hairs on the data image. Cross-hairs can be used to determine the position and depth of objects in the data image. Use the **Left** and **Right** arrows or buttons to change the position and the **Up** and **Down** arrows or buttons to change the depth. The Position and Depth values at the location of the cross-hairs are displayed.

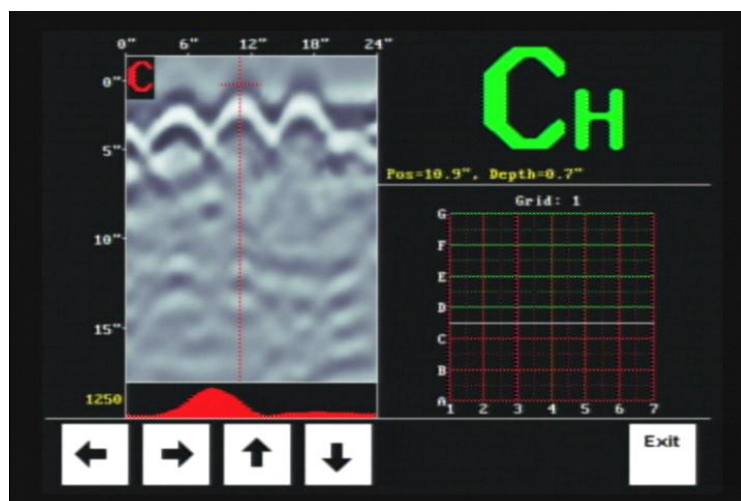


Figure 7-10: Grid Scan screen showing the cross-hairs to determine the position and depth of objects.

Turn the cross-hairs off by selecting **Exit** or pressing **Enter**.

7.4.6 PCD (Power Cable Detector) Response

The PCD response is displayed as a red graph under the cross-section image on the left. The PCD graph indicates the strength of the magnetic field produced by AC current flowing near the sensor (Section 2.6). Strong peaks may indicate the presence of a cable with flowing AC current.

The PCD scale is plotted in nanoteslas (nT). When a Grid Line is completed, the PCD data is plotted with a vertical scale adjusted for the peak response with the maximum scale value displayed (Figure 7-6).

7.4.7 Reviewing and Rescanning Grid Lines

The **Line #** button is used to review collected grid lines. With the **Line #** button selected, use the **Up** and **Down** arrow keys or the DVL **6** button to change the number. The corresponding line is automatically displayed.

Pressing **Enter** or the DVL **A** button toggles between Alpha and Numeric lines.

If, while reviewing lines, you see that a line was not collected properly (perhaps the start position is off or it was scanned too quickly), lines can be re-collected. With the **Line #** button selected, use the **Up** and **Down** arrow keys or the DVL **6** button to move to that line. Then, select the **Scan** button and re-collect the line.

7.5 Slice View Image Computation

A key feature of Conquest is its ability to transform the raw sensor information into a series of depth-based slice images in the material. In general, depth slice images are generated after all the lines in the grid have been collected, but images can also be generated when a partial grid has been collected. This is useful when the grid area is smaller than the grid mat or when part of the grid is obstructed and not all the lines can be collected.

Small grids can usually be processed in less than one minute. Larger grids may take several minutes.

It is not necessary to reprocess data every time you want to view it. Once a grid has been processed, the images are always immediately available by selecting **Slice View** from the main menu (Figure 5-1) or from the **Grid Scan** menu (Figure 7-4).

Any time the Concrete Type changes, the grid scan data should be reprocessed as this value affects image clarity and depth estimates.

While the GPR Depth Slice images are generated, the PCD data are processed to generate a PCD image that is displayed in the **Slice View** menu.

7.5.1 Concrete Type

A correct Concrete Type value is important to obtain clear depth slice images and accurate depth estimates. After a Grid Scan in complete and **Slice View** selected, the user is prompted to select the data to use for calculating the Concrete Type.

There are 5 options to calculate the Concrete Type and process the data into depth slices:

Automatic: Selecting **Alpha Lines**, **Num Lines** or **Combo: Alpha + Num** will automatically determine the Concrete Type using the alpha lines, numeric lines or a combination of both sets of lines (recommended, in most cases), and then process the grid data to produce depth slices.

To determine whether to use Alpha Lines or Num Lines instead of Combo, exit from the Concrete Type calculation and go to the **Line #** button and use the **Up** and **Down** arrows or **DVL 6** button to scroll through the data lines and find which set of lines has the best hyperbolas, preferably ones from targets that were crossed perpendicularly. Then, select the **Slice View** button and select the desired set of lines. If in doubt, select **Combo**.

Using Representative Data Line: Using the **Line #** button, use the Up and Down arrows to scroll through the data lines and find one that has one or more good hyperbolas, preferably ones from targets that were crossed perpendicularly. Then, select the **Concrete Type** button. In the sub-menu, press **Star (*)** or the **DVL 3** button under **Auto**. The system processes the current Grid Scan line data to determine the Concrete Type. The most accurate Concrete Type is determined from data with clearly defined hyperbolic responses. The Concrete Type number in the bottom right corner of the button will update. To use this Concrete Type to process the Depth Slices, move to the **Slice View** button and select **User**.

Manually: Select the **Concrete Type** button and, in the sub-menu, use the **Up** and **Down** arrows to change the Concrete Type to the desired value. To use this Concrete Type to process the Depth Slices, move to the **Slice View** button and select **User**.

Lines should NOT be used for the Concrete Type calculation if they have any of the following;

1. Very shallow targets.
2. Targets that are not crossed at a 90° angle; crossing at an angle will change the shape of the hyperbola, resulting in a calibration value that is too high.
3. Data with no targets.
4. Complex data with multiple targets close together.

In these cases the user can force the system to determine the Concrete Type using only the Alpha lines or the Numeric lines or even one specific, user-defined line.

8 Slice View

Slice View is usually accessed from the Grid Scan menu after grid data collection is complete, but if one or more grids have been previously collected and processed into depth slices, it can also be accessed from the main menu (Figure 5-1).

After a Grid Scan is complete and **Slice View** selected, the user is first prompted to select the data to use for calculating the Concrete Type (Section 7.5.1). Depth slices are then generated and displayed.

Initially, you may find it somewhat difficult to understand the plan view maps if you are not used to viewing 3D information, but working with Depth Slices generated by your Conquest system will quickly increase your expertise, knowledge, and proficiency.

There are 2 ways to display Grid Scan data:

- 1) The Multi-Slice display (Section 8.4.1) lets you slice up and down through the concrete volume in the vertical direction.
- 2) The 3D display (Section 8.4.2) lets you slice through the concrete volume in 3 directions (Alpha cross-section, Numeric cross-section and depth slice).

The best way to think of the depth slices are as photograph-like views from above. The rectangular regions to the bottom and the right should be thought of as cross-sections through the concrete in each direction at the positions of the cross-hairs (Figure 8-1).

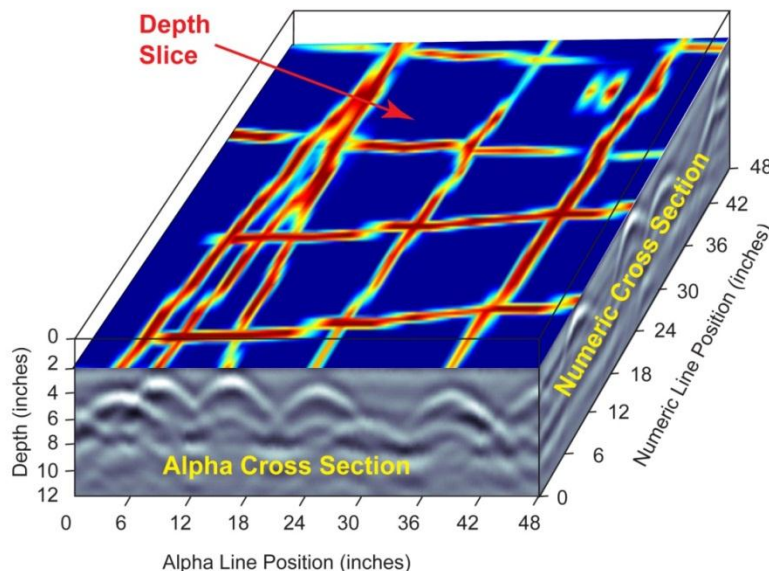


Figure 8-1: A conceptual Conquest Grid Scan image to understand the relationship between depth slice images, Alpha cross-section images and Numeric cross-section images.

8.1 Slice View Screen

The Slice View screen is shown in Figure 8-2.

The depth slice image displays the grid mat Alpha line letters on the left axis, the distance along the alpha lines on the top axis, grid mat Numeric line numbers on the bottom axis and the distance along the numeric lines on the left axis.

Along the bottom edge of the screen, Slice View displays the date and time the grid was collected, the Concrete Type used to process the grid data (Section 2.2), and if the IEP is off (Section 9.5.4).

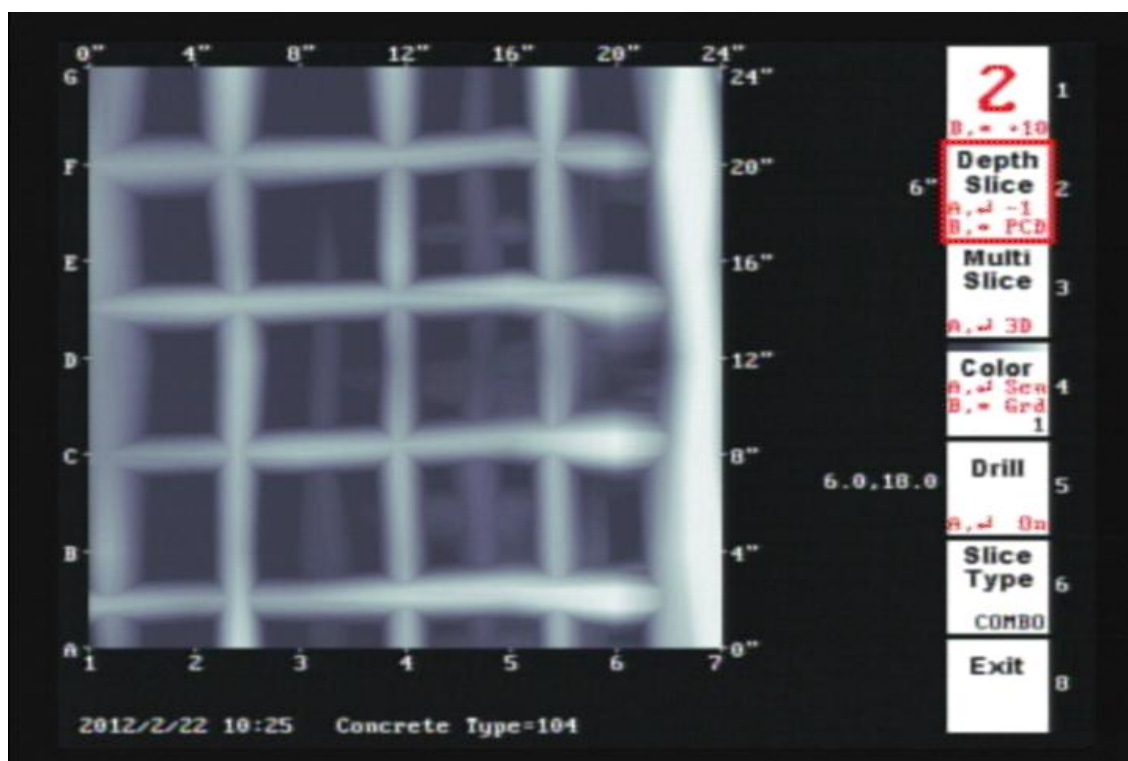


Figure 8-2: Slice View screen. The depth slice at the depth indicated is displayed. Axes around the image correspond to Alpha and Numeric grid lines and grid dimensions. The Concrete Type used to generate the depth slices is displayed below.

8.2 Grid Number

Grid Scans are numbered from 1 to 99. With the **Grid #** button selected, use the **Left** and **Right** arrows or the DVL **1** button to change the number. You can move through the Grid numbers quicker by pressing the **Star (*)** button or DVL **B** key to increment by 10s.

The corresponding saved grid is automatically displayed.

8.3 Depth Slice

Depth slices represent the plan map view looking down on the grid scan area (Figure 8-1).

Depth Slices are 25 mm or 1 inch thick, depending on the units selected (Section 9.2). The depth slice currently displayed is controlled by the Depth Slice button.

With the **Depth Slice** button selected, use the Sensor Head **Left** and **Right** arrows to change the depth slice image displayed. Or use the DVL **2** button to slice down to a deeper depth slice in the grid scan or slice up using the **Enter** key or DVL **A** button.

The depth value to the left of the button shows the depth to the TOP of the current slice displayed. For example, if the depth is 0", the current depth slice is from 0 to 1 inch.

8.3.1 Conquest Resolution

One of the first things to note when looking at depth slices is the resolution of Conquest. Features will show up with a minimum size of about 30 mm (1.5 inches). This is a fundamental limit of the transducer response characteristics. You should not interpret a Conquest feature to be fully representative of the dimension in the Depth Slice image. The object may be 1 inch in diameter or 1/8 of an inch in diameter but it still will result in a 1.5 inch wide event on the depth slice image. Be careful about interpreting sizes to features.

Scroll through the depth slices and look for patterns. Normally regular patterns of rebar will appear at different depths. Sometimes when a bar or conduit has a dip or a tilt, it will show up partially at one depth and then show up at another depth more clearly as the bar or conduit cuts down through the selected depth range.

8.3.2 PCD Image

Pressing the **Star (*)** button or DVL **B** key while the **Depth Slice** button is selected toggles the image between the Depth Slice image and the PCD image. The PCD image shows the locations of flowing electrical AC current within the grid area (Section 2.6).

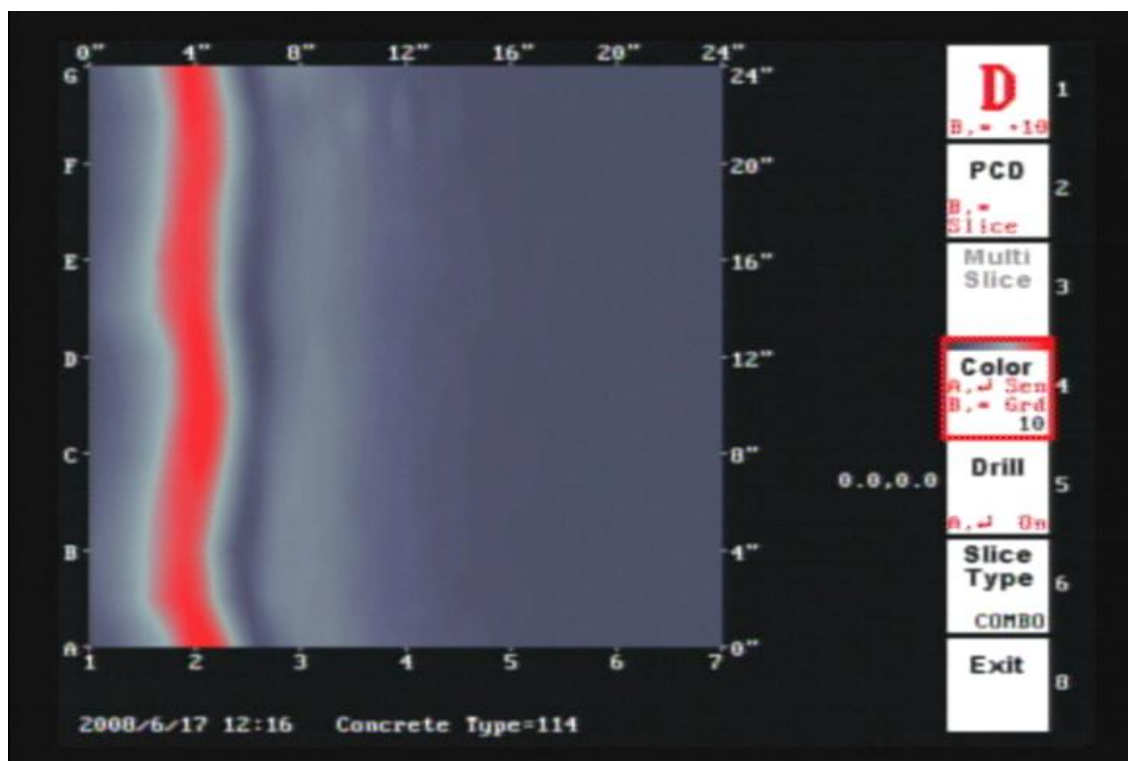


Figure 8-3: PCD Image.

Unlike depth slice images, the PCD image is a single image that is NOT associated with a specific depth range.

Notice that, similar to GPR responses from rebar and other objects described above, the PCD response is broad compared to the actual size of the cable. The width of the PCD response has no relation to the size of the cable. In fact, sometimes the PCD response from a cable can appear so broad in width that a 2' x 2' (600 x 600 mm) grid may not show the edges of the response and the whole image appears as one strong color. In this case it may be necessary to collect a larger grid to see the edges of the PCD response.

8.4 Data Display Types

8.4.1 Multi-Slice

The Multi-Slice option displays one or more depth slices on the screen at once, starting at the depth of the current Depth Slice (Section 8.3).

With the **Multi-Slice** button selected, use the **Left** and **Right** arrows or the DVL **3** button to change the number of depth slices from 1 to 4, 9, 16 or 25.

The range of depths displayed is written to the left of the Multi-Slice button. For example, if Depth Slice is set to 6" and 4 depth slices are displayed, the depth range is 6 – 9" (Figure 8-4).

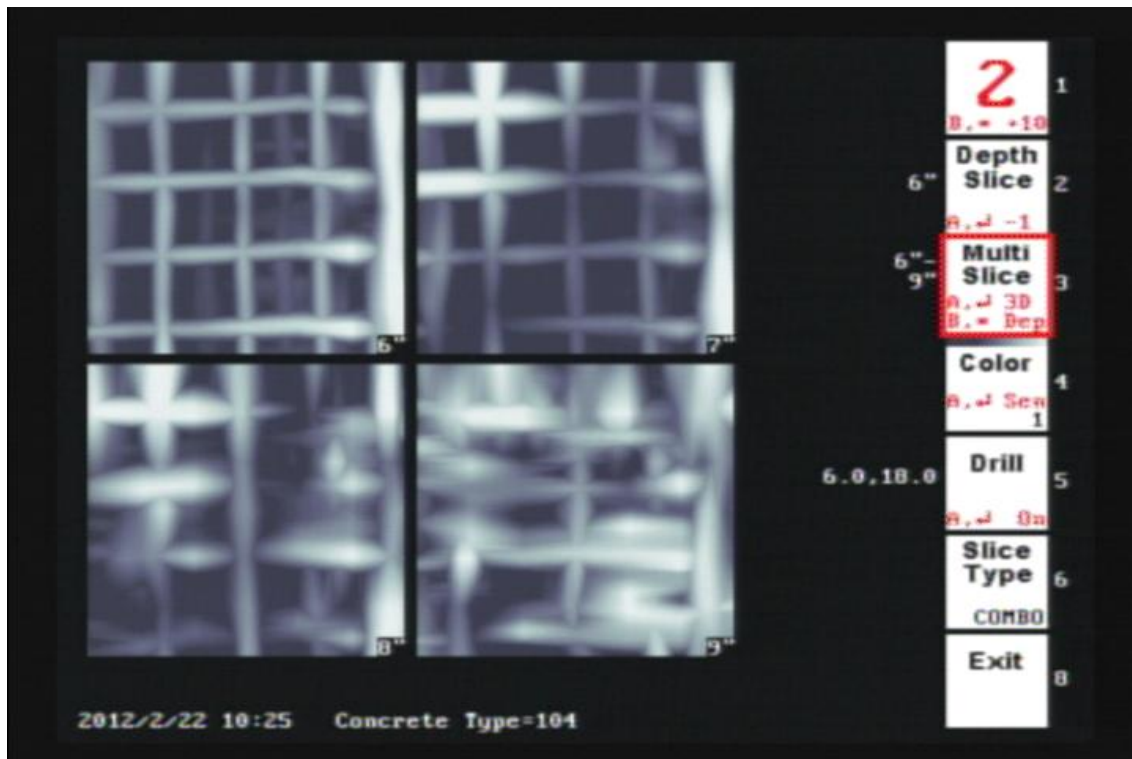


Figure 8-4: Multi-slice displays 1, 4, 9, 16 or 25 depth slices on the screen at once.

Pressing the **Star (*)** button or DVL **B** key while the Multi-Slice button is selected toggles the display of depth values in the bottom right corner of the depth slice images (Figure 8-4).

8.4.1.1 Drill Locator

With the **Drill Locator** button selected, use the **Enter** key or the DVL **5** button to turn on the Drill Locator. In the sub-menu, the Drill Locator can be moved around the depth slices to find the coordinates of a drill hole location that is free of objects. Move the drill locator using the **Up**, **Down**, **Left** and **Right** arrows.

As the drill locator is moved, the current location in the grid coordinate is displayed to the left of the Drill button. The first number is the distance in the Alpha line direction and the second number is the distance along the Numeric line direction.

Pressing the **Star (*)** button changes the diameter of the drill locator; the diameter is displayed to the left of the **Drill/Size** button.

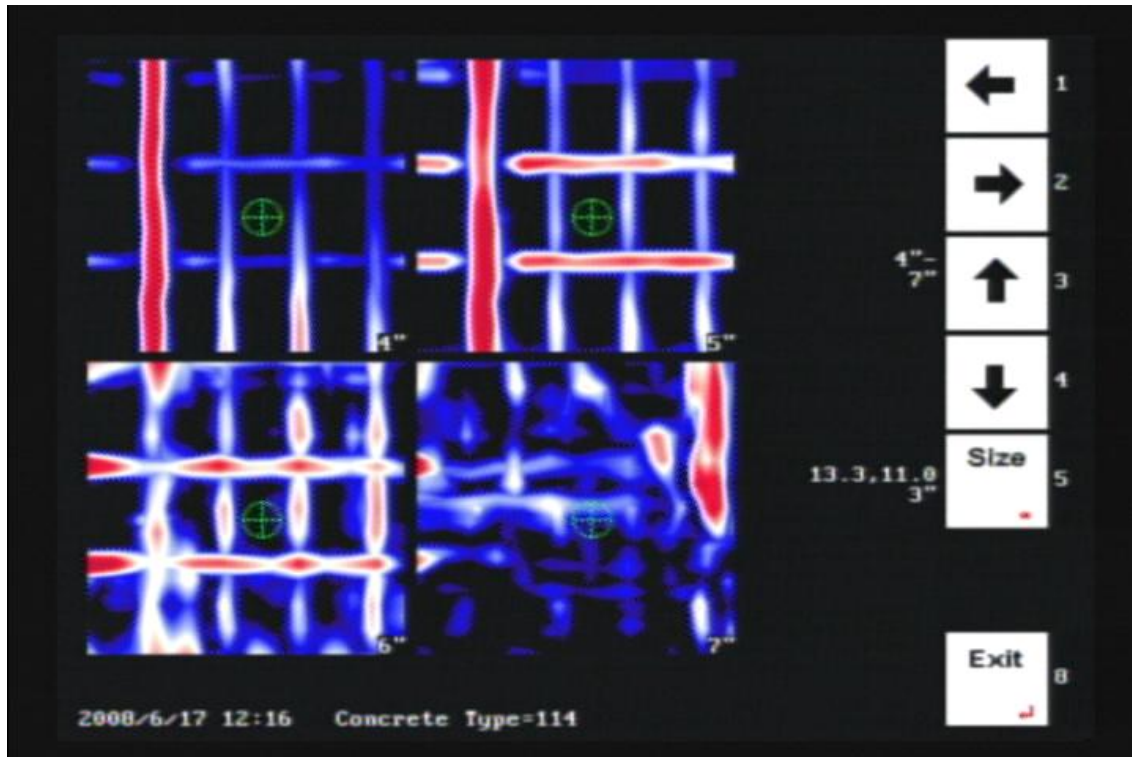


Figure 8-5: Depth Slice image showing Drill Locator tool.

When the drill locator is on, the user can exit from the drill locator sub-menu and move to other buttons and modify the image, (for example, changing the number of depth slices displayed or changing the depth slice to the PCD image). The drill locator will always be visible in the data image(s).

To turn the drill locator off, with the **Drill** button selected, press the **Enter** key or the DVL **A** button.

8.4.2 3D View

Pressing the **Enter** key or DVL **A** button while the Multi-Slice button is selected toggles the image between the Multi-Slice image and the 3D image (Figure 8-6).

On the 3D image, the depth slice image is displayed in the upper left corner and represents the plan map view looking down on the grid scan area (Figure 8-6). The images to the right of and below the depth slice image are the Numeric and Alpha cross sectional views through the Grid

Scan, defined by the red cross-hairs on the depth slice. Conceptually, the cross-section views are like looking at the sides of the cube (Figure 8-6).

The display allows you to view any pair of cross section images on the sides of the 3D view. This is very instructive because you can see both the lateral position and the depth as you learn how to use the three views.

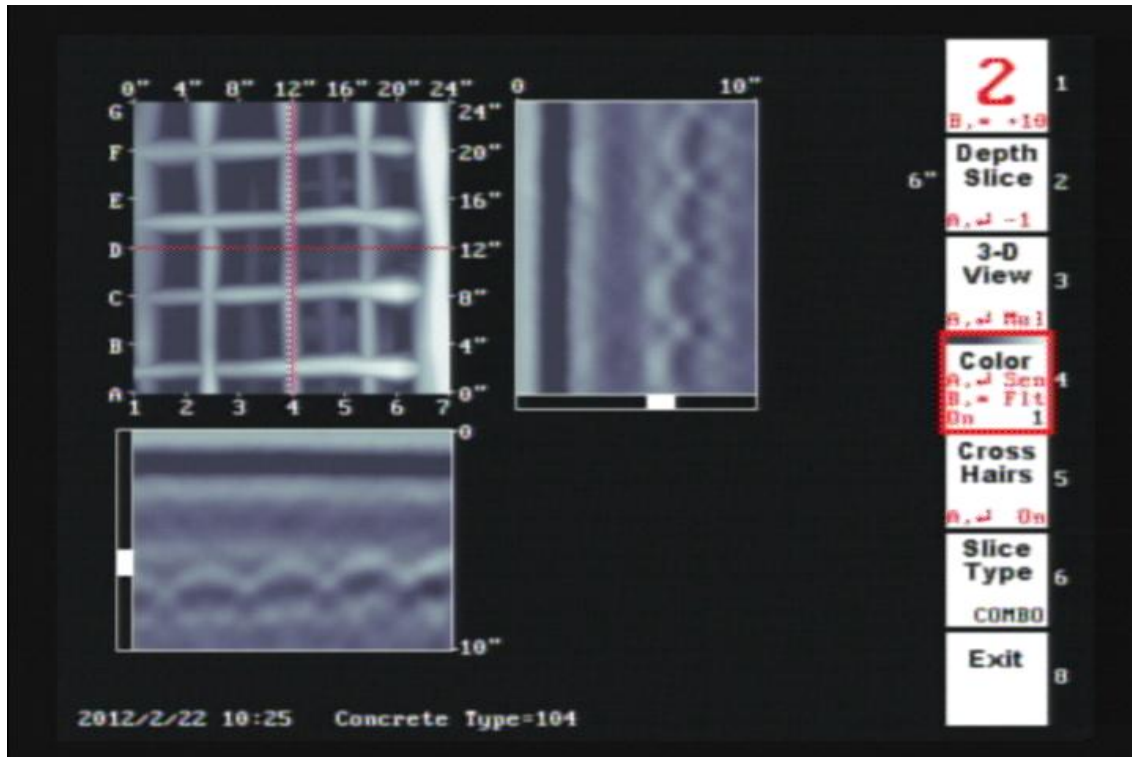


Figure 8-6: 3D image of concrete as displayed by Conquest.

To change the current depth slice, select the **Depth Slice** button using the **Up** and **Down** arrow keys or the DVL **2** button and then use the **Left** and **Right** arrow keys or DVL **2** button to move up and down through the grid scan. Slice up using the DVL **A** button.

As the depth slice changes, the white sliders on the sides of the cross-sections move to indicate the depth of the current depth slice (Figure 8-6).

8.4.2.1 Cross-Hairs

The grid position of the current Alpha cross-section displayed under the depth slice is indicated by a red horizontal line on the depth slice image.

The grid position of the current Numeric cross-section displayed to the right of the depth slice is indicated by a red vertical line on the depth slice image.

With the **Cross Hairs** button selected, use the **Enter** key or the DVL **5** button to turn on the cross-hairs. Enabling the cross-hairs allows the user to move to different Alpha and Numeric

cross-sections in the 3D view. In the sub-menu, move the cross-hairs using the **Up**, **Down**, **Left** and **Right** arrows. As the cross-hairs are moved, the corresponding cross-sections change.

To exit from the cross-hairs, press the **Enter** key or the DVL **8** button.

8.5 Color

Color is used to change the color palette for the data display (Depth Slice or PCD). Conquest has 11 different color palette options. The current color palette number is displayed in the lower right corner of the **Color** button.

To change the current color palette, with the **Color** button selected, use the **Left** and **Right** arrows or the DVL **4** button.

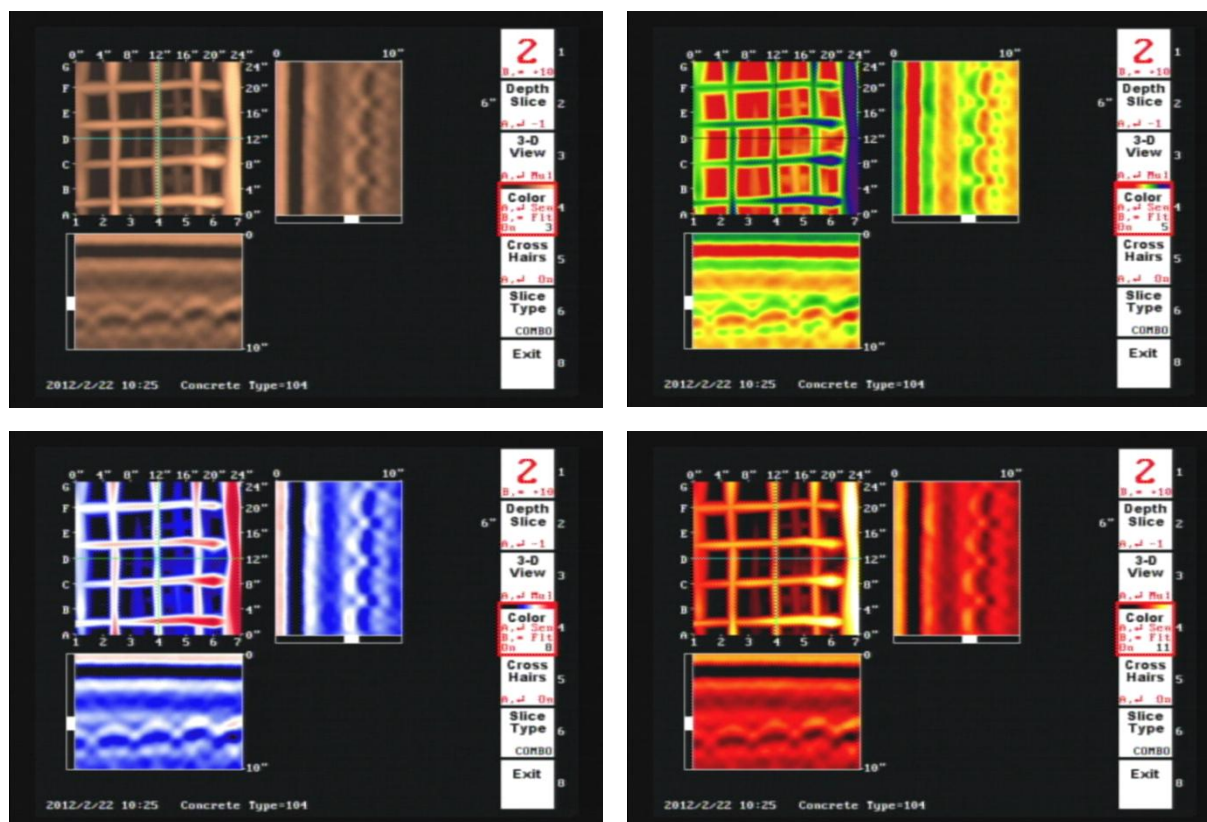


Figure 8-7: Some of the color palettes available in the 3D View.

8.5.1 Grid

When the Grid Scan is displayed in a Multi-Slice view (Section 8.4.1) with a single depth slice visible on the screen, Alpha and Numeric grid mat lines can be superimposed on the depth slice by pressing the **Star (*)** key or the DVL **B** button. The grid option makes it easy to see the location of an object with respect to the grid lines.

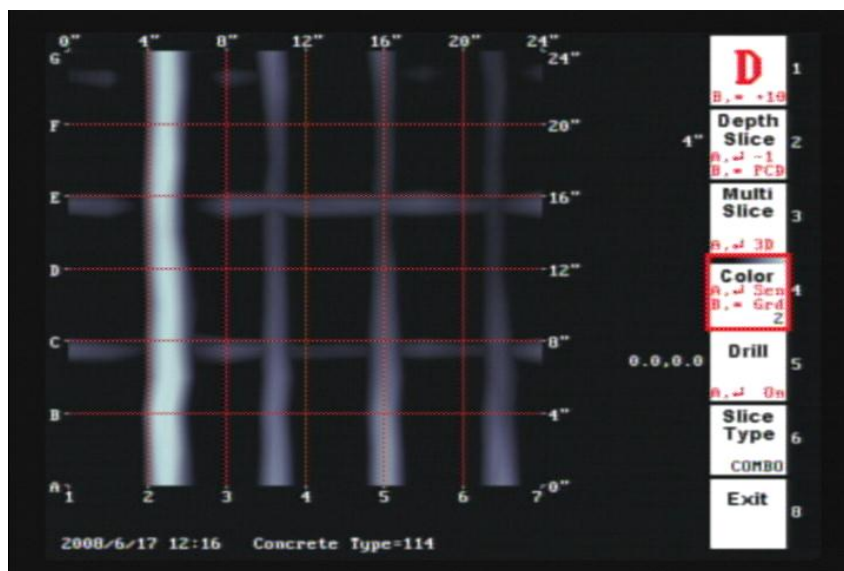


Figure 8-8: Depth slice image showing Grid tool.

8.5.2 Sensitivity

Pressing the **Enter** key or DVL **A** button when the Color button is selected toggles between normal and high sensitivity display. Displaying with higher sensitivity is useful for revealing weaker targets in the concrete, like non-metallic conduits which can sometimes be difficult to see.

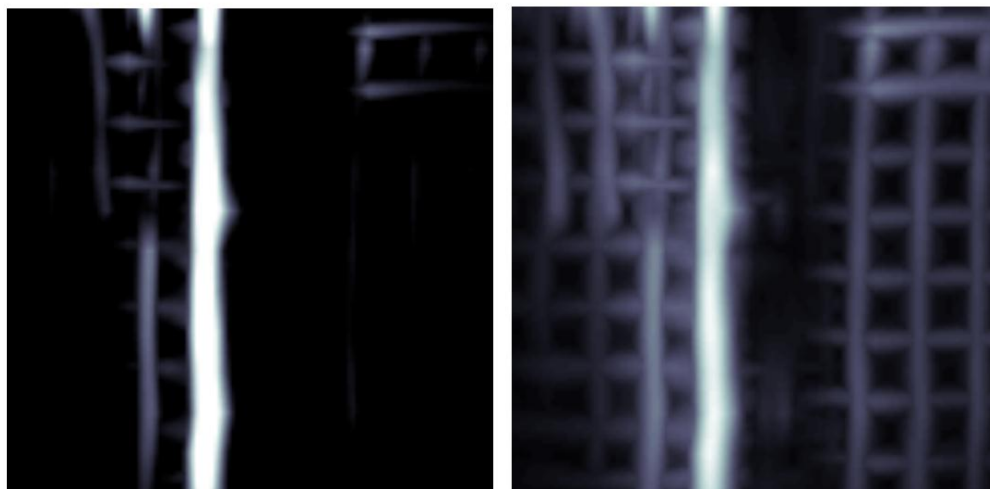


Figure 8-9: Depth slice images with normal (left) and high (right) sensitivity.

8.5.2.1 Filter

When viewing data in 3D (Section 8.4.2), the **Filter** option is available when the **Color** button is selected. Pressing the **Star (*)** key or DVL **B** button toggles the Filter on and off.

When the filter is on, flat-lying responses in the Alpha and Numeric cross-sections (like the surface reflection) are filtered out so that hyperbolic (inverted “V”) responses from crossing objects like rebar and conduits perpendicularly are enhanced. The filter is especially useful for identifying the top of hyperbolic responses from shallow objects that are masked by the strong, flat surface reflection. Avoid using the filter when looking for the flat-lying features such as the bottom of concrete in the cross-section data.

Note that the filter only applies to the cross section images and has no effect on the depth slices.

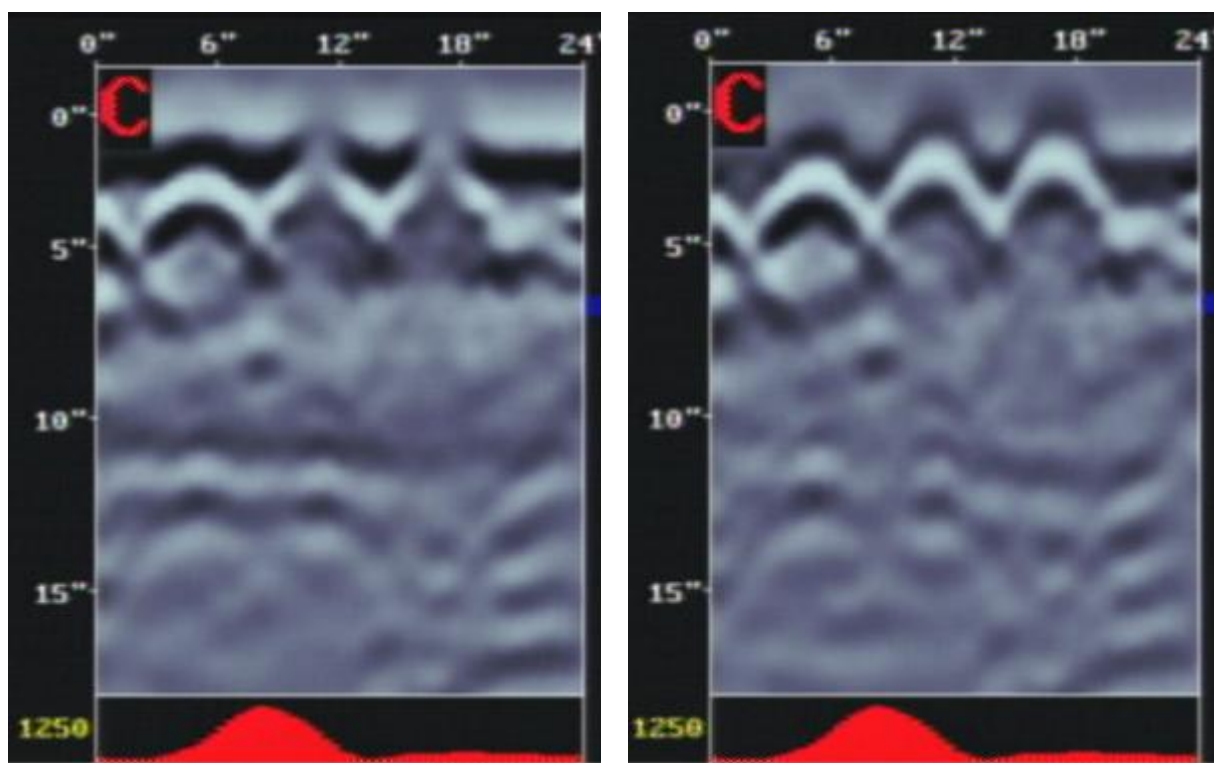


Figure 8-10: Cross-section images showing the effect of the Filter tool. Left: filter off. Right: filter on.

8.6 Slice Type

Depth slices are generated using the data from the Alpha lines, Numeric lines or a combination of both.

Targets like rebar are most visible on lines that cross them perpendicularly. For example, rebar aligned with the Alpha lines are most visible in the Numeric line cross-section images.

In complex situations, targets may be imaged more clearly in Depth Slices by only using lines in one direction (for example, using the Alpha lines only).

The current slice type is displayed in the bottom corner of the **Slice Type** button. To change the current Slice Type, select the **Slice Type** and then use the **Left** and **Right** arrow keys or DVL 6 button to change from COMBO to ALPHA or NUM.

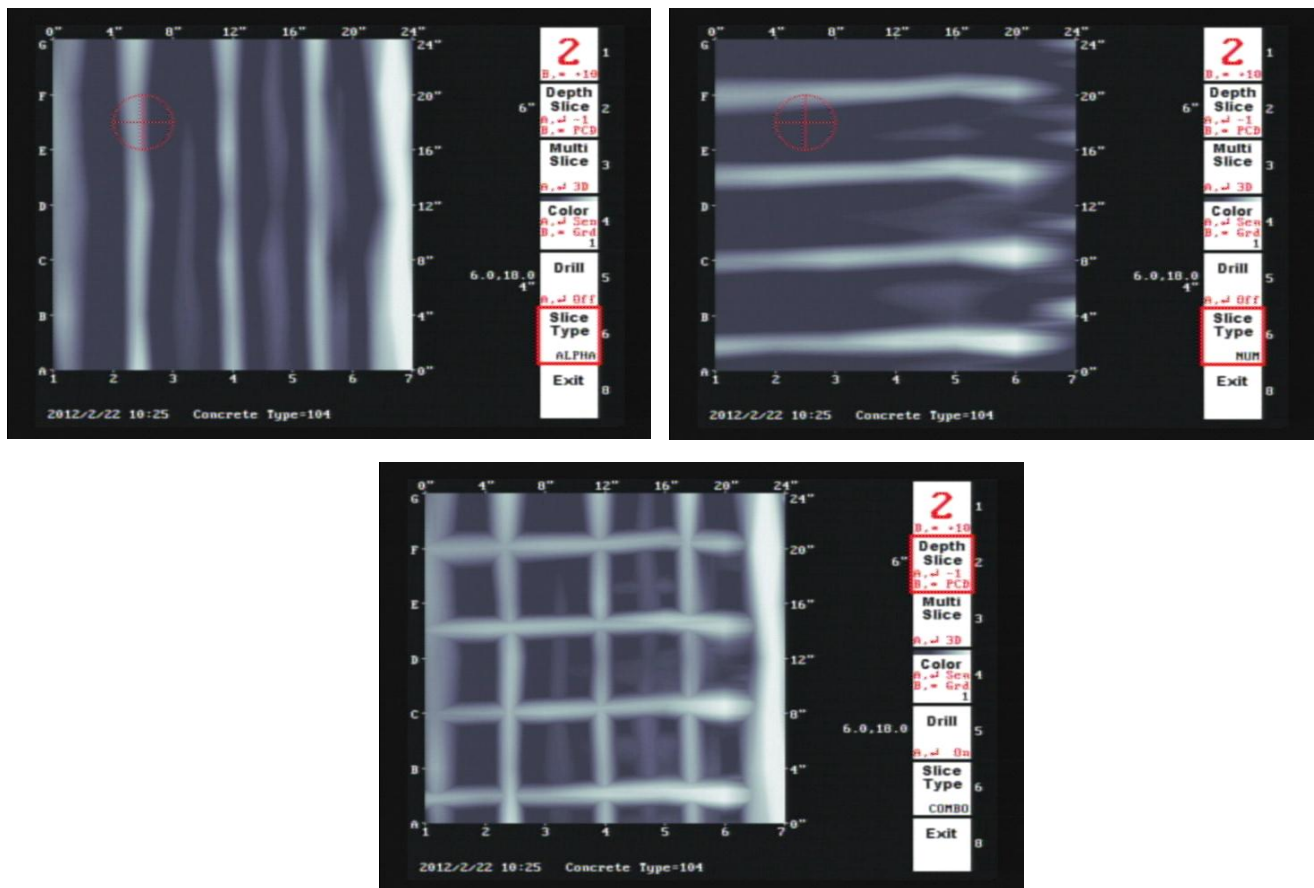


Figure 8-11: Slice Type determines which grid scans are used to generate the depth slices. Using Alpha Lines only (top left) and Numeric Lines only (top right) emphasizes objects perpendicular to that line direction. Combo uses both Alpha and Numeric Lines together to generate the depth slice.

8.7 Re-Processing the Grid Scan with a Different Scan Depth

Conquest always collects and saves grid scan data to a depth of about 1000 mm (40 inches) but data are processed and displayed as depth slices based on the **Scan Depth** parameter under **Grid Scan Parameters** (Section 7.3.3).

To view deeper depth slices it is NOT necessary to collect the Grid Scan data again; it is only necessary to reprocess the Grid Scan data with a deeper Scan Depth value. Select **Grid Scan** from the main menu and change the **Scan Number** to a previously collected grid (red text). Then, change the **Scan Depth** parameter to a new value. Now select **Scan**. This opens the **Grid Scan** screen and, because the grid was already collected, displays the first cross-section and the grid image (with all the lines in red because they have been collected).

Select **Slice View** and process the data using the new scan depth value. When the data opens in **Slice View**, deeper depth slices are now available.

9 Tools

The **Tools** sub-menu (Figure 9-1) contains a variety of options and settings controlling the operation of the system in **Grid Scan** and **Line Scan** modes. It is accessed from the main menu (Figure 5-1).

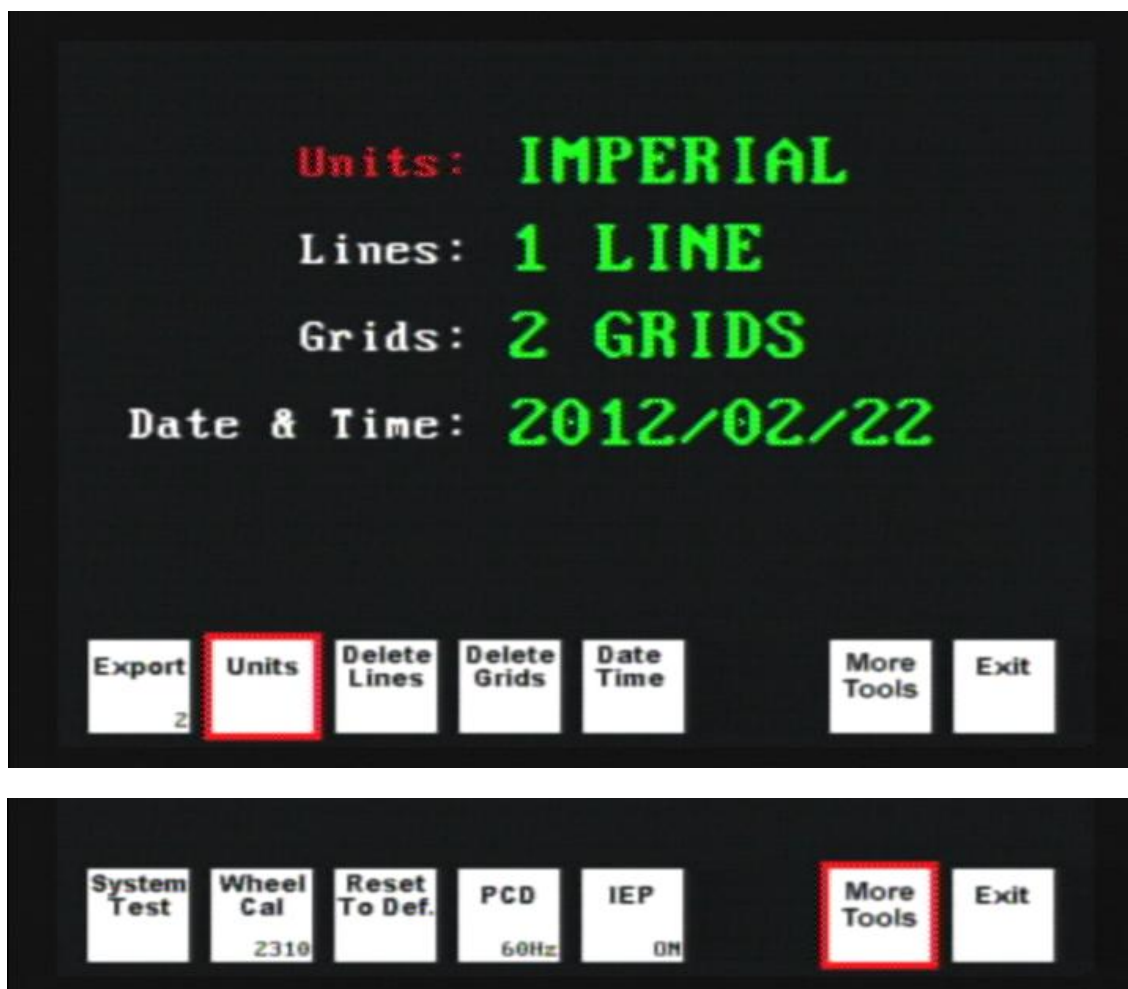


Figure 9-1: The Tools and More Tools menu options.

9.1 Export

Line and Grid Scans are saved to Conquest's internal memory. The **Export** option copies data from the internal memory to an optional removable Compact Flash card so it can be transferred to a PC.

To copy data to the removable drive (Figure 3-13); first ensure that Conquest is powered off. Loosen the two thumbscrews on the top of the DVL and rotate the door open. Insert a Compact Flash card into the slot, pressing down gently to ensure it is properly seated. Power on Conquest, go the **Tools** menu, and select the **Export** option.

Each time Conquest data are exported to a Compact Flash card, a new folder with an incrementing number is created (i.e. EXPRT001, EXPRT002, etc.). The current Export number is displayed in the bottom corner of the **Export** button.

Grid Scan data are copied to the GRIDS sub-folder (i.e. \EXPRT001\GRIDS), and Line Scan data are copied to the LINES sub-folder (i.e. \EXPRT001\LINES).

Since Conquest can collect up to 99 Grid Scans, each grid is saved to a sub-folder with a number corresponding to the grid number (i.e. CONQ001, CONQ002, etc.). Therefore, Grid Scan data will be found in folders with names like: \EXPRT001\GRIDS\CONQ001.

To copy data from the Compact Flash card to a PC, insert the card into a card reader connected to the PC. Then use Windows Explorer (or My Computer) to read the removable drive and copy the folders containing data files to the PC.

PC software for displaying Conquest Line Scans and Grid Scans are available from Sensors & Software (Section 10.1).

9.2 Units

Select Imperial or Metric. Imperial units display data in inches. Metric units display data in millimeters (mm).

9.3 Delete Lines/Grids

The total number of saved Line Scans is displayed. Select **Delete Lines** to delete all Line Scans from the internal memory.

The total number of Grid Scans is displayed. Select **Delete Grids** to delete all Grid Scans from the internal memory.

9.4 Date/Time

The current date and time saved with Conquest data is displayed.

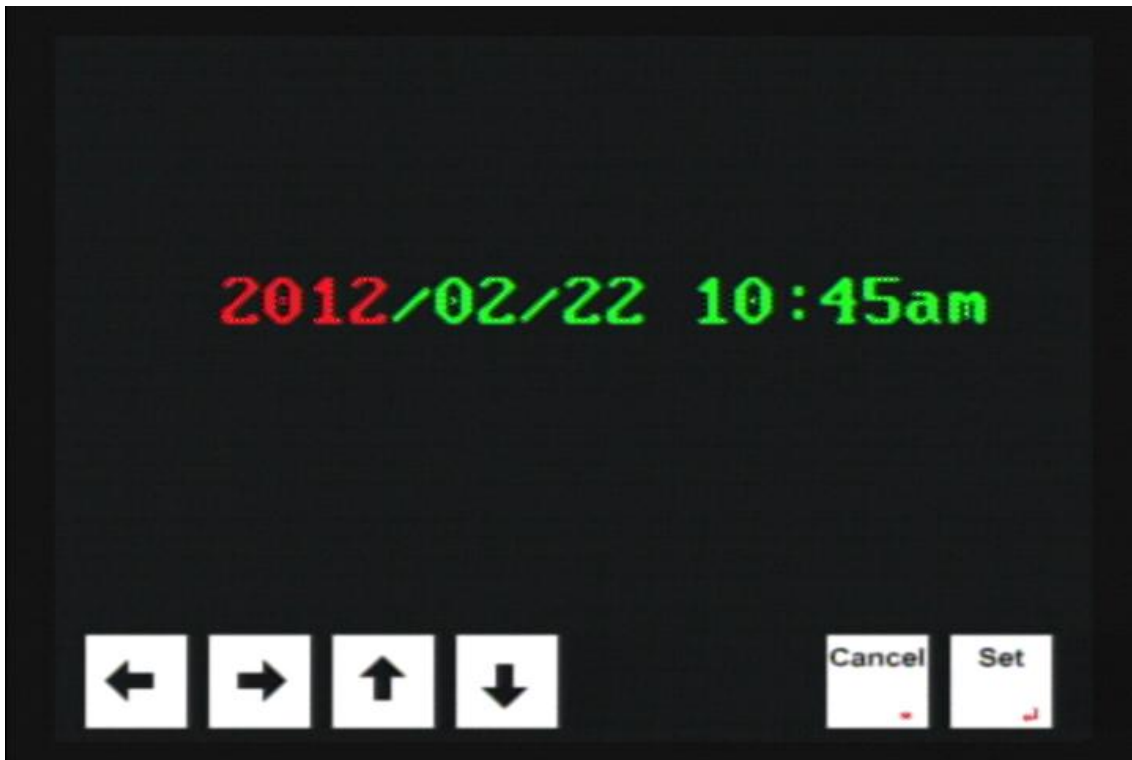


Figure 9-2: The Date / Time Tools option.

Use the **Left** and **Right** arrow buttons to highlight a number in red and then edit the number using the **Up** and **Down** arrow buttons.

When finished, select **Set** (or **Enter**) to save the new date/time or **Cancel** (or **Star ***) to exit without saving.

9.5 More Tools

9.5.1 System Test

The System Test is run to ensure that all Conquest functions are working properly and the system is properly calibrated.

If the IEP option is enabled (Section 9.5.4), the user is prompted to run the System Test if the system detects that it is out of calibration.

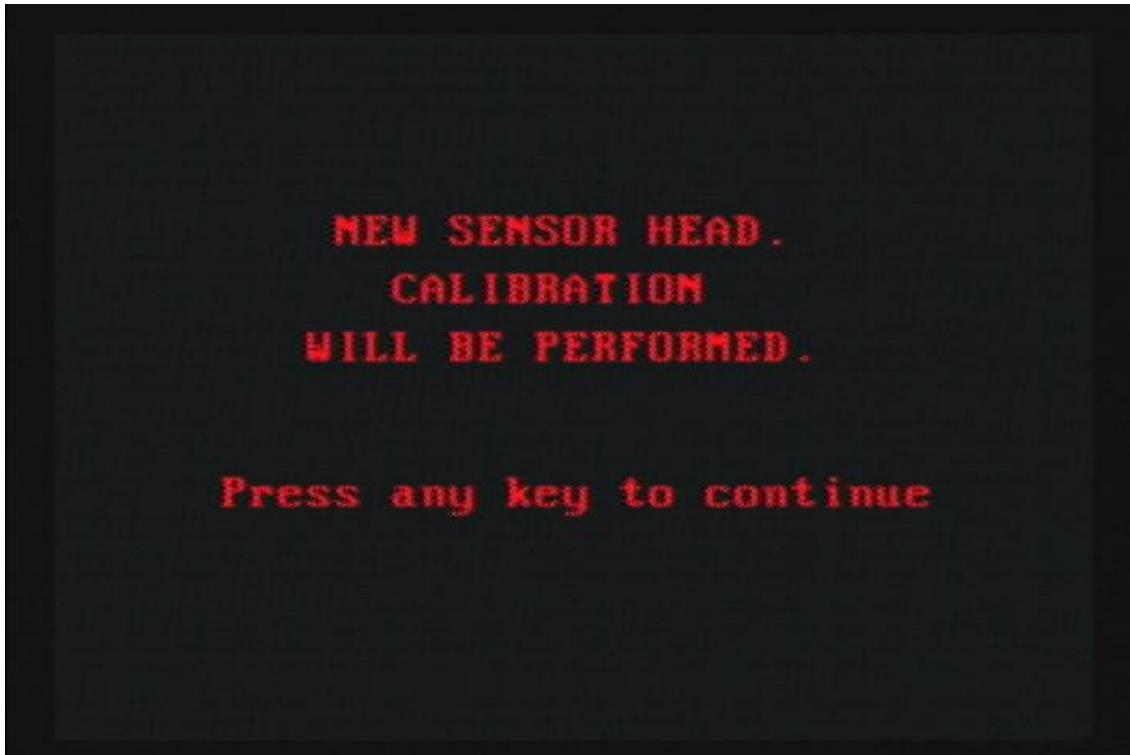


Figure 9-3: If the Conquest system ever detects that calibration is necessary, the user is prompted to run the System Test.

There are several reasons why the system may require a System Test be completed:

1. Replacing hardware components like the Sensor Head or cable,
2. Large changes in the surface materials in the scan area (for example a grid scan partially collected on a metal plate on the surface).
3. Working in extremely variable temperature conditions.
4. Operating in a temperature very different from the temperature that the System Test was last performed in.

To perform the system test, follow the simple, on-screen instructions.

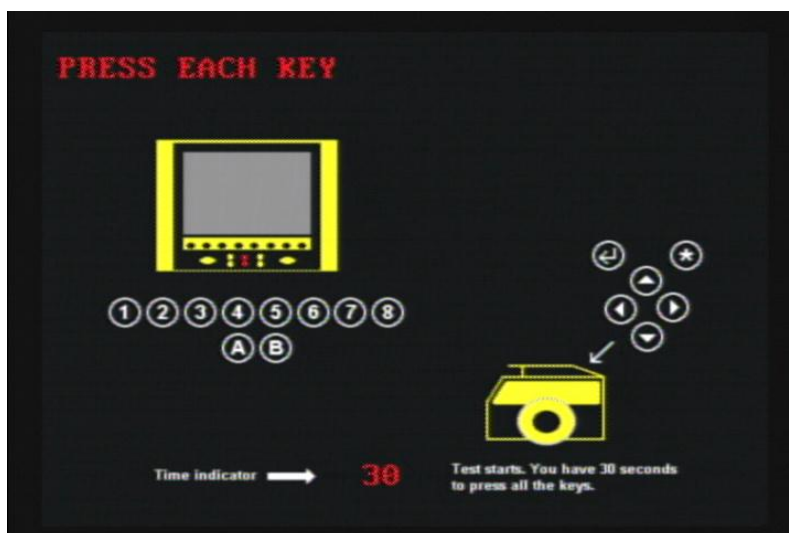


Figure 9-4: System Test: press all the buttons on the DVL and Sensor Head keypads.

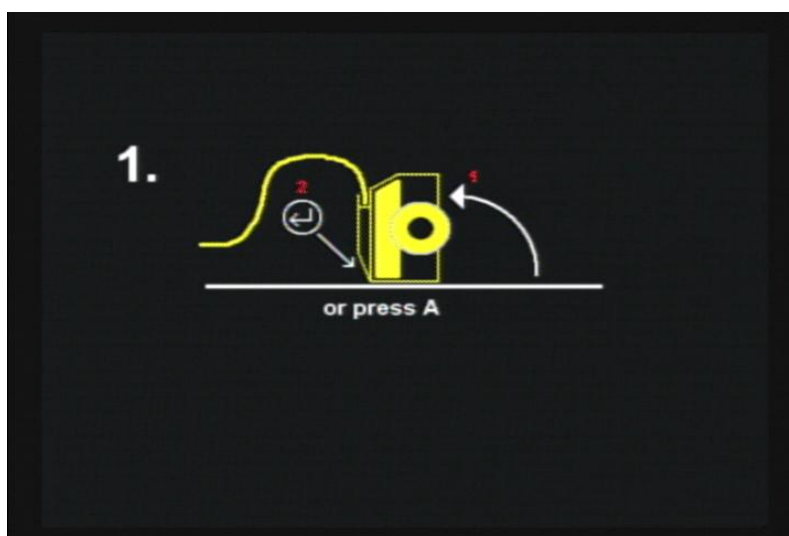


Figure 9-5: System Test: Position the Sensor Head as shown and press the Enter key or DVL A button.

If Conquest constantly prompts the user to run the System Test, it may be necessary to turn the IEP feature off and collect the data without it (Section 9.5.4).

9.5.2 Odometer Wheel Calibration

The odometer wheel calibration is done under **Wheel Cal** in Tools. The odometer wheel should be periodically calibrated, perhaps once a week or once a month. It should also be re-calibrated if you are collecting data on a different surface than usual, for example, on a textured floor rather than smooth concrete. Calibrating on long lines ensures the highest accuracy.

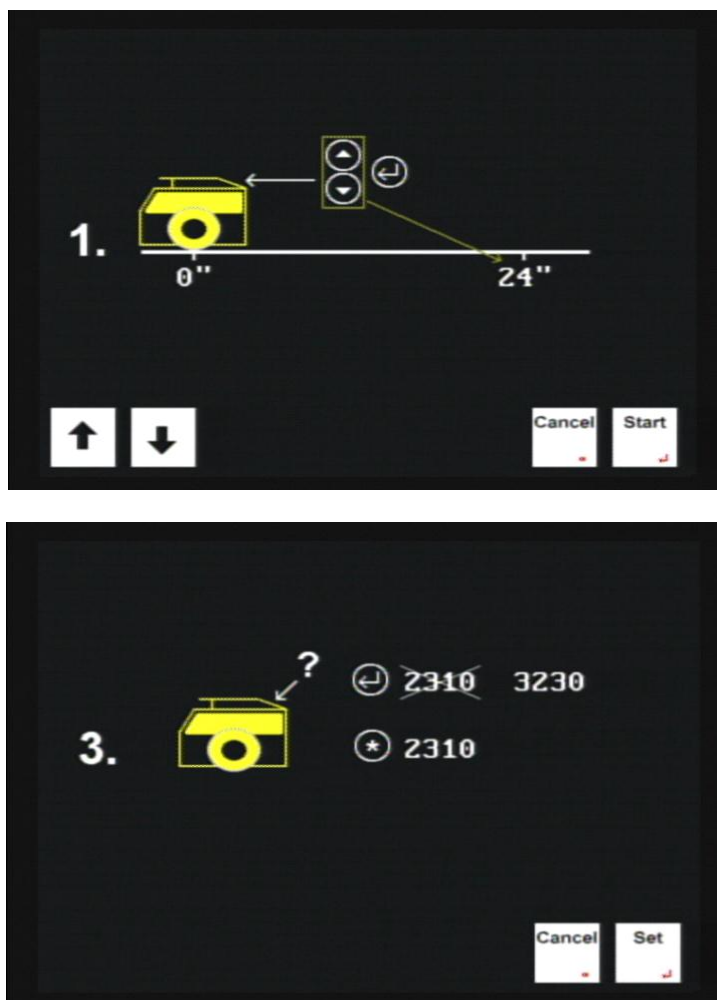


Figure 9-6: Odometer wheel calibration screens.

Measure the odometer calibration distance on the surface and center the sensor on the zero mark. Using the sensor keypad, use the **Up** and **Down** arrows to edit the calibration distance from the default distance of 24" or 600 mm and then press **Enter**. Move the sensor head the exact distance that was specified and press **Enter** to finish the calibration. The old and new odometer calibration values will be displayed on-screen and the user must choose to accept the new value by pressing the **Enter** key or reject it and use the old value by selecting the **Star (*)** key.

The default wheel calibration value is 2310. If the measured value is far off from 2310 the wheel calibration may have been performed incorrectly.

9.5.3 PCD Frequency

The PCD should be set to the frequency appropriate for the geographic location, i.e. 60 Hz for North America and 50 Hz for Europe and Australia.

9.5.4 Image Enhancement Processing (IEP)

The IEP feature automatically and continuously tests the system for proper calibration during operation. If the system is ever found to be out of calibration, the user is immediately prompted to run the **System Test** (Section 9.5.1) and re-calibrate. The IEP option ensures that Conquest always collects the highest quality data and displays the most accurate images.

The IEP option is automatically enabled when Conquest is turned on and is normally left on. In fact, if IEP is turned off, the user is informed on all Line Scan, Grid Scan and Depth Slice screens. As well, the next time that Conquest is turned on, IEP will be automatically re-enabled.

There may be situations when the operator is constantly prompted to run the System Test resulting in the inability to collect data. In these cases, IEP can be temporarily turned off. If IEP is disabled, allow the system to warm up for 5 minutes before starting data collection. Even if data are collected without IEP, it can still be applied in the ConquestView software after the data are transferred to a PC.

10 Transferring Data to a PC (Optional)

Conquest systems provide the option of transferring data to a PC for further analysis. This is available if you selected the enhanced system option or purchased the enhanced upgrade option after purchasing the base system.

Details on Exporting data from Conquest are described in Section 9.1.

10.1 PC Software

Line Scan data are displayed using the EKKO_View software.

Grid Scans are processed and displayed using the ConquestView software. ConquestView gives the same display as on the DVL. With ConquestView, you can perform all of the display and process functions available on the DVL but have the added benefits of printing or exporting images to other software (for more details, see the ConquestView User's Guide).

ConquestView also exports Conquest data into a 3D format that can be viewed with 3D visualization software like Voxler (available from Sensors & Software).

10.2 Conquest Grid Parameter (.CV2) File Definition

To display a Conquest grid scan in ConquestView, the user must open the Conquest Grid Parameter file. This file is saved in the same folder as the grid scan data and has a .CV2 extension. The name of the file is based on the following format:

MMDD_NNG.CV2

where MM is the month 01 – 12

DD is day 00 – 31

NN is grid number. Currently 01 – 99, and 00 for demo

G is the Grid size indicated by the following letters:

A = 2' x 2' or 600 x 600mm

B = 4' x 4' or 1200 x 1200mm

C = 8' x 8' or 2400 x 2400mm

D = 2' x 4' or 600 x 1200mm

E = 2' x 8' or 600 x 2400mm

For example, a 4' x 4' grid scan numbered 17 and collected on October 7 will have a Conquest Grid Parameter file called 1007_17B.CV2

11 Examples & Interpretation

Conquest depth slices are interpreted by looking for the dark areas on a light background or light features on a dark background depending on the color palette. These areas indicate the presence of an object in the subsurface at a particular depth.

In general, you will find that bars, pipes and conduits make straight lines across the depth slice whereas layers and horizons such as the bottom of concrete show up as uniform coloring which is somewhat marbled across the area.

Experience is required in understanding the images that you obtain. It is fairly straightforward to get a first order sense of a site by stepping Up and Down through the depth slices to understand the observations. You can see what depth you are at by looking at the slider bars on the side of the vertical cross sections. By looking at the cross sections you can get a sense of what features are occurring at different depths, whereas the depth slice gives you the spatial location of these features.

Case #1

This grid scan was conducted on the 5th floor of a medical building that was undergoing some renovations. The grid size was 600 x 600 mm, normal resolution.

In Figure 11-1a, the rebar are located between 60 - 90 mm in depth. The deeper 240 – 270 mm depth slice (Figure 11-1b), shows two conduits running obliquely across the grid area. In the slice immediately below that, Figure 11-1c, there are some features at numeric lines 4 & 6.

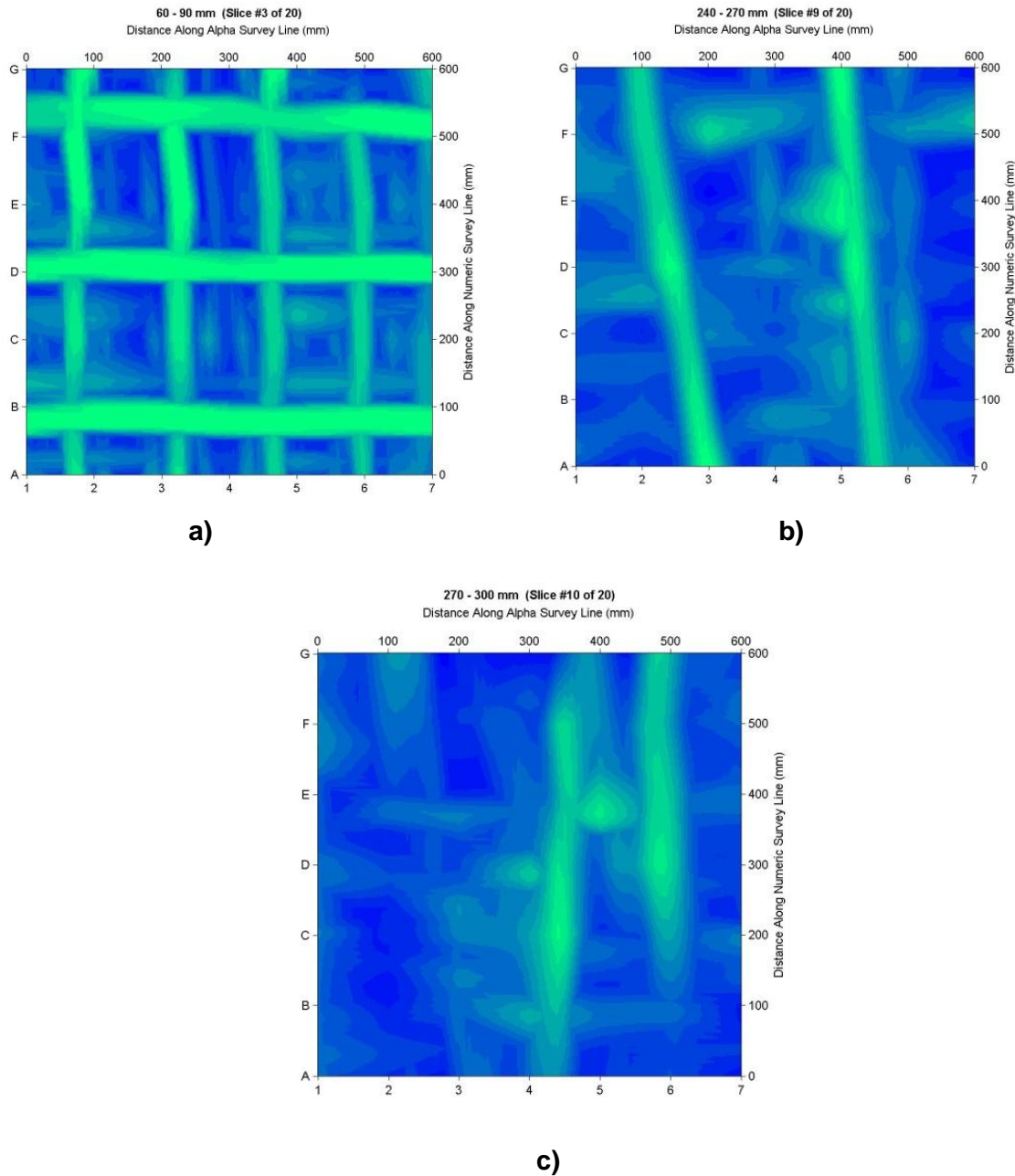


Figure 11-1: Case #1 depth slice images

Case #2

This scan was conducted at a test pad outdoors (Figure 11-2a & Figure 11-2b). The grid size was 1200 x 1200 mm, normal resolution.

The main feature of this grid scan is the overlapping wire mesh, seen prominently at adjacent depths. The reason that it shows at 2 different depths is that the mesh dips in certain areas, a result of the weight of the concrete as it was being poured. From the pictures, it can be seen that the mesh has a spacing of 200 mm.

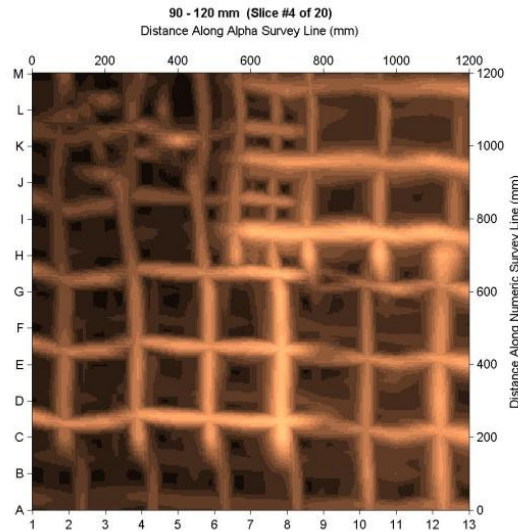
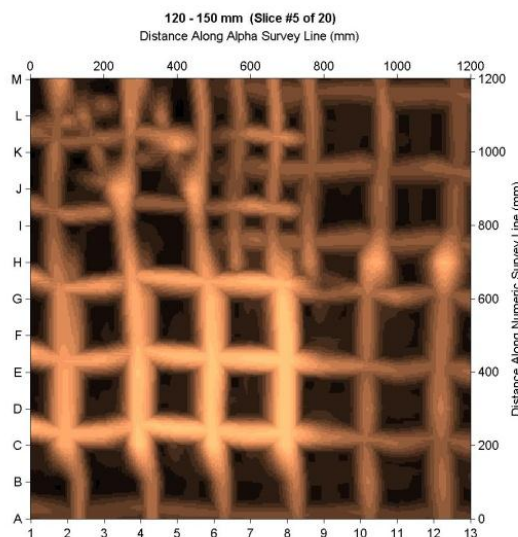
**a)****b)**

Figure 11-2: Case #2 depth slice images

Case #3

Figure 11-3a shows wire mesh with two conduits running at oblique angles directly beneath the mesh. Figure 11-3b shows the bottom of concrete between 9.6 - 10.8 inches deep. In this case, it is slab on pan which is a metal support sheet on which concrete was poured during construction. GPR signals cannot penetrate metal, and hence, the signals are reflected entirely.

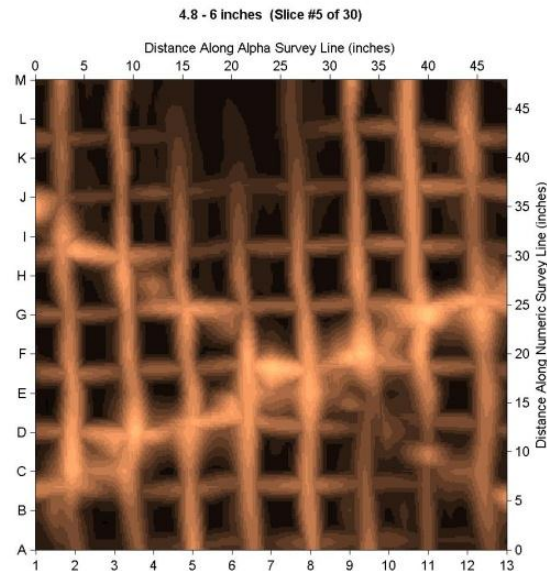
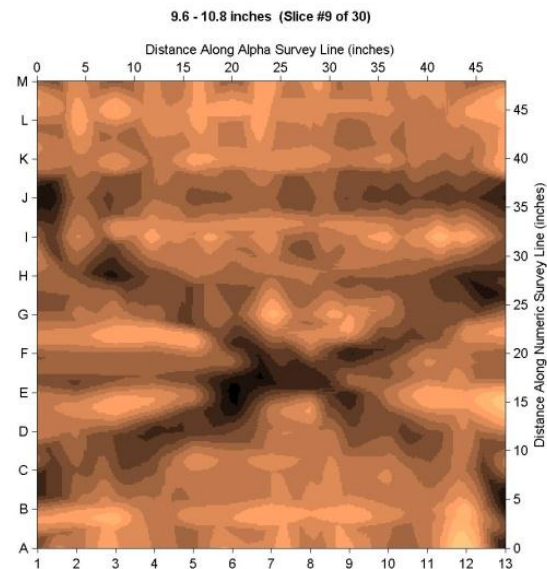
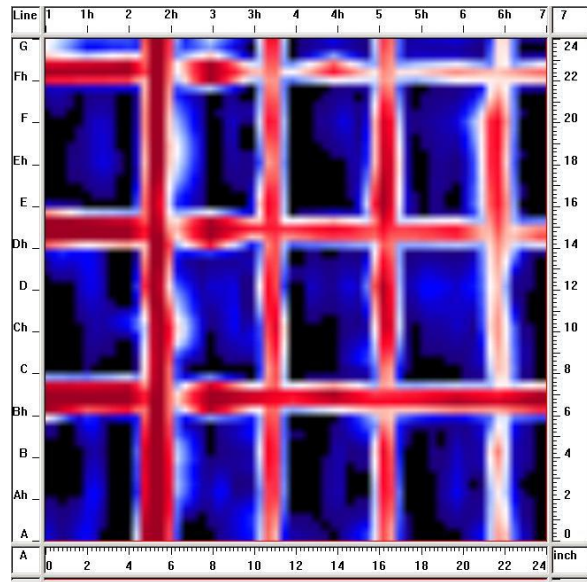
**a)****b)**

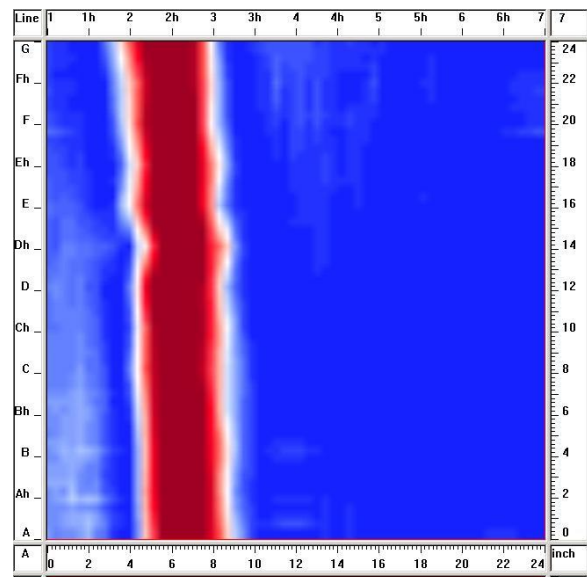
Figure 11-3: Case #3 depth slice images

Case #4

In Figure 11-4a there is a typical rebar pattern at a depth of 5-6 inches. The PCD image (Figure 11-4b) reveals a strong magnetic field response that may be associated with the leftmost vertical rebar. The interpretation is that an AC current-carrying cable has been tied to the rebar.



a)



b)

Figure 11-4: Case #4 depth slice images

12 Helpful Hints

12.1 Marking the Site

It is necessary to view the depth slices through the total depth range in order to mark the site. The normal process is to step down through each depth and look for linear features which usually indicate rebar, post-tension cables, pipes and conduits. At each depth, mark the location of the feature on the surface using the grid as a guide. You can mark directly onto the sheet with erasable marker. Sensors & Software also have paper grids that can be placed on the site (call for availability).

Each linear feature should be marked on to the surface of the area. Marking the site will obviously be dictated by the site conditions. In an open concrete structure at a construction area site you can use chalk or a crayon to mark the surface. In finished floor areas one may want to use a washable marker or some other type of easily removable indicator. You will no doubt need to adapt for your specific site condition.

Make sure to document all site markings using a digital camera, hand drawn maps and measurements for future reference.

12.2 Scan Speed and Data Quality

Conquest uses DynaQ, an advanced patented technology that adjusts data quality as the Sensor Head movement speed varies. In most situations, moving the Sensor Head at a comfortable speed generates data of good quality. In situations where target resolution or maximum penetration depth is critical, moving slower increases data quality.

During data collection, the progress bar moves across the screen as the Conquest Sensor Head is moved to indicate that data are being collected (Line Scan and Grid Scan modes). With DynaQ, the color of the progress bar indicates the quality of the data at that point along the line:

White = No Data (too fast!)
Yellow = normal quality
Light blue = better quality
Dark Blue = highest quality

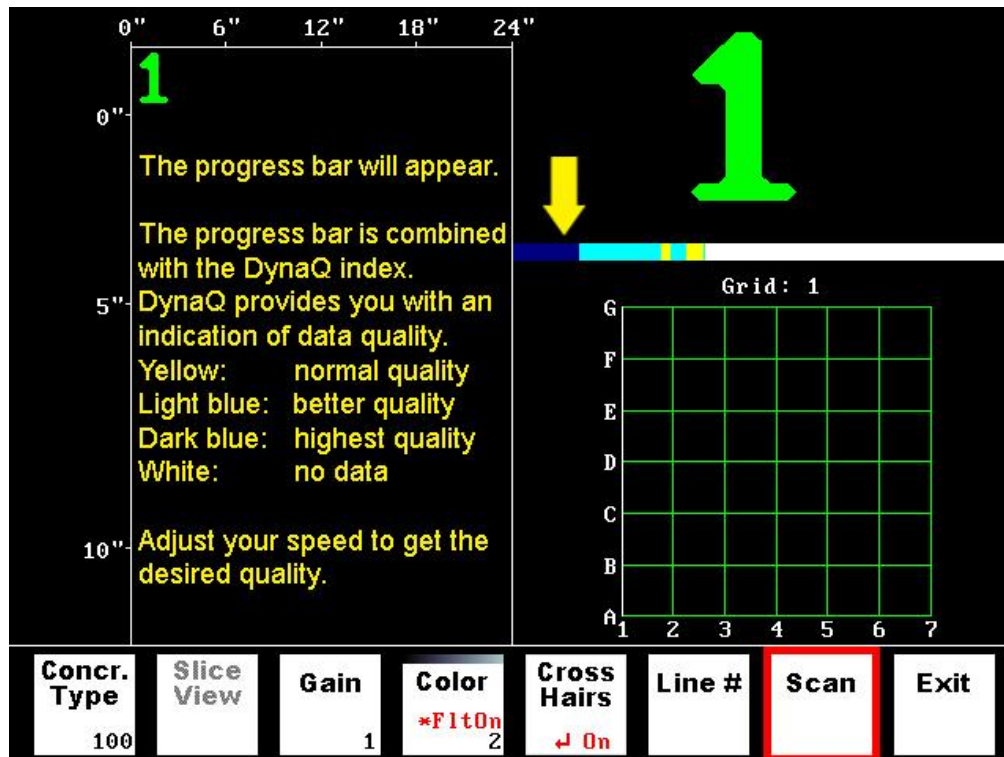


Figure 12-1: Conquest uses DynaQ, where the color of the progress bar indicates the quality of the data being collected. Dark blue, indicating the highest quality of data, is achieved by moving the Sensor Head more slowly compared to the speed for the light blue or yellow colors.

In general, avoid collecting data at extremely high rates of speed. There are limits on the speed of movement to ensure data quality. The system will beep twice to indicate that a data quality issue has been detected. If this occurs, the operator is prompted to recollect the line.

12.3 Sensor Head Positioning

Proper positioning of the Sensor Head is very important for generating accurate depth slice images. Before starting a line, use the arrows to ensure that the center of the Sensor Head is correctly aligned on the start line on the grid mat (Figure 7-5).

When collecting a Grid Scan, the sensor head has to be pushed slightly beyond the end line on the far edge of the grid mat (1-2 cm) before the survey line stops.

If lines collected during Grid Scans seem to finish before the end line on the far edge of the grid mat is reached, or they end more than 1 or 2 cm (1 inch) after the end of the line, recalibrate the wheel odometer (Section 9.5.2). An inaccurate odometer calibration value may result in poor data positioning resulting in lines which are too long or too short.

Verify that the grid size and measurement units selected in the **Tools** menu match the vinyl or paper grid mat being used. For example, Conquest comes with 24 inch imperial grids or 600 mm metric grids that differ slightly in size.

12.4 Collecting a Short Line or Partial Grid

To stop a Grid Scan line early, press the **Enter** button.

12.5 Line Scan Data File Length

Line Scan data are saved to a maximum line length of approximately 6.4 m (21 feet). The system will beep to indicate the maximum length has been reached. If a Line Scan is longer than this length, only the last 6.4 m (21 feet) is saved.

12.6 Extending the Depth after Collecting Data

The system always scans to a depth of approximately 3 feet or 1000 mm, regardless of the depth setting the user has selected. The user depth setting only controls the depth of data displayed on the screen. The display depth can be changed using the **Depth** menu item in **Line Scan** mode. To see deeper in **Grid Scan** mode, change the **Scan Depth** setting for the grid on the **Grid Scan parameters** menu (Section 8.7).

13 Troubleshooting

Conquest systems are designed to minimize user problems; however, all electronic devices are subject to possible failure. The following are troubleshooting hints if your Conquest fails to operate or something operates incorrectly.

13.1 Restart the System

The vast majority of problems can be fixed by powering down the system, checking that all connections are tightly secured (use a screwdriver, if necessary) and not damaged and then powering back up again.

Sometimes vibrations cause the cable connections to loosen just a bit and break contact, which can cause errors. Disconnecting cables and reconnecting them may provide better contact and solve the problem. Turn the system back on and try running again.

Check cables for problems like bent or recessed pins that can break the connection and cause system errors.

If the power supply and cables are OK, the problem is likely a failure of the internal electronics. Contact Sensors & Software Inc. (Section 13.11).

13.2 Power Supply

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

13.3 Warning Beep in Line Scan Mode

When collecting Line Scan data, if the system starts to “beep”, there are three possible causes:

1. The operator is holding down the **Enter** button or DVL key too long when starting the Line Scan. The system may register this as two button presses, resulting in the system starting and stopping immediately. In this instance the beep is occurring because the scan is being stopped. A lighter touch on the button is necessary.
2. The Sensor Head is being pushed too fast. This happens most often when the Stretch Factor is large. A high stretch value uses more computer resources for the screen display, slowing data acquisition. Reduce the Stretch value or simply slow down the speed of the Sensor Head to eliminate the warning.

If the beeping keeps occurring and you don't think that you are moving too fast, check the odometer calibration value and recalibrate if necessary (Section 9.5.2). An inaccurate odometer calibration value may result in poor data positioning and/or acquisition of too much data.

3. The Sensor Head has reached the maximum saved line length of about 6.4 m (21 feet). Continuing the Line Scan will result in the data overwriting the previously saved data so that only the last 6.4 m (21 feet) of any Line Scan is saved.

13.4 Warning Beep and Flashing in Grid Scan Mode

When collecting Grid Scan data, if the system starts to “beep”, there are two possible causes:

1. If the system “beeps” twice when attempting to collect a Grid Scan line, the operator may be holding down the **Enter** button or DVL key too long. The system registers this as two button presses, resulting in the system starting and stopping immediately. A lighter touch on the button is necessary.
2. When collecting Grid Scan data, if the system “beeps” and the current line number or letter flashes, this means that the sensor head is being pushed too fast. When this occurs, the operator is prompted to recollect the same line. To ensure good data quality, simply slow down the speed of the Sensor Head. If this error keeps occurring and you don’t think that you are moving too fast, check the wheel odometer calibration value and recalibrate if necessary (Section 9.5.2). An inaccurate wheel odometer calibration value may result in poor data positioning and/or acquisition of too much data.

13.5 Sensor Head Key Pad Doesn't Respond

If the Sensor Head keypad does not respond, the usual reason is that the Sensor Head has come unplugged during operation. When the Sensor Head is reconnected, it will beep and some of the keypad functions will start to work, but other functions will not. Power down the system and restart it to restore full keypad functionality.

13.6 System Does Not Start with the Sensor Head

The system does not recognize the presence of the Sensor Head keypads unit after it has been initialized. The user must press any key on the DVL keypad to start the system.

13.7 Power Light on DVL Not Illuminated

The system is plugged in but there is no light on the DVL keypad:

1. Check the connections between the AC converter (or battery) and the control module on the back of the DVL.
2. The LED may be faulty; press any keypad button to attempt to power up the system.

13.8 Export Menu Item Not Accessible

The **Export** menu item under **Tools** will be greyed out and not accessible if:

1. No Compact Flash card is installed in the system when it starts up. The system should be powered down, the card inserted and the system powered up again. Be aware that inserting a Compact Flash card with the system powered up can damage the card.
2. The card is not recognized by the system. Sensors & Software recommends the use of the professional grade series Compact Flash cards. These cards are widely available at consumer electronics stores.
3. The card is improperly formatted and is not recognized by the system. Try reformatting the card and restarting the system. The flash card can only be formatted as FAT 16 or FAT32. If, after reformatting, the card is still not recognized, a new card of the type recommended above should be used.
4. The compact flash card does not have enough free memory space to accept all the data in the Export folder. The system should be powered down, the card ejected, all files removed from the card, the card re-installed, the system powered up, and Export attempted again.

13.9 Constant Prompt to Perform System Test

If the operator is constantly prompted to run the System Test (Section 9.5.1) resulting in the inability to collect data, turn off IEP (Section 9.5.4) in the **Tools** menu. If IEP is disabled, allow the system to warm up for 5 minutes before starting data collection.

If the system is constantly prompting to perform a system test, it may indicate a problem with the equipment. Scanning can be continued with IEP turned off but if the problem persists, it is recommended that Sensors & Software Inc. be contacted to help remedy the problem.

13.10 Creating a Test Line for Data Quality

One of the best ways of detecting problems with the Conquest system is by comparing data with data collected previously along the same line.

Soon after receiving the system and getting comfortable with its operation, collect a line of data at a convenient, easily accessible location. The line does not have to be too long, but 1-2 m (3-6 feet) is a good guide. This data line should be saved electronically and perhaps plotted out on paper and dated. The test line could be collected say, every 6 months and, by reviewing the previous data, system problems can be detected early. As well, if there is a suspected problem with the system, this test line could be collected and compared with earlier tests.

13.11 **Contacting Sensors & Software Inc.**

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

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

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

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

1. System Serial Number. This is found on the back of the DVL.
2. Version number of the data acquisition software (displayed on the bottom corner of the main menu, see Figure 5-1)
3. The error number or the specific error message appearing.
4. A brief description of when the error is happening and the operating conditions (temperature, humidity, sunshine, system and survey setup, etc.).

14 Care and Maintenance

14.1 Cable Care

Cables are designed to be as tough as practical.

Careless use of cables by making them carry loads for which they are not designed for can cause internal damage.

Connectors are weak points in any system. With the use of this product in rough, dusty and outdoor environments, users can minimize potential down time if they care for cables and treat connectors with respect.

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

14.2 Conquest Sensor Head Wear Pad

The bottom of the Sensor Head is covered with a wear-resistant skid pad. The skid pad is designed to take the majority of the abrasive wear. If the pad wears down enough, the less-resistant plastic housing may start to wear. If this occurs, it is best to replace the skid pad. It is easily removed and a new one can be purchased from Sensors & Software Inc.

14.3 Storage Cases

Equipment that is transported and stored loosely is more susceptible to damage. All equipment should be stored in its shipping case or a storage box. Sensors & Software has shipping cases available as options for all systems.

14.4 Spare Parts

Customers working in remote areas or for whom downtime in the field is unacceptable should consider buying spare parts like extra cables.

Appendix A: Health & Safety Certification

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

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

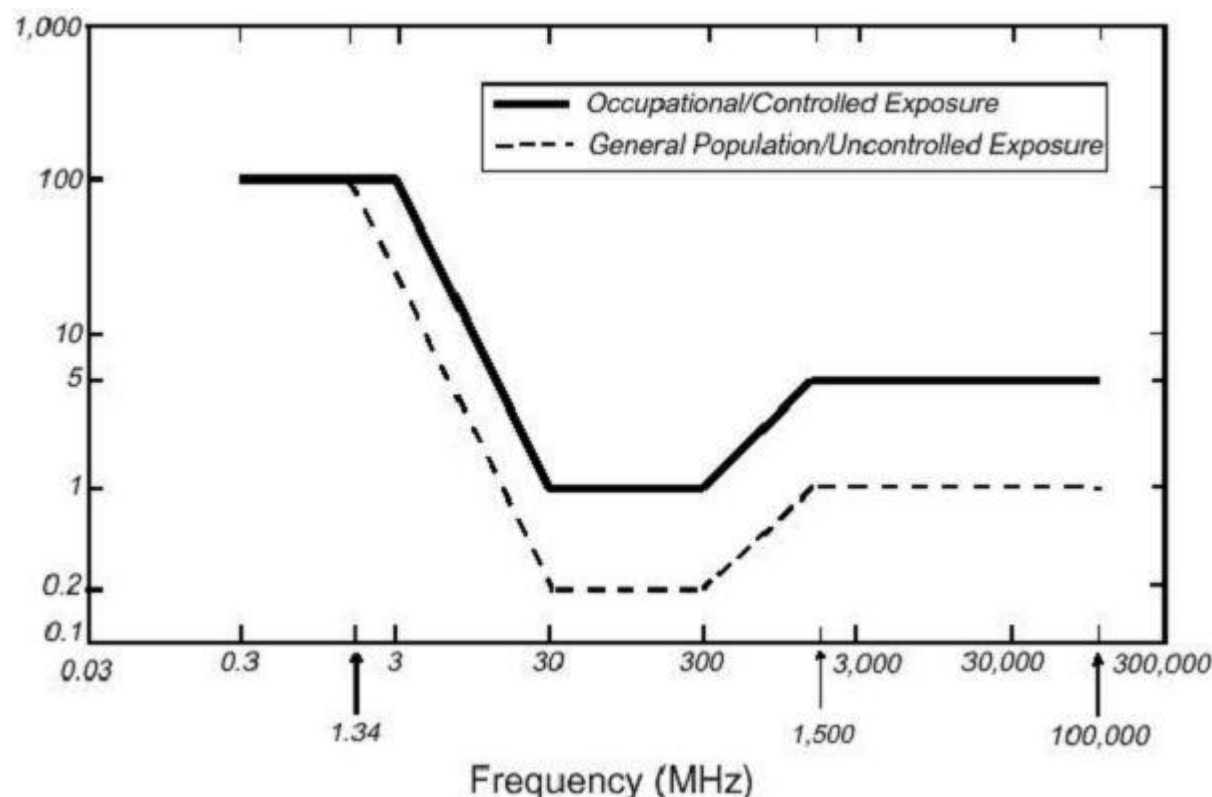


Figure B-0-1: FCC limits for maximum permissible exposure (MPE) plane-wave equivalent power density mW/cm^2 .

All Sensors & Software Inc. GPR products are normally operated at least 1 m from the user and as such are classified as “mobile” devices according to the FCC. Typical power density levels at a distance of 1 m or greater from any Sensors & Software Inc. product are less than 10^{-3} mW/cm^2 which are 200 to 10,000 times lower than mandated limits. As such, Sensors & Software Inc. products pose no health and safety risk when operated in the normal manner of intended use.

Appendix B: GPR Emissions, Interference and Regulations

All governments have regulations on the level of electromagnetic emissions that an electronic apparatus can emit. The objective is to assure that one apparatus or device does not interfere with any other apparatus or device in such a way as to make the other apparatus non-functional.

The manufacturer test their GPR products using independent professional testing houses and comply with latest regulations of the USA, Canada, European Community, and other major jurisdictions on the matter of emissions.

Electronic devices have not always been designed for proper immunity. If a GPR instrument is placed in close proximity to an electronic device, interference may occur. While there have been no substantiated reports of interference to date, if any unusual behavior is observed on nearby devices, test if the disturbance starts and stops when the GPR instrument is turned on and off. If interference is confirmed, stop using the GPR.

Where specific jurisdictions have specific GPR guidelines, these are described below.

B-1 FCC Regulations

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

this device may not cause harmful interference and

this device must accept any interference received, including interference that may cause undesired operation.

Part 15 – User Information

This equipment has been tested and found to comply with the limits for a Class A digital device, where applicable, and for an ultrawide bandwidth (UWB) device where applicable, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

WARNING

Changes or Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

Certification of this equipment has been carried out using approved cables and peripheral devices. The use of non-approved or modified cables and peripheral devices constitutes a Change or Modification outlined in the warning above.

Operating Restrictions

Operation of this device is limited to purposes associated with law enforcement, firefighting, emergency rescue, scientific research, commercial mining, or construction. Parties operating this equipment must be eligible for licensing under the provisions of Part 90 of this chapter.

FCC Interpretation of Operation Restrictions issued July 12, 2002

(FCC Order DA02-1658, paragraph 9)

The regulations contain restrictions on the parties that are eligible to operate imaging systems (See 47 C.F.R. 5.509(b), 15.511(b), and 15.513(b)). Under the new regulations, GPRs and wall imaging systems may be used only by law enforcement, fire and emergency rescue organizations, by scientific research institutes, by commercial mining companies, and by construction companies. Since the adoption of the *Order*, we have received several inquiries from the operators of GPRs and wall imaging systems noting that these devices often are not operated by the users listed in the regulations but are operated under contract by personnel specifically trained in the operation of these devices. We do not believe that the recent adoption of the UWB rules should disrupt the critical safety services that can be performed effectively only through the use of GPRs and wall imaging systems. We viewed these operating restrictions in the broadest of terms. For example, we believe that the limitation on the use of GPRs and wall imaging systems by construction companies encompasses the inspection of buildings, roadways, bridges and runways even if the inspection finds no damage to the structure and construction does not actually result from the inspection; the intended purpose of the operation of the UWB device is to determine if construction is required. We also believe that the GPRs and wall imaging systems may be operated for one of the purposes described in the regulations but need not be operated directly by one of the described parties. For example, a GPR may be operated by a private company investigating forensic evidence for a local police department.

FCC Permitted Mode of Usage

The GPR antenna must be kept on the surface to be in compliance with FCC regulations. Use of the antenna is not permitted if it is lifted off the surface. Use as a through-the-wall imaging device is prohibited.

GPR Use Coordination

FCC regulation 15.525(c) (updated in February 2007) requires users of GPR equipment to coordinate the use of their GPR equipment as described below:

TITLE 47--TELECOMMUNICATION

CHAPTER I--FEDERAL COMMUNICATIONS COMMISSION

PART 15_RADIO FREQUENCY DEVICES

Subpart F_Ultra-Wideband Operation Sec.

15.525 Coordination requirements.

(a) UWB imaging systems require coordination through the FCC before the equipment may be used. The operator shall comply with any constraints on equipment usage resulting from this coordination.

(b) The users of UWB imaging devices shall supply operational areas to the FCC Office of Engineering and Technology, which shall coordinate this information with the Federal Government through the National Telecommunications and Information Administration. The information provided by the UWB operator shall include the name, address and other pertinent contact information of the user, the desired geographical area(s) of operation, and the FCC ID number and other nomenclature of the UWB device. If the imaging device is intended to be used for mobile applications, the geographical area(s) of operation may be the state(s) or county(ies) in which the equipment will be operated. The operator of an imaging system used for fixed operation shall supply a specific geographical location or the address at which the equipment will be operated. This material shall be submitted to:

Frequency Coordination Branch, OET

Federal Communications Commission

445 12th Street, SW, Washington, D.C.

20554

Attn: UWB Coordination

(Sensors & Software Inc. Note: The form given on the following page is a suggested format for performing the coordination.)

(c) The manufacturers, or their authorized sales agents, must inform purchasers and users of their systems of the requirement to undertake detailed coordination of operational areas with the FCC prior to the equipment being operated.

(d) Users of authorized, coordinated UWB systems may transfer them to other qualified users and to different locations upon coordination of change of ownership or location to the FCC and coordination with existing authorized operations.

(e) The FCC/NTIA coordination report shall identify those geographical areas within which the operation of an imaging system requires additional coordination or within which the operation of an imaging system is prohibited. If additional coordination is required for operation within specific geographical areas, a local coordination contact will be provided. Except for operation within these designated areas, once the information requested on the UWB imaging system is submitted to the FCC no additional coordination with the FCC is required provided the reported areas of operation do not change. If the area of operation changes, updated information shall be submitted to the FCC following the procedure in paragraph (b) of this section.

(f) The coordination of routine UWB operations shall not take longer than 15 business days from the receipt of the coordination request by NTIA. Special temporary operations may be handled with an expedited turn-around time when circumstances warrant. The operation of UWB systems in emergency situations involving the safety of life or property may occur without coordination provided a notification procedure, similar to that contained in Sec. 2.405(a) through (e) of this chapter, is followed by the UWB equipment user.[67 FR 34856, May 16, 2002, as amended at 68 FR 19751, Apr. 22, 2003]

Effective Date Note: At 68 FR 19751, Apr. 22, 2003, Sec. 15.525 was amended by revising [[Page 925]] paragraphs (b) and (e). This amendment contains information collection and recordkeeping requirements and will not become effective until approval has been given by the Office of Management and Budget.

FCC GROUND PENETRATING RADAR COORDINATION NOTICE

NAME:

ADDRESS:

CONTACT INFORMATION [CONTACT NAME AND PHONE NUMBER]:

AREA OF OPERATION [COUNTIES, STATES OR LARGER AREAS]:

FCC ID: QJQ-CONQ-DE1

EQUIPMENT NOMENCLATURE: CONQUEST DE

Send the information to:

Frequency Coordination Branch., OET

Federal Communications Commission

445 12th Street, SW

Washington, D.C. 20554

ATTN: UWB Coordination

Fax: 202-418-1944

INFORMATION PROVIDED IS DEEMED CONFIDENTIAL

B-2 ETSI Regulations for the EC (European Community)

In the European Community (EC), GPR instruments must conform to ETSI (European Technical Standards Institute) standard EN 302 066-1 v1.2.1. Details on individual country requirements for licensing are coordinated with this standard. For more information, contact Sensors & Software's technical staff.

All Sensors & Software ground penetrating radar (GPR) products offered for sale in European Community countries or countries adhering to ETSI standards are tested to comply with EN 302 066 v1.2.1.

For those who wish to get more detailed information, they should acquire copies of the following documents available from ETSI.

ETSI EN 302 066-1 V1.2.1 (February 2008) Electromagnetic compatibility and Radio spectrum Matters (ERM); Ground and Wall- Probing Radar applications (GPR/WPR) imaging systems; Part 1: Technical characteristics and test methods

ETSI EN 302 066-2 V1.2.1 (February 2008) Electromagnetic compatibility and Radio spectrum Matters (ERM); Ground and Wall- Probing Radar applications (GPR/WPR) imaging systems; Part 2: Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive

ETSI TR 101 994-2 V1.1.2 (March 2008) Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics for SRD equipment using Ultra Wide Band technology (UWB); Part 2: Ground- and Wall- Probing Radar applications; System Reference Document

B-3a Industry Canada Regulations - English

Industry Canada published its regulations for ground penetrating radar (GPR) on Mar 29 2009 as part of the RSS-220 titled 'Devices Using Ultra-Wideband (UWB) Technology'.

Industry Canada has made a unique exception for GPR by not requiring user licensing. The user does have to comply with the following directives:

This Ground Penetrating Radar Device shall be operated only when in contact with or within 1 m of the ground.

This Ground Penetrating Radar Device shall be operated only by law enforcement agencies, scientific research institutes, commercial mining companies, construction companies, and emergency rescue or firefighting organizations.

Should the ground penetrating radar be used in a wall-penetrating mode then the following restriction should be noted by the user:

This In-wall Radar Imaging Device shall be operated where the device is directed at the wall and in contact with or within 20 cm of the wall surface.

This In-wall Radar Imaging Device shall be operated only by law enforcement agencies, scientific research institutes, commercial mining companies, construction companies, and emergency rescue or firefighting organizations.

Since operation of GPR is on a license-exempt basis, the user must accept the following:

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

B-3b Règlement d'Industrie Canada - Français

Industrie Canada a publié des règlements pour les appareils géoradar (GPR) le 29 mars 2009, dans le cadre du RSS-220 intitulé "Dispositifs utilisant la bande ultra-large (UWB)".

Industrie Canada a faite une exception unique pour GPR en n'exigeant pas de licence par utilisateur. L'utilisateur doit se conformer aux directives suivantes:

Ce géoradar périphérique doit être utilisé que lorsqu'il est en contact avec ou moins de 1 m du sol.

Ce géoradar périphérique doit être utilisé que par les organisations d'application de la loi, les instituts de recherche scientifique, des sociétés minières commerciales, entreprises de construction et de secours d'urgence ou des organisations de lutte contre les incendies.

Si le géoradar est utilisé dans un mode de pénétration au mur, la restriction suivante est à noter par l'utilisateur:

Ce dispositif d'imagerie radar doit être utilisé lorsque l'appareil est orienté vers le mur et en contact avec ou dans les 20 cm de la surface du mur.

Ce dispositif d'imagerie radar doit être utilisé que par les organisations d'application de la loi, les instituts de recherche scientifique, des sociétés minières commerciales, entreprises de construction et de secours d'urgence ou des organisations de lutte contre les incendies.

Parce que l'exploitation de GPR est sur une base exempte de licence, l'utilisateur doit accepter le texte suivant:

La fonctionnement est soumis aux deux conditions suivantes: (1) cet appareil ne peut pas provoquer d'interférences et (2) cet appareil doit accepter toute interférence, y compris les interférences qui peuvent causer un mauvais fonctionnement du dispositif

Appendix C: Instrument Interference

Immunity regulations place the onus on instrument/apparatus/device manufacturers to assure that extraneous interference will not unduly cause an instrument/apparatus/device to stop functioning or to function in a faulty manner.

Based on independent testing house measurements, Sensors & Software Inc. systems comply with such regulations in Canada, USA, European Community and most other jurisdictions. GPR devices can sense electromagnetic fields. External sources of electromagnetic fields such as TV stations, radio stations and cell phones, can cause signals detectable by a GPR which may degrade the quality of the data that a GPR device records and displays.

Such interference is unavoidable but sensible survey practice and operation by an experienced GPR practitioner can minimize such problems. In some geographic areas emissions from external sources may be so large as to preclude useful measurements. Such conditions are readily recognized and accepted by the professional geophysical community as a fundamental limitation of geophysical survey practice. Such interference being present in the GPR recordings is not considered as an equipment fault or as a failure to comply with immunity regulations.

Appendix D: Safety Around Explosive Devices

Concerns are expressed from time to time on the hazard of GPR products being used near blasting caps and unexploded ordnance (UXO). Experience with blasting caps indicates that the power of Sensors & Software Inc.'s GPR products are not sufficient to trigger blasting caps. Based on a conservative independent testing house analysis, we recommend keeping the GPR transmitters at least 5 feet (2m) from blasting cap leads as a precaution. Some customers do experimental trials with their particular blasting devices to confirm with safety. We strongly recommend that GPR users routinely working with explosive devices develop a systematic safety methodology in their work areas.

The UXO issue is more complex and standards on fuses do not exist for obvious reasons. To date, no problems have been reported with any geophysical instrument used for UXO. Since proximity and vibration are also critical for UXO, the best advice is to be cautious and understand the risks.