SUBSURFACE VIEWS

CELEBRATING
OUR NEWSLETTER
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In this issue

NEW!!! FINDAR ® – Enhanced Features for Forensic Investigations

The FINDAR® GPR system was created for law enforcement to use ground penetrating radar (GPR) technology to search for evidence buried under the ground. The advantage of GPR compared to other commonly-used subsurface search technologies, such as metal detectors, is its ability to detect non-metallic objects. For forensic investigations, this allows investigators to identify clandestine graves, items made of plastic or wood, caches of drugs and money, and hidden bunkers.

After analyzing feedback from our customers, a new, enhanced version of FINDAR® has been released.

Forensic investigators often use many forms of technologies; a common challenge is staying sharp on technologies that they do not use every day. FINDAR®, an application-specific GPR, solves this problem with its intuitive touchscreen interface that is designed to be operated with minimal training.

FINDAR® has two modes of operation – Line Scan and Grid Scan. Line Scans generate cross-sectional images of the subsurface and are useful for reconnaissance data collection over a large area or when working in confined areas around houses and trees, where grid collection is not possible.

Line Scans can be started immediately, with no setup of parameters required. When an anomaly is located, the back-up arrow is used to pinpoint the location of buried objects and disturbed soil.

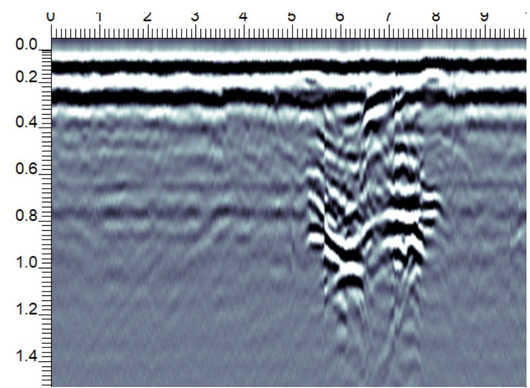

Figure 1: Line Scan showing disturbed soil.

Grid Scan is the preferred survey method when more accessible areas like backyards or fields need to be searched because it provides three-dimensional data, resulting in more detailed images of the subsurface. Predefined grid sizes allow for rapid setup to quickly start data collection.

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One common problem with forensics investigations is the presence of obstacles, such as trees, that just can't be moved for the GPR survey. FINDAR addresses this problem with improved obstacle avoidance during grid collection by automatically guiding the operator on the additional grid lines to collect. You can also collect odd shaped grids by just ending lines short or skipping lines altogether.

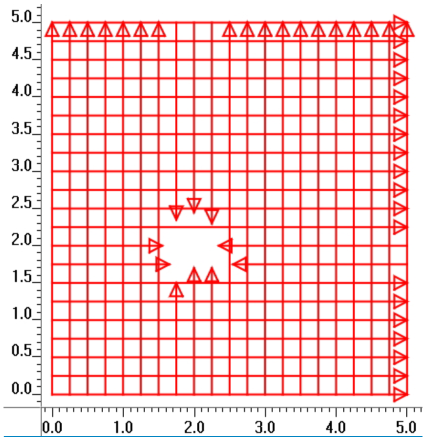

Figure 2: Collecting Grid data around obstacles is easy.

Forensic investigations require quick and informed decisions at an investigation site, so the ability to process the GPR data in the field is critical. Grid Scans are processed into 3D data right on the Display Unit and are shown as a series of 2D depth slices, cutting deeper and deeper into the ground, 5 cm (2 inches) at a time.

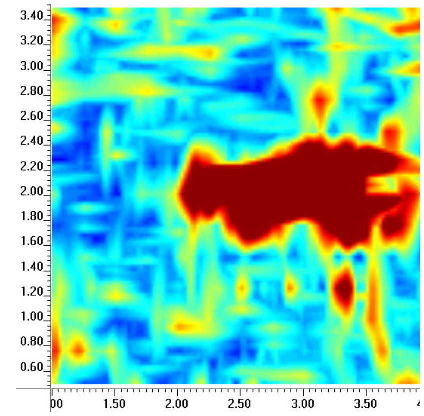

Figure 3: Depth Slice showing an area of strong reflections in red.

Data images of interest can be saved by pressing the Camera button on the Display Unit to capture the current screen image. FINDAR's built-in GPS adds geo-reference tags to these screenshots for future reference. Images can be displayed easily in Google Earth™ and other GIS programs. The new FINDAR® allows these screen images to be emailed directly from the investigation site using a Wi-Fi network - even your phone's Hot-spot. This allows investigators to quickly share findings with those not at the investigation site.

For larger scale surveys, consisting of multiple Line and Grid Scans, positioning all the data on a common coordinate system is critical. Traditional methods for doing this are grid layouts and placing flags or markers at areas of interest.

The new FINDAR® allows for more accurate positioning with the addition of an external GPS. This enables the spatial relationship between all the collected lines and grids to be displayed in the field in Map View. This helps identify areas that may have been missed during the GPR survey.

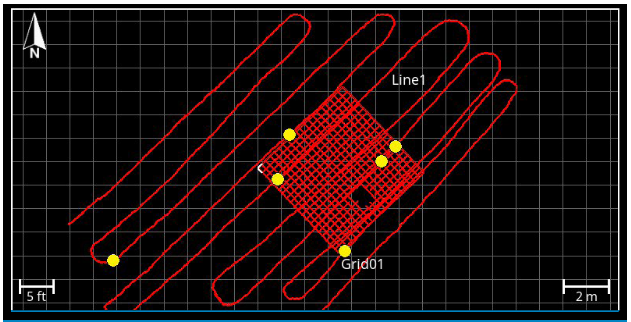

Figure 4: With external GPS, see a map of Grid Scans, Line Scans and field interpretations on the screen

FINDAR® also allows the user to add field interpretations as data are being collected or while replaying the line later. Interpretations can be classified using different colors for different types of GPR responses. These interpretations are plotted on the Map View screen along with the lines and grids. This allows investigators to look for patterns that may be significant for recovering buried evidence.

Figure 5: Add color-coded interpretations to the data by touching the screen .

Using an external GPS enables another extremely powerful and potentially time-saving feature. Using the EKKO_Project™ PC-based software, Line Scans collected with GPS can be processed into depth slices to quickly "slice" through the data and identify targets of interest. What this means is that it is not always necessary to collect a traditional grid when covering large size or difficult shaped areas anymore. Operators can now collect long, windy, lines that form "pseudo-grids" to cover the survey area (essentially, collect FINDAR® data like they are mowing a lawn or painting a floor). This allows odd-shaped areas to be covered much faster than collecting data in multiple Grid Scans.

An important part of any investigation is saving and archiving the findings; FINDAR® makes this easy. All the raw data from a project is saved as a single file (.GPZ), when the data is downloaded to a USB memory stick. All data is time-stamped and geo-referenced (if an external GPS is used), ready to be archived. Results can also be output as PDF reports or standard file formats (including KMZ (Google Earth), CSV (Excel) and DXF (AutoCAD)) quickly and easily using the EKKO_Project™ PC software.

The new FINDAR® brings a new level of functionality and efficiency to forensic investigations. For more information about the new FINDAR®, contact Sensors & Software at sales@sensoft.ca

"Bodies" located with GPR - A forensic field school exercise

There are many applications for GPR in the field of law enforcement and security. One common application is to locate forensic evidence at a crime scene. In these cases, evidence is usually a body, weapon or a container which may contain drugs, money or documents. Many law enforcement agencies worldwide are using GPR to aid in locating this type of evidence.

Earlier this year, the Portuguese Criminal Police hosted a CSI Police School in Lisbon, Portugal. This was attended by Forensic Archaeologists and Crime Scene Analysts from the Netherlands, Sweden, Denmark, Switzerland, Germany and Portugal. Part of the field school involved a simulated exercise as described below:

The Portuguese Criminal Police are investigating the disappearances of four persons who went missing at the beginning of 2018. There is information available that the missing persons are buried near a building, in four separate graves. The Portuguese Criminal Police has requested an international team to help them locate these potential graves using different GPR units. Teams will be asked to excavate, map, document and analyze the four graves and to present their preliminary findings to the prosecutor the day after the excavation.

Sensors & Software participated in this exercise, using a Noggin® SmartCart® with a 500 MHz transducer (Figure 1). Noggins are powerful, easy to operate GPR systems, that are adaptable for a wide range of applications.

Figure 1: Surveying with the Noggin® 500 SmartCart®

Contrary to what is sometimes depicted on television, GPR cannot actually show the outline of a body. Instead, operators are typically looking for areas of disturbed soil or anomalies in the subsurface associated with the body.

The search methodology first involved collecting reconnaissance Line Scans to identify areas of disturbed soil. The Noggin® system easily navigated the site despite the long grass and vegetation. Based on the Line Scan findings and obstacles, such as trees and surface tree roots, a grid was set up. The grid covered a distance of 19m from left to right, with the length of each line varying between 1m and 11m. Line spacing was 0.25m (Figure 2). The goal of the grid was to generate a series of depth slices to better delineate suspicious areas.

Figure 2: Collected lines overlaid on an aerial photo

The grid was collected in about 30 minutes and, within seconds, depth slices were ready for viewing on the Noggin® DVL (digital video logger). A depth slice of the entire grid (Figure 3) and a GPR line across one of the graves (Figure 4) illustrate anomalies seen in the GPR data.

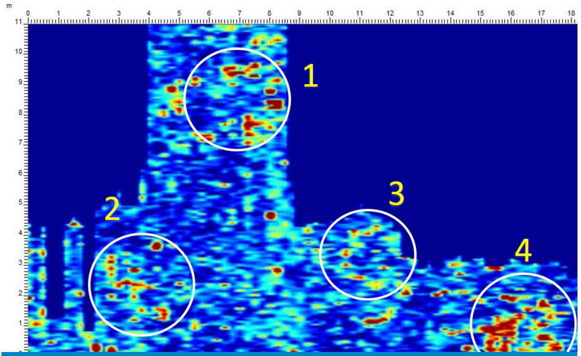

Figure 3: Slice at 20-25cm depth

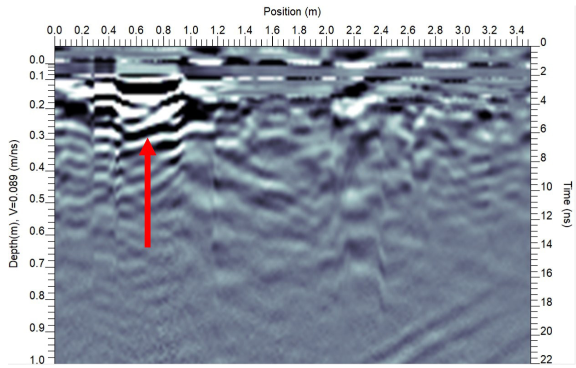

Figure 4: Cross-section line crossing grave #4

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After all the teams had completed their survey and presented their results, the excavations began. To simulate a body, plastic dummies had been buried (Figure 5).

Figure 5: Plastic dummy buried

As revealed during the excavations, the Noggin® SmartCart successfully pinpointed the locations of the 4 bodies. Those in attendance were impressed with the capabilities of the Noggin® SmartCart, including the flexibility to adapt a grid layout to varying field conditions. Rapid generation of depth slices in the field is an asset to police agencies who need to work fast and make important decisions in the field. Data collected with the Noggin® was easily imported into the EKKO_Project™ software, where reports were created to present their findings.

Sensors & Software's line of GPR products allow law enforcement agencies to locate evidence in real time and direct their excavation efforts to suspect areas, rather than guessing where to excavate - saving time and increasing the probability of finding important evidence.

TIPS: The Power of Average Trace Amplitude (ATA) Plots

Plotting the average of all the traces in a GPR cross-section shows the response character versus time and provides the user with insights and key understandings of the nature of the data.

GPR lines are commonly displayed in varying colors based on signal amplitude (Figure 1a). However, the best way to show trace data is by plotting the GPR data as a wiggle trace (Figure 1b). A wiggle trace plot depicts the amplitudes of the signal as deflections from zero amplitude.

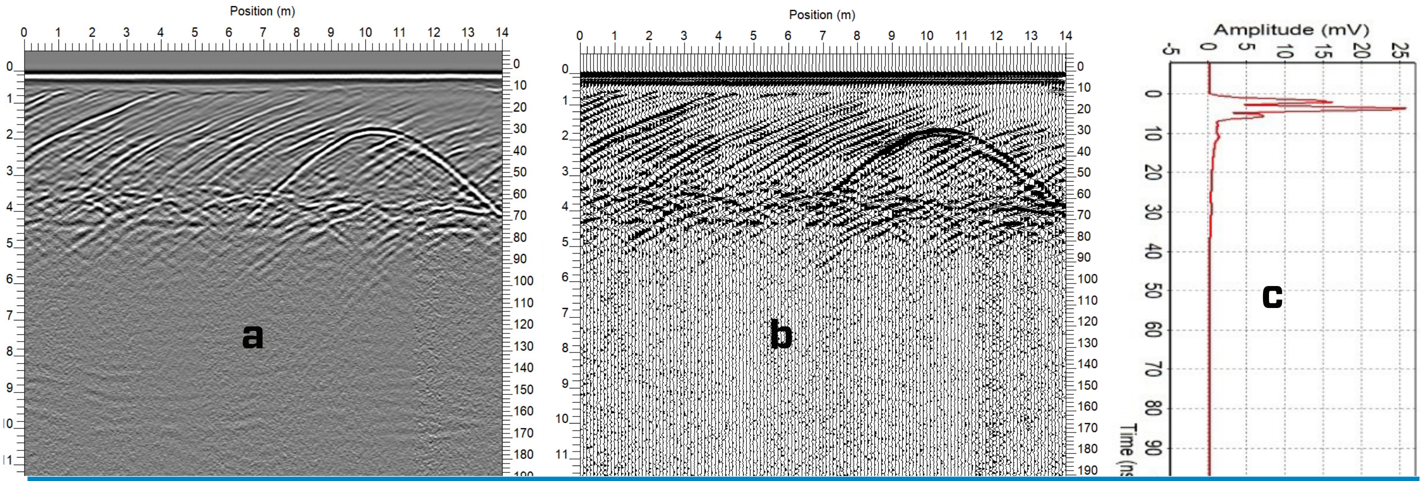

Figure 1: GPR line plotted in variable color (gray shades) traces (a) and wiggle trace (b). To create an ATA plot and then averaged to a single trace (c).

To generate an ATA plot, all the traces from a GPR line are rectified (also called absolute value) to show all the signals as positive amplitudes. Then, the rectified traces are averaged to a single trace (Figure 1c). The averaging of rectified data means that the noise and signals are all included in the resulting average.

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ATA plots are usually plotted with the average trace on its side (Figure 2); time in the X direction and amplitude in the Y direction. Also, since there is such a large dynamic range in the GPR signal amplitudes, the average trace amplitude plot is usually plotted with a logarithmic amplitude scale.

The premise of using ATA plots is that the GPR line length is sufficiently long to contain a wide variety of responses that are generally representative of the site being surveyed. Key points to remember about ATA plots:

a) The plot can be used for assessing and quantifying random noise and the depth of penetration of the GPR signals.
b) Flat lying reflectors are emphasized; reflectors that dip or vary in depth are averaged and blur into the average amplitude variation with time (or depth).
c) Coherent system noise which is time-invariant will show up in the ATA plot and can be diagnosed as such.
d) The plot can also show if the GPR signals are being clipped.
e) The decay curve of the amplitude with time is a good indicator of ground attenuation.
f) The ATA amplitude decrease provides a guide to the appropriate time gain function to be applied to data.

In this article, we focus on how to use the Average Trace Amplitude (ATA) plot for a and e.

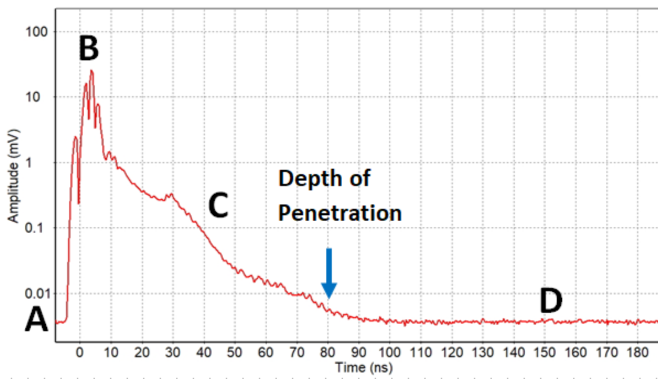

Figure 2: Average rectified trace plotted in a logarithmic scale. A and D = background RF noise, B = the transmit pulse and C = attenuating signals. The "Depth of GPR Penetration" is the depth that GPR signals have attenuated down to the RF noise floor (A+D)

The GPR receiver begins recording before the GPR transmitter fires, resulting in only background radio frequency (RF) noise in the data (A in Figures 2 and 3).

After the GPR transmitter fires, the highest amplitude signal in an ATA plot is usually the direct arrival of the GPR transmit pulse at the receiver; this signal travels through air at the speed of light (B in Figures 2 and 3). This is called the "direct air wave".

Following the direct pulse, GPR signals arriving at the receiver are weaker, as they have been attenuated after travelling through the subsurface. The further the GPR signals travel in the ground, the weaker they become and the later they arrive in time (C in Figures 2 and 3).

After all the GPR signals have attenuated, the receiver again records the background RF noise (D in Figures 2 and 3).

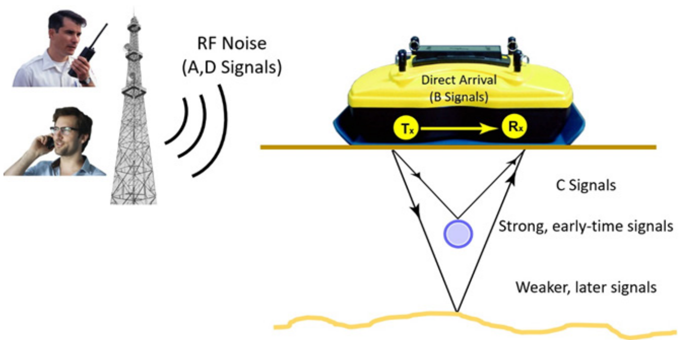

Figure 3: Illustration of the types of signals received by the GPR

The depth at which GPR signals are the same amplitude as the background noise (so they can no longer be differentiated) is defined as the GPR "Depth of Penetration"; this varies based on the electrical properties of the material (Figure 5).

Background RF Noise

Before the GPR transmitter fires, the GPR receiver is recording other radio frequency emitters in its bandwidth (A in Figure 2). In the example in Figure 2, the background noise floor is approximately 0.004 millivolts.

Examples of ATA plots of 100 MHz data with background random noise varying from 0.08 to 12 mV (1500x stronger) are shown in Figure 4. Background noise can vary tremendously depending on the RF environment – areas, usually urban areas, with many strong radio transmitters can generate signals 1000 times stronger than other, more remote or rural areas with few RF emitters. High background noise reduces the depth of GPR penetration.

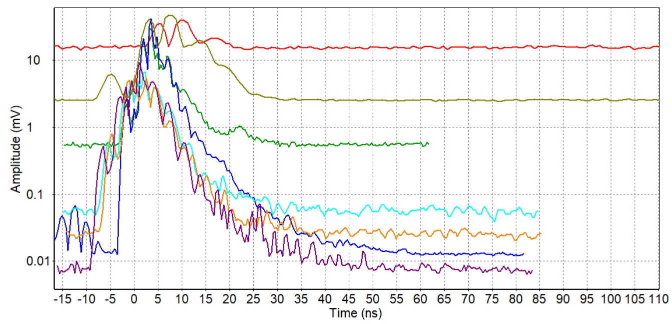

Figure 4: ATA plots showing varying levels of background radio frequency noise.

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The ATA plots show that GPR amplitudes decay with time. Figure 5 shows extreme attenuation curves of 100 MHz antennas. The red line slopes very gradually, indicating low attenuation and deep GPR signal penetration. In fact, at 850 ns (about 45 meters), the signal has still not attenuated down to the noise floor; this means that the operator would have seen deeper if they set a longer time window. The green line shows higher attenuation, with the GPR signal rapidly falling into the background noise floor, indicating limited GPR signal penetration at this site.

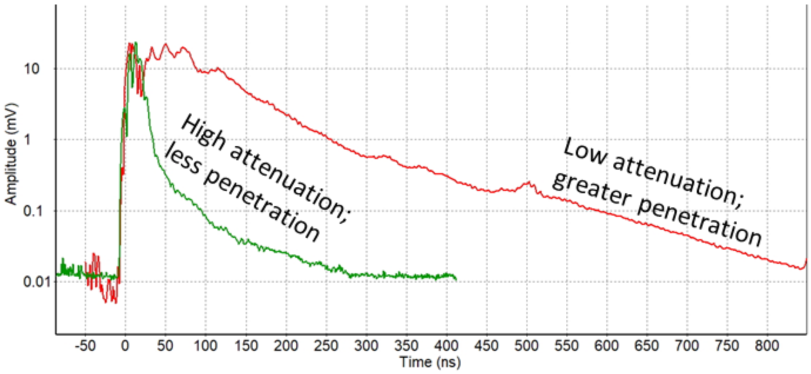

Figure 5: Low (red line) and high (green line) attenuation curves.

We've only just scratched the surface of the value of ATA plots in this TIPS article. In addition to background noise and depth of penetration analysis, ATA plots can also help identify coherent system noise and air waves. Stay tuned for future articles on this topic.

When used in a controlled manner, the ATA method is extremely powerful and should be a methodology used by all professional GPR analysts. ATA plots are available in the Processing module of the EKKO_Project™ software.

Upcoming Courses

Subsurface Utility Locating with GPR (Nulca-accredited) - August 16, 2018. Orlando, FL, US
Subsurface Utility Locating with GPR course (Nulca-accredited) - September 10, 2018. Mississauga, ON, Canada
Concrete Scanning with GPR course - September 11, 2018 Mississauga, ON, Canada
2-Day Subsurface Utility Locating course (Nulca-accredited) - October 2-3, 2018. Mississauga, ON, Canada
European 3-Day GPR course - October 10-12, 2018. Höhr-Grenzhausen, Germany

Upcoming Tradeshows

EAGE Near Surface Geoscience Conference and Exhibition 2018 September 9-13, 2018, Porto, Portugal
EAA 2018 September 5-8, 2018, Barcelona, Spain
ROCIC 27th Annual homicide Conference September 30-October 3, 2018, Nashville SE, TN

Celebrating our 25th Anniversary of Subsurface Views Newsletters since 1993

25th Anniversary

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