January 2014

Subsurface Views

GPR Innovations: Hardware and Software

GPR Locates a Hero

The memory of the canine hero Cloud II will be honored for years to come with the help of ground penetrating radar (GPR).

Over a period of four years as a member of the Ontario Provincial Police (OPP) Canine unit, the German Shepherd worked with his handler Ray Carson to capture fugitives, find missing children, and rescue lost hunters. After dramatically disarming three escaped juvenile offenders, Cloud II was inducted into the Purina Animal Hall of Fame on September 12, 1974, "for his unflinching courage against great odds." Then in 1975 his stellar career came to a sudden end when he was tragically shot while trying to apprehend a suspected murderer. He is the only OPP dog ever killed in the line of duty.

Cloud II was interred on the grounds of the OPP District Headquarters in North Bay, Canada. His funeral was attended by numerous officers, local citizens and school children. At the time he was buried in a simple plywood casket that was encased in concrete. When the headquarters were moved to a new site, local officers did not want to leave him behind; his remains were exhumed and relocated to the OPP Museum in Orillia.

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Cloud II & his handler Ray Carson

Photos courtesy of OPP

LMX100 Redefines Utility Locating

The underground utility landscape is growing increasingly complex. The ground is full of traditional metallic utilities such as pipes and cables installed over the past centuries. In addition, a new generation of non-metallic utilities such as fiber optic cables and PVC piping have been installed, creating a more challenging underground locating situation. Utility locators, armed with only traditional direct-connect or induction-type equipment, see only part of the picture; this means that they are vulnerable to dangerous accidents, costly repairs, and liability. To better understand what is happening in the subsurface, the common sense approach for locators is to use all the technologies available.

LMX100

LMX100 completes the locator's toolbox

As one of the most affordable GPR utility locating tools , LMX100 augments the locator's toolbox, offering a more complete picture of the underground infrastructure.

Using GPR has the advantage of detecting:

- *Metallic and non-metallic objects.*
- *Disturbed soil often associated with utility burial.*
- *Unexpected buried structures such as old foundations that can cause problems for excavations or construction.*

LMX100 offers the perfect balance of depth penetration and resolution for accurate locating. Data is collected in Locate & Mark mode; this provides a real-time image in the field to identify utilities and mark their locations.

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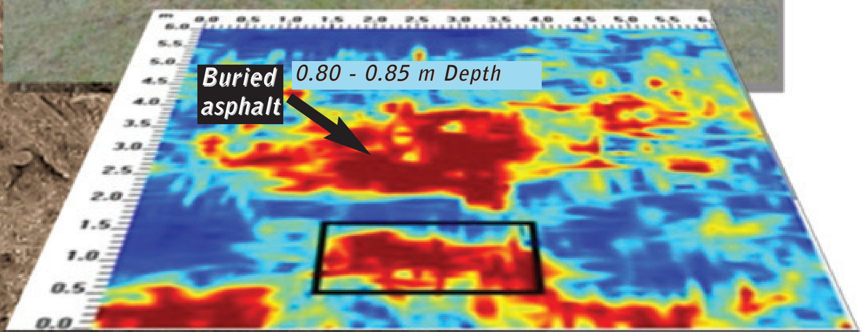
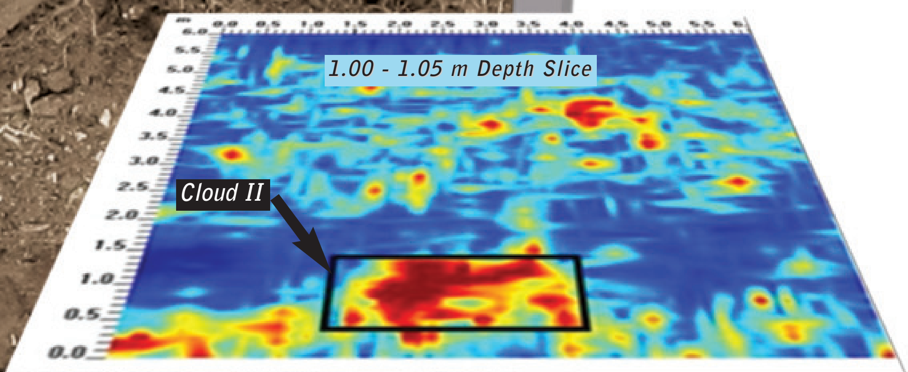
Sensors & Software

Setting up the grid





Cloud II's casket encased in concrete was excavated

GPR Locates a Hero

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The OPP used a GPR system to quickly locate Cloud II's remains, saving both time and money. A search grid was established on the front lawn of the North Bay OPP detachment. Trained OPP personnel gathered the GPR grid data at a 0.25 meter line spacing, in about half an hour. The FINDAR GPR system processes grid data into depth slices out in the field, right on the data logger.

Depth slices are plan maps of GPR signal strength at different depths. They reveal the depth, shape and areal extend of buried objects that contrast with the natural soil. In this case each depth slice was 5 centimeters thick. The depth slices revealed several interesting artifacts including a possible metal vault located at a depth of 0.75 meters.

A large anomaly visible at the center of the grid in the 0.80 to 0.85 meter depth slice was found to be a chunk of asphalt. The original driveway to the headquarters had been buried and this generated some initial confusion in identifying Cloud II's final resting place. Once the largest of the anomalies visible on a deeper 1.00 to 1.05 meter depth slice was excavated it was confirmed as Cloud II's casket.

Ray Carson was on hand for the small exhumation ceremony. After 36 years encased in concrete, witnesses found that all things considered the dog's body was in good condition. "He looked just like my dog laying down – he wasn't decomposed at all" said Sargent Rob Mondor, an OPP canine handler and friend of Mr. Carson.

The OPP held a special recognition ceremony at their General Headquarters in Orillia for Cloud II. OPP members, local dignitaries, retired and active Canine Unit handlers, their dogs and Friends of the OPP Museum members were in attendance to hear stories about the hero and how his legacy persists in the Canine Unit's operations today. The German Shepherd's remains were cremated and laid to rest in a special stone urn on display at the OPP Museum along with his photo and plaque that tells his story.

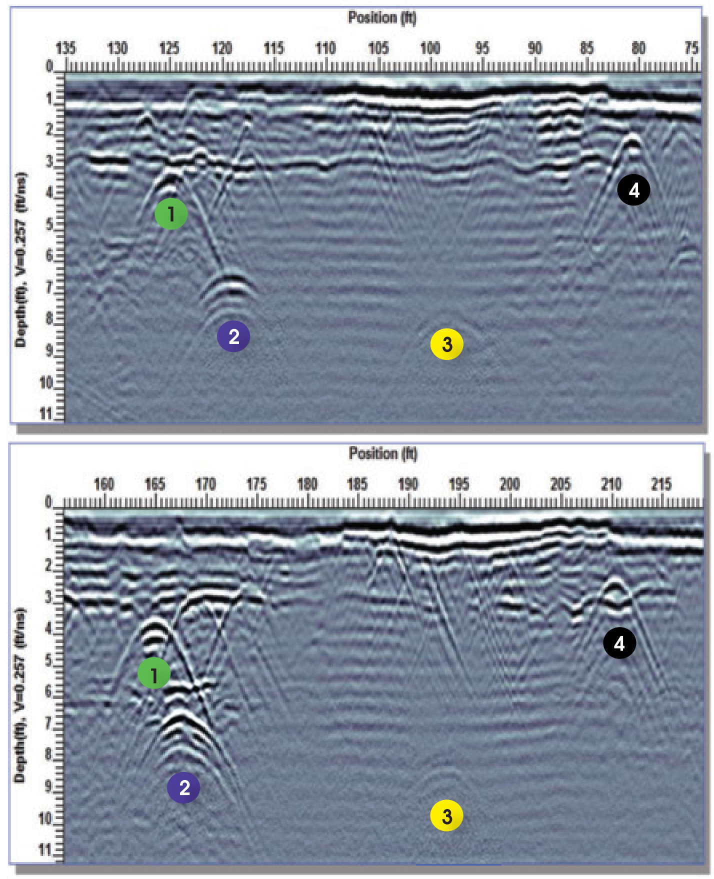
LMX100 Redefines Utility Locating

(continued from page 1)

To Locate & Mark simply push the LMX100 across the surface perpendicular to the direction of suspected utilities. An integrated direct-drive odometer triggers the GPR transmitter to fire radio frequency energy into the subsurface every 5 centimeters (2 inches). Reflections from objects in the subsurface are gathered by the GPR receiver and displayed on the Digital Video Logger (DVL). This action builds up a cross-sectional image of the subsurface on the DVL screen, one vertical data trace at a time. Utilities typically appear as inverted U's (hyperbolas) in the cross-section.

Real-time utility marking with GPR requires the use of the human eye to identify the characteristic hyperbolic pattern in reflected GPR waves displayed on the DVL screen. While computer recognition technology is improving, nothing surpasses an experienced human.

GPR data to the right shows four utilities seen on two parallel lines, separated by several meters. The strength of the GPR reflections vary, but the character, shape, and depth for each utility is similar on both lines. This pattern recognition allows operators to follow a single utility in complex situations.



Four utilities seen on two parallel GPR lines, separated by several meters. Note how, even though the strength of the GPR reflections vary, the character, shape, and depth for each utility is similar on both lines.

To pinpoint the target location operators simply back up along the same path. The odometer runs in reverse and the DVL indicator guides you back until the GPR system is over the target. A huge advantage of GPR over the traditional utility-locating techniques is the accuracy of target locations, often within 5 centimeters of the actual location as compared to up to a meter for other tools. When surveying with GPR, it is not unusual to see a paint mark on the ground left by a previous locator that is nowhere near the actual location of the utility.

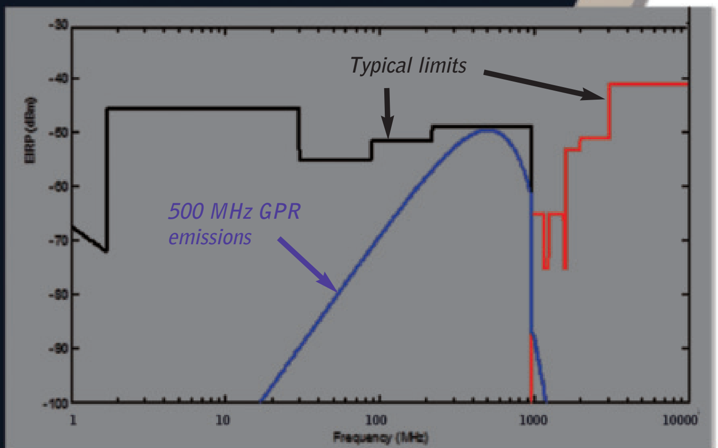
GPR does have its limitations. Soils with high electrical conductivity, such as clay-rich or saline soils, absorb GPR signals before they penetrate to the deeper utilities. GPR is also sensitive to all changes in the subsurface, not just utilities. Fluctuations in water content, different soil layers, tree roots, rocks, and other buried objects create responses in the GPR image, making unique identification of utilities difficult at times.

The technology behind the LMX100 is the fusion of the unrivalled pedigrees of the pulseEKKO and Noggin GPRs. These high-end, ultra-wide band GPR systems were developed over decades of pioneering research and are chosen by the world's most discerning scientific professionals.

The LMX100, with its highly intuitive graphical interface greatly simplifies surveying, allowing the operator to use GPR with minimal training.

Today's buried infrastructure requires a multi-technology attack. Understanding where and when a particular locating technology is the most cost effective solution comes with experience as well as the knowledge of construction practices and local soil conditions. Adding the LMX100 to your utility locating arsenal puts you in the position to take on the most challenging locate projects.

GPR Regulations



Example of GPR spectrum (blue line) and the typical emissions limits (black line) in EIRP (equivalent isotropic radiated power) in units dBmW (-100 equals 10 uW and - 10 equals 100 uW) Emissions regulations change at around 1000 MHz (red line). Below 1000 MHz (depends on jurisdiction) power is a quasipeak in 120 kHz bandwidth while above it is an average power in 1 MHz bandwidth. The notches at about 1200 MHz and 1600 MHz are the GPS bands. The blue line shows a typical GPR with a 500 MHz center frequency spectral distribution.

From attending scientific conferences and listening to our customers, there is a lot of misinformation about the regulations that govern the use of GPR. Comments such as:

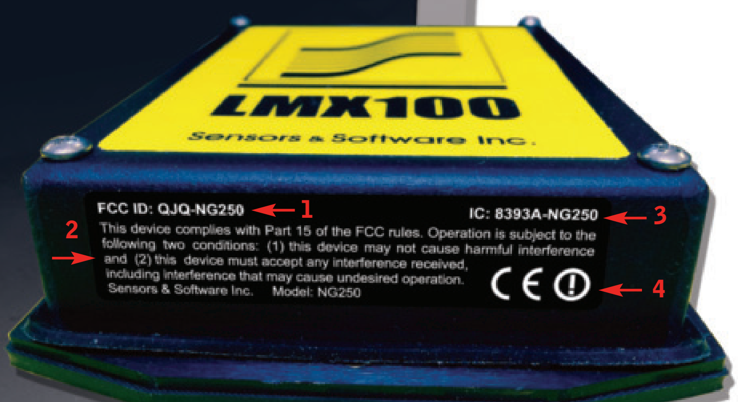
Use of GPR is illegal
100 MHz antennas are illegal
Unshielded GPR antennas are illegal
GPR operating below 30 MHz is not permitted!

made us realize a refresher on the regulations for GPR is necessary.

GPR devices are considered radio frequency emitters and all governments have strict rules on the creation and emission of radio frequency signals. Radio signals can occupy a wide range of frequencies, typically from 9 kHz to over 100 GHz which is referred to as "spectrum". Governments generate large amounts of revenue by selling parts of the frequency spectrum for exclusive or shared commercial or public use and also reserve parts of the spectrum for exclusive use by both civilian and military government agencies. It is common to hear that telecom companies have paid billions of dollars at a public auction for use a newly released part of the spectrum.

GPR devices are considered ultra wideband (UWB) devices and must generate signals over a wide swath of frequencies. For example, a 100 MHz GPR will typically have substantial energy at all frequencies in band from 50 to 150 MHz. The range of frequencies is referred to as the bandwidth of the GPR device. Such a GPR runs into direct conflict with the conventional TV and FM radio spectrum licenses which are in this frequency range.

Since there are all sorts of essential electrical devices that create emissions, either intentionally or unintentionally, regulatory agencies managing and policing spectrum usage have to devise ways for these devices to co-exist while protecting the rights of licensed spectrum users. This is achieved by ensuring that these devices emit at sufficiently low power levels so they do not interfere with licensed users. The debate is then about what level is small enough. Licensed spectrum users argue for zero while the device proponents want it as large as possible. A compromise has to be reached and this is how emissions limits are defined. *Sometimes zero is the result!!*



GPR systems must display the device approval codes:

1 - FCC ID
2 - FCC declaration of conformity
3 - Industry Canada ID
4 - European Community (ETSI)

There are no regulations on the type of GPR antenna or how a GPR is constructed. Any GPR can operate at any frequency provided its emission levels are under the limits; the rules DO NOT explicitly outlaw any specific GPR antenna frequencies. The constraint for GPR devices is achieved by demonstrating emitted power for the device is below specified limits when tested in a defined manner normally by a certified testing body.

The FCC (Federal Communications Commission) governs GPR in the USA. GPR devices must be tested by an approved testing body, the results must be filed with and reviewed by the FCC, approval and unique identification issued by the FCC, and the product and manuals must display the unique device approval codes and FCC warnings. In Canada, Industry Canada regulates GPR and the same processes as used by the FCC apply. In Europe, manufacturers must self-declare (and have technical documentation available if needed to prove) that devices comply to an ETSI standard and then issue compliance notifications as to which standards the device complies with. GPR devices that do not follow this process cannot be sold or used and the penalties for violation can be severe!

For GPR purchasers, the key is to select GPR systems that have demonstrated regulatory approval. Ask for product codes or letters of compliance! In Canada and the USA, all approved devices are listed on government web sites.