Ground Penetrating Radar (GPR)

What it is, how it works and applications in utility locating

Wikipedia Explanation

Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. This nondestructive method uses electromagnetic radiation in the microwave band (UHF/VHF frequencies) of the radio spectrum, and detects the reflected signals from subsurface structures. GPR can have applications in a variety of media, including rock, soil, ice, fresh water, pavements and structures. In the right conditions, practitioners can use GPR to detect subsurface objects, changes in material properties, and voids and cracks.

GPR uses high-frequency (usually polarized) radio waves, usually in the range 10 MHz to 2.6 GHz. A GPR transmitter emits electromagnetic energy into the ground. When the energy encounters a buried object or a boundary between materials having different permittivities, it may be reflected or refracted or scattered back to the surface. A receiving antenna can then record the variations in the return signal.

The electrical conductivity of the ground, the transmitted center frequency, and the radiated power all may limit the effective depth range of GPR investigation. Increases in electrical conductivity attenuate the introduced electromagnetic wave, and thus the penetration depth decreases. Because of frequency-dependent attenuation mechanisms, higher frequencies do not penetrate as far as lower frequencies. However, higher frequencies may provide improved resolution. Thus operating frequency is always a trade-off between resolution and penetration. Optimal depth of subsurface penetration is achieved in ice where the depth of penetration can achieve several thousand meters (to bedrock in Greenland) at low GPR frequencies. Dry sandy soils or massive dry materials such as granite, limestone, and concrete tend to be resistive rather than conductive, and the depth of penetration could be up to 15-metre (49 ft). In moist and/or clay-laden soils and materials with high electrical conductivity, penetration may be as little as a few centimeters.

Uses in utility locating

Locating utility lines and structures generally uses an electronic locator that transmits a radio signal down a metallic cable, pipe or tracer wire. A receiver detects the radio signal emitted on the line and enables the locator to determine the location. Electronic locating is the best way to quickly and accurately locate and identify buried utility lines. There are however instances where a utility line is unlocatable due to the line being non-metallic. This is where GPR can be useful as it does not require the line to be metallic. GPR can be the only way to locate non-metallic lines without randomly potholing. As the GPR scans while rolling along the ground it shows the ground layers and voids. Conduits show up as voids which look like inverted "U"s which are called hyperbolas.

Common unlocatable lines and structures that GPR can locate include:

- Water lines
- Sewer lines/drain field
- Empty conduit
- Plastic or hidden culverts
- Sewer tanks/water cisterns
- Gas lines with no tracer wire
- Storm drains
- Buried manholes/dry wells
- Ditch lines
- Sprinkler/irrigation lines
- Unknown or unexpected buried objects
- Lines that could have been missed by traditional locate

GPR is also a good tool locating for pre-design/engineering and can possibly find water leaks.

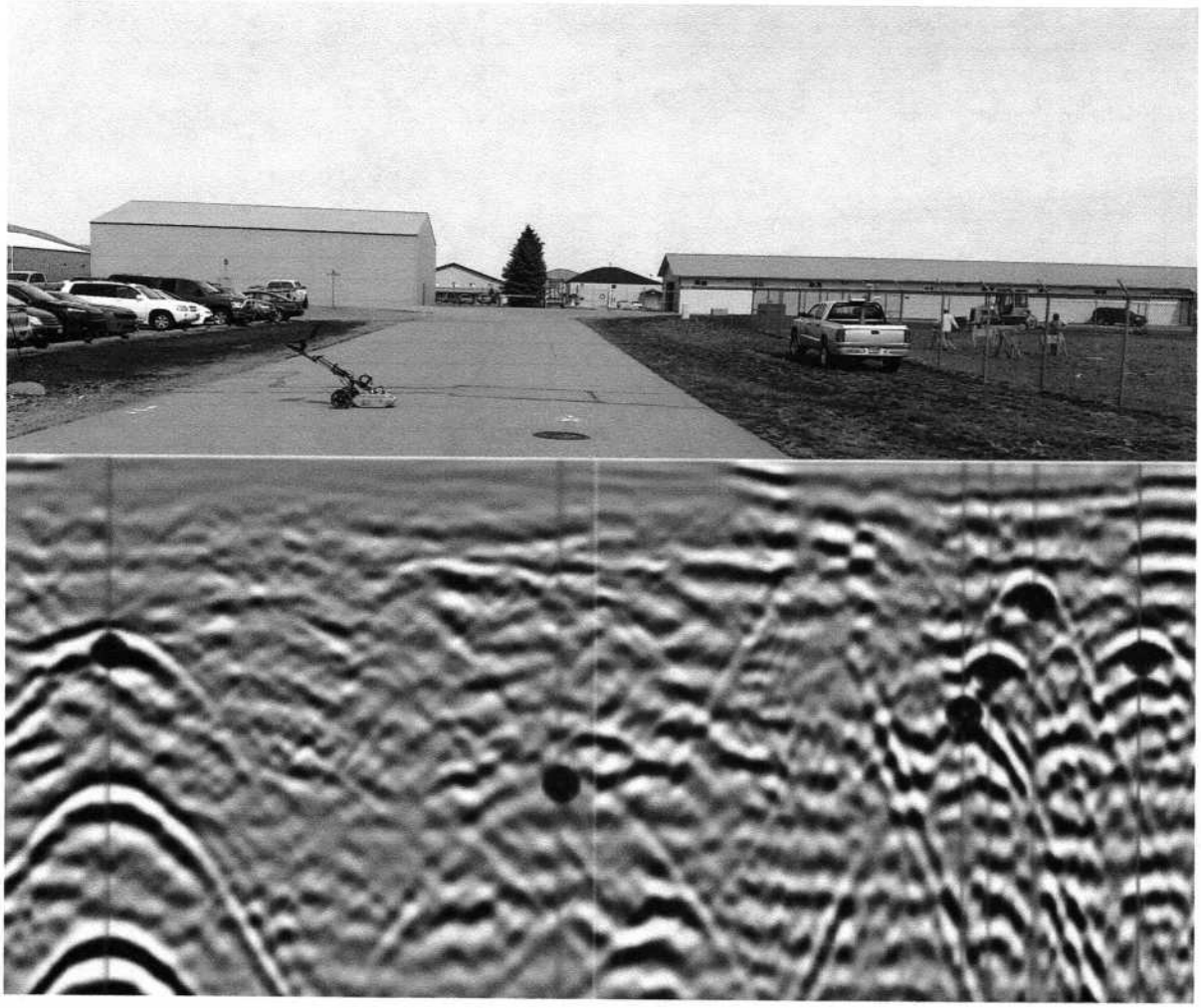
Like every tool it has its limitations. The machine has to roll over the ground to be able to scan therefore relatively flat, mostly free of obstructions and good access are important. More importantly GPR is also limited by ground conditions. Wet clay, silts and highly conductive soil can absorb the signal and make inconclusive results. Size and depth of the line is also a factor. Generally the deeper the line is the bigger it has to be to be seen by the GPR. Also GPR cant distinguish the difference between different utilities (exception is larger water lines as they can show up differently)

GPR survey steps

1. Call 811 to have known utilities marked and electronic locate homeowner/private utility lines (GPR will locate all buried lines therefore locating other utilities electronically first narrows down the possible location of the target utility line)
2. Set up GPR machine and calibrate
3. Look for evidence of the line to try to narrow down the area if possible (valves, route markers, ditch lines, etc.)
4. Scan area in a grid pattern starting perpendicular to where the line is believed to be
5. Mark spots of interest while scanning
6. Once scan is done connect marks to complete the survey
7. Can be potholed to verify if necessary

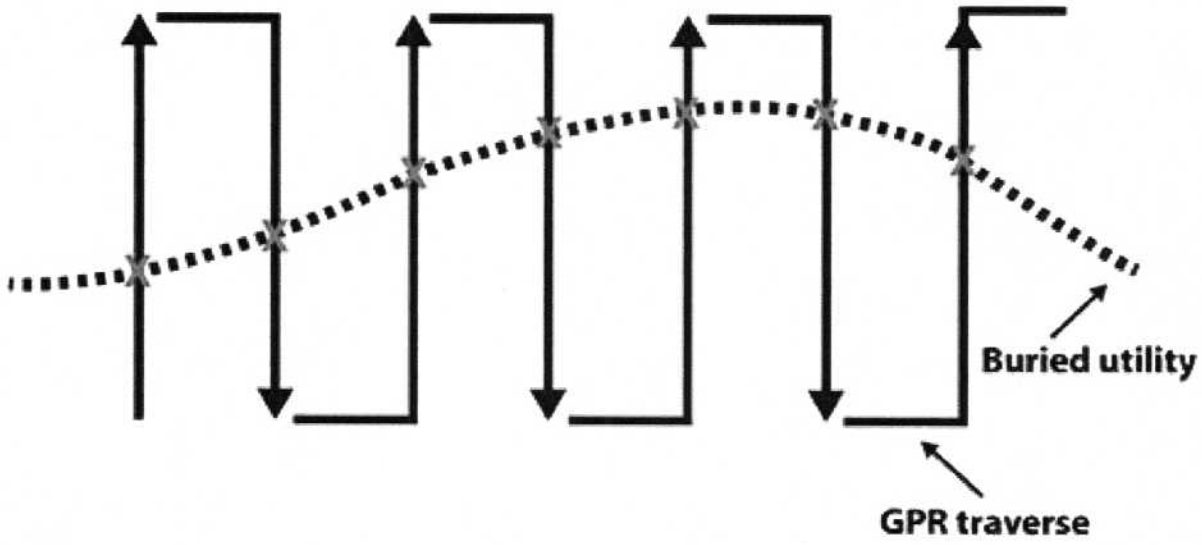
Ground Penetrating Radar can be a very important tool in utility damage prevention

We currently have a newer IDS Detector Duo GPR with dual frequency antenna. Dual frequency antenna allows to have good resolution at shallow and deep depths simultaneously. The Detector Duo also allows saving acquisition data and is GPS compatible.

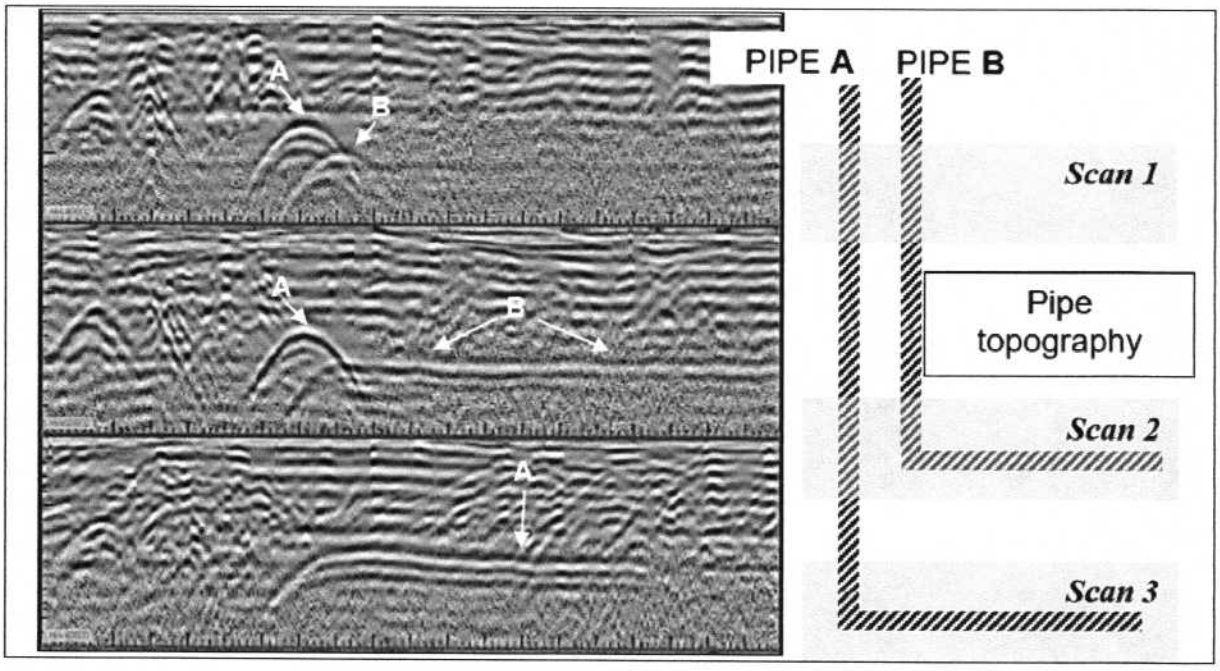


Water **Sewer** **Power** **Phone** **Gas** **Cable**

How a scan cross section would line up

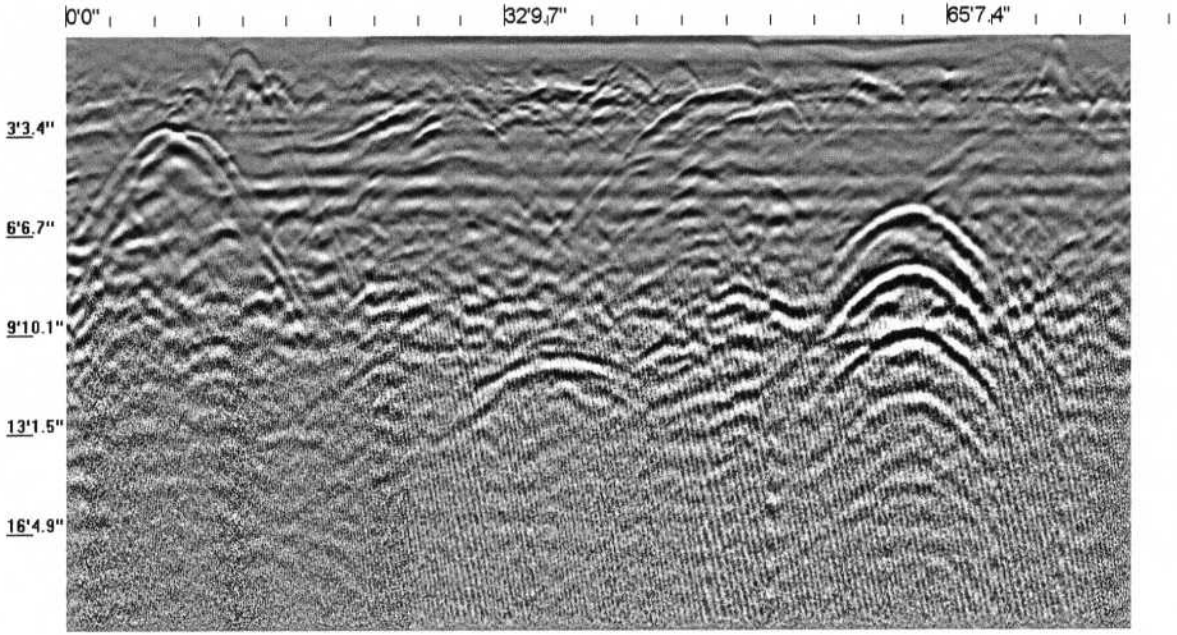


Grid pattern perpindicular of utility line



3 scans showing what utility line looks running perpendicular and parallel

Acquisition: tanager Scan: 1 Date: Wednesday 5 April 2017 Page: 1	Prescan note: Prescan note not present	IDS INGEGNERIA DEI SISTEMI S.p.A.



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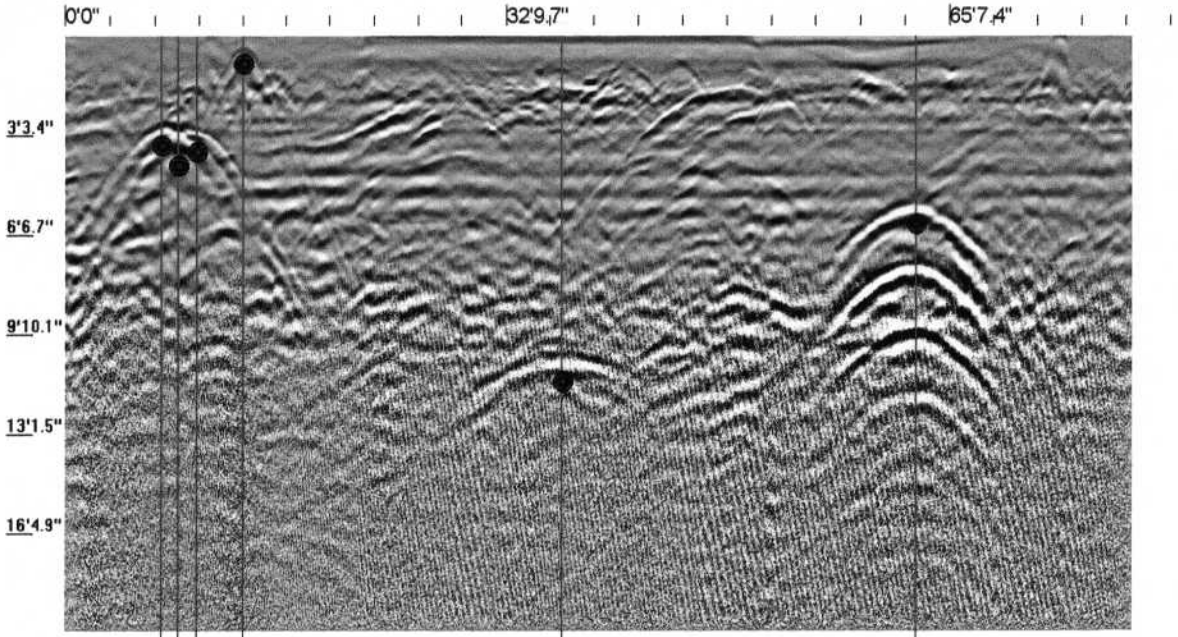

>7'0.3" v3'3.4"
Gas pipe
>8'3.6" v3'11.2"
Power cable
>9'8.1" v3'5.7"
Telecom cable
>13'1.9" v0'7.1"
Other

>37'0.1" v11'1.1"
Sewer pipe

>63'1.5" v5'10.5"
Water pipe

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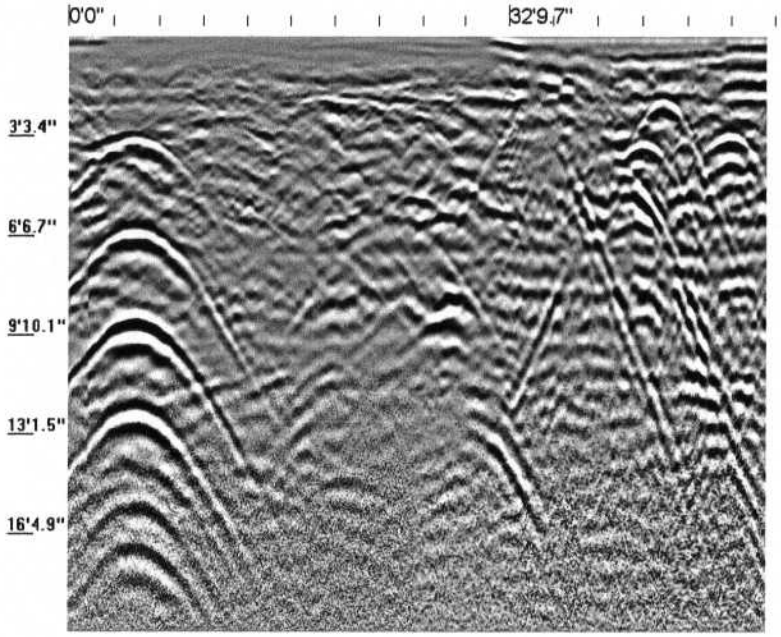

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