UNDERGROUND UTILITY DETECTION AND MAPPING WITH GROUND PROBING RADAR METHODOLOGY

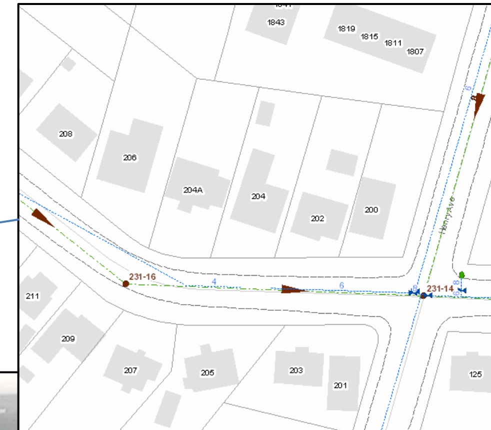
Survey design and planning

Damage to critical facilities could pose an **extreme safety hazard**

Subsurface utility engineering as a practice works to classify information according to quality levels.

1. Quality Level A is the most basic level of information for utility locations which comes solely from existing utility records or verbal recollections. This level is primarily useful for project planning activities.
2. Quality Level B involves surveying visible above ground utility facilities (such as manholes, telephone boxes, et cetera) and correlating this information with existing utility records.
3. *Quality Level C involves the application of surface geophysical methods to determine the existence and horizontal position of virtually all subsurface utilities within a project's limits. Non-destructive technology like ground-penetrating radar and electromagnetic tools are often leveraged at this stage to accurately detect even non-toneable assets including PVC or plastic pipe, sewers, and assets containing broken tracer wires. Level B information is correlated with levels C and D to provide a comprehensive subsurface utility dataset that includes abandoned lines and other discrepancies, while confirming the accuracy of record data.*
4. Quality Level D, also known as "daylighting," is the highest level of accuracy presently available. It provides information on the precise vertical and horizontal positions of underground utilities along with the type, size, condition, material, and other characteristics of the assets. This is usually accomplished through hydro-vacuuming or hand digging in a select area.

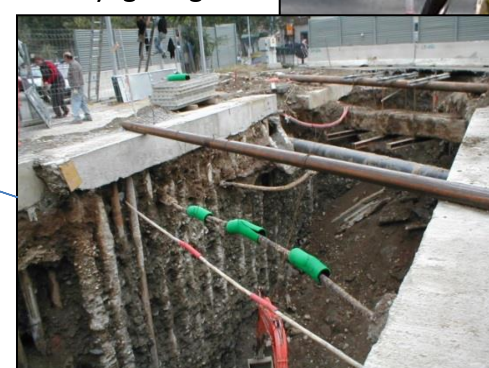
A- existing map



B- Manhole check

B-GPR survey

D-daylighting



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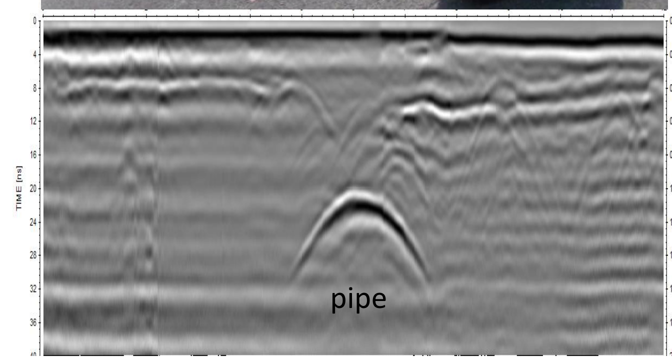
The Ground Probing Radar (GPR)

The Ground Probing Radar (GPR) a geophysical method used to investigate the near surface underground, can detect underground storage tanks and pipes, underground utilities of any type (metal, plastic and concrete). A typical GPR survey requires the acquisition of a series of lines arranged in a regular grid, in order to investigate the entire site. When a radar profile crosses a cylindrical shape (pipe or tank) across its axis, the electromagnetic signal undergoes a reflection effect that results in a typical hyperbolic shape .



For any kind of work involving excavation of the ground, the exact knowledge of the location of underground structures is a key element for proper execution of the work. In this perspective, the use of GPR is an excellent tool to obtain all the information needed to perform the actions provided for in an effective way, safe and without damage to the infrastructure.

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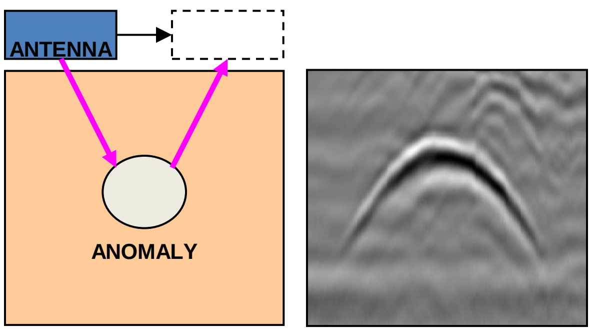
Basic principles

How the GPR works?

The GPR (Ground Penetrating Radar) is based on the response of an electromagnetic signal of impulsive high-frequency (20 to 2000 MHz) from a transmitting antenna. The electromagnetic signal generated by the antenna propagates in the subsoil: the difference of electromagnetic properties of the material causes reflection of electromagnetic waves with a energy incident on the discontinuity.



Acquisition Radar diagram

The reflection can be generated by geological contact, soil-rock interface, groundwater levels, different kinds of artifacts and other objects (pipes, cables, etc.) characterized by different dielectric properties.

Penetration depth

Depth of GPR penetration depends on the material being surveyed and also upon the antenna frequency being used. For instance, GPR will penetrate ice, rock, soil and asphalt differently due to each material's unique electrical properties. Lower frequency antennas will generally penetrate deeper, but there is a loss in resolution with the drop in frequency.
Soil conditions can vary greatly, which in turn affects GPR penetration. In general, dry sandy soils with little salt content return excellent survey resolution, but heavy clay-based soils are difficult to penetrate with GPR. In some situations, penetration depth may be limited to 1 m or less within clays, whereas pipes residing in sandy soils could be detected at depths up to 10 m.

Technically speaking:

1) high frequency antennas (with a wavelength very small and very high resolution, 1.5-2 GHz antennas), for **high detailed investigation of concrete structure** (rebar location, etc). Depth of penetration < 50 cm
2) intermediate frequencies, 250-500 MHz antennas are used in most applications (underground utilities location, archeology, etc..); **they represent the best compromise between the degree of detail and depth of investigation**; Depth of penetration 3 – 6 m
3) low frequencies, ie 100-200 MHz antennas, characterized by longer wavelength and lower resolution capabilities. They can reach 10 m depth, but can only identify big structures of minimum dimensions of some decimeters

Techgea GEOPHYSICS

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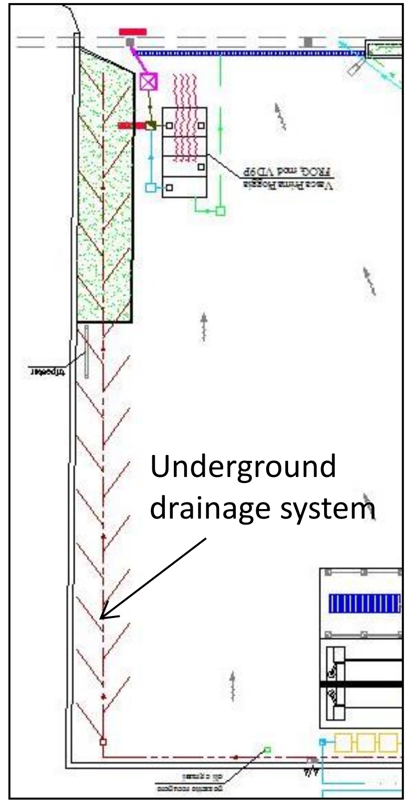
The IDS multiarray system

Techgea Srl utilize the multiarray IDS system RIS MF Hi-Mod. It is a specialized ground penetrating radar system capable of investigating large areas with a 3D view of the subsoil with a high capability of resolution and penetration depth. Thanks to the radar's capacity and the archaeologist's experience buried underground objects can be detected with a high level of confidence and consequently plan the excavation activities. RIS MF Hi-Mod offers:

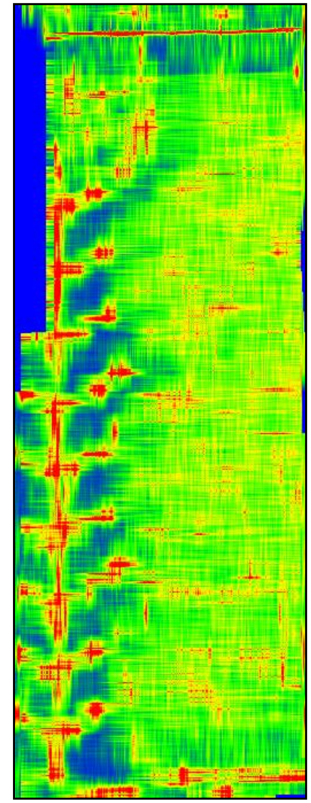
- Consolidated complete procedure from field acquisition to the final output (maps on CAD or GIS);
- Mechanical structure for all urban environments and terrains;
- Automatic target recognition: automatic tools help the operator locate pipes and cables;
- 2D & 3D tomography: optimized tomography for an immediate visualization of pipes and cables;
- Multi-frequency data fusion: automatic fusion of data from 400 and 900 MHz antennas;
- Automatic transfer to CAD/GIS: localized pipes and cables automatically transferred to CAD or GIS maps.

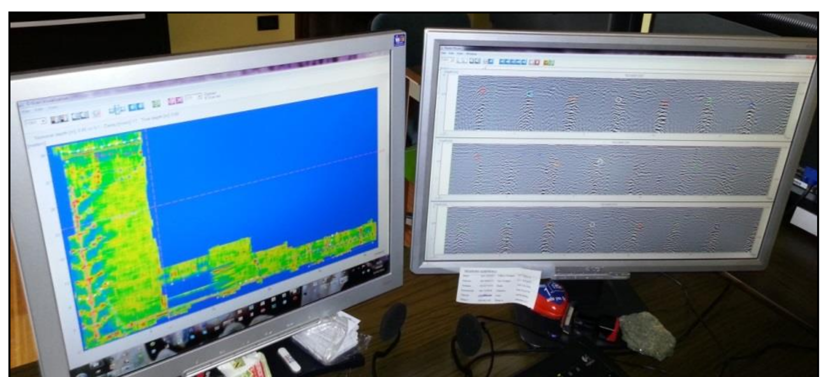
The RIS MF Hi-Mod GPR solution is equipped with an array of multi-frequency antennas to provide a high resolution survey of the shallower depths, using 900 MHz antennas, while guaranteeing a great depth range with the 400 MHz.

As built drawing



Tomography of the subsoil





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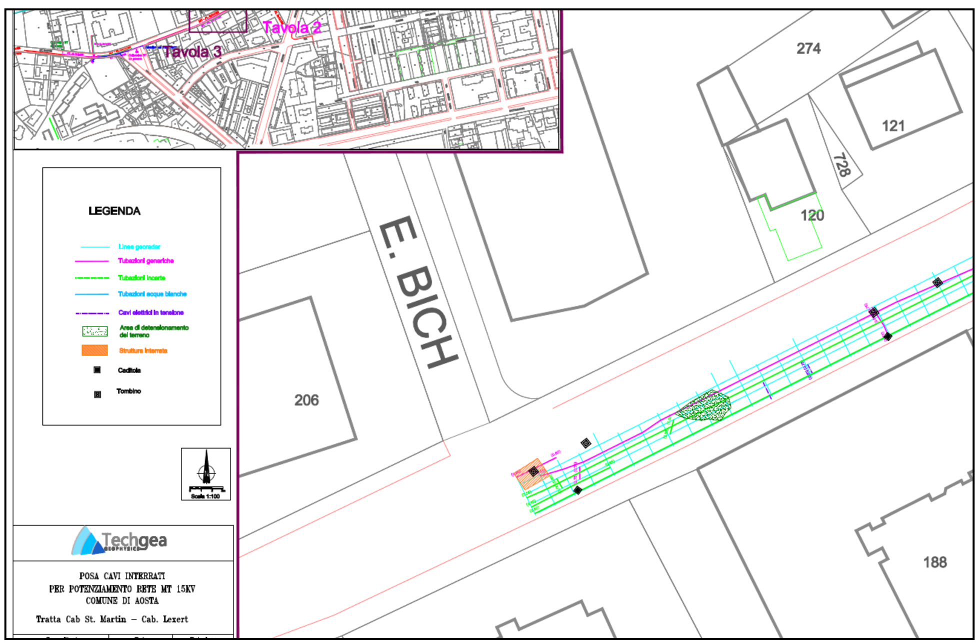
The IDS multiarray system

Why use an array of Antennas?

- to correlate information coming from several data channels;
- to accurately reconstruct the path of underground utilities in complex situations;
- to ensure accuracy and productivity. An array scan is much more powerful than many single antenna scans.

The RIS MF multi channel - multi frequency data is processed with a dedicated software to fully exploit the system characteristics. The main processing and interpretation software features the interactive use of multi GPR sections, displays tomographic maps and operates in a CAD environment. A relational data base manages the collected data. The software can generate a final CAD cartographic map in 3D containing both surface evidence and GPR interpretation. RIS MF is also able to acquire cross-polar data; a dedicated software uses this data on the post-processing unit to provide information on soil type. Finally, the cartographic map is automatically generated, containing all the results in cross section and planar view.

2D CAD map



3D CAD view