GPR acquisition in Polimi, Milano Campus

Date: December 6th, 2019

Test campaign report

Courses:

Geophysical imaging

Subsurface imaging and detection

Homework instructions:
Please answer/comment the notes in red in the document

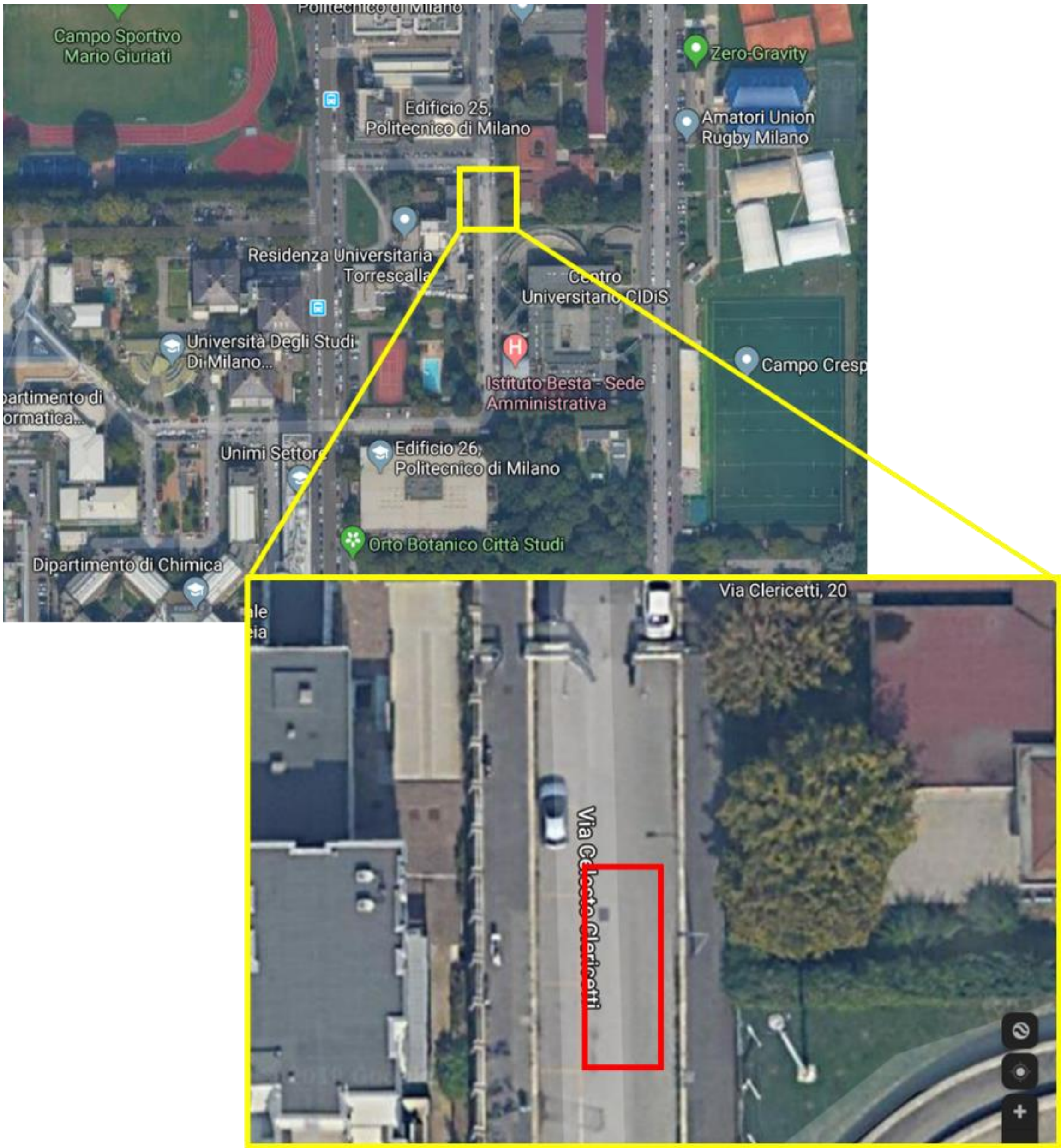
Objective

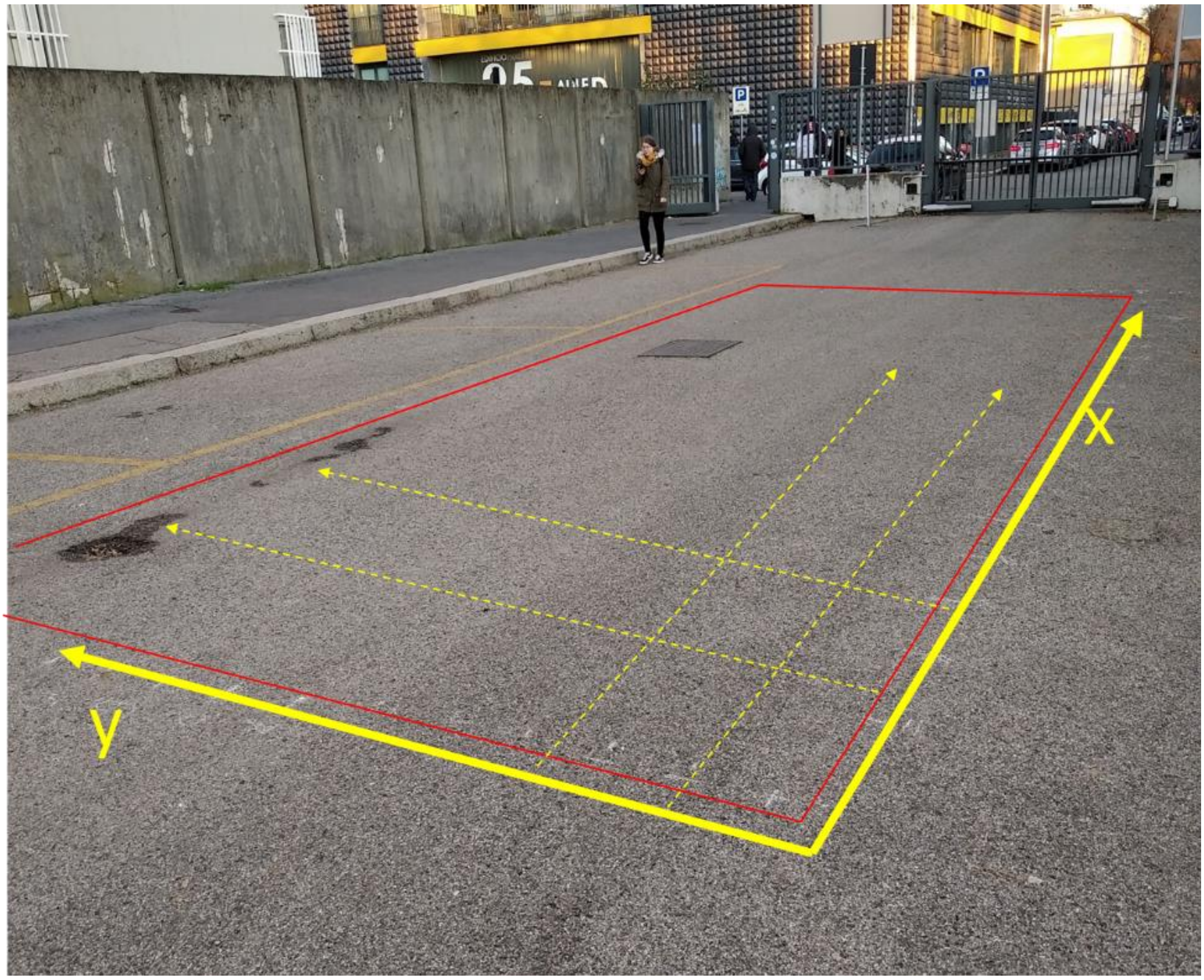
On December 6th we performed a GPR acquisition in the location presented in the next section in order to identify subsurface service lines (pipes, cables, tunnels).

Description of the location

The investigated area is located on Via Clericetti, 20133 MILANO. We collected 17 X-profiles, 10 m long, with a distance between the lines of 0.25m, and 21 Y profiles, 4 m long, with a distance between the lines of 0.5m.

The following figures detail the location and the acquisition lines





Please notice there is 1 metallic object on the surface (1 closure) that will be used as “marker” in the final result.

Please note also there are some holes in the asphalt were water is penetrating in the soil.

Homework

WHAT DOES IT HAPPEN WHEN THE GPR IS OVER A METAL SURFACE?

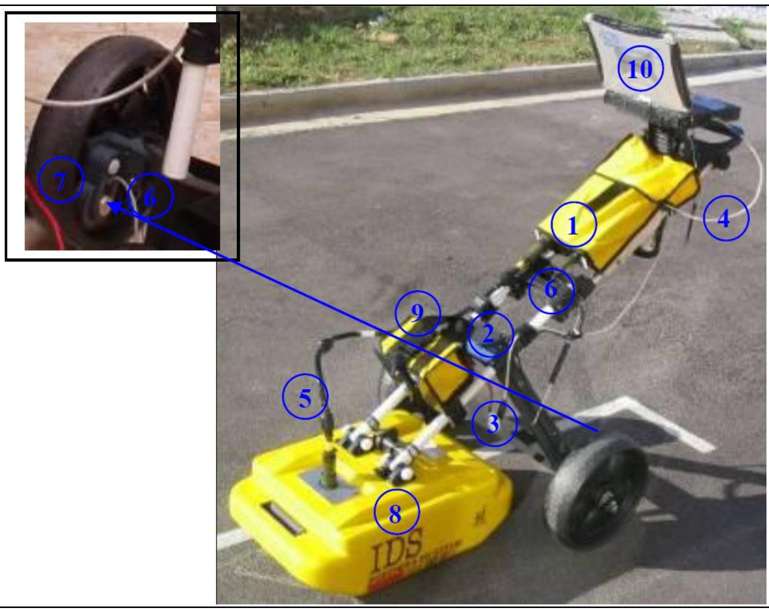
The GPR cannot penetrate through metallic objects, the reflections of this type of material have a great amplitude with very low attenuation, so we will see the rebounds of the signal sent by the antenna during the whole route of the metallic surface with shapes continuous hyperbolics shown on the radar.

WHAT IS THE EFFECT OF THE PRESENCE OF WATER IN A GPR ACQUISITION?

Since that water has a high value of dielectrical constant, water increases conductivity -> decrease of skin depth -> less penetration. So the effect of the presence of water generates a variation with respect to the penetration of the measurements.

Equipment

We used a Detector Duo from Ingegneria dei Sistemi (IDS). It is a dual antenna system, one at 250MHz, the other at 700Mhz.



- DAD DECT DUO Control unit(1).
- Two wheeled trolley used to move the system (2).
- Power cable (3).
- Inverted network cable (4).
- Antenna Box - Control Unit connection cable (5).
- Position sensor connection cable (6).
- Position sensor (7).
- Detector Duo Antenna (8).
- 12V lead battery (9) .
- Notebook computer (10).

GENERAL CHARACTERISTICS OF THE CONTROL UNIT	
NUMBER OF CONNECTABLE ANTENNAS	2
VOLTAGE	12V +/- 10%
ENVIRONMENT FEATURES	IP65
PANEL CONNECTORS	LAN, BATTERY, ANT.1, WHEEL
ABSORBED POWER	8W (1 antenna)
OPERATING TEMPERATURE	-10 / +40 °C

Homework 3

FIND SOME INFO ABOUT THE NEW VERSION OF DETECTOR DUO IN

https://idsgeoradar.com/products/ground-penetrating-radar/opera-duo

Opera Duo is the most robust and intuitive GPR for locating and mapping utilities. 100% manufactured by utility market leader IDS GeoRadar, the Opera Duo is a compact, easy to transport and deploy ground penetrating radar leveraging robustness, data quality and intuitiveness for unparalleled utility location and mapping. Opera Duo is available in two versions:

- Two-wheels: a compact and lightweight solution;
- Four-wheels: an adaptable solution for use on rough terrain.

Opera Duo is now available with the new camera kit whose aim is to reduce acquisition times, combine surface data with underground detection and allow a post-scanning analysis like you were on site!

During acquisition phase the grid on the camera guide you in the scanning to do parallel scans!

Furthermore the software generates automatic and referenced documentation to support the survey carried out.

Main features include:

- Superior Maneuverability – A large, comfortable handle to make pushing and pulling easier, large wheels for better control and a balanced weight distribution to offer minimum resistance.
- Robustness – Engineered and built to withstand the harshest field conditions, the Opera Duo is suitable for heavy use in every type of terrain.
- Data Quality – Large bandwidth offering the highest resolution; the largest dynamic range for the best penetration depth; and dual-head sensor integrating ultra-wide band antennas (250MHz and 700MHz).
- Intuitiveness – Just click the start button to receive the best performance in every soil condition. No need to perform calibration or adjust any other manual settings.
- Results Delivered On Site – The system tracks the position of the radar and marks targets automatically. All of the acquired data can be exported to CAD and GIS, and reports can be produced directly on site.
- Innovative in data processing – Opera Duo leverages IQMaps, the post-processing software for faster and smarter GPR data analysis.

Basic Software:

The uNext platform offers an all-in-one, non-intrusive utility detection software solution which exploits the most advanced technologies and methodologies in the market.

100% developed by utility market leader IDS GeoRadar, the uNext platform is based on the Opera Duo and DS2000 Ground Penetrating Radars (GPR) leveraging, data quality and intuitiveness for unparalleled utility location and mapping.

The uNext platform is designed to operate directly on site maximizing user experience. Moreover, the solution is fully compatible with Leica Geosystems' DX Manager software allowing for data storage and sharing in the cloud.

uNext Basic leverages:

- Any GNSS and/or TPS – seamless interface to IDS GeoRadar, Leica Geosystems and any other positioning sensors to provide the best geographical positioning of multiple utility targets – in a very short time.
- Cable locators – to quickly and easily integrate information on cable and pipe positioning. Users can benefit from an integrated view of GPR and EML data.
- Survey Report – to export survey reports including extracted maps and targets directly in the field.
- CAD/GIS – to transfer the identified targets to CAD or GIS maps for professional SUE / utility mapping.
- Cartography– to import the cartography of the surveyed area from different sources, and visualise geo-referenced underground asset position in real time.

Advance Software:

The uNext Advanced platform leverages all the functionality comprised in the uNext Basic software. Moreover, it offers:

- Tomography – to create an even more accurate, faster 3D reconstruction of the underground utility network and merge this information with any existing cartographies. On site processing of radar tomographies to ease theinterpretation of results.
- Assisted Pipe Tracker – to detect a pipe or cable once and automatically have the software map the exact position of the utility over the surveyed area. Users can benefit from more accurate, reliable data and perform data acquisitions more productively, and in a shorter amount of time.
- Data re-processing – In addition to on-site data acquisition and processing features, users can re-process roughradar data to ultimately optimise data processing as well as customise data visualisation with filtering capabilities.

The uNext platform is continually developed by our R&D department. More features will be avaliable to everyone as part of new software releases.

WHAT IS THE ADVANTAGE OF HAVING TWO PAIRS OF ANTENNAS AT DIFFERENT FREQUENCIES?

The advantages of having two pairs of antennas at different frequencies are that subsurface measurements can be made at different scales, even for subsurfaces with widely varying characteristics. This method integrates the measurements of data acquired from the different antennas to overcome the inevitable compromise between resolution and penetration, in this way we can make more reliable measurements at all levels of the subsoil thanks to this combination of frequencies, that is, good penetration and resolution. combining both types of measurements.

GPR: theory short notes

Homework 3

READ AND COPY HERE THE INTRODUCTION OF

https://en.wikipedia.org/wiki/Ground-penetrating_radar

Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. It is a non-intrusive method of surveying the sub-surface to investigate underground utilities such as concrete, asphalt, metals, pipes, cables or masonry.[1] 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.[2][3]

GPR uses high-frequency (usually polarized) radio waves, usually in the range 10 MHz to 2.6 GHz. A GPR transmitter and antenna 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 principles involved are similar to seismology, except GPR methods implement electromagnetic energy rather than acoustic energy, and energy may be reflected at boundaries where subsurface electrical properties change rather than subsurface mechanical properties as is the case with seismic energy.

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 metres (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 metres (49 ft). However, in moist or clay-laden soils and materials with high electrical conductivity, penetration may be as little as a few centimetres.

Ground-penetrating radar antennas are generally in contact with the ground for the strongest signal strength; however, GPR air-launched antennas can be used above the ground.

Cross borehole GPR has developed within the field of hydrogeophysics to be a valuable means of assessing the presence and amount of soil water.

Processing steps

The following figures show the processing steps for an x-profile and the low frequency antenna (250MHz). Left is initial data, right after processing.

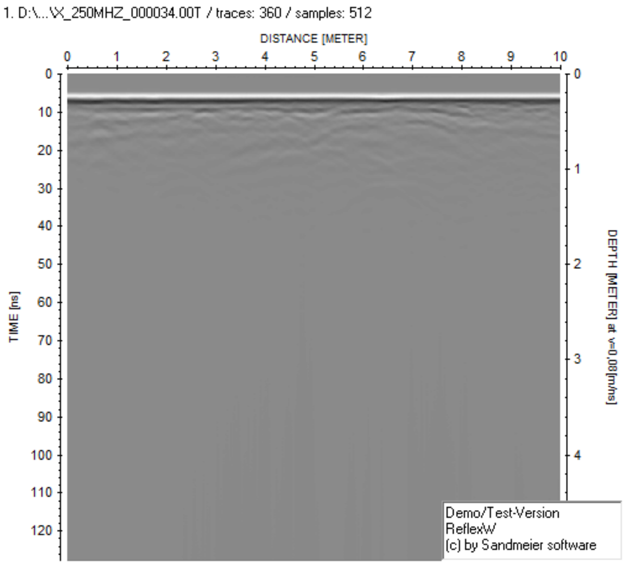
<u>Background removal through trace average and subtraction</u>

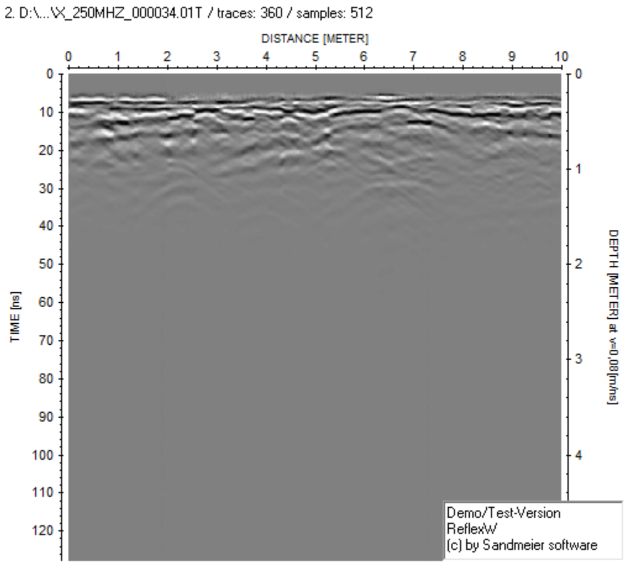
Processing -> 2D filter -> Background removal

Homework 3

WHAT IS IT THE BACKGROUND NOISE?

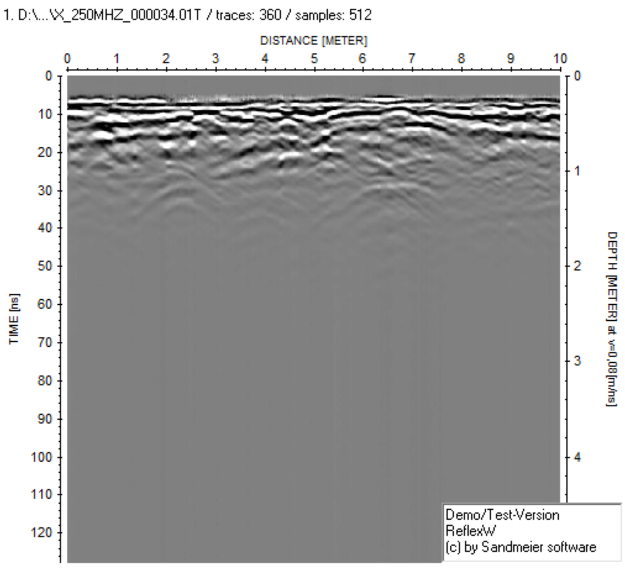
The quality of ground penetrating radar data can suffer from many different sources of noise. Some of these sources are varying distances of the antennas to the ground due to rough surfaces, different surface conditions (e.g. compression due to tractor tracks), external electromagnetic fields and instrumental noise and instabilities.

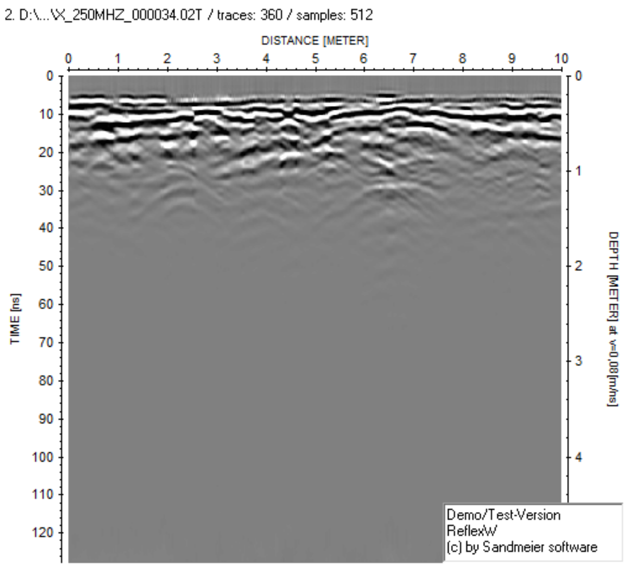




<u>Bandpass filtering</u>

Processing -> 1D filter -> bandpassfrequency





Homework 3

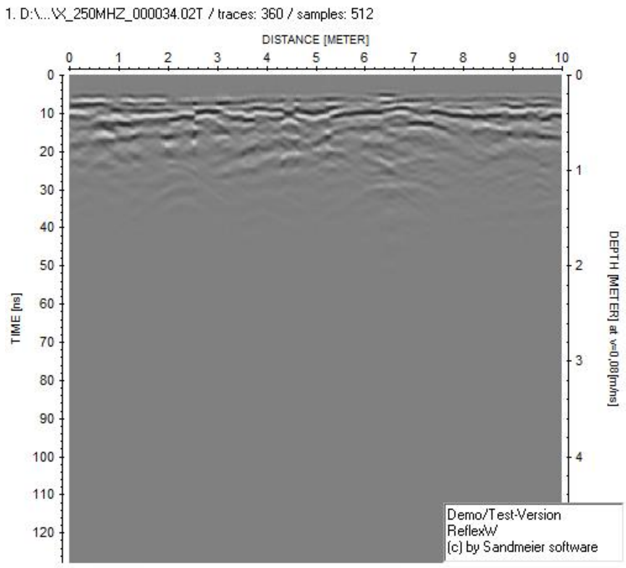
HOW TO ESTIMATE HE BANDPASS FILTER PARAMETERS (KNOWING THE CENTRAL FREQ OF THE TX ANTENNA)?

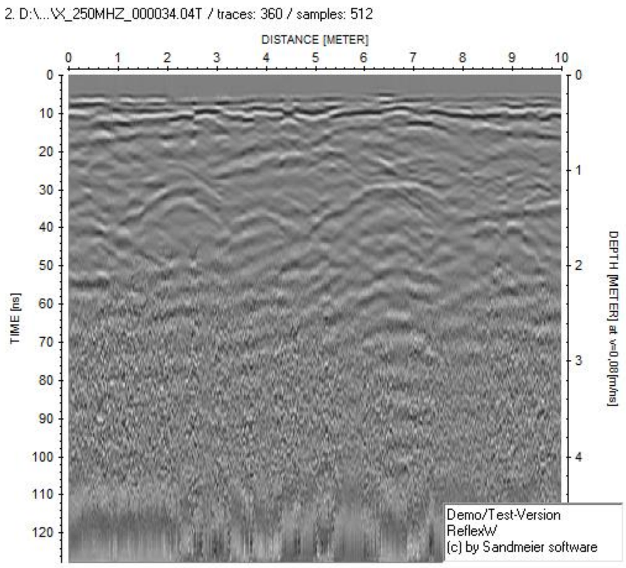
The bandpass filter is the combination of highpass and lowpass filters, it is used to eliminate signals outside of a spectrum which are noise. For this case we must apply cuts for high frequencies (upper plateau, upper cut off) and cuts for low frequencies (lower plateau, lower cut off).

As an example for a 125 to 375 Hz spectrum, we can use a band pass filter with the following attributes: lower cut = 100, lower plateau = 110 and upper plateau = 400, upper cut off = 450.

<u>Gain recovery (energy compensation)</u>

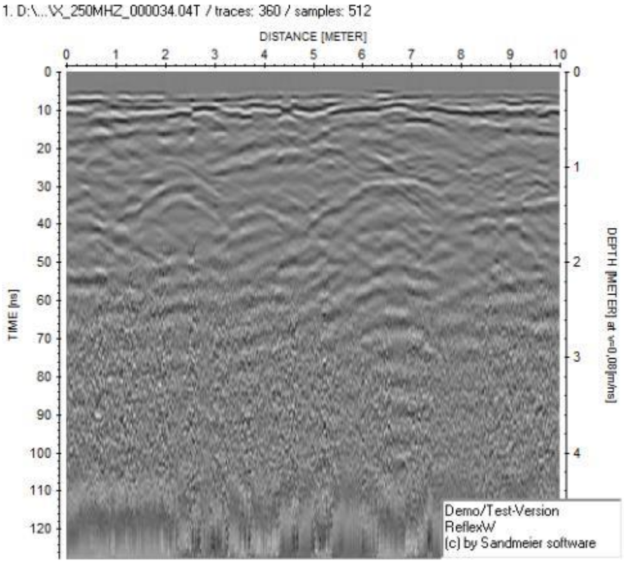
Processing -> Gain -> energy decay

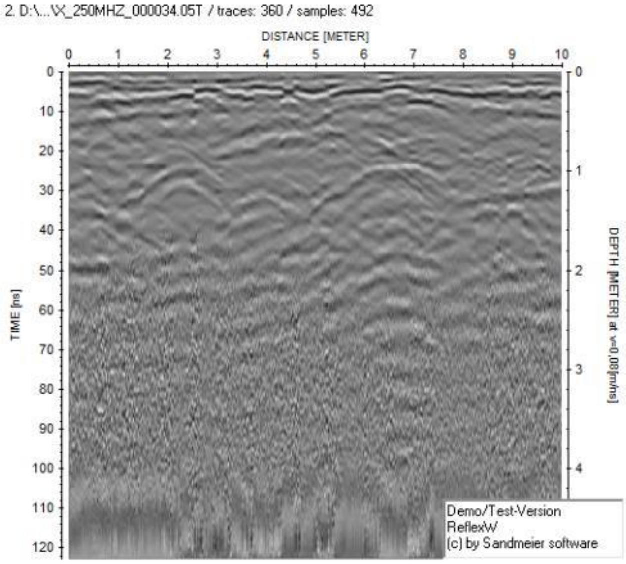




Move startime to t=0

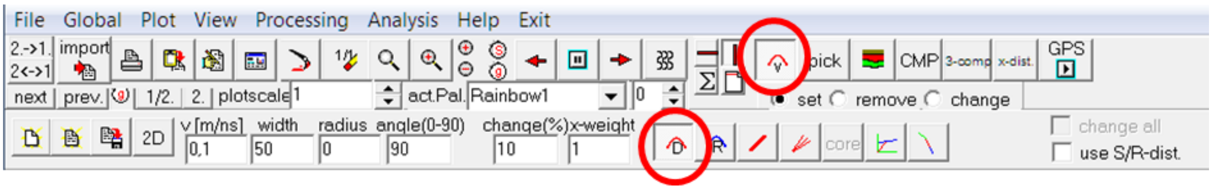
Processing -> Static correction-> move startime

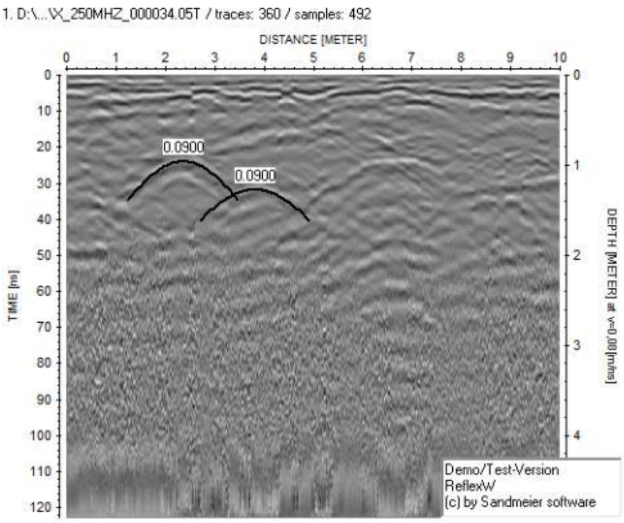


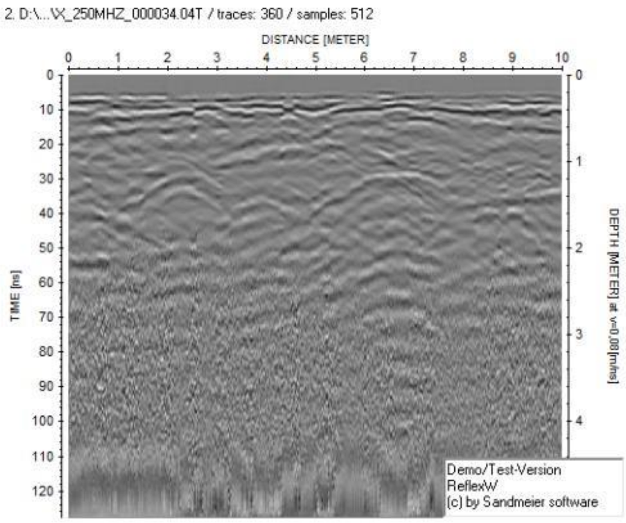


Velocity analysis

Press V button and then D (diffraction)

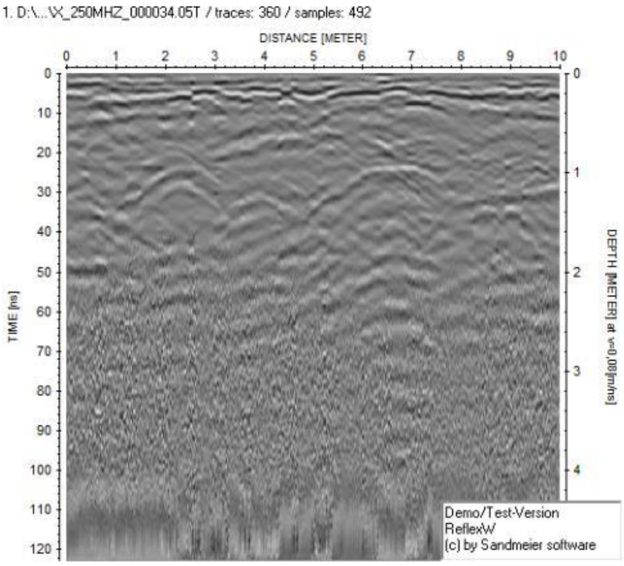


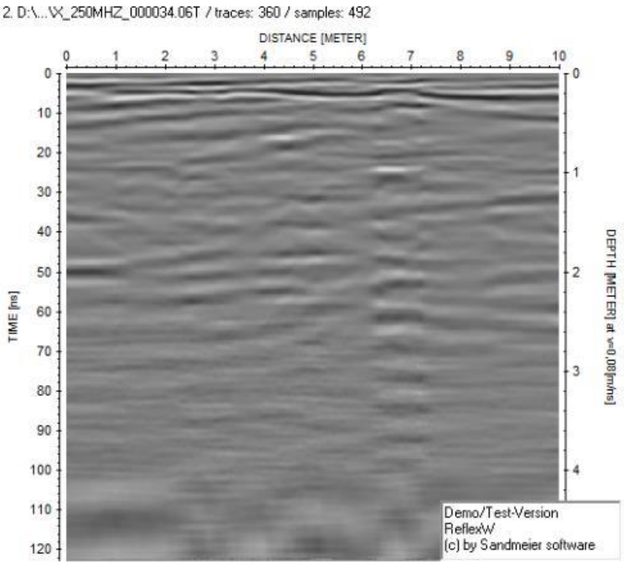




Migration

Processing -> Migration-> diffraction stack



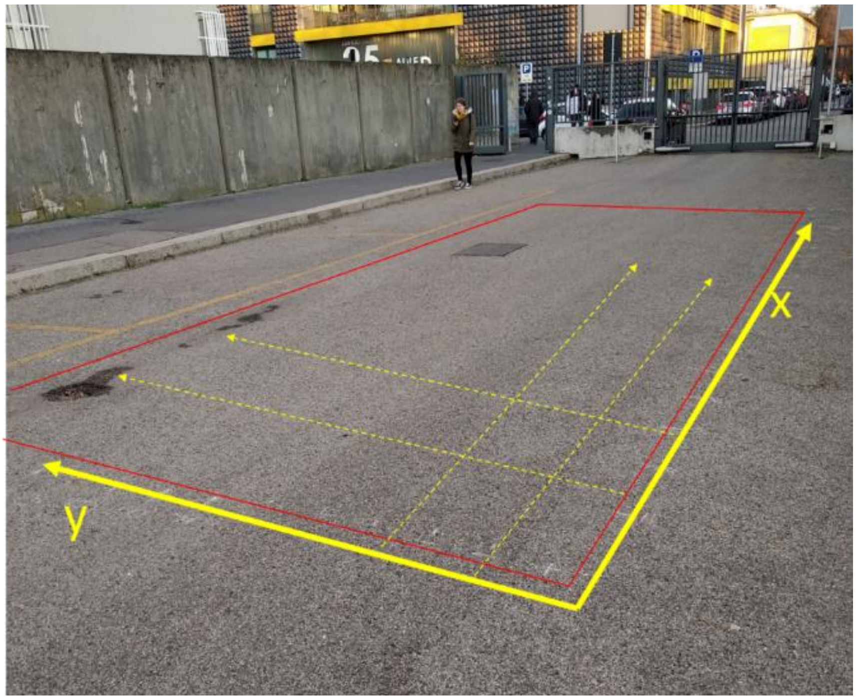


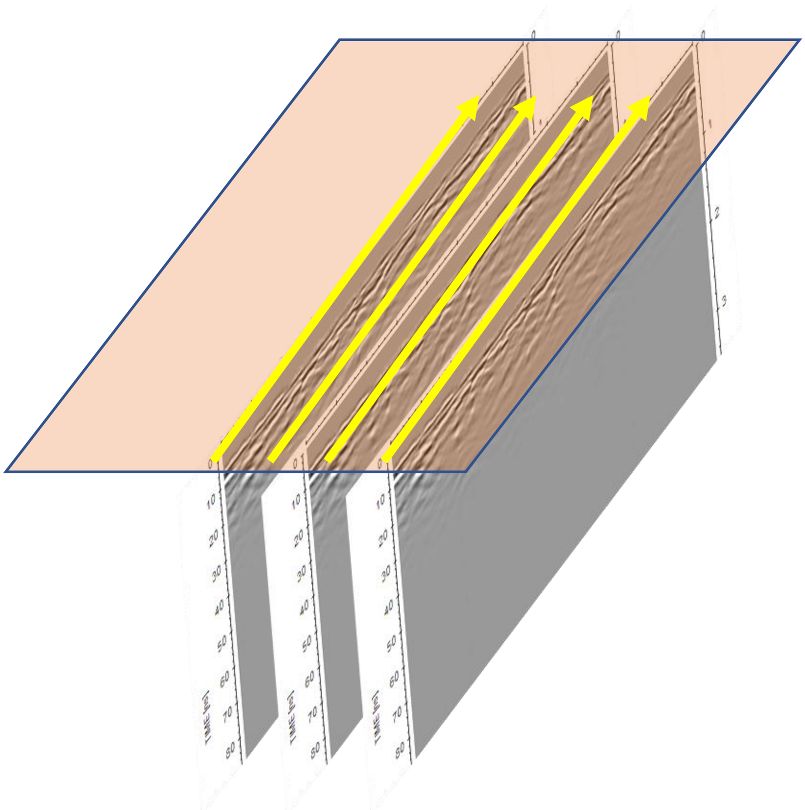
List of processing steps:

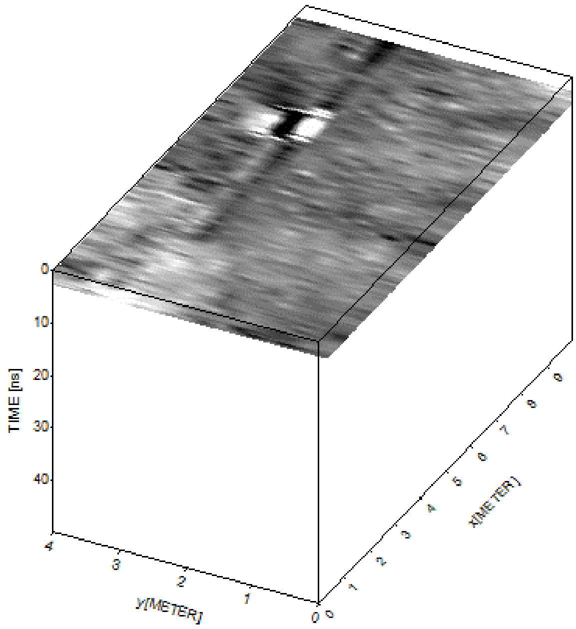
file: PROJDIR\ PROCDATA\X_250MHZ_000034.00T
fix profile length / 10 / 0 / 0 / 0 / / 0 / 0 / 1 / 386 background removal / 0 / 127,75 / 0 / 9,99456 / / 0 / 0 / 1 / 360 bandpassfrequency / 50 / 90 / 400 / 800 / / 0 / 1 / 1 / 360 AGC-Gain / 20 / 1 / 10000 / 32000 / / 0 / 1 / 1 / 360 move starttime / -5 / 0 / 0 / 0 / / 1 / 1 / 1 / 360 diffraction stack / 40 / 0,9 / 0 / 122,75 / / 0 / 45 / 1 / 360

3D reconstruction

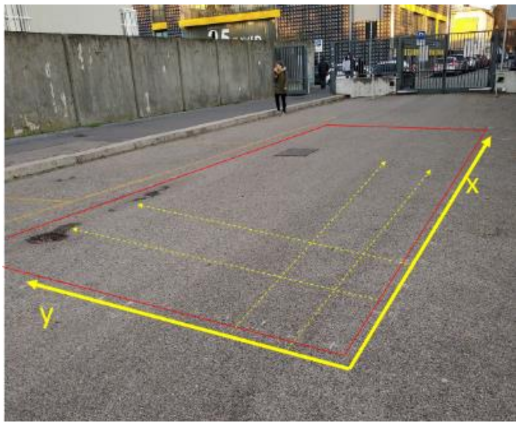
The 17 x-profiles for the 250Mhz antennas have been processed with the same processing flow. The migrated gather for each line has been arranged in a 3D volume. Here we show some “slices” of the volume

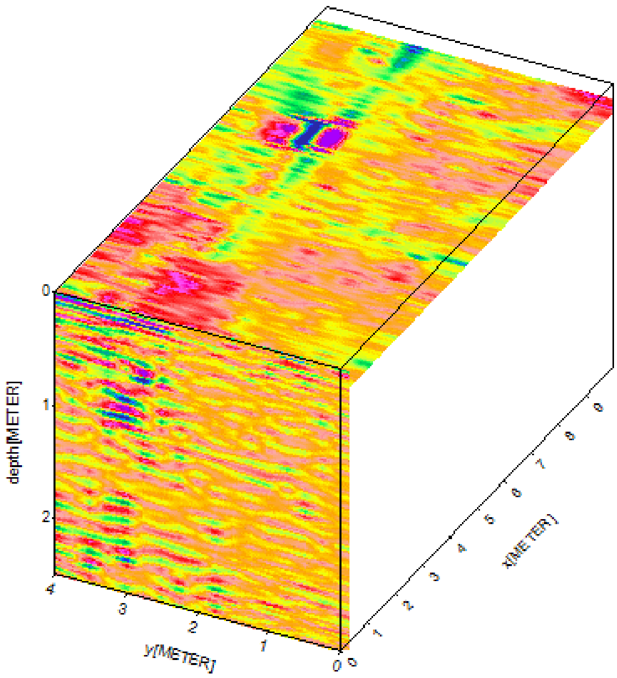




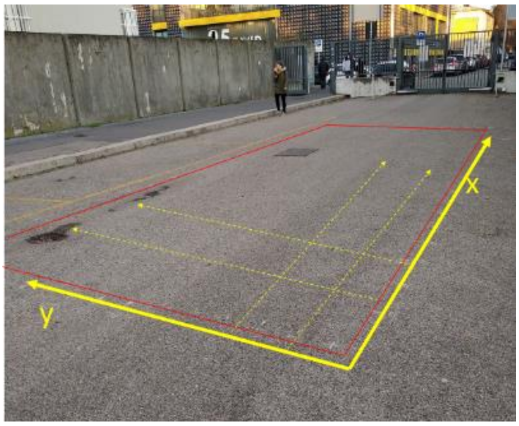


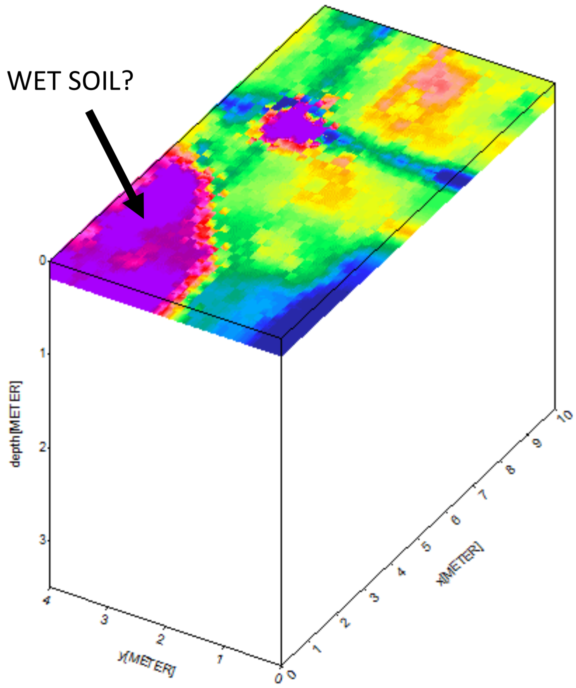
Slice at 20cm from the surface (gray scale).
Visible the metal surface.



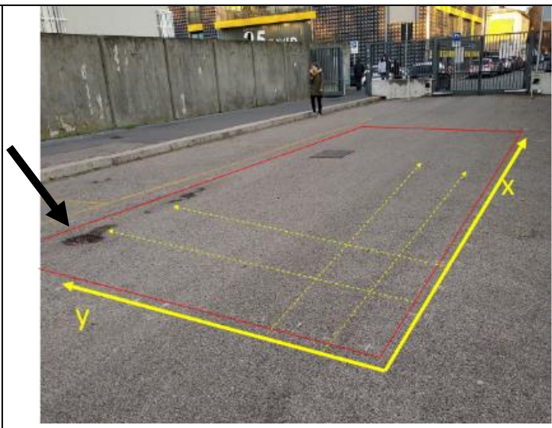


Slice at Slice at 20cm from the surface (colors).
Visible the metal surface.





X and Y profiles processed together. Slice at 20cm from the surface (colors).



Conclusion

The GPR can be used to map service lines

The conductivity of the media affects the depth of investigation, having low penetration for high conductivity: this is evident over metal surfaces