DETECTION METHODS OF UNDERGROUND PIPELINES

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ABSTRACT

Urban infrastructures are becoming more complex last century. In order to prevent third party companies from possible damages to infrastructural equipments and people, detection of underground pipeline and cable locations is very important, In addition, locations and positions of infrastructural elements with respect to each other must be known for the new infrastructural projects and for the process of operation and replacement of current infrastructure.

Technology is developing rapidly, so there are a lot of equipments for the detection of pipeline and cable locations today. These equipments are working with two methods in general. One of them is electromagnetic detection method with electromagnetic induction, and the other is GPR (Ground Penetrating Radar) method working with the principle of determining the underground structure and underground holes. Especially with the new equipments and computer algorithms developed in the last years, the locations of infrastructural elements with respect to each other are determined more accurately.

In this study, two sample applications and results made for IGDAS (Istanbul Natural Gas Distribution Company) by using electromagnetic method and Ground Penetrating Radar method will be evaluated.

Key words: 1.Asset Detection, 2.Damage Prevention, 3.IGDAS, 4.GPR, 5.Electromagnetic Induction.

METHODS OF DETECTING LOCATIONS OF UNDERGROUND LINES

1. INTRODUCTION

As the infrastructural diversity in the metropolitans has enhanced and underground infrastructures have gained intensity and complexity, it is essential to know before excavation, the locations of said plants at the phase of projection of those to be newly constructed, and operation, maintenance and renewal of those already existing. Some infrastructural institutions acted sensitively in such case, having produced detailed infrastructure maps by measuring the lines at the phase of production of the infrastructure. However most of such infrastructure bodies have either no such detailed maps or those maps are not of required sensitivity. Thus, creating a sensitive map that shows the locations of all infrastructures together (Electricity lines, natural gas pipes, water pipes, waste water channels, rainwater channels, telephone lines, cable TV cables, oil pipes, etc…) cannot be made possible.
In such case, it is often taken into agenda, the issue of detecting the locations of the infrastructures erected before, without practising any excavation. There are two major methods in detecting the locations of the underground infrastructures. These are, the electromagnetic method and the Georadar (Ground Penetrating Radar) (GPR) method. Electromagnetic method is used only for detecting the locations of metal infrastructures. GPR method works with the principle of "underground abnormality detection". GPR method may also be used in three-dimensional detecting of locations of the underground lines that form a different ambient according to the nature of the soil. In the first chapter of this article, the above mentioned methods have been explained and in the second one, the practices related to said methods performed in Istanbul have been referred to.

2. Methods of Detecting the Locations of Underground Lines

2.1. Electromagnetic Method

The issue of detecting the inductors such as metal pipes and cables buried in shallow ground, is involved in the geotechnical studies in geophysics. Such buried structures are named as "linear conductors" and can theoretically be detected by geophysics methods, as they demonstrate a physical contrast to their environments. [1]. In this method, location of the line is detected by the presence of a magnetic field created over the pipe. The detectors manufactured for searching the metal infrastructures may work with various methods. In order to detect the line sought, there must be signals released from one edge of the respective pipe by certain frequency. This signalling process may be realized by connecting directly to one edge of the line (from the regulator or valve etc.), even by attaching in a ring form or by placing the transmitter in a way that it will be on the line over the ground. The most efficient and correct result is achieved by attaching the transmitter to one edge of the direct line. Detection would be possible up to 5-10 km distance from the transmitter. When equipments are extremely near to the transmitter (up to 10 mt. only) the equipment may confuse the signals. Such devices are widely used for the detection of steel lines and cables. Depth of the pipe can also be measured by the said equipments. A large number of equipments with similar features, manufactured by various firms are available in the market.

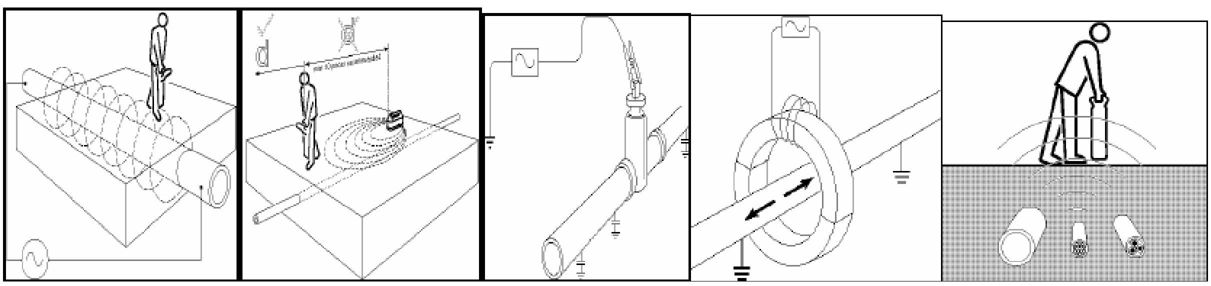

Figure 1 - Forms of detection by electromagnetic method.

2.1.1. Superiorities of Electromagnetic Method: An easy-to-use, practical and cost-effective method, not requiring any interpretation. The equipments produced to be used for the detection of underground lines are portable and their prices are cheap.

2.1.2. Inferiorities of Electromagnetic Method: It can be used only for metal pipes. PE pipes cannot be detected by this method. The detection equipments can only detect the magnetic fields over such lines, but not the pipes or cables themselves. Accordingly, it may cause an active problem affecting the magnetic field that created by a buried conductor and a magnetic field disturbance may occur. Magnetic field disturbances may cause errors in the detections.

2.1.3. Impact of the insulation over pipes and cables on detection.

The exterior walls of cables and pipes located underground are coated by insulation materials bearing ultra-high impedance in order to obstruct contact with surface or to prevent any corrosion. On a study, it has been witnessed that insulation did not significantly affect the detection of such insulated underground pipes and cables. Whether the buried conductor has insulation or not, almost the same reaction has been measured over-ground by the Electromagnetic Slingram system. Such situation may be accepted as an advantage for the Electromagnetic methods.

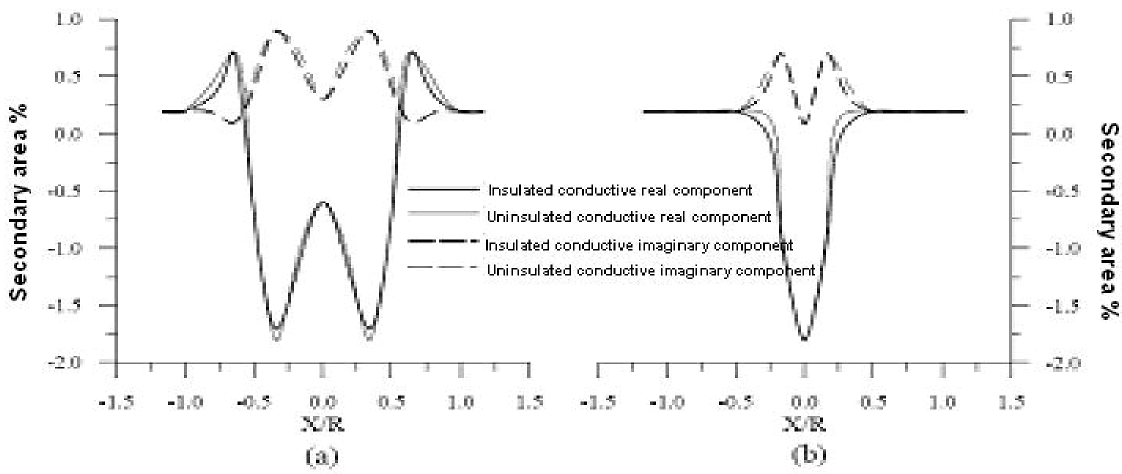

Figure 2 - Test graphics of insulated and uninsulated conductors [2]

2.2.Scanning Method with Georadar (Ground Penetrating Radar)

Ground Penetrating Radar (Gpr) has been in use globally since the 1960's. The georadar, which initially was used in glacial geology, has later enlightened very many geological and geophysical problems. GPR system is composed of a transmitter, receiver, antenna and a control unit. The electromagnetic waves transmitted to the earth by a transmitter, spread therein, depending on physical and chemical characteristics of the environment and subject to the dielectric constant and magnetic conductivity of such environment, create some data regarding the underground profile. The generated data are processed by some data-transaction phases in the computer environment, interpreted; and thus, some results are achieved [3].
GPR method is a remote sensing technology that enables the sensation of the earth ground; or in general terms, the objects and layers under the ground and positioning of the same by using electromagnetic techniques [4]. GPR provides the identification of the infrastructure systems that exist underground with a complex structure and are composed of various materials.
The electromagnetic pulse signals transmitted to underground by the equipment are received back in the same moment. Signals confronting any abnormality under the ground are converted to 3 dimensional images by the advanced software of the equipment. As the underground pipes form a kind of cavity under the ground, they constitute an abnormality therein and locations of the pipes can be detected with this method. These equipments have some models that can be pulled or pushed by hand or can perform scanning as mounted to the rear of vehicles.

Figure 3 - Some pictures of GPR equipment

Superiorities of Georadar Method

This method can detect any pipes over a certain diameter, without discriminating the type of such pipes. Additionally, linear map can be produced by processing the radar pictures through a computer program and the correlations of the data on the radar pictures among each other can be interpreted. GPR system shortens the excavation time, decreases the cost and eliminates any risks that may occur during the excavations, performed without data. By the help of GPR, the economic, precise and smoothly recordable images of the underground can be produced and there is no need for any permission to realize such actions.

2.2.2. Inferiorities of Georadar Method

In this method, the generated results are based on interpretation to some extent. Sometimes the information may be wrongfully interpreted and this hinders the method to be fully reliable. The method can be used on locations of flat terrains only; wet or clayish surfaces may create problems. Because the electromagnetic waves are exposed to absorption in clayish earth. On gravelled environments, misleading diffractions may occur. Such diffractions may be sensed, as if there are conductive structures underground. Along with progressive technology, as the shielded antennas are used, any changes that may arise from the potential area have been minimized [3].

3. PRACTICES

3.1. Field of Application

A practice was held on a region in Sancaktepe district, located on the north of Asian side of Istanbul; that had been produced within 2003/2004. Both steel and PE natural gas lines exist at the area of application. These natural gas lines at the area of application had been estimated in all during the production and their maps produced, thus all locations of the lines are well known. During the practice, 4 equipments, -2 of each per methods mentioned above- (Electromagnetic method, GPR method) were tested on the same area. The location data achieved by the end of this test were compared to the existing location information.

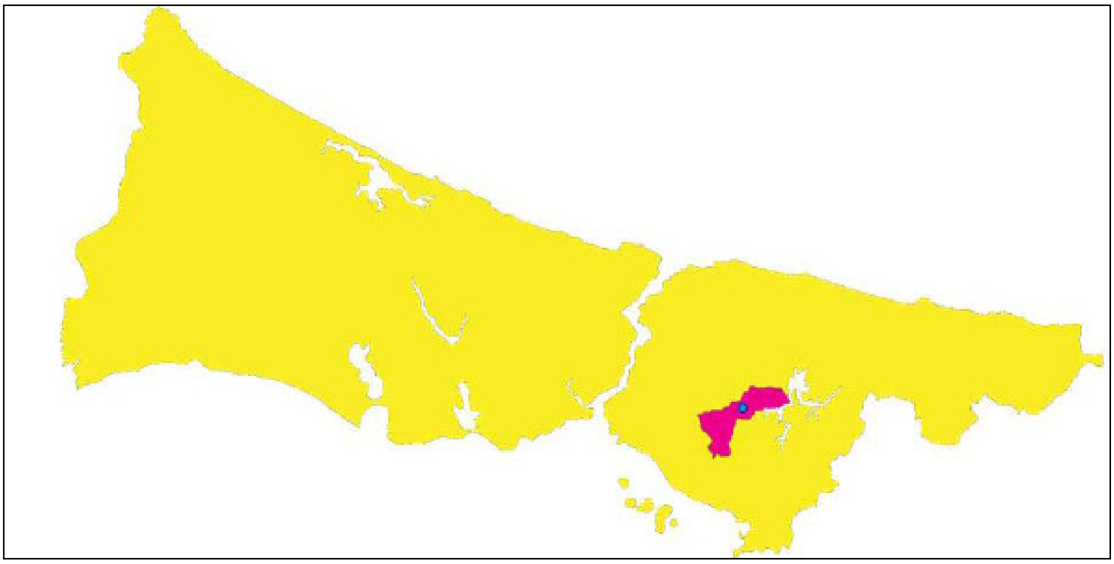

Figure 4 - Location of the practice area on the map of Istanbul

3.2. Results of the Test Run by Electromagnetic Method

3.2.1. Tests performed by RD- 8000 Device

The receiver of the device was connected to the inlet line of the region regulator on the test area. Position of the inlet line to the region regulator was recorded. These recorded points were measured by the map measuring device and compared in the office. It was observed that the achieved results matched the actual values (both horizontal location and the depth). It was ascertained that RD-8000 device was a suitable and practical equipment for the detection of pipe location through the steel lines, due to being easy-to-use, precise and free of interpretation.

Figure 5 - Photographs taken during detection

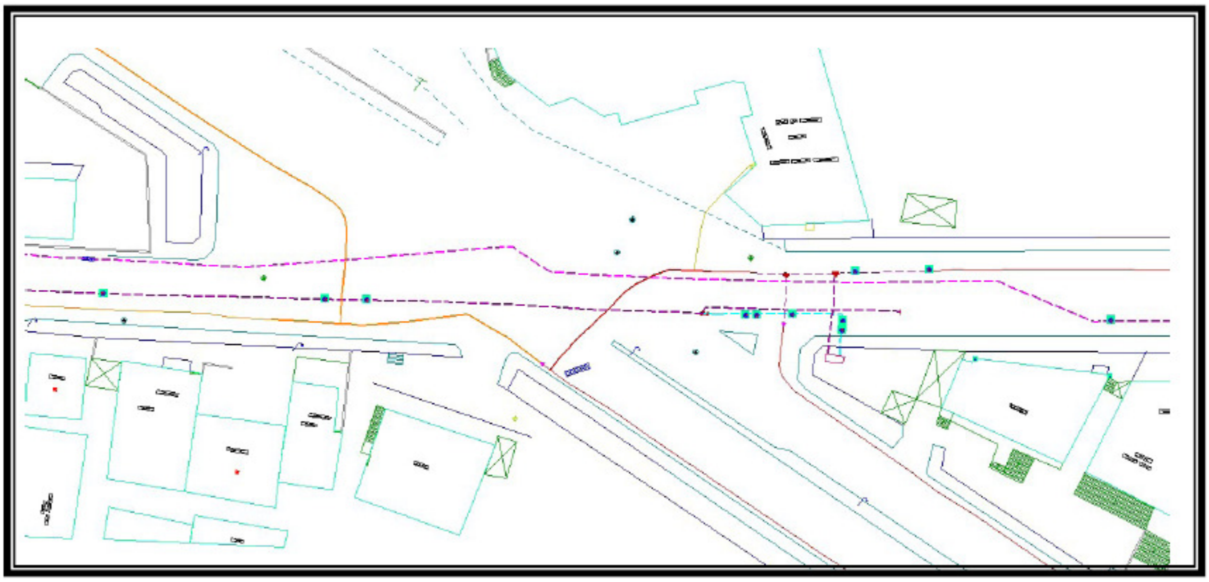

Figure 6 - How the measurements taken during detections matched with the existing map

3.2.2. Tests Performed by Installation Detector

RIDGID - Niva Track Model
Direct connection method and also method of over-ground induction without any connection have been tried by using Ridgid -Niva Track Model installation detector and two separate practices were performed.

3.2.2.1. Direct connection method

Position detection of 4” and 6” lines reaching the district regulator was recorded with the same method, by connecting the transmitter of the device to the inlet line of the district regulator on the test area of RD 8000. Detections were made on the line with the receiver of the device, locations of the detected points were measured by the map measuring device. Achieved position data were compared to the existing numeric maps.

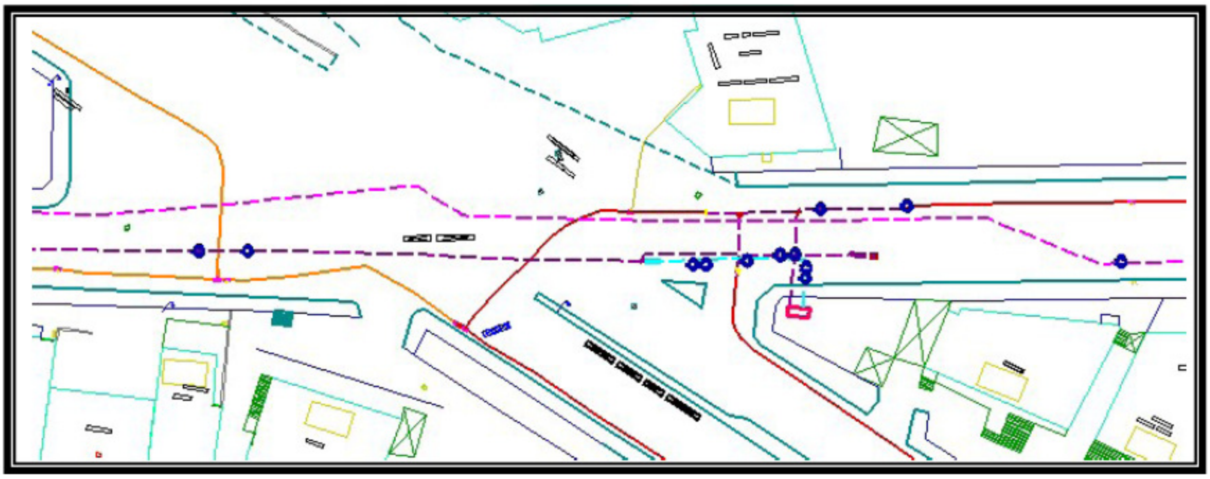

Figure -7 - How the measurements taken during direct connection detections matched with the existing map

Figure 8 - Installation detector and screen display

Figure 9 – Photographs taken during detection

3.2.2.1. Induction Method

The induction method was tested on a route close to the area specified in the first method. At this area, there are intensely laid electric lines parallel to the line, subject to testing. The data acquired from the detections with the device have been compared to the existing maps. It was observed that, the induction method, where the positioning data acquired at the end of the test were wrong, electricity lines spread around had caused degradation of the magnetic field or confusion of the signals. The map that shows the comparison of positioning data resulting from induction method with the existing maps has been given below. It was witnessed that, detected points on the map did not correspond to the pipes.

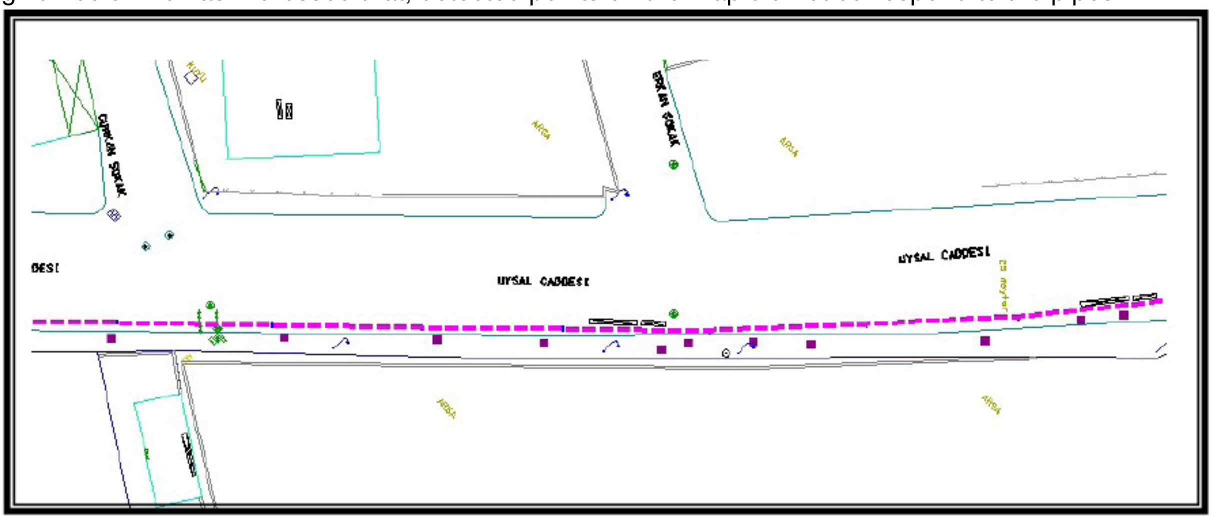

Figure 10 - How the measurements taken during detections by induction method matched with the existing map

3.3. Results of the Test Performed by Georadar

3.3.1. Tests Performed by RD 100 GPR Device

The device was tested again in the same area around the district regulator, where both steel and PE lines had been intensely installed. The device has performed scanning on the route 90 degrees perpendicular to the pipe line (cross the street) and sensed the pipes and cables across this route. First the device fulfills scanning, then moving opposite the scanned route, location of the pipe is detected. The points, the device detected during testing were measured by the map measuring device and compared to the existing maps. It was seen that results quite coincided with the actual positioning values, however images on the display needed interpretation and some pipes could not be detected. It was apprehended that, device could not sense the service lines due to their having small dimensions (20mm, 32mm).

Figure 11 – Photographs taken during detection with RD100 GPR device

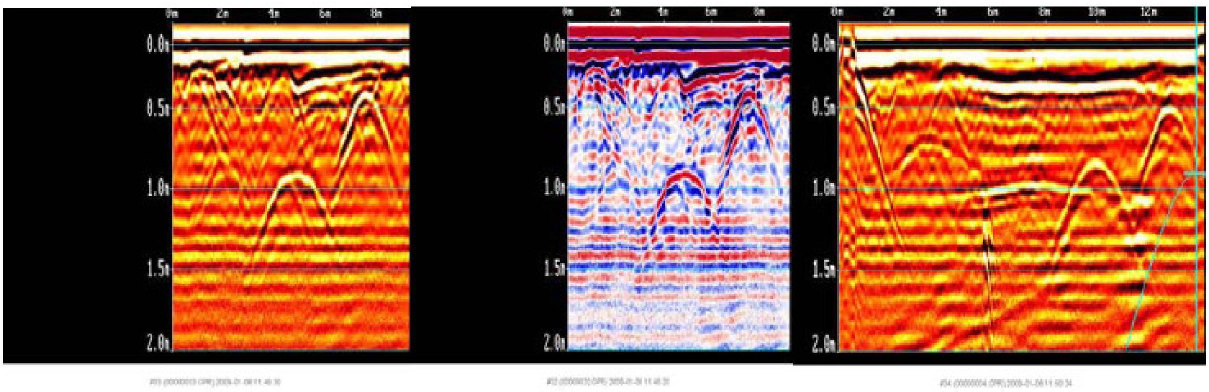

Figure 12 - Display images achieved by the detections

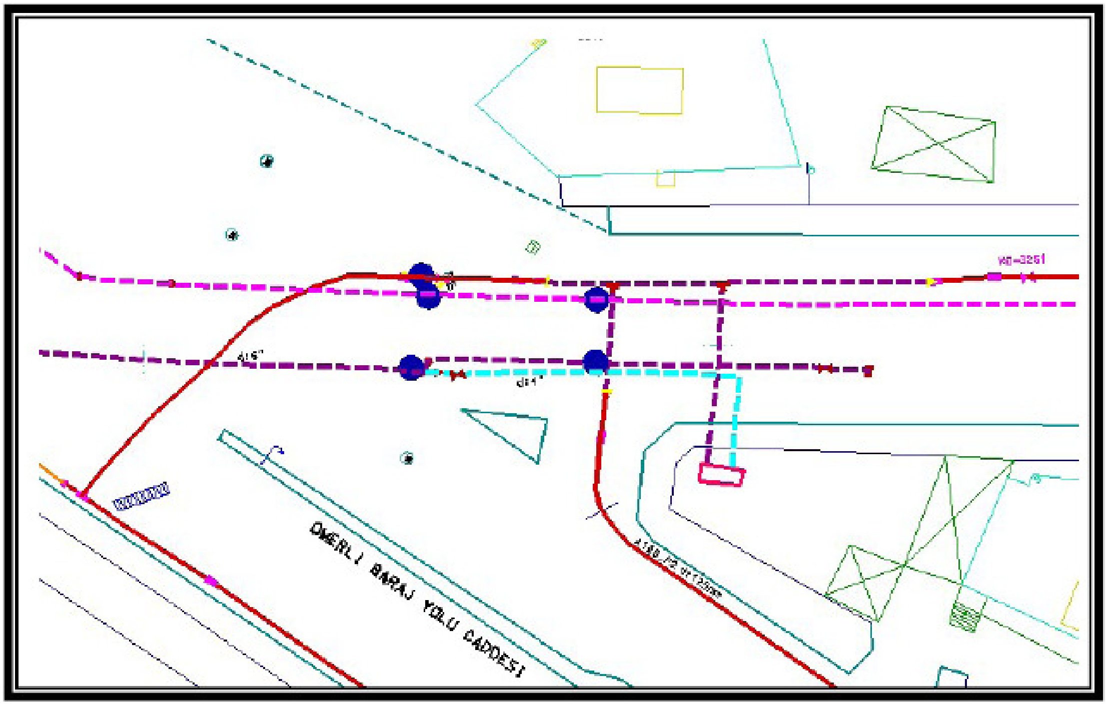

Figure 6 - How the measurements taken during detections matched with the existing map

3.3.2. Tests Performed by GSSI – Terravision brand georadar.

1) GPS (**Global Positioning System**) integrated **GSSI – Terravision** brand device, that can perform scanning as mounted to a vehicle, was tested on the same testing area. The data collected during the application were processed in the office and compared to the existing maps. The detection covered a scanning of an area of 3000 square meters with 2 meters depth. Locations of 656 meters natural gas line out of 706 meters were approximately detected, in addition to the other lines in the scanned area. About 50 meters of the line could not be detected. Also, it was seen that one connection of a PE line was false interpreted, thus was shown as connected to a different line.

Figure 13 - Photographs taken during detection

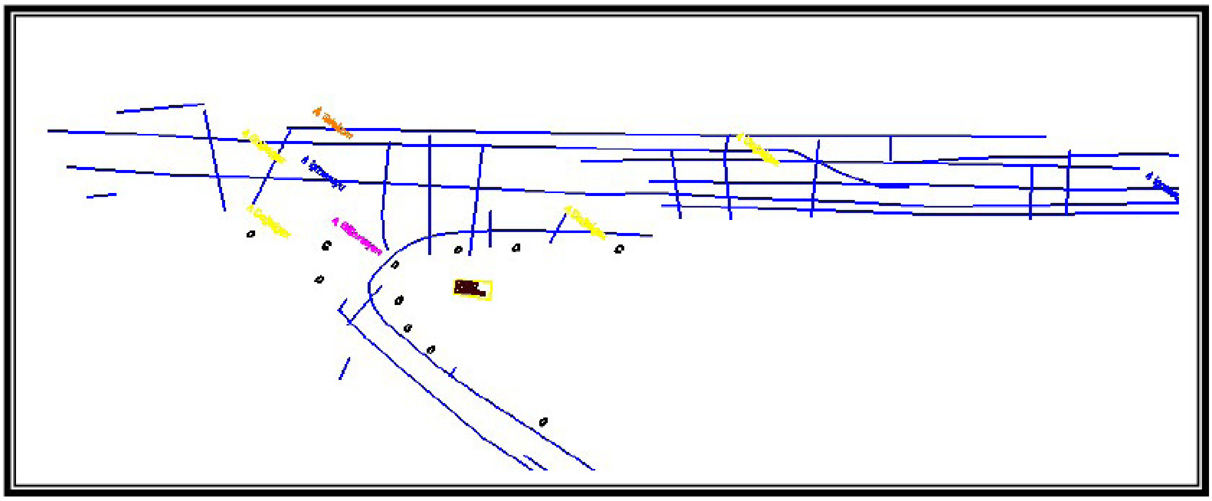

Figure 13- The drawing realized by computer processing of the data collected by GPR device

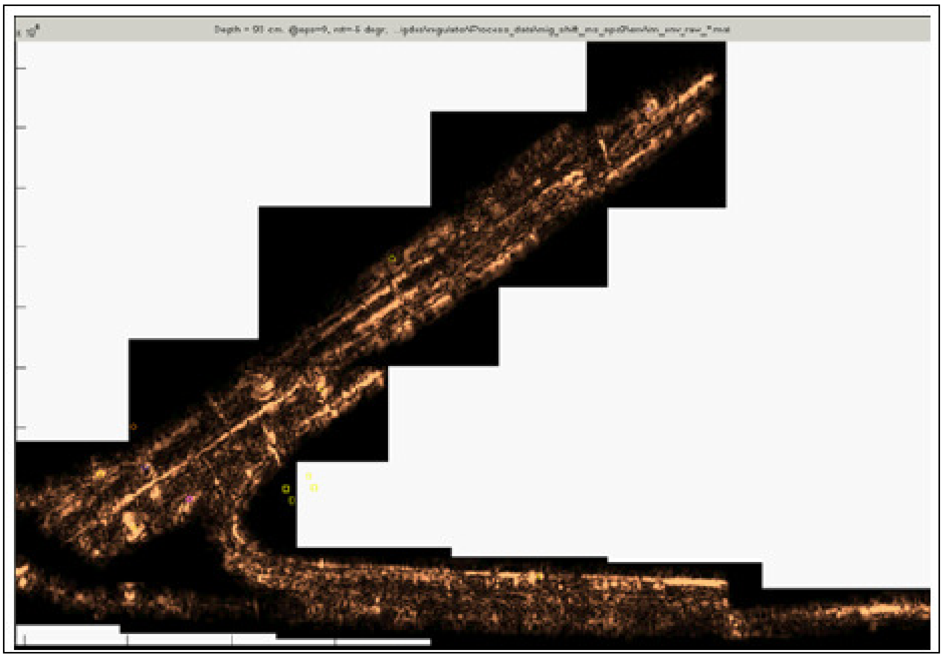

Figure 14 - Image of 90 cm depth taken from the Terravision brand ground penetrating radar

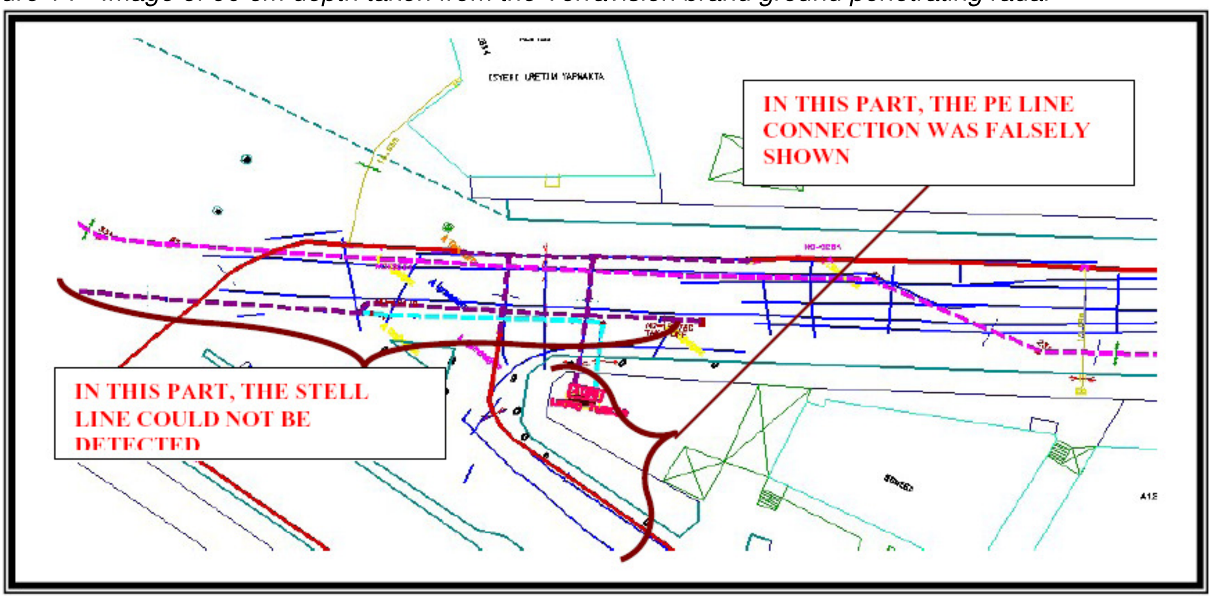

Figure 15 - Comparison of GPR data with the existing maps

4. RESULT

The systems for detecting underground pipelines without any excavation minimize risks that may occur during excavations. By collecting some data related to sub-ground with these systems, negative results such as excavation costs, traffic jam in the excavation site and environmental damage can be prevented. Besides, no permissions are needed for practising these activities.

Two methods for detecting underground pipelines, whose locations are undecided or unknown, are analysed in this study. The first of the analysed methods, the electromagnetic method is deemed to be an advantageous method for detection of underground metal pipes, since it is a cost-effective and practical method which does not require interpretation and produces more accurate results. In addition to this, the disadvantages of the method are that it cannot be used for the detection of non-metal pipes and it is affected from some magnetic field interferences. The georadar method is an advantageous method in that it can be used in the detection of all underground pipelines over a certain diameter. The method is expensive and its results require interpretation, and it is negatively affected by some ground structures, which can be considered among the disadvantages of the system.

COMPARISON OF METHODS FOR DETECTING UNDERGROUND PIPES		
	ELECTROMAGNETIC METHOD	**GEORADAR (GROUND PENETRATING RADAR) METHOD**
APPLICATION AREA	CAN BE USED IN DETECTING THE LOCATIONS OF METAL PIPES ONLY	CAN BE USED IN DETECTING ALL PIPES
WAY OF DETECTION	POINT DETECTION CAN BE MADE.	FIELD SCANNING CAN BE MADE. THE RELATION OF THE DETECTED LINES WITH EACH OTHER CAN BE INTERPRETED.
LAND CONDITIONS	CAN BE USED IN ALL KINDS OF LAND CONDITIONS.	CAN BE USED IN FLAT GROUNDS.
GROUND STRUCTURE	CAN BE USED IN ALL KINDS OF GROUND STRUCTURES.	DOES NOT OPERATE EFFICIENTLY IN CLAYED AND WET GROUNDS.
ASSESSMENT OF DETECTION RESULTS	DOES NOT REQUIRE INTERPRETATION.	REQUIRES INTERPRETATION AND EXPERTISE.
COST	A COST-EFFECTIVE METHOD.	AN EXPENSIVE METHOD.
PRACTICABILITY	PRACTICAL AND EASY-TO-USE	REQUIRES EXPERTISE – A BULKY METHOD.

Table 1 - Table for comparison of methods.

5. DISCUSSION

In accordance with the abovementioned information, if the detection of steel pipelines is in question only, the electromagnetic system is an easy, cost effective and practical method. However, if the aim is to remap undecided pipelines and to detect their locations according to other infrastructures, the methods can be used together in detection. It is not possible to consider the detections as certainly accurate. The detections should be compared with data, if any, which were previously collected or obtained with different methods, and non-corresponding locations and angles should be checked.

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