IMPROVING THE TECHNIQUES FOR COLLECTION, PROCESSING AND USE OF INFORMATION ON MUNICIPAL INFRASTRUCTURE

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***Abstract**: Over the years, on surface or underground utilities have increased quickly in urban and rural areas. The location and class/kind of many of these utility routes have not always been properly documented. Accurate information about the existing underground utilities is necessary in the planning, installation of new utilities and exploration of existing utilities. Deficiency of knowledge on this may result in fatality and catastrophic damages of the existing underground utilities and disruption to utility services. Industries may suffer greatly, in terms of financial loss if utility services such as power supplies are interrupted because of accidents during excavation works due to inaccurate utility information.*

Underground utility mapping is a new domain for land surveyors to vary their expertise in positioning technology. The new approach that combines the use of detection and positioning technology requires the land surveyors to acquire new skills, knowledge and technique. This paper presents a method of improving the data collection, processing and exploiting the data regarding underground utilities networks.

***Keywords:** underground utility, network, automated processing, GPR.*

1. Introduction

Underground utility mapping is the identifying process of the position and labelling public utility mains which are located underground. These mains may include lines for telecommunication, electricity distribution, natural gas, water mains and wastewater pipes. In some location, major oil and pipe lines, national defence communication lines, mass transit, rail and road tunnels also compete for space. [1]

Underground utility mapping refers to the detection, positioning and identification of buried pipes and cables beneath the ground. It deals with features mainly invisible to the naked eye.

While the determination of position for ground utilities can be obtained with conventional or modern survey equipment, the detection and identification of underground utilities require special tools and techniques. Principally, underground utility mapping is the between two major fields of knowledge namely**:** geophysics and geomatics.

Land surveyors, had always been associated with geodetic surveys, engineering surveys, topographical surveys, hydrographical surveys and map making. In the recent years, land surveyors had also gained the experience of using LIDAR technology, GIS and other related novel technologies**.**

Underground utility mapping presents a completely new field for land surveyors to diversify their expertise in positioning technology. Thus, underground utility mapping which combines the use of detection and positioning technology requires the land surveyors to acquire new skills, knowledge and approach.

2. The current methods of data collection and processing

Depending on the utility destination, there are several techniques of data collection and each has its own way of processing. It is worth mentioning the GPR (ground penetration radar), radio detection, or in some cases even visual inspection is used.

Ground penetrating radar (GPR) is one of the most commonly used geophysical techniques in high resolution studies of the shallow subsurface.

Although GPR has many similarities to radar systems, there are some key differences, which need to be considered when comparing them with conventional radar systems. GPR systems are a special class of ultra wideband (UWB) radar system and can radiate energy in the range of frequencies from a few MHz up to 10 GHz with a bandwidth of up to a decade, but more usually 2-3 octaves. The typical average radiated power, integrated over the band of interest, may be in the order of a milliwatt, but the power per Hz may be as low as picowatts.[2]

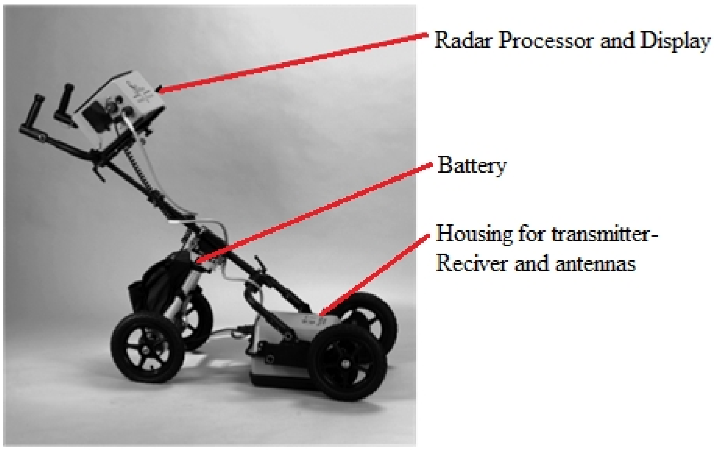

Fig. 1. Example of GPR

Besides GPR**,** Electromagnetic Line Location (EMLL) could be mentioned. EMLL techniques are used to locate the electromagnetic field resulting from alternating electric current flowing along a conducting metallic line. The magnetic field forms a cylindrical shape around the conductor and is called the “signal.” These signals can arise from currents that are naturally present in many conductors (known as passive signals) or currents applied to a line with a transmitter designed to produce a current of known frequency (known as active signals). The most common passive signals are generated by live 50-60-Hertz (Hz) power cables, power system return currents and long wave radio transmissions flowing along the convenient paths of lower resistance provided by metal pipes and cable sheaths. Active signals can be introduced by physically connecting a transmitter to the line at an accessible point and completing the circuit by a connection to ground. The conducted signal will usually then travel along the line and will be detectable over a distance dependent upon the type and size of the line, the type of joint, and the surrounding soil conditions. This is referred to as electromagnetic conduction (EMC). Alternatively, an active signal can be introduced onto a line through electromagnetic induction (EMI). This involves transmitting a high frequency a.c. current through the air to create a primary electromagnetic field in the space surrounding an underground line, which then induces a secondary magnetic field signal onto the line which is detectable by a receiver. Metallic pipes can be located using the induction mode by either placing the transmitter on the ground above or in close proximity to the utility, or by means of placing an induction clamp around the line. An induction clamp can only be used at accessible portions of the utility lines in vaults or breaker boxes. Non-metallic pipes can be located using EMI by placing a probe inside of the pipe. The probe transmits a controlled frequency electromagnetic field that is then detected at the surface by a receiver above the transmitter.

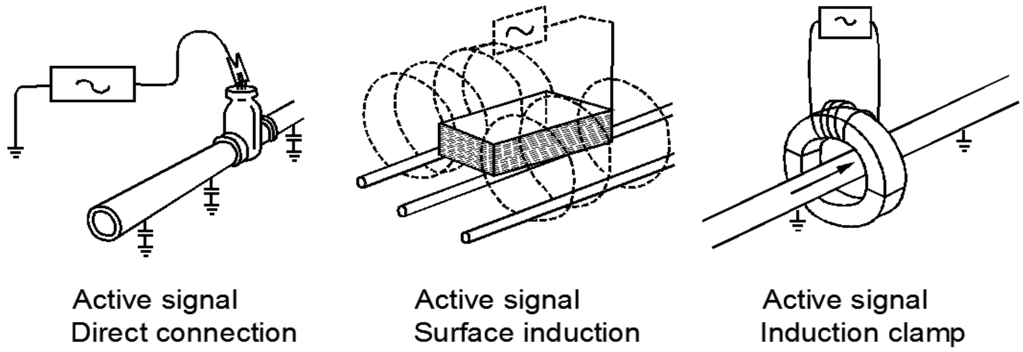

Fig. 2. Radio detection

The detection of underground utilities is dependent upon the composition and construction of the line of interest. Utilities detectable with standard line location methods include the majority of continuously connected metal pipes, cables/wires or non-metallic utilities equipped with tracer wires. These generally include water, electric, natural gas, petroleum, telephone, cable TV and other conduits related to facility operations. If there are no passive currents present, then these utilities must be exposed at the surface or in accessible utility vaults in order to have an active signal placed on them. Utilities that require additional EMLL techniques include those made of non-electrically conductive materials such as polyvinyl chloride (PVC), fiber-glass, vitrified clay, and metal pipes with insulated connections.

Metallic Pipe - Direct surface and induction (source: www.surfacesurveys.com)

Non-metllic pipe - probe (source: www.utiliscope)

Fig. 3. Data collection

Buried objects can also be detected, without direct contact, by using the induction mode. This is used to detect buried metal utilities and near surface metal objects such as rebar, manhole covers, USTs, and various metallic debris. The induction mode is used by holding the transmitter-receiver unit above the ground and continuously scanning the surface. The unit utilizes two orthogonal coils that are separated at a specified distance. One of the coils transmits an electromagnetic signal (primary magnetic field) which in turn produces a secondary magnetic field about the subsurface metal object. Since the receiver coil is orthogonal to the transmitter coil, it is unaffected by the primary field. Therefore, the secondary magnetic fields produced by a buried metal object will generate an audible response from the unit. The peak of this response indicates when the unit is directly over the metal object.

There are many processing means for each data collection presented. For the manual data collection the processing stage needs time and most often human errors are met. Completing physical forms comes along with disadvantages, such as: lack of real-time data verification, errors introduced when manually filling data, no automatic reports, losing trace of papers in time, no organized data base and many more.

For the GPR method, the work over cover the next stages:

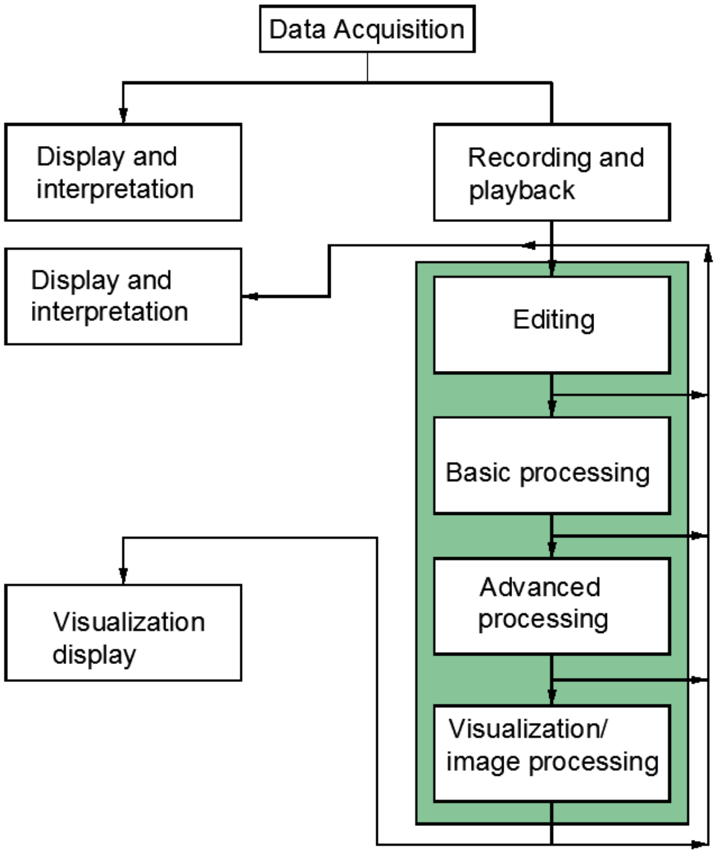

Fig. 4. A general overview of GPR data flow

The first phase is the acquisition and most often is accompanied by real time display (used for on-site interpretation). Frequently**,** data is recorded and available for post-acquisition processing and re-display. The next stages are office stages that are covered the post-processing team. [3]

3. Proposed method of data collection and processing

After analysing the advantages and disadvantages of each data collection and processing method, it can be proposed a technique to improve the existing workflow. So, the main change is to replace the physical form of data recording with a digital one. The data could be recorded into a custom design data base. This digital alternative can enable real time verifications**:** exclude human errors, export graphic and other client/user requirements.

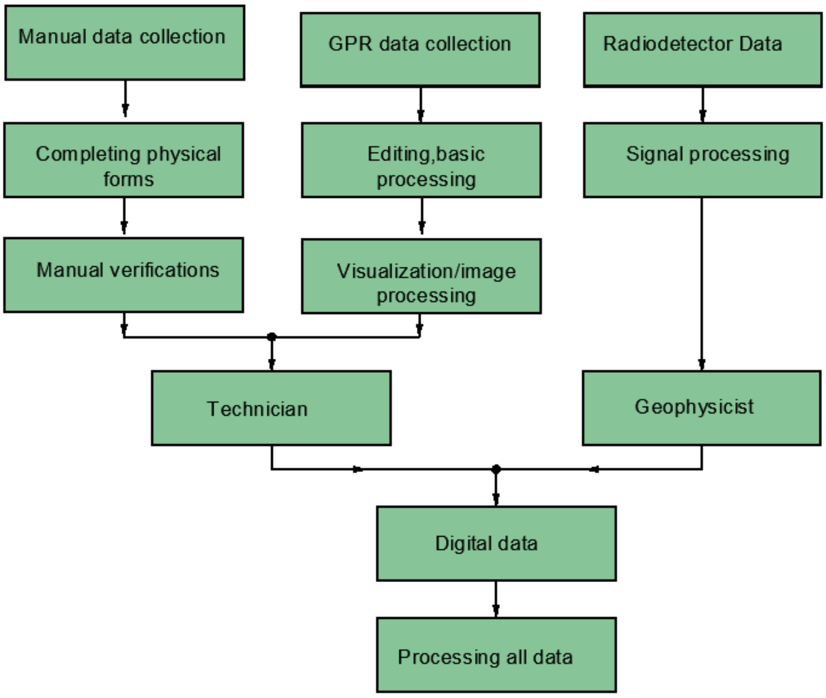

Fig. 5. Current workflow

The main phases for the proposed improved method are shown below:

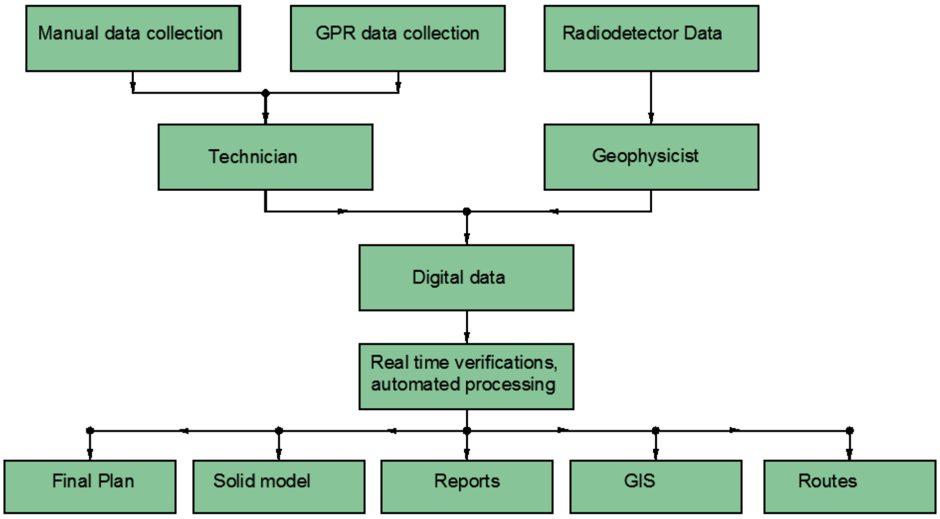

Fig. 6. Improved workflow

The data base can be completed with data from GPR and from other instruments, finally containing a complete and consistent data set. The entire base can be checked**,** saved and completed in time. In the end, from this data base can be exported reports, routes, processing results and any requested queries from the client in different formats. Therefore, many stages will be skipped, and the time and costs will be reduced.

This automated proposed method can be used by small companies but it also could be very useful for state institutions. A common data base could be created, that could include all utilities and enable easier future monitoring and surveys.

4. Applications and practical results

As final results may be mentioned the following: checking the network (after entering all data in the system is achieved grid consistency checking), 2D DXF export (to the export network dxf format, compatible with AutoCAD 2000 to a scale specified by the operator), export the 3D model, export the report in excel format and text (allows exporting all information regarding both access points and connections in Excel and text. Each data access point or connection will be represented on one line thus creating tables easier to configure.).

5. Conclusions

It can be said that this work will serve as guidelines in choosing technologies and working methods in the work.

In addition, the new approach proposed for storing and manipulating data will help complete much faster with this specific work, while eliminating the errors inherent in manual processing.

6. Abbreviation

DXF - Drawing Interchange Format
EMC - Electromagnetic conduction
EMI - Electromagnetic induction
GIS - Geographic Information System
GPR - Ground penetrating radar
LIDAR - Light Detection and Ranging
UTS - Utilities Technical Service

7. References

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2. *David Daniels, Ground Penetrating Radar, Chapter 21*
3. *Sensors & Software INC., Practical Processing of GPR Data, Canada 1999*