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Map location of water losses by using GPS technology

Eles Gabriel[1] Popescu Daniela[1] Bakos Mihaela Violeta[1]

Abstract: Water loss is an important part of the revenue in the water supply system. The fight to control and reduce these losses is not over, and fortunately, a range of equipment and techniques have been developed to handle this situation, from the ones based on acoustic waves produced by water coming out with pressure through the breakage, to the tracer gas or methods based on radionuclide. The proposed work method is based on the efficient data collection regarding the location of the area where the water losses occur, by using GPS equipment. The correct detection of the areas with the water losses is a mandatory stage in the strategy to reduce these losses, for which the correct location of the areas with problems is essential.

Keywords: water loss, GPS equipment, latitude and longitude, TransDat soft

1. ASPECTS RELATED TO THE WATER LOSS

Water losses cannot be avoided, their frequency depending on the general condition of the network and the manner in which it is administered. Most drinking water pipes are made of PEHD, with an average life of 50 years, meaning that in a network of 700 km (as it has Timisoara) and 14 km should be changed every year, the conclusion being that losses will always occur. Problems arise, as a rule, in the case where the ratio of produced water (treated) and the used (billed) water is to the disadvantage of the company. Loses greater 10% requires priority attention and a corrective action.

Fig. 1 Loss of water [7]

If that losses occurring in the system are the result of an accident, (fig. 1) these must be only repaired and monitored.

In most cases, losses should be identified, an ongoing challenge for specialists in the field, a mix between logical and psychological, very often the loss being in a certain area and water refueling at a considerable distance from that area or cases in which the excavations have as a result the detection of "dry areas". Leak detection is a good opportunity for the water company to improve services for customers.

There are different methods for detecting leaks in a distribution system. Most are based on identifying the acoustic waves produced by the water leaking out. Listening devices varies, some may be put on pipes or hydrants, others can be listened directly on the ground (geophones) or other devices that allow simultaneous listening to two points on the pipeline to identify the exact leaking location (using correlates).

These devices can be mechanical or electronic and use mechanisms or sensitive materials to pinpoint leak-induced sound or vibrations. Modern electronic devices have signal amplifiers and noise filters. Filters eliminate the noise outside the frequency interval given by the leaking signals and the amplifiers improve the signal-noise in order for the weak signals to be heard. The operation of the listening devices is simple, but their effectiveness depends on the user's experience. Most people use these acoustic methods for leak detecting, but problems can occur on plastic pipes (PVC). Plastic pipes do not transmit sound as efficiently as metal pipes being dominated by low frequency components (below 50 Hz inaudible to human ears).

Water losses can be detected through other non - acoustic means: tracer gas method, infrared images or radar. Tracer gas method is based on the use of nontoxic gas and lighter than air, such as helium or hydrogen which is injected into an isolated segment of a water pipe. In the losses area there are gas leaks and being lighter than air, the gas comes to the surface through the ground and pavement. The use of these techniques is still very limited, expensive and their effectiveness is not as well established as the one of the acoustic methods. The benefits of reducing the network losses come from the fact that they are detected, repaired and properly located in time on the map in

[1] Faculty of Civil Engineering, Department of Hydro technical Engineering, Street George Enescu, Number 1/A, Zip code 300022, Timisoara, e-mail address:eles.gabriel@yahoo.com

order to be monitored.

2. DATA COLLECTION USING GPS TECHNOLOGY

Global Positioning System (GPS) is a location system based on a constellation of about 24 satellites (in 6 orbital planes with 4 satellites in each plane) orbiting the Earth at altitudes of about 20.000 kilometers. Orbital time is 12 hours which means that at any time, any point on Earth can be seen between 5 and 8 satellites.

GPS was developed by the United States Department of Defense, to be used as a military locating utility. However, in recent years, GPS has proven to be a useful tool for civil applications in measurement and processing of geodetic networks and topographic measurements by default.

GPS is based on the calculation of distances between the receiver and the position of at least three satellites starting from the basic relationship:
Distance = velocity × time, where we known the signal propagation velocity, remaining to determine the time to radio signals.

GPS has been created to determine the exact location on Earth or the atmosphere, information supplied in latitude, longitude, altitude and time.

Latitude and longitude is an absolute reference system for locations on Earth's surface. (fig.2)

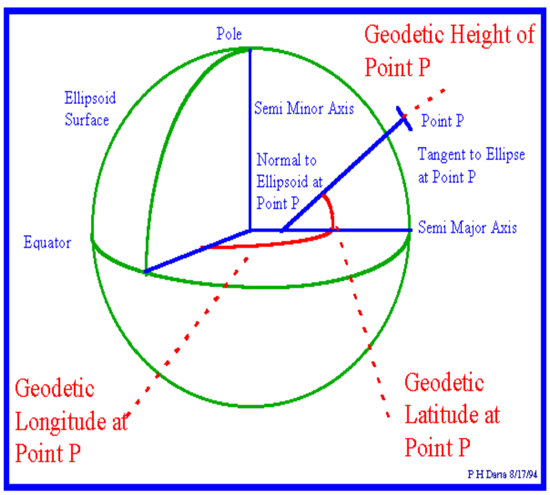

Fig. 2 GPS coordinates, latitude and longitude [8]

However errors can cause deviations of 50 -100 m in the location of a receiver. The most significant sources of errors are caused by atmospheric (ionosphere and troposphere which refracts signal) GPS signal errors caused by falling on a reflecting surface (water, glass, metal) before reaching the receiver or due to alignment errors, geometry, group of satellites from which signals are received, calculated receiver position varying by using satellites. Removing these errors is obtained by differential correction.

There are three types of GPS receivers available on the market, each with its requirements and offering different levels of precision:

- C / A receivers (one frequency) which provides an accuracy of 1-5 meters (within 1 sec) with differential correction, so a sufficient accuracy to be useful in most GIS applications.
- Carrier receivers (one frequency) offering 10 to 30 cm accuracy with differential correction (within 5 min), thus providing a higher level of precision required applications.
- Receivers that receive signals from satellites on two frequencies simultaneously and are capable of providing the millimeter lens position with differential correction.

3. METHOD OF WORKING

A GPS receiver continuously receives signals from all the satellites can see. Signals are in visible spectrum, so they will pass through clouds, glass and plastic but will not pass through solid objects (buildings, mountains, trees).

A GPS signal contains three bits of information: a pseudo identifier (which identifies the satellite that sent the information), ephemeris data (satellite state data, time and date) and almanac data (where the receiver should communicate to find each satellite at a certain time of day). The receiver has the information, determines time differences, and performs complex calculations to identify the locations. Location is displayed in latitude and longitude. Altitude is displayed according to the sea level.

Surveying works on Romanian territory are mainly executed in Stereo 70 Projection System (cadastral maps and plans, topographical maps, etc.). This projecting system was introduced around 1970 replacing the old Gauss-Kruger projection representing Romania in 3^0 or 6^0 fuses. However, the system used on wide scale as reference system for GPS measurements in Europe is ETRS89 (European Terrestrial Reference System).

With the introduction of GPS technology, the demand for direct and inverse transformations between the national / international and local coordinates (WGS 84, ETRS89) has become increasingly acute. Thus A.N.C.P.I passed from determining a set of seven parameters (Helmert) of coordinate's transformation to the development of software called TransDatRO (fig.3), which includes a distortion model that provides correspondence between multiple systems.

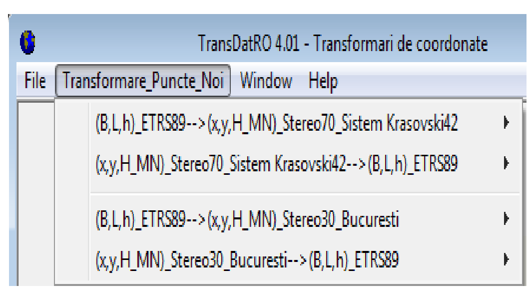

Fig.3 Coordinate transformations with software TransDatRO 4.01 [5]

TransDatRO coordinate transformation is the method used in this work.

100/100 m field. (fig.7)

4. RESULTS GENERATED BY USING THE SOFTWARE TransDat RO4.01

In the case study an area from the Timis county was selected; it is Jdioara village where there was a water loss in the distribution network. The loss was spotted in the field, and we needed the correct location on the plan to be monitored. With the help of the GPS (fig.4), the following coordinates were read:

Lat:$45^0 37' 17''$N si Lon: $022^0 06' 10''$E

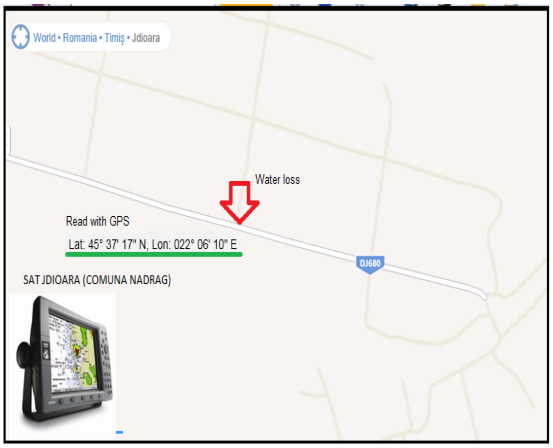

Fig. 4 Locating water loss using GPS technology [9]

Using the TransDatRo (fig.5) were converted the ETRS89 coordinates into X and Y coordinates (Stereo 1970).
Were obtained rectangular coordinates of the point, as

$$X_A = 462055{,}569m$$
$$Y_A = 274246{,}272m$$

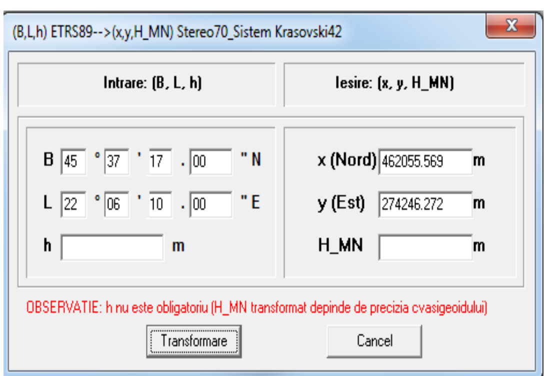

Fig. 5 Coordinate transformations for case study

Having the rectangular coordinates X and Y of the point and the plan in Stereo 70 Projection System, we can locate the correct area where the incident occurred. (fig.6)

In the case of topographic plans drawn on paper (analog) for reporting a point of known rectangular coordinates we have the grid plan, prepared according to the plan representation scale.

For instance on the plan having the numeric scale 1:1000, aspect grid dimensions are 10/10 cm which is

Fig. 6 Location X and Y coordinate on a digital plane Stereo 1970

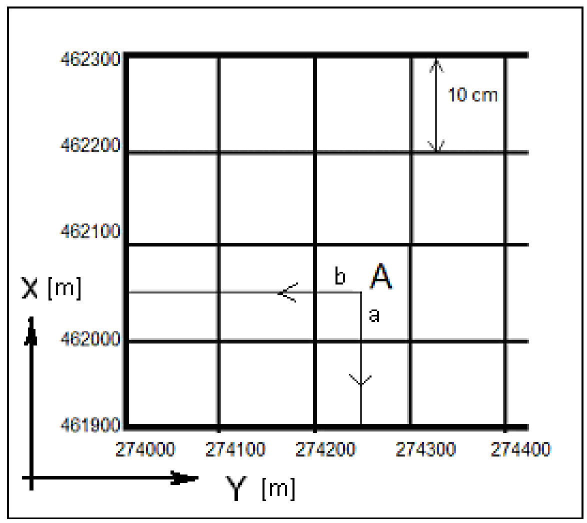

Fig. 7 Locating the X and Y coordinates on an analog plane

To point out the location on an analog plane a grid network is made, consisting square with 10 cm sides and have set the scale 1:1000. Point representation at point A with coordinates:

$$X_A = 462055{,}569m$$
$$Y_A = 274246{,}272m$$

Reporting will be done by calculating values:

$$a = \frac{55{,}569}{1000} = 5{,}56\ cm$$

$$b = \frac{46{,}272}{1000} = 4{,}63\ cm$$

5. CONCLUSIONS

The proper location of the network losses (the plans digital or analog) is one of the most important steps in the water resources management.

In this paper we are using the ETRS89 coordinates transformed into Stereo 70 coordinates using TransDatRo software, program licensed and authorized by ANCPI.

However, currently, there are GPS units, which, through appropriate settings of the software can provide and provides point coordinates in Stereo 70 Projection System. This paper presents a way of solving a positioning problem in the most unfavorable situation, when for the GPS units we don't have the necessary parameters in order to obtain the point coordinates into the Stereo 70 Projection System.

The results helped us for a proper identification on a plan of water loss from the water distribution network in order to be monitored.

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