

# Global positioning system application for monitoring of the engineering infrastructure facility safety

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**Abstract:** Oil and gas companies need to ensure continuous operation of critical equipment, no matter how remote. This means knowing exactly where your fleets and equipment are, how they are performing and identifying problems as they occur. There are number of existing security systems developed to protect linear systems like oil pipelines for transportation of oil and gas products from the first point of development up to collection stations. In the current stage is the gap of the oil and gas pipeline systems security purposes of use of space technology advances. This paper dedicated to the subject of linear pipeline monitoring with use of global positioning system for observation of changes of land in the areas actively functioning of natural disaster factor<sup>[1]</sup>.

**Keywords:** Global Positioning System; Natural Disasters; Monitoring, Linear System; Engineering Facility Safety.

## 1. Introduction

There is no doubt that the study planet structure and natural disasters such as earthquakes, volcanoes, landslides, floods take the key place for Azerbaijan. As it says by scientists the world's atmosphere is becoming more turbulent and unpredictable which demand to come up with approach and developing a new instruments being able to reduce and prevent as much as possible damage to life and property.

It makes important engagement of engineers in geology/geotechnical/chemical and any other related scientists to take high attention to study the structure of the earth and develop models/methods/instruments to learn about continental drift and simulate/predict/forecast the faults in the Earthcal/chemical and any other related scientists to take high attention to and learn about soil eruptions is very important for the country. As far as

obvious landslides study are also important in engineering activities consequences needed to be undertaken during all stages of project design. It is important in the exploitation stage of engineering facilities as well.

The fact is that permanent monitoring of the Earth in the areas of engineering facilities is require for engineers, architects and project designers as an source and key instrument in construction and designing new engineering infrastructure with consideration features of environmental changes<sup>[2]</sup>.

The use and application advances of a high technology in particular space technology in the case of offered conception is a vital for achievement, satisfied accuracy in the process of monitoring of Earth observation for dynamic changes of the environment. It is important to reduce risks of pipeline systems in the active natural disaster areas.

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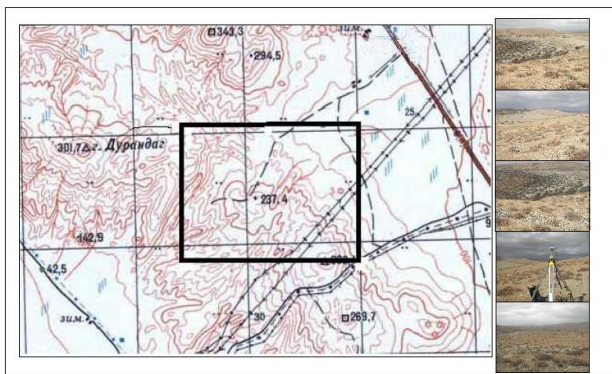
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## 1.1 Investigated Area

The area under investigation is located at 60km to the south-west from Baku, Azerbaijan in the Gobustan district, near the Goturdagh mud volcano (**Figure 1**). The landscape is hilly with low or absent vegetation. Geodesic survey for the fourth cycle of monitoring was started in December 2015 with installation datum monuments. The cycles of five monitoring were embraced on February, June, October 2016 and June 2017 and the last one were conducted on December 2017.



**Figure 1.** An area of investigation

## 2. Method of Measurement

5 Datum (DM) and 15 Surface (SM) ground movement monuments and 6 Top-Dead Centre Target Points of pipe were installed during the first phase of field execution. Geodesic Surveyor performed field survey of ground movement monuments and Top-Dead Centre (TDC) Target points of pipe as a fourth cycle of monitoring to obtain their coordinates and elevation data. Together with the previous data obtained during first three monitoring cycles, these data is expected to be used for further monitoring stages.

The scope of fourth monitoring cycle was included the followings:

Measurement of angles and directions of reference network;

Determination of coordinates and elevations of surface (SM) ground movement monuments;

Determination of coordinates and

elevations of Top-Dead Centre (TDC) Target points of pipe; and

Processing of the geodesic survey results.

World Geodetic System 1984 (WGS-84) was used as the reference geodetic system for horizontal projection. Kroonstad Datum (MSL Baltic Sea) was applied for the local vertical datum.

The coordinates of the Datum (DM) monuments were calculated with average square error of 5mm.

### 2.1 Equipment Used for Topographical Survey

The topographical survey was performed by tachometric survey with the contour interval 0.5m with use of electronic tachometer TS 16 (by Leica) with plugged-in application program.

Topographical equipment has been checked at site prior to commencing work each day and when required.

### 2.2 Field Works

The works were performed as follows:

Determination of horizontal and vertical position of DM points in WGS-84 system.

Measurement of angles and directions of triangulation network.

Adjustment of linear-angular and elevation network.

Determination of horizontal and vertical position of SM points.

Determination of horizontal and vertical position of TDC points.

Processing of geodesic survey data.

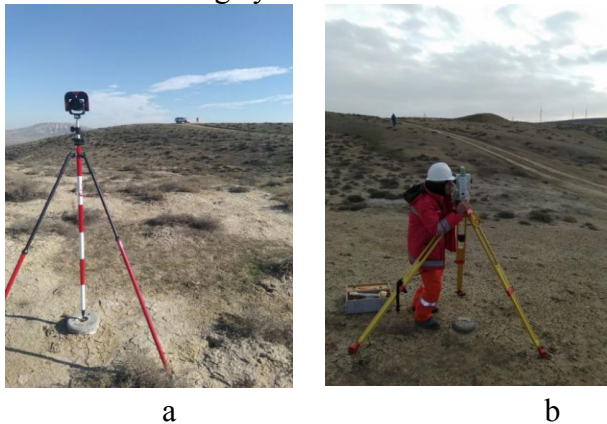
In the initial stage of the field works it has been established DM points meeting the requirements identified by the owner of the oil pipeline system). Those requirements were important for the high accuracy of measurement achievement. An establishment of DM points has been shown in the **Figure 2** (a, b).

### 2.3 Establishment Datum Monuments (DM)

Triangulation network represents the series of triangles. Coordinates of all Datum (DM) monuments are determined in WGS-84

system. Satellite positioning receivers SR20 (produced by Leica) were used for determination of plane coordinates and elevations. Measurements were carried out in a static mode.

The aim of geodesic survey of datum (DM) ground movement monuments was to determine the change in their coordinates and elevations between first, second, third and fourth monitoring cycles.



**Figure 2.** Establishment of datum monuments

The fourth stage of measurements started after equalization of line-angular reference network. Geodesic survey of surface (SM) monuments was performed with use of direct angular and linear interference method.

Measurements were carried out with use of electronic tachometer TS 16 (by Leica) from the reference network point by three receptions with required closing to the adjacent datum (DM) monument. A landmark with reflector was centered on a measured point with use of bipod. Coordinates and elevations of each point were determined from two points of reference network.

Elevations of points were determined with use of trigonometric leveling method.

Determination of horizontal and vertical position of each Top-Dead Centre (TDC) Target point was performed from two points of reference network with use of direct angular and linear interference method.

## 2.4 Measurement

Measurements were carried out with use of electronic tachometer TS 16 (by Leica) from the reference network point by three receptions with required closing to the adjacent datum (DM) monument. A landmark with reflector was centered on a measured

point with use of tripod. Coordinates and elevations of each Top-Dead Centre (TDC) Target point were determined from two points of reference network.

Elevations of points were determined with use of trigonometric leveling method.

Geodesic and topographical information stored in the electronic memory of tachometer was imported into computer with use of Leica Geo Office Tools software. The average square error of measurements accuracy is 5mm.

Triangulation network represents the series of triangles. Coordinates of all Datum (DM) monuments are determined in WGS-84 system. Satellite positioning receivers SR20 (produced by Leica) were used for determination of plane coordinates and elevations.

Measurements were carried out in a static mode. Initially before installation of Surface (SM) and Datum (DM) monuments temporary points TP1 and TP2 coordinates were determined in WGS-84 system.

The process and conditions of measurement were the followings:

The basic receiver was located at the geodesic reference network point with known coordinates during the whole measurement process;

The second receiver was placed at the determinate point with satellite data set during 0.3-1.0 hours (depending on the distance from the basic station);

Processing of field data consisting of adjustments of measurements and transformation of data (Pulkovo 1942 Zone 8) system was performed with use of Leica Geo Office software.

The purpose of triangulation network measurements was to determine the relative position of Datum (DM) monuments with the highest possible accuracy.

Total station software added proportional correction to the measured lines for:

- Atmosphere;
- Mean sea level reduction;
- Bringing oblique line to horizon.

During measurement time the air temperature was determined with use of sling thermometer and atmospheric pressure with use of aneroid barometer. The air temperature was 5 – 10°C, pressure 1003-1013 kPa during the whole geodesic survey time. Correction for meteorological data is 5-8 mm/km.

Upon completion of measurements the register of

closure of triangles was prepared. The average square error was calculated according to formulae below and was equal to 1".42 which corresponds to the third class of accuracy.

$$m_{\beta} = \sqrt{\frac{\sum \omega^2}{3n}}$$

Measured lines were corrected for bringing the lines on a Gauss-Kruger projection according to formulae:

$$D = \frac{y^2}{2R^2}$$

Where y- distance from axis meridian;

R – Earth radius

D – measured line.

Measured lengths of triangulation sides and received from GPS survey are given in the Table 1.

From	To	Grid Distance	
		TS 09 plus	GPS
DM2	DM4	172.520m	172.518m
DM4	DM5	223.556m	223.549m
DM2	DM1	128.772m	128.760m
DM1	DM3	129.372m	129.368m
DM1	DM5	279.295m	279.291m

**Table 1.** Triangulation measurement

Adjustment of linear-angular network was performed by parametric method. Elevations of the points are determined by trigonometric leveling with the basic point DM3 taken from GPS measurements. Measurements were carried out by 3 receptions on GPR 121(Leica) reflectors with constant correction of 0.

The second stage of measurements started after equalization of line-angular reference network. Geodesic survey of Surface Monuments (SM) was performed with use of direct angular and linear interference method.

Measurements were carried out with use of electronic tachometer TS 09 Plus (by Leica) from the reference network point by three receptions with required closing to the adjacent Datum (DM)

monument. A landmark with reflector was centred on a measured point with use of bipod. Coordinates and elevations of each point were determined from two points of reference network.

Elevations of points were determined with use of trigonometric levelling method.

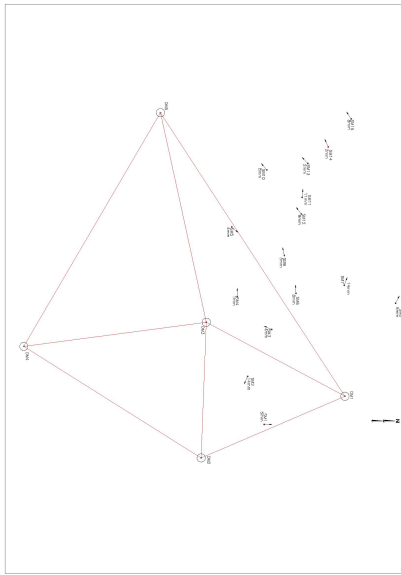
Geodesic and topographical information stored in the electronic memory of tachometer was imported into computer with use of Leica Geo Office Tools software. The average square error of measurements accuracy is 5mm.

### 3. Geospatial Data and GIS Interpretation

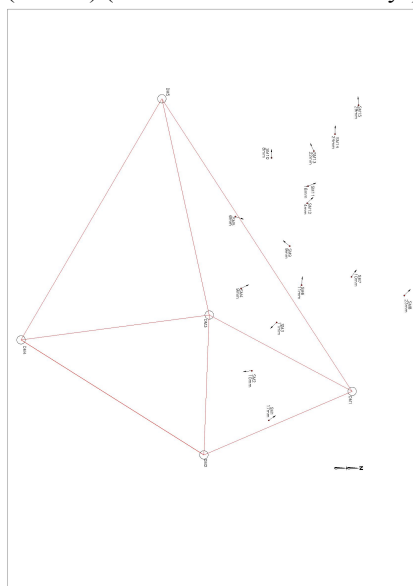
The fact is that it is important and necessary to detect any changes of the land with linear infrastructure in the area with sensitive behavior into the natural processes. The area selected for investigation is highly danger due to the active volcanic natural processes. This circumstance makes necessary to conduct continuous monitoring of the area with pipeline system as an infrastructure for oil transportation<sup>[3]</sup>.

For this purpose within the period of 2016 - 2017 has been carried out of the geodetic measurements by determination of horizontal and high-rise land motion of 15 deformation reference points near the mud volcanos area. The area of liner system location is hilly and established reference points for monitoring are constructed mainly on slopes sine the area was such of nature. This approach of measurement system development was the way to run the definition and monitoring of landslide processes near the mud volcano.

The Figures 3 and 4 demonstrate results of observed landslide condition based on the used monitoring method.



**Figure 3.** Displacement vectors of surface (SM) ground movement-monitoring monuments at mud volcano complex and Wester Rout Export Pipeline (WREP) (from first to second surveys)



**Figure 4.** Displacement vectors of surface (SM) ground movement monitoring monuments at mud volcano complex and Wester Rout Export Pipeline (WREP) (from first to fifth surveys)

It has been carried out five cycles of measurements/monitoring within 2 years in the different seasons. Initially before measurements it has been implemented on definition of planned and levelling positions of monuments of constructed for monitoring of geodetic network<sup>[4,5]</sup>.

The results of the measurements are observed of land deformation of land with increasing of shifting

vectors in the direction of slope comparatively of reference points in the cycles of 2 and 5. As it is seeing from the **Figure 4** the greatest landslide is monitored in the area close to the volcanic crater.

## 4. Conclusion

This paper has been dedicate to the study of liner transportation engineering systems safety. It is demonstrated technological/methodical aspects of global positioning system applications for achievement expectation of monitoring and observation of any natural changes in the area of operating linear system.

A special description has emphasized to the details of technological aspects during execution stage of observation such as establishment of monuments for monitoring of landslide effects in the selected area. It is reflected results of measurement and processing of data, which pointed out of consequences of natural processes going on affecting by volcanic processes. It was the information for owners of the linear system for further required decision making for safety options.

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