THE REQUIREMENTS TO CREATE A GEODETIC INSTRUMENT CALIBRATION POLYGON

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Abstract
In this paper, the environmental, climatic and geological obstacles preventing the development of the most suitable geodetic instrument calibration polygon in Latvia are shortly described. Having assessed the information from previous researches in the relevant fields of science, Engure municipality was selected as the target place for the establishment of the calibration polygon. In order to confirm the suitability of territory during the cameral work, the most suitable 17 land plots were selected and later surveyed on field works. The results of the survey showed that only 8 of selected land plots were suitable or partially suitable for creating a calibration polygon, but only one of the selected land plots met all the requirements completely.
Key words: geodetic instrument calibration polygon, geodetic instrument

Introduction

With the current rapid development of science and technologies, the number of geodetic instrument and instrument application users increases every day. Nowadays these actions manifest themselves not only as the usage of instruments in surveying or other geodesy works, or as scientific development, where they are usually employed by well-qualified specialists of an area, but also as tools to make multiple daily tasks easier, where they are used by lay people and other unqualified users. Considering the varied usage of instruments there are situations when a necessity to check and control some quality indicators of instruments arises among unqualified users. The biggest issue concerning these situations in Latvia is related to the fact that there are only a few calibration laboratories that possess the necessary equipment, but they are restricted for the majority of people, especially for those without any qualification in the field of geodesy or similar fields. These reasons propose a necessity of a place to control quality indicators of instruments that would be available for everyone.

The need to control the quality indicators of instruments is manifesting itself with the fact that after using a geodetic instrument on regular basis, it starts to depreciate and loses the initial quality of some indicators and then needs to be checked and restored. In order to avoid the frequent process of restoring the initial quality of the instrument, calibration needs to be performed. Legislation (About the Conformity Assessment, 1996; About the Measurment Unity, 1997) defines calibration as an operation, involving a process with certain obstacles present, during which a connection between a measurement instrument or a size of values indicated in the measuring system and an adequate benchmark are recognised. So the necessity to develop a calibration polygon open for everyone along with better availability to modern geodetic instruments has only become more significant.

The increasing necessity has stimulated the idea to develop a project of an open field geodetic instrument calibration polygon, but in order to start the development it is necessary to explore all potential territories considered suitable for the polygon. The main aim of the research is *to define the most suitable territories for the establishment of a geodetic instrument calibration polygon in the Engure municipality.* To successfully achieve the aim the following tasks for the research were set:

1. to review and summarize the information on calibration polygons and conditions for developing and maintaining open field calibration polygons in literature and regulations in Latvia and other countries;
2. to define the main and most suitable conditions for creating a calibration polygon in the Latvian territory;
3. to explore potential territories and geological data in the Smārde county and to analyse the obtained results;
4. to evaluate the suitability of territories for creating a geodetic instrument calibration polygon.

In cooperation with representatives of the Engure municipality and a few other specialists from the area, the authors of the research participated in exploring the territories in the Smārde county owned by the Engure municipality. The Smārde county of the Engure municipality was considered to be the most suitable for the research based on the findings of researchers Ratkevics (Ratkevičs), Celms (Celms) and Jager (Jäger) as well as the available geological data of this territory. The research of Ratkevics and Celms investigate the requirements to create a geodetic instrument polygon in Latvia based on polygons created in Scandinavia, Germany, and several other countries over the world (Celms, Ratkevičs, 2011; Ratkevičs, Celms, Jäger, 2015).

The territories were explored by surveying 17 land plots selected previously in cameral works using the cadastral map of the Engure municipality and an orthophoto from 2009, gathering the data for the analysis, and processing and analysing the results of previous research.

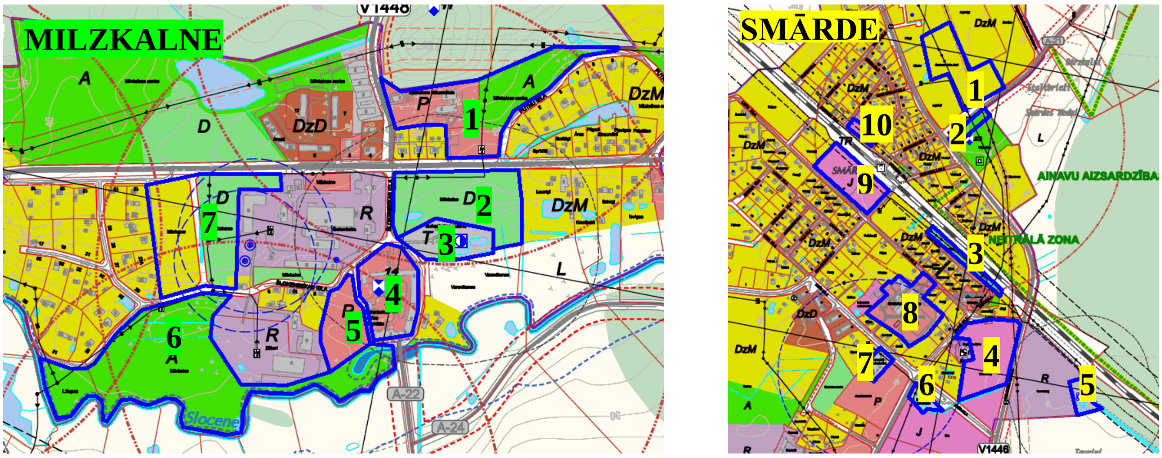
The desired surroundings of a territory that would be the most suitable for the polygon was defined based on the requirements for field procedures of testing geodetic and surveying instruments like theodolites, global positioning instruments, electro-optical distance meters (EDM) and levellers described in the international and Latvian standards (LVS ISO 17123-2, 2001; ISO 17123-3, 2001; ISO 17123-4, 2012; ISO/DIS 17123-8, 2014).

Methodology of research and materials

Having analysed the research based on the comparison of the environment, climate, and geology of Latvia and Scandinavian countries (Ratkevičs, Celms, Jäger, 2015), it was clarified that in order to create a calibration polygon successfully the most important condition is that all elements of a polygon (in this future polygon – pylons placed in polygon) need to carry out their designed tasks qualitatively. In order to comply with this condition, the pylons have to be placed and strengthened on a solid and stable rock layer not deeper than 2 metres. If it is not possible to provide such stable and solid base, there is a risk that the pylons will not maintain constant condition or that the construction installation costs and anchorages will be much higher (Ratkevičs, Celms, Jäger, 2015). Having considered these reasons, it is very important to know the geology of a territory where the location of calibration polygon is planned.

Knowledge of geology in the area is based on 11 geological drill holes made in the Smārde village (the centre of the Smārde county) in 2011, where it was discovered that the rock layer of dolomite can be found at a depth from 2 to 4 metres from the land surface (Geotechnical research of.., 2011). The territory of a calibration polygon was planned as close as possible to the Smārde village.

Before the surveying phase, potentially suitable land plots were selected by using a cadastral map of the Engure municipality and an orthophoto from 2009. In total, 17 land plots in the Smārde countywere selected: 7 land plots are located in the Milzkalne village and 10 land plots are located in the Smārde village (Fig. 1).



Source: made by the authors by using the territorial plan of the Engure municipality for years 2013–2025

Fig. 1. Land plots selected for surveying in Milzkalne and Smārde villages

During the survey, the suitability of surroundings was evaluated. Based on the requirements for field procedures of testing geodetic and surveying instruments described in the international and Latvian standards (LVS ISO 17123-2, 2001; ISO 17123-3, 2001; ISO 17123-4, 2012; ISO/DIS 17123-8, 2014), it was decided to observe and note which land plots have less bushes, trees, woods, or buildings which might be disturbed due to the deployment of pylons and which have large and transparent areas. During a visual evaluation of surroundings these observations were made in all 17 land plots. In suitable or partially suitable territories samples of a land in the depth of 1 metre were taken with a soil probe to find out whether dolomite can be found there closer to the land surface than in drill holes back in 2011.

Discussions and results

The results of surveying 17 land plots in Milzkalne and Smārde villages showed that there were only two suitable land plots (M-2, M-7) in the Milzkalne village and three land plots (S-1, S-2, S-3) in the village. Three land plots in the Milzkalne village and seven in the Smārde village were recognised as partially suitable (Table 1).

Table 1

The evaluation of land areas selected for surveying

No	Land plot symbol	Short describe of an area	Evaluation
1	M - 1	a transparent meadow with several separate trees on W-SW-S, a school in the centre, a forest on NE-E	Partially suitable
2	M - 2	a transparent meadow, a ditch covered with bushes from S to N, garden allotments on W	Suitable
3	M - 3	a meadow with separate bushes on W, building in the centre, pond on SE, bushes on S and E	Partially suitable
4	M - 4	a lawn on S and W, the manor of Šlokenbeka covers the largest part	Partially suitable
5	M - 5	covered with bushes	Not suitable
6	M - 6	thick bushes on S, meadow with separate trees and bushes on N	Not suitable
7	M - 7	a transparent meadow	Suitable
8	S – 1	a transparent meadow, power line from SE to SW	Suitable
9	S - 2	a transparent territory of the recreational park “Garden of Winds” (“Vēju dārzs”)	Suitable
10	S - 3	a meadow with trees and bushes next to a railroad	Not suitable
11	S - 4	a transparent meadow	Suitable
12	S - 5	buildings, many bushes, poor transparency	Not suitable
13	S - 6	a bus stop and bushes in the centre surrounded by meadows	Not suitable
14	S - 7	buildings and bushes	Not suitable
15	S - 8	buildings, few separate trees and bushes	Not suitable
16	S - 9	a meadow with bushes and trees next to a railroad	Not suitable
17	S - 10	a transparent meadow next to a railroad	Not suitable

Source: made by the authors

During the process of evaluating the land plots, 20 samples of the land in the depth of 1 metre were taken with a soil probe in 8 land plots with a suitable or partially suitable evaluation. 5 samples were taken in the land plot labelled M-1, 3 in land plots labelled M-2, S-1, 2-4, 2 in land plots labelled M-7, S-2, and 1 in land plots labelled M-3 and M4. Along with the taken samples, in these points coordinates were measured based on the global positioning method (Table 2). The results of the analysis of these samples confirm that there is a rock layer of dolomite found in the depth lower than 1 m, but it was found only in a single sample point market with the number 17 (coloured in grey, Table 2) in a land plot labelled S-1. But, as it is known, rock layers are not positioned in straight horizontal lines, so even after few centimetres the depth of the layer may be located much deeper, which makes these promising results not very definite and convincing.

Table 2

Coordinates of the points of land samples

No	Land plot symbol	Coordinates	
		x	y
1	M - 1	315300.39	453003.68
2		315310.03	453061.06
3		315249.35	453015.40
4		315236.59	453016.81
5		315222.64	453080.82
6	M - 2	315157.49	453190.01
7		315160.14	453155.68
8		315041.97	452988.14
9	M - 3	314990.21	453085.46
10	M - 4	314192.05	452935.56
11	M - 7	314850.12	452624.17
12		314930.90	452617.74
13	S – 1	312753.61	459891.43
14		312809.59	459935.62
15		312855.70	459931.70
16	S - 2	312918.21	459892.80
17		312982.16	459842.11
18	S - 4	312131.61	460199.59
19		312131.80	460157.64
20		312031.38	460185.45

Source: made by the authors

Due to the foundation of dolomite layer being so close to the land surface in this area, it was assessed that the territory of recreational park "Garden of Winds" and surrounding territories were the most suitable to develop the project, but geology was still unclear. So the promising but unconvincing results of land samples provided the research and analysis of geology base only on the geotechnical research in the Smārde village completed by geological and geotechnical company Ltd. 'BG Invest' on 18th of March and 5th of April, 2011.

Table 3

The depth of dolomite found in drill holes in 2011

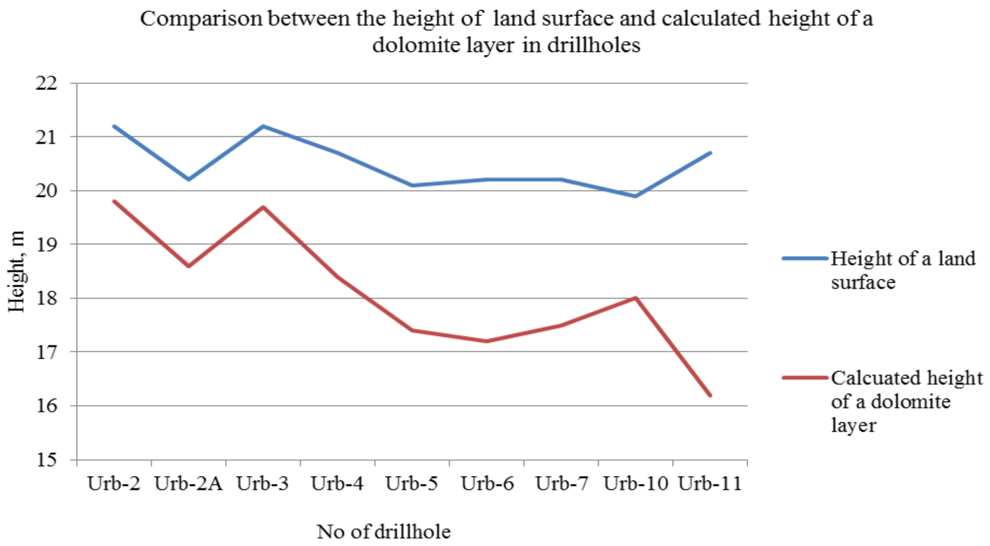
No of drill hole	Absolute height of land surface, m	Lowest rock level			
		Upper depth, m	Lower depth, m	Calculated absolute height, m	Description
Urb-1	21.80	2.3	3.0	-	Moraine clay loam, detailed plastic, brown with water-saturated small sand layers
Urb-2	21.20	1.4	-	19.80	Dolomite rock, moraine clay loam with dolomite chippings and flour from 1.2 m
Urb-2A	20.20	1.6	-	18.60	Dolomite rock, dolomite chippings and flour from 1.4 m
Urb-3	21.20	1.5	-	19.70	Dolomite rock, dolomite chippings and flour from 1.4 m
Urb-4	20.70	2.3	-	18.40	Dolomite rock, dolomite chippings and flour from 1.4 m
Urb-5	20.10	2.7	-	17.40	Dolomite rock, dolomite chippings and flour from 2.5 m
Urb-6	20.20	3.0	-	17.20	Dolomite rock, dolomite chippings and flour from 2.9 m
Urb-7	20.20	2.7	-	17.50	Blue-grey dolomitic marlstones, dolomite chippings and flour from 1.1 m
Urb-8	19.60	1.1	3.0	-	Moraine clay loam, tough plastic, red-brown, from 2.4 m depth with water-saturated small sand layers
Urb-9	20.80	2.4	3.0	-	Clay loam, tough plastic, light brown
Urb-10	19.90	1.9	-	18.00	Dolomite rock, dolomite chippings and flour from 1.4 m
Urb-11	20.70	4.5	-	16.20	Blue-grey dolomitic marlstones, dolomite chippings and flour from 2.9 m

Source: made by the authors from the data in Ltd. 'BG Invest' geotechnical description

The geotechnical research was carried out based on the order by the company Ltd. 'FIRMUS Design and Construction'. This order was completed for the development of a reconstruction project of water collection and production systems and the expansion of a water supply and sewerage system (SIA 'BG Invest', 2011).

Having assessed the location of the drill holes and the depths where the rock layer of dolomite was found in them (Table 3), as well as possessing the only available positive result from land samples, an approximate depth of the dolomite layer in the territory of the recreational park "Garden of Winds" was calculated.

The geotechnical research found that dolomite forms a layer in all drill holes, except the ones labelled No Urb-1, Urb-8, and Urb-9. The layer consisting of dolomite was reached in the depth between 1.1 to 4.5 metres from the land surface, but chippings and other signs were observed even higher, in the depth between 1.1 to 2.9 metres. The location of the dolomite layer is calculated based on the height of the land surface and the depth of the dolomite layer in drill holes, and it varies between 16.20 to 19.70 metres above the sea level in the Latvia Height System 2000.5 (LAS-2000.5), mostly concentrating between 17.50 to 18.50 metres above sea level (Fig. 2).



Source: made by the authors from data in Table 2

Fig. 2. Comparison between the height of the land surface and the calculated height of the dolomite layer in drill holes.

During the research of Ltd 'BG Invest', mainly dolomite chippers forming small layers with few areas of dolomite and dolomitic rock were found in the points on the red coloured line. According to the information provided by the geotechnical bank, under this layer there is a layer of Upper Devonian Salaspils suite rocks (D_3Slp), a semi-hard and hard clay with dolomitic rocks and dolomite. With regards to the stability of the polygon element construction and their connection to the bedrock, the layer of dolomitic rocks and dolomite are the most suitable for the establishment of a calibration polygon in the planned territory.

Conclusions and proposals

1. Currently, there is no geodetic instrument calibration polygon open for everyone in Latvia.
2. To successfully construct polygon elements, it is necessary to know the environment, climate and geology of the territory, because the elements of the polygon need to be stable to maintain itself for a long period of time.
3. Eight land plots selected as potential areas for the polygon were evaluated as suitable or partially suitable, but dolomite was found only in one of them.
4. Out of all the territories that were checked and analysed, the most suitable territory, having met all the requirements, was a territory of a recreational park "Garden of Winds", so it was recognised as the territory where a geodetic instrument calibration polygon should be developed.
5. We propose to fulfil the idea of creating a geodetic instrument calibration polygon.

References

1. About the Comformity Assessment: Law of Republic of Latvia (1996). *Latvijas Vēstnesis* No. 139 (624), 20th of August.

2. About the Measurment Unity: Law of Republic of Latvia (1997). *Latvijas Vēstnesis* No. 69/70 (784/785), 11th of March.
3. Celms A., Ratkevičs A. (2011). Geodetic instrument and technology calibration polygons and base comparators: *Geography. Geology. Environmental science. Thesis of papers*. Riga: University of Latvia, 508 pp.
4. ISO 17123-3: Optics and optical instruments – Field procedures of testing geodetic and surveying instruments – Part 3: Theodolites. 2001.
5. ISO 17123-4: Optics and optical instruments – Field procedures of testing geodetic and surveying instruments – Part 4: Electro-optical distance meters (EDM measurements to reflectors). 2012.
6. ISO/DIS 17123-8: Optics and optical instruments – Field procedures of testing geodetic and surveying instruments – Part 8: GNSS field measurement systems in real-time kinematic (RTK). 2014.
7. LVS ISO 17123-2: Optics and optical instruments - Field procedures of testing geodetic and surveying instruments - Part 2: Levels. 2001.
8. Ratkevičs A., Celms A., Jäger R. (2015). Geodetic Instrument Calibration Polygon Element Structure and Construction.: *Civil Engineering `15,* Volume 5, p.174 -181.
9. Geotechnical research of the base (2011). Project of a reconstruction of water collection and production systems and an expansion of water supply and sewerage system in Smārde village.: Livani, Ltd “BG Invest”.

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