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THE GEODESIC NETWORK'S APPLICATION IN THE SYSTEMATIC CADASTRE WORKS IN VINGA COMMUNE

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Abstract: *In this paper is depicted the creation of the geodetic network of Vinga commune. Vinga is a commune in Arad County, close to the boundary with Timiș County. The commune also includes the settlements of Mănăștur and Mailat, with a total area of around 14142 ha. The following criteria were considered before selecting the points that will thicken the national network and be determined by GNSS measurements: to ensure the point's preservation for a long time, to be visible from 15 degrees above the horizon, to have GNSS receivers set to collect data every 5 seconds, and to be accessible regardless of the weather conditions. There should be no high-power electrical installations near the stations or emission relays, according to the fundamental criteria that are decided to be able to be employed in future operations. The measurements were totally carried out using satellite technology. The following activities were carried out in order to create this geodetic network: GNSS measurements using the static technique for thickening the support network, and GNSS measurements using the radio method for thickening the support network. Feno terminals were used to make field markings for the GNSS approach of thickening the network. With reference to the locations in the national geodetic network RO, two L1 / L2 dual frequency receivers, model LEICA VIVA GS08, were utilized for measurement. The geodetic thickening network is being built to meet some economic and legal administrative criteria, and it will serve as the foundation for topographic measurements for various reasons.*

Keywords: *geodetic network, static determinations, radio determinations, Vinga*

INTRODUCTION

The commune of Vinga, Mailat, and Mănăștur (MAYOR'S OFFICE-VINGA) has a total area of 14,142 ha in Arad County, of which approximately 945 ha are land in built-up areas. The goal of this article is to use GNSS technology to thicken the geodetic network (SIMON ET ALL 2018, MIȚA ET AL. 2020). All measurements were done utilizing satellite technology (ȘMULEAC ET ALL 2012, 2015, 2017).

The identification, measurement, description, and registration of buildings in technical papers (BABUCA ET AL. 2009; POPESCU G. ET ALL 2016), as well as their depiction on cadastral plans and data storage on digital media, are all examples of systematic cadastral activities.

The systematic registration process comes to a close when the information is entered into the land book. Based on measurements, the cadastre calculates the location of the adjoining structures' borders (ANCPI). The geodetic thickening network is made up of a succession of carefully selected sites that will be determined using the national geodetic network (SIMON ET ALL 2018), following the idea of going from higher to lower order.

By defining the geographical position (CASIAN ET ALL 2019; HERBEI M. ET ALL 2018) and milestones, this network aids in the cadastral determination of the administrative territory, including built-up areas.

Feno type terminals will realize the points proposed and determined in the field, forming a geodetic network (CARTIS ET ALL 2019) that will span the study's territories.

The number of sites in this network was determined by the terrain arrangement, as well as the kind and performance of the measuring equipment (PAUNESCU ET ALL 2020). The fieldwork equipment used to thicken the geodetic network was a Leica Viva type, model GS08, with the existence of old points, belonging to the support network, visibility, and density of points taken into consideration for the positioning of Feno terminals.

The network was designed to take into consideration the existence of ancient signals that make up the national geodetic network, which were found to be appropriate and useable after a field recognition procedure (VLAD ET ALL 2017; ȘMULEAC ET ALL 2019, 2020).

The mutual visibility limit terminals must be placed at a distance that allows the total station to measure angles and distances. The spots must also be in an open area, free of barriers, with a clear horizon of at least 15 degrees above the horizon.

We took into consideration both the permanent GNSS stations that are part of the Class A National Geodetic Network and the constraints of the national geodetic triangulation network while constructing the network and arranging the GNSS measurements. The approximate placements of the new border posts were designed using all of these criteria. It was also taken into consideration that the distance between the terminals must be measured with the whole station and must not exceed 1.5 to 2 kilometres.

MATERIALS AND METHODS

The recognition of the land (LALU ET ALL 2020; ȘMULEAC ET ALL 2017), for the identification of the working area (fig. 1), with the estimation of the density of the elements to be raised topographically, i.e. the characteristic elements that must be represented on plans, as well as the operations of identifying the points in RGIR (Geodetic Thickening and Lifting) carried out in advance, verifying also the integrity of the surface.

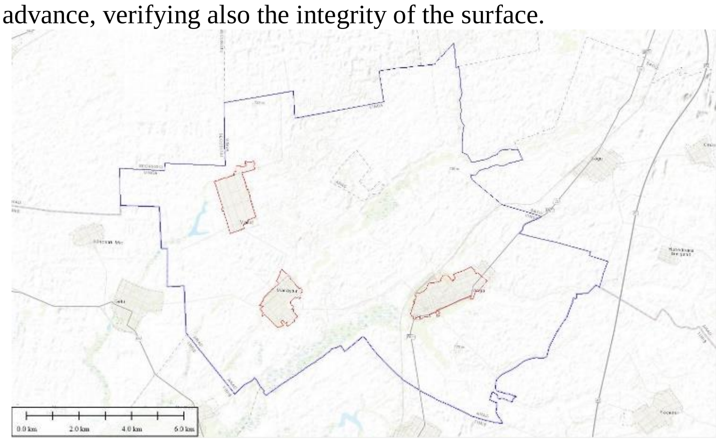

FIG. 1 - Location of the study area (GEOSPATIAL)

Marking is the process of turning topographic features into physical objects in the field. The topographic points appear on the field via terminals that stay on the field after the measurements are completed (SMULEAC ET ALL 2017).

The distance between the locations is defined by the field circumstances, the amount of vegetation or structures covering the area, the purpose of the topographic elevation, and the topographic equipment available (POPESCU ET ALL 2016, 2019).

The following sorts of works were carried out in the regions inside the built-up areas of the localities:

- GNSS determinations using the STATIC technique;
- RADIO method GNSS determinations.

The measurements were made using two Leica Viva GS08 dual frequency receivers and the "static" approach. Using the points from the national geodetic network ROMPOS (Arad, Faget, Resita, and Timisoara) as reference stations, 15 additional points were determined, which were read in the vicinity of the dense geodetic network's Vinga, Mailat, and Manastur points (ȘMULEAC ET ALL 2019).

The GNSS technique of field marking for the thickening network was employed using Feno terminals, with four terminals installed for each locality, and three Feno terminals placed outside the town and two extra DTM signals that could be utilized to cover the whole ATU.

The "radio" measurements were conducted with two Leica 1200 GNSS receivers, one of which served as a reference station and the other as a rover for the radio determinations.

RESULTS AND DISCUSSIONS

1. The static technique of GNSS measurements for thickening the support network

In the ETRF2000 datum, era 2000.0 (ROMPOS), the network was constructed from the following geodetic points from the national GNSS ROMPOS network (table 1).

Table 1

Reference stations used

No. Crt.	Name	ID	B(m)	L(m)	He(m)
1	Arad	ARAD	46°10'23.51005"N	21°20'40.51046"E	167.684
2	Faget	FAGE	45°51'16.42753"N	22°10'37.78289"E	216.490
3	Resita	RESI	45°17'34.45921"N	21°53'54.54481"E	300.238
4	Timisoara	TIM1	45°46'47.65264"N	21°13'51.46341"E	154.714

We considered the following factors (ANCPI) while selecting the locations that will thicken the national network and will be decided by GNSS measurements:

- there will be visibility from 15g over the horizon;
- GNSS receivers will collect data every 5 seconds;
- it will be accessible regardless of weather conditions;
- the basic points that are determined will be able to be used in subsequent works;
- there will be no high-power electrical installations near stations or emission relays.

The measurements were carried out using the "static" approach with the following equipment: two Leica Viva GS08 dual frequency receivers. With the points from the national geodetic network ROMPOS (Arad, Faget, Resita, and Timisoara) as references, 16 additional points in the region of Vinga, Mailat, and Manastur localities, Arad county, were found, forming the thickening geodetic network (table2).

The field marking for the GNSS technique of thickening network implementation was done with Feno terminals, with four terminals installed for each community, and two Feno terminals placed outside the town and two additional DTM signals that could be utilized to cover the whole ATU.

Stationing on higher order points was also investigated (figure 2) in order to thicken the geodetic network by satellite measurements, as was the verification of the coordinates acquired by post-processing the raw data and comparing them with coordinates from the Cadastre Offices' coordinate inventory.

The parking time for each terminal, taking into consideration the longest base, was an essential force parameter. In this situation, each terminal's session will last 1 minute per kilometre plus 15 minutes of control time in order to achieve accurate post-processing findings.

Table 2

The state of the pyramids

Geodesic signal	Condition	X(m)	Y(m)	Z(m)
ZADARENI SUD	Good	517249,898	207049,481	126,21
VALEA LOVRIN N-EST	Destroyed	515681,220	205513,116	-
MAILAT NORD EST	Destroyed	514539,806	202218,383	-
MAILAT NORD	Destroyed	513938,705	199341,739	-
ZATRENI	Destroyed	510987,697	200895,732	-
DEALUL MORII DE VANT	Demage	510800,543	206862,195	135,67
CALONIA MICA	Destroyed	508599,682	197170,754	-
DEALUL FLAMANZI	Destroyed	506206,920	198560,810	-
VALEA MANASTUR	Destroyed	505518,666	201678,966	-
DEALUL CALACEI	Destroyed	506863,541	204702,686	-

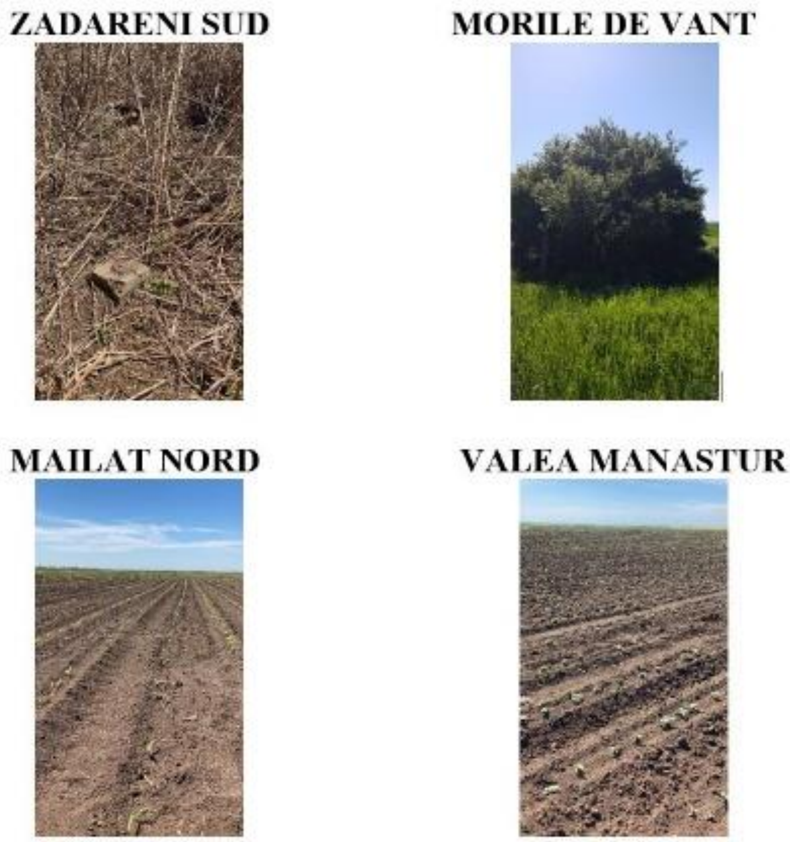

Fig. 2 - State of geodetic signals

The stationary duration for static measurements on the administrative territory of Vinga commune was 1.5 hours each measurement session (SIMON ET ALL 2017). This translates to 70 minutes for the longest base of 70 kilometers plus 15 minutes for control, for a total of 95 minutes of parking time.

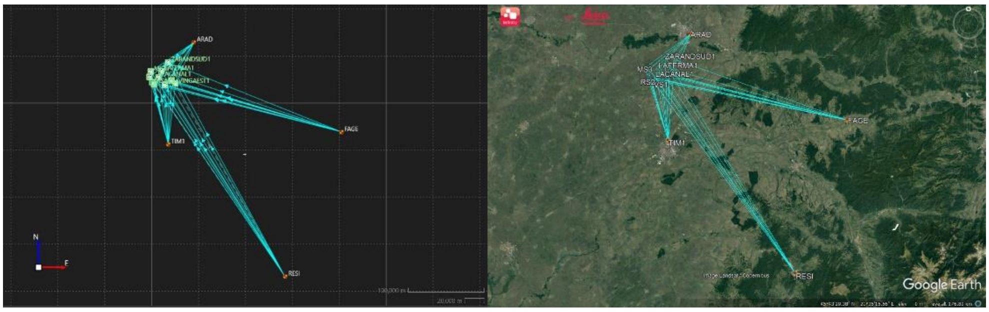

Fig. 3 - Outline of the support network

Leica Infinity software was used to process the data (figure 3). This data must be processed with a precision of 5 cm +/- 2ppm. Four vectors were used to calculate the sites in the geodetic thickening network (ŞMULEAC ET ALL 2015).

The locations ARAD, FAGE, RESI, and TIM1 were considered fixed points while adjusting the network, with the caveat that the reference station coordinates were rectified in the Leica Infinity software using the accurate coordinates obtained from the ROMPOS.RO website.

Summary

#	Point ID	Point Role	Easting [m]	Northing [m]	Ortho. Height [m]	Ellips. Height [m]	Code	Tilt [gon]	3D CQ [m]	2D CQ [m]	1D CQ [m]	Date/Time
1	LACANAL1	Averaged	202,896.982	510,859.857	104.000	37.421		-	0.009	0.007	0.006	06/04/2021 12:34:57
2	LAFERMA1	Averaged	204,196.107	513,580.330	125.307	58.714		-	0.007	0.005	0.004	06/04/2021 12:35:12
3	MS1	Averaged	199,645.589	513,435.599	120.501	53.925		-	0.018	0.010	0.015	06/03/2021 12:35:02
4	MS2	Averaged	199,569.751	513,391.919	121.169	54.593		-	0.009	0.005	0.007	06/03/2021 12:34:57
5	MS3	Averaged	199,078.022	511,089.881	118.572	52.007		-	0.018	0.017	0.007	06/03/2021 14:31:32
6	MS4	Averaged	199,142.971	511,045.314	118.725	52.160		-	0.014	0.012	0.006	06/03/2021 14:31:32
7	RS1	Averaged	200,296.341	508,888.322	116.548	49.983		-	0.002	0.002	0.001	06/07/2021 11:40:12
8	RS2	Averaged	200,237.996	508,859.191	116.282	49.717		-	0.000	0.000	0.000	06/07/2021 11:40:17
9	RS3	Averaged	200,988.092	508,058.095	119.229	52.664		-	0.023	0.001	0.023	06/07/2021 13:30:02
10	RS4	Averaged	201,076.861	508,048.204	119.183	52.619		-	0.005	0.004	0.003	06/07/2021 13:32:47
11	VINGAEST1	Averaged	210,158.581	508,223.087	112.215	45.686		-	0.029	0.014	0.025	06/09/2021 15:35:47
12	VS1	Averaged	205,635.283	507,652.323	103.477	36.919		-	0.011	0.002	0.011	06/08/2021 13:54:57
13	VS2	Averaged	205,647.071	507,708.656	104.497	37.940		-	0.009	0.006	0.007	06/08/2021 13:55:02
14	VS3	Averaged	208,444.649	509,574.528	130.143	63.590		-	0.029	0.008	0.028	06/08/2021 11:55:37
15	VS4	Averaged	208,511.536	509,679.057	130.938	64.384		-	0.021	0.005	0.020	06/08/2021 11:55:32
16	ZARANDSUD1	Averaged	207,049.481	517,249.900	126.178	59.555		-	0.012	0.010	0.007	06/09/2021 12:45:22

Fig. 4 – Point Quality Report

2. Radio-based GNSS measurements for thickening the support network

The topographic surveys by radio technique were carried out with two Leica 1200 GNSS receivers, one of which was utilized as a reference station (base) and the other for radio determinations (rover).

For each radio session (figure 4), rover readings were taken for all other feno terminals and implicitly metal bolts after mounting the base on a statically calculated feno terminal with known coordinates (DRAGOMIR ET ALL 2014). Comparisons were done between data produced by the radio technique and data obtained by the Real Time Kinematic (RTK) approach for feno terminals and metal bolts. After ten seconds of occupancy, the coordinate discrepancies on X, Y, and Z were maximal 1-5 cm (DRAGOMIR ET ALL 2013).

After installing the base on a statically determined Feno terminal with known coordinates for each radio session, readings for all other Feno type terminals and implied metal bolts were taken with the Rovers. Comparisons were done between data produced by the radio technique and data obtained by the Real Time Kinematic (RTK) approach for Feno terminals and metal bolts. After two minutes of occupancy, the coordinate discrepancies on X, Y, and Z were maximal 1-5 cm (figure 5).

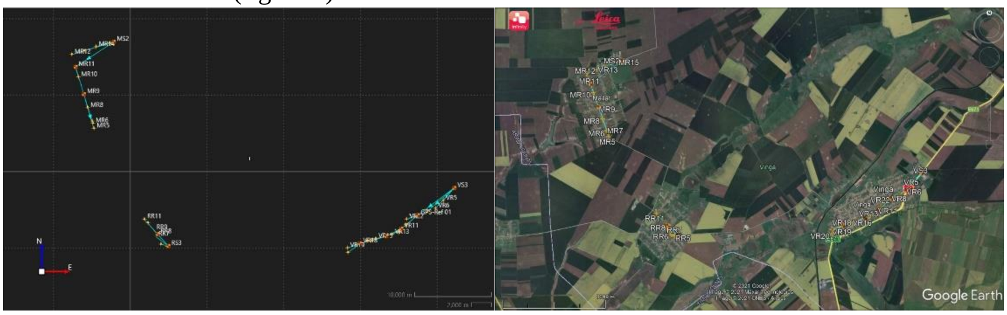

Fig. 5 - Outline of the thickening network on all 3 urban areas

Five new points were radiated from the stationary station "MS2," three new points were radiated from "MR11," and four new points were radiated from "MR9," all of which were materialized during field work by feno type terminals (figure 6).

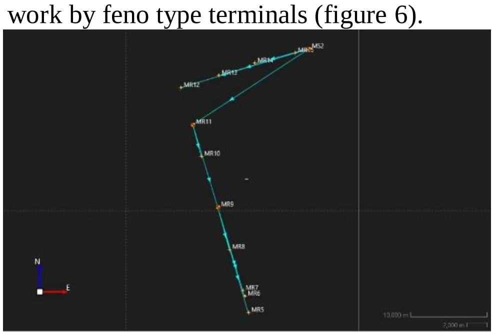

Fig. 6 - Outline of the thickening network for Mailat

Four new points were radiated from fixed station "RS3," and three new points were radiated from fixed station "RR8," points that appeared during field operations utilizing feno type terminals (figure 7).

Four new points were radiated from the fixed station "VS3," three new points from "VR8," three new points from "VR11," four new points from "VR14," and two new points from "VR18," all of which were materialized during field work by feno type terminals and metal bolts (figure 8).

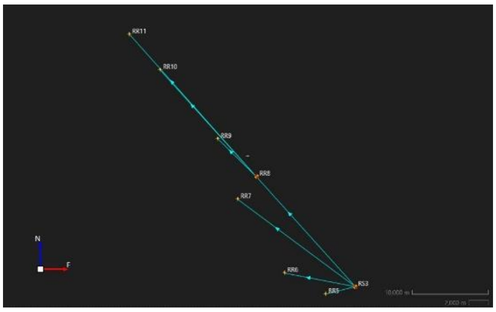

Fig. 7 - Outline of the Manastur's expanding network

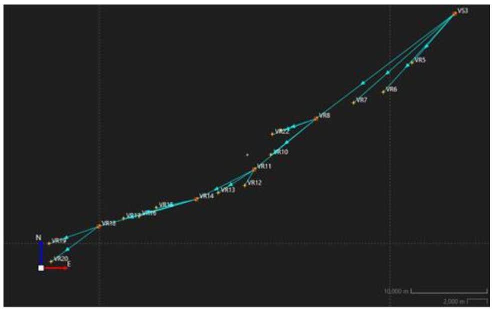

Fig. 8 - Outline of the thickening network for Vinga

The completion of the Geodetic Thickening and Lifting Network (figure 9) is a vital step in ensuring the technical conditions for all subsequent measurements and technical activities required to reach the project's end goal (table 3 and 4).

Fig. 9 - Location of the landmarks

Table 3

Inventory of new points determined by static measurements

Point Id	Easting	Northing	Ortho. Height	Geoid Separation	CQ 3D	CQ 2D	CQ 1D	SD Easting	SD Northing	SD Ortho. Height
LACANAL1	202896.9821	510859.8568	103.9998	-66.5787	0.0091	0.0069	0.006	0.0062	0.003	0.006
LAFERMA1	204196.1071	513580.3297	125.3072	-66.5933	0.0066	0.0054	0.0037	0.0044	0.0032	0.0037
MS1	199645.5891	513435.5987	120.5013	-66.5766	0.0185	0.0104	0.0153	0.0085	0.0061	0.0153
MS2	199569.7513	513391.9194	121.1686	-66.5759	0.0085	0.0053	0.0067	0.0044	0.0029	0.0067
MS3	199078.0218	511089.8812	118.5719	-66.5651	0.0182	0.0169	0.0068	0.0023	0.0167	0.0068
MS4	199142.9707	511045.314	118.7254	-66.5654	0.0136	0.0121	0.0062	0.0066	0.0102	0.0062
RS1	200296.3409	508888.3216	116.5483	-66.5649	0.0019	0.0017	0.0009	0.0003	0.0016	0.0009
RS2	200237.9964	508859.1915	116.2818	-66.5645	0.0005	0.0003	0.0004	0.0002	0.0002	0.0004
RS3	200988.0924	508058.0951	119.2289	-66.5644	0.0234	0.0012	0.0234	0.001	0.0007	0.0234
RS4	201076.8612	508048.2042	119.1832	-66.5646	0.0049	0.0042	0.0026	0.0041	0.0009	0.0026
VINGAEST1	210158.5813	508223.0875	112.2146	-66.5288	0.0288	0.0141	0.0251	0.0087	0.011	0.0251
VS1	205635.2835	507652.323	103.4769	-66.5574	0.0115	0.0024	0.0112	0.002	0.0013	0.0112
VS2	205647.0712	507708.6559	104.4974	-66.5577	0.0087	0.0058	0.0065	0.0031	0.0049	0.0065
VS3	208444.649	509574.5276	130.1433	-66.5529	0.0287	0.008	0.0275	0.0079	0.0011	0.0275
VS4	208511.5362	509679.0567	130.9375	-66.5532	0.0206	0.005	0.02	0.0046	0.0018	0.02
ZARANDSUD1	207049.4812	517249.8998	126.1784	-66.6236	0.0124	0.0105	0.0066	0.0095	0.0044	0.0066

Table 4

Inventory of new points determined by radio measurements

Point Id	Easting	Northing	Ortho. Height	Geoid Separation	CQ 3D	CQ 2D	CQ 1D	SD Easting	SD Northing	SD Ortho. Height
MR5	199050.114	511124.5039	118.555	-66.565	0.0297	0.0125	0.0269	0.0081	0.0096	0.0269
MR6	199018.5662	511263.3211	118.5001	-66.5652	0.0194	0.0082	0.0176	0.0053	0.0063	0.0176
MR7	199003.4348	511314.3184	118.0583	-66.5653	0.0176	0.0079	0.0157	0.0051	0.006	0.0157
MR8	198887.7632	511667.4981	118.944	-66.5656	0.0155	0.0066	0.014	0.0041	0.0051	0.014
MR9	198789.9409	512028.6965	119.7651	-66.5661						
MR10	198647.6091	512467.2868	119.1587	-66.5666	0.0167	0.0086	0.0143	0.0052	0.0068	0.0143
MR11	198574.4424	512740.4522	119.1187	-66.567						
MR12	198470.9058	513057.9838	118.2127	-66.5674	0.0099	0.0055	0.0083	0.0036	0.0042	0.0083
MR13	198794.1941	513160.1592	119.0328	-66.57	0.0108	0.0061	0.0089	0.0038	0.0048	0.0089
MR14	199103.0106	513265.7141	119.3291	-66.5724	0.0088	0.0049	0.0073	0.0031	0.0038	0.0073
MR15	199449.9372	513354.2355	120.4784	-66.575	0.0082	0.0045	0.0068	0.0028	0.0035	0.0068
RR5	200905.6338	508037.5769	118.1532	-66.5641	0.0126	0.0071	0.0104	0.0048	0.0053	0.0104
RR6	200793.1808	508095.2583	113.0064	-66.564	0.0151	0.0085	0.0124	0.0054	0.0066	0.0124
RR7	200664.6806	508297.3913	100.9429	-66.5643	0.0101	0.0057	0.0084	0.0037	0.0044	0.0084
RR8	200716.3389	508359.1145	101.2022	-66.5646						
RR9	200610.0374	508463.1653	99.9214	-66.5646	0.0123	0.0063	0.0105	0.0039	0.0049	0.0105
RR10	200451.1407	508652.2901	105.1421	-66.5647	0.0157	0.0075	0.0137	0.0047	0.0059	0.0137
RR11	200367.2806	508749.7046	113.5117	-66.5647	0.0135	0.0064	0.0119	0.0041	0.005	0.0119
VR5	208149.9701	509234.6034	128.4942	-66.5525	0.0096	0.0048	0.0084	0.0029	0.0038	0.0084
VR6	207952.3653	509036.0966	127.8469	-66.5525	0.0096	0.0048	0.0083	0.0029	0.0039	0.0083
VR7	207747.1021	508962.4472	125.7038	-66.5533	0.0098	0.0053	0.0083	0.0033	0.0041	0.0083
VR8	207491.6319	508855.8927	124.9585	-66.5543						
VR9	207249.025	508772.9148	124.1439	-66.5553	0.0102	0.0052	0.0088	0.0032	0.0041	0.0088
VR10	207179.7211	508605.646	124.1586	-66.5546	0.0117	0.0055	0.0103	0.0034	0.0043	0.0103
VR11	207066.9324	508506.7406	123.72	-66.5547						
VR12	206998.4243	508395.4054	121.0517	-66.5544	0.0167	0.0075	0.0149	0.0048	0.0057	0.0149
VR13	206815.1767	508346.8358	121.8433	-66.5552	0.0177	0.0077	0.0159	0.0049	0.0059	0.0159
VR14	206669.0574	508304.2923	121.4812	-66.5558						
VR15	206391.2418	508241.8588	120.0795	-66.557	0.0115	0.0059	0.0099	0.0039	0.0044	0.0099
VR16	206272.7963	508188.1371	120.8836	-66.5573	0.0088	0.0047	0.0075	0.0032	0.0035	0.0075
VR17	206165.1321	508168.9946	120.9089	-66.5578	0.0149	0.0076	0.0128	0.005	0.0057	0.0128
VR18	205993.8036	508116.8567	121.1909	-66.5584						
VR19	205652.2962	507998.9712	116.6703	-66.5594	0.0197	0.0123	0.0153	0.0066	0.0103	0.0153
VR20	205665.9459	507874.6739	114.2094	-66.5586	0.0236	0.015	0.0182	0.009	0.0121	0.0182
VR22	207190.4056	508746.7362	122.7313	-66.5555	0.0109	0.0054	0.0095	0.0033	0.0042	0.0095

CONCLUSIONS

The completion of the Geodetic Thickening and Lifting Network (RGIR) is a critical stage in ensuring the technical conditions for all subsequent measurements and technical activities required to meet the project's end goal.

The static approach is the most accurate way for finding coordinates, assuming that all of the prerequisites for geodetic network thickening are satisfied.

The construction of geodetic thickening networks strives to meet certain administrative, economic, and legal standards, and it serves as the foundation for topographic measurements for a variety of purposes:

- Aerial photogrammetric flights are completed, culminating in the orthophotoplan;
- Making a photogrammetric reconnaissance in order to create an orthophotoplan;
- Making measurements that lead to the creation of the Digital Terrain Model (MDT) and its variants;
- In order to build up blueprints, topographic measurements (complete topographic surveys) are taken.

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