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TOPOGRAPHIC AND CADASTRAL DOCUMENTATION FOR THE REGISTRATION IN THE LAND BOOK OF A PROPERTY LOCATED IN URICANI ADMINISTRATIVE UNIT, CÂMPU LUI NEAG VILLAGE, HUNEDOARA COUNTY

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***Abstract**. The present paper focuses on the preparation of a topographic and cadastral documentation aimed at registering a real estate property in the Land Register, located within the administrative territory of Uricani (UAT Uricani), Câmpu lui Neag village, Hunedoara County. The main objective of the project is to accurately determine the position and boundaries of the property, to generate the corresponding topographic plans, and to compile the required documentation in accordance with the regulations of the National Agency for Cadastre and Land Registration (ANCPI). For this purpose, a planimetric reference system was established by verifying and extending the existing geodetic triangulation network using the method of conditioned measurements and the back-intersection (Bonea) technique for network densification. Topographic measurements were carried out using a Pentax V-227N total station, ensuring high precision in both angular and distance determinations. The topographic detail survey was performed using the polar coordinate method, with observation points 101 (newly determined) and 102 serving as stations, resulting in accurate point coordinates in the Stereographic 1970 national coordinate system. The acquired data were processed through computational software and graphically represented using AutoCAD for the elaboration of the Site and Boundary Plan (PAD). This work combines theoretical and practical aspects specific to engineering surveying and cadastral science, demonstrating the technical competence required to obtain precise spatial data and to comply with the current legal framework governing property registration in the integrated cadastre and land registry system of Romania.*

***Keywords**: Cadastral documentation; topographic surveying; geodetic triangulation network; conditioned measurements; back-intersection (Bonea method); polar coordinate method; total station; Stereographic 1970 system; AutoCAD; land registration; ANCPI; geospatial data accuracy; planimetric reference system.*

INTRODUCTION

The purpose of this paper is to develop the topographic and cadastral documentation required for the registration in the Land Register of a property located within the administrative-territorial unit (ATU) Uricani, Câmpu lui Neag village, Hunedoara County (CASIAN A ET. AL., 2019). The property includes a building designated for residential use. The documentation was prepared in accordance with the requirements of the National Agency for Cadastre and Real Estate Publicity (ANCPI) and the Hunedoara County Office for Cadastre and Real Estate Publicity (OCPI Hunedoara).The documentation includes the preparation of site layout and boundary plans, processing of topographic measurements, verification of the geodetic network, detailed topographic surveying, and drafting of the necessary documents for registration in the Land Register (NEAMȚU, M., ATUDOREI, M., 1982; DIMA, N. ET AL.,1996).

Site Description and Topo-Geotechnical Data

The Jiu Valley Coal Basin, also known as the Petroșani Basin, is located in the southwestern part of Hunedoara County and covers an area of approximately 163 km². It has a

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triangular shape, with a length of 45 km and a width ranging from 1.5 km in the west to 9 km in the east. The depression is bounded by the Retezat Mountains to the west, the Sebeș Mountains to the north, the Parâng Mountains to the east, and the Vâlcan Mountains to the south.Road and railway access are provided by the national road DN 66 (Simeria – Petroșani – Târgu Jiu) and the electrified railway line.The town of Uricani is situated in the western part of the Jiu Valley, along the course of the Western Jiu River, in an intramontane depression bordered by the Retezat–Sebeș massifs to the north and the Vâlcan–Parâng massifs to the south (HERBEI, M., & SALA, F., 2016; ŞMULEAC A. ET AL., 2017).

The geological structure of the area consists of Paleogene and Neogene deposits, predominantly Neogene sedimentary rocks containing significant coal reserves. The surface soil layer is composed of Quaternary sedimentary deposits, several hundred meters thick (MIHUȚ ET AL., 2024). These include leveling fills, gravel, clayey sands, and marls. At greater depths, the subsoil consists mainly of marly sandstones (MIHUȚ C. & NIȚĂ L., 2018; VEREȘ, I., 2006; RUSU, A., 1965).

Figure 1. Location of the studied property

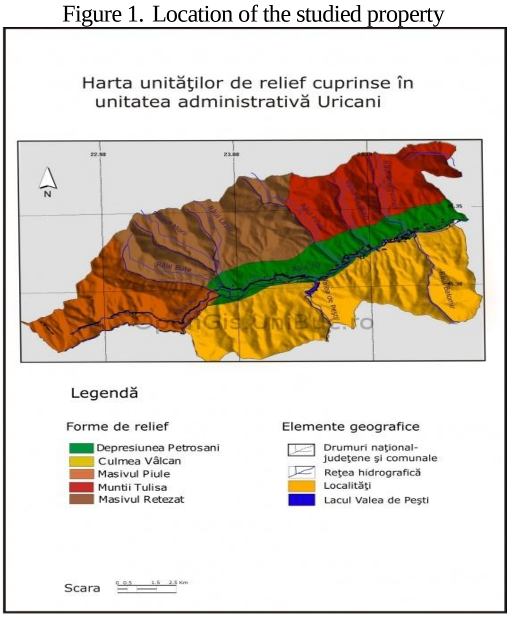

Figure 2. Relief map of Uricani Administrative-Territorial Unit (UAT)

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MATERIAL AND METHODS

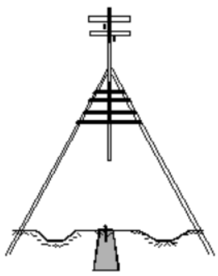
Description of the Network Points and Equipment Used (CRISTESCU, N., NEAMȚU, M., 1980; DIMA, N., 1985; DIMA ET. AL., 1970).

For the verification of the planimetric control network, four points were selected from the existing triangulation network in the area. These points were positioned so as to form a quadrilateral with two diagonals. The coordinates of these points are presented in the table below:

Table 1

Support network coordinates

Name Point	Notation	Coordinates	
		X (North)	Y (East)
Pleșa	A	423.624.457	338.851.497
Vârful Păroasa	B	427.887.374	345.857.058
Cioaca Negrului	C	420.105.851	343.791.755
Vârful Gârbovului	D	419.655.970	339.409.301



The points are marked on the ground with pyramids.
The equipment used for measurements consisted of:

- 30 m measuring tape;
- Pentax total station, type V-200, with accessories.

The main technical specifications of the total station are presented in the following table:

Table 2

Technical specifications of PENTAX total stations, V-200 series

Model	Pentax total station, type V-227N	Pentax total station, type V-227
TELESCOPE		
Magnification	30 x	

Angle measurement	
Measurement method	Encoder absolut rotativ
Minimum value	5"(10cc)/10"(20cc) selectabila
Accuracy (ISO 17123-3	7"

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Objective diameter	45 mm	
Resolving power	3”	
Field of view	1°30’	
Minimum focusing distance	1m	
Instrument constant	100	
Target constant	0	
Focusing method	manuala	
DISTANCE MEASUREMENT		
Laser class	Visible laser: Class II (2)	
Measured distance (under good conditions)		
Without prism	1.5m - 90m	
Miniprism	1.5m - 800m (1100m)	1.5m - 600m (900m)
One prism (1P)	1.5m - 1400m (1900m)	1.5m - 1000m (1300m)
Tree prismes (3P)	1.5m - 1900m (2400m)	1.5m - 1300m (1600m)
Distance measurement accuracy		
With prism	±(3+2ppm x D) mm	
Without prism	±(5+2ppm x D) mm	
Repetitive measurement	Normal: Prism 2.0 sec (1mm) Track: Prism 0.4 sec (1cm	

Compensator	Simplu ax
Level sensitivity	
Toric level	30”/2mm
Spherical level	8’/2mm
Internal memory	
Point coordinates	6000 de puncte
Power supply	
Type	Rechargeable Ni-MH battery, 4300 mAh, DC 6V
Operating time	Continues mode ~ 5h (ETH+EDM), 12h (ETH)
Charging time	~ 2.2 ore
Additional characteristics	
Communication port	RS-232C
Water resistance	IP44 (just intrument)
Operating temperature	-20°C ~ + 50°C
Carrying case dimensions	5/8" x 11
BC03 charger and AC01 AC adapter	imput voltage (AC01) : 100 - 240 V output voltage (BC03) : DC 7.5V
Carrying case	Detachable

The site terrain consists of terrace deposits composed of boulders, gravel, and sand, having a conventional design bearing capacity of 350 kPa, according to STAS 8316-77. The frost penetration depth is 1.0 m, in accordance with STAS 6054-77.According to the P100-92 Seismic Design Code, the seismic zone is classified as Zone F, with a seismic coefficient Ks = 0.08 and a corner period Tc = 0.7 s. The relief is characteristic of mountainous regions, being rugged and uneven, with gorges formed by the Eastern and Western Jiu Rivers. The depression is bordered by the Vâlcan Mountains (south), Retezat Mountains (north), Parâng Mountains (east), and Godeanu Mountains (west), the highest peak being Parângul Mare (2,519 m).

The hydrographic network consists of the Eastern Jiu, the Western Jiu, and numerous mountain streams. Groundwater with higher flow rates is found in the floodplain of the Western Jiu River, between the localities of Uricani and Iscroni.

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The dominant soils are automorphic and hydromorphic, typically consisting of brown and yellowish-brown podzolic forest soils. The average annual temperature is 7.6°C, while in the summer months it ranges between 15.6°C and 17.2°C, reaching maximum values of 25.1°C in August. Precipitation is abundant, averaging 62–68 mm/month, and snowfall is frequent, occurring approximately 45 days per year.Air circulation is limited due to the surrounding mountain massifs, resulting in approximately 56.6 days per year without wind. The last severe storm, accompanied by flooding, occurred in June 2020.

Verification and Adjustment of the Triangulation Network

For the verification of the triangulation network in the area of interest, points A, B, C, and D were identified as belonging to the national geodetic network, forming a fourth–fifth order network with a quadrilateral configuration and diagonals.

At these points, directional observations were carried out using the method of complete series, resulting in the measured angles numbered 1–8.

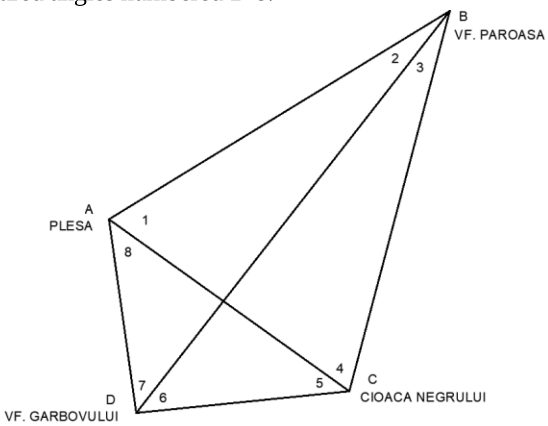

Figure. 3 Sketch of the triangulation network

The purpose of processing the measurements was to determine the most probable values of the angles while satisfying the geometric conditions imposed by the network configuration (RUSU, A., 1965).

For the computation, the coordinates of points A and B, the orientation (qAB = 65.1992g), and the distance (AB = 8200.631 m) were considered known. The network is independent, with point A having known coordinates and a determined orientation.

The number of network conditions is as follows:

- r = 4 total conditions,
- w_1 = 3 figure conditions,
- w_2 = 0 center conditions,
- s = 1 side condition.

Based on the observations, the error equations were established, and the coefficients corresponding to the normal equation system were computed using the method of conditioned measurements and the least-squares minimization criterion ($[vv]$=min).

The system was solved using the successive reduction scheme of Gauss.

Table 3

Gauss Sketch

	[aa]	[ab]	[ac]	[ad]	w	s	CONTROL
	4	0	2	-0.2738662	-13	-7.2738662	-7.2738662
	-1	0	-0.5	0.0684665	3.25	1.8184665	1.8184665
k1=	11.302757	4	2	0.1895623	-7	-0.8104377	-0.8104377
		0	0	0	0	0	
		4	2	0.1895623	-7	-0.8104377	-0.8104377
		-1	-0.5	-0.0473906	1.75	0.2026094	0.2026094
	k2=	9.508641	4	2.1306038	16.00	26.1306038	26.1306038
			-1	0.1369331	6.5	3.6369331	
			-1	-0.0947811	3.5	0.4052189	
			2	2.1727558	26	30.1727558	30.1727558
			-1	-1.0863779	-13	-15.0863779	-15.0863779
		k3=	-15.757894	16.8859056	-8	10.9322055	10.9322055
				-0.0187507	-0.8900651	-0.4980165	
				-0.0089835	0.3317340	0.0384071	
				-2.3604338	-28.2458248	-32.7790144	
				14.4977377	-36.8041560	-22.3064183	-22.3064183
				-1	2.5386137	1.5386137	1.5386137
			k4=	2.538614			

As a result of the calculations, the following correlations were obtained:
(k1 = 11.302757), (k2 = 9.508641), (k3 = -15.757894), (k4 = 2.538614).
Angular corrections are given by the following equations:

$$v_i = a_i k_1 + b_i k_2 + c_i k_3 + d_i k_4 (i = 1,2,3,4)$$

The calculation of corrections is presented in the following table:

Table 4

Corrections calculation

Unghi	a*k1	b*k2	c*k3	d*k4	V
1	11.302757	0	0	1.089133	12.391890
2	11.302757	0	0	-6.751401	4.551356
3	11.302757	0	-15.757894	5.920962	1.465825
4	11.302757	0	-15.757894	-0.953934	-5.409071
5	0	9.508641	-15.757894	2.887480	-3.361773
6	0	9.508641	-15.757894	-2.445727	-8.694981
7	0	9.508641	0	2.445321	11.953962
8	0	9.508641	0	-2.405848	7.102792

For verification, it is calculated whether [vv] = -[kω], according to the following table:

Table 5

Verification calculation

v	v v	k	w	kw
12.391890	153.5589384	11.302757	-13	-146.935841
4.551356	20.71484273	9.508641	-7	-66.560484
1.465825	2.148642306	-15.757894	16	-252.126301
-5.409071	29.25804859	2.538614	-8	-20.308910
-3.361773	11.301518	[kw]		-485.9315
-8.694981	75.60269027			
11.953962	142.8971971			
7.102792	50.44965799			
[v v]	485.9315			

Using the obtained correction values, the probable angle values are calculated.

$$(\hat{1}) = \hat{1} + v_1; (\hat{2}) = \hat{2} + v_2; ......; (\hat{8}) = \hat{8} + v_8$$

Table 6

Probable angle values

Angle	Measured values	v	*Compensated value*
1	74.1993	12	74.2005
2	22.8966	5	22.8971
3	25.7858	1	25.7859
4	77.1170	-5	77.1165
5	45.9125	-3	45.9122
6	51.1862	-9	51.1853
7	51.1915	12	51.1927
8	51.7090	7	51.7097

For the calculation of the orientations, it is first necessary to determine the orientation of the AB direction. The orientation of the AB direction, as well as the orientation of any other direction, is defined as the angle formed between that direction and the positive direction of the X-axis. This angle increases clockwise.

If θAB represents the orientation angle of the AB direction, it is calculated using the following relation:

$$tg\theta_{AB} = \frac{y_B - y_A}{x_B - x_A} = \frac{\Delta y_{AB}}{\Delta x_{AB}}$$

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After obtaining the calculated value, it must be adjusted to the quadrant to which the orientation belongs. For the present case, we have: $\theta_{AB} = 65.1992^g$

Calculation of sides:

$AB = \sqrt{(x_B - x_A)^2 + (y_B - y_A)^2}$ - coordinates (x_A, y_A) şi (x_B, y_B) of points A, B the sides were considered known.

The length of side: AB = 8200.631 m

Next, using the Law of Sines, all sides of the network will be calculated.

$$\frac{AB}{\sin(4)} = \frac{BC}{\sin(1)}$$ De aici: $BC = AB\frac{\sin(1)}{\sin(4)}$

Table 7

Calculation of network side lengths

Triunghiul	Latura de sprijin	Unghiurile			Sin(α)	Sin(β)	Sin(γ)	Laturi calculate	
	c	α	β	γ				a	b
ABC	AB= 8200.631	74.2005077	48.6830	77.11649994	0.91900	0.69233	0.93609	BC= 8050.928	AC= 6065.157
ACD	AC= 6065.157	51.7097	45.912229	102.3781	0.725839	0.660277	0.999302	CD= 4405.403	AD= 4007.479
BCD	BC= 8050.928	25.7859285	123.02873	51.18534241	0.394060	0.935284	0.720149	CD= 4405.399	BD= 10456.036

Table 8

Coordinates calculation

Punct sprijin			Latura	Orientarea	Lungimea	Cos(θ) / Sin(θ)	Δx / Δy	Punct nou		
A	x	423624.457	AC	139.3997	6065.157	-0.5801309	-3518.584	420105.873	x	C
	y	338851.497				0.81452329	4940.211	343791.708	y	
A	x	423624.457	AD	191.1094	4007.479	-0.9902644	-3968.464	419655.993	x	D
	y	338851.497				0.13919945	557.839	339409.336	y	
A	x	423624.457	AB	65.1992	8200.631	0.51982794	4262.917	427887.374	x	B
	y	338851.497				0.85427099	7005.561	345857.058	y	

Expansion of the Triangulation Network with a New Point

For the extension of the triangulation network, several methods can be employed:

- Forward intersection,
- Backward intersection (resection),
- Polygonal traverse method.

In this case, to densify the network, the backward intersection method was applied, using the barycentric coordinates method (Bonea) for computation.

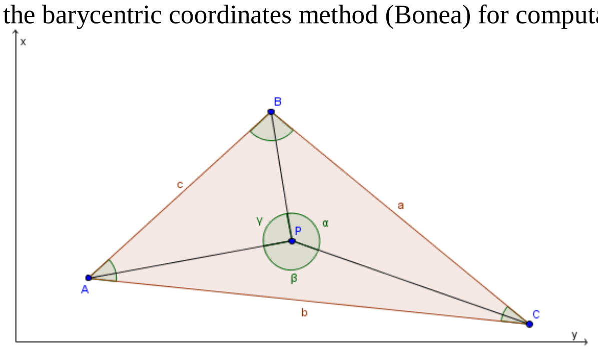

Figure 4. Method of barycentric coordinates

Topographic Detail Surveying Using the Polar Coordinates Method

Topographic detail surveying consists of measuring and calculating the positions of ground features in order to represent them accurately on a map or plan. Characteristic points are identified, and their positions are determined relative to the topographic control network.

The polar coordinates method is used for surveying details around a known point by measuring the horizontal angle and the slope distance with a theodolite or tacheometer. Important points are often double-radiated to increase measurement accuracy. The results are then plotted on the plan either graphically (using the polar method) or by transforming the polar coordinates into rectangular coordinates referenced to the topographic grid.

Method Application

To determine the new point 101, three known points from the geodetic control network were used:

Table 8

Point	Notation	X [m]	Y [m]
Pleșa	A	423.624.457	338.851.497
Vârful Păroasa	B	427.887.374	345.857.058
Cioaca Negrului	C	420.105.851	343.791.755

Based on the difference in side orientations, the angles of triangle ABC were calculated:

- angle A = 74.2004g
- angle B = 48.6834g
- angle C = 77.1162g

From point 101, angular measurements were taken toward points A, B, and C, yielding:

- angle α - 187.2897
- angle β - 73.1609
- angle γ - 139.5494

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Based on these values, the barycentric weights were calculated:pa = 0.186186

- pb = 1.684171
- pc = 0.916114

By applying the Bonea method equations, the coordinates of the new point 101 were obtained X= 425044.187 Y=344709.948

CONCLUSIONS

Using the resection method with barycentric coordinates (Bonea), the position of the new point 101 was accurately determined, completing the existing triangulation network and providing adequate density for subsequent topographic and cadastral works.

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