STUDY ON DISTANCE REDUCTION IN PROJECTION PLAN IN CADASTRE

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Abstract

Distance reduction is a very important operation for cadastral and topographic works. Reduced distances are used both for determination of support network points and determination of detailed points. The formulas for distance reduction should be used correctly, otherwise can lead to very large positioning errors. For these reasons overlapping of parcels measured for tabulated can occur. Apparently the overlapping are real, but actually they are virtual overlapping, due to incorrect usage of formulas.

Keywords: *coordinate, reduced distance to projection plan, stereographic projection 1970.*

INTRODUCTION

The cadastre is a registry system of property and has 3 components: technical, legal and commercial. The technical component refers to positioning the perimeter points on a plan or space which define a property. Positioning is defined on projection plan used on national or local level. The projection plan used in Romania is Stereographic 1970. Stereographic 1970 projection is a conform projection. There is also a plan perspective azimuthall projection on secant plan which has polar coordinate projection at the point Q_o on a coordinate Bo=46° and Lo=25° East Greenwich. The projection has been adopted on September 1971 when the Decree 305 „regarding surveying, topographic, photogrammetric and cartographic activity" was released. As a reference surface was adopted Krasovski ellipsoid. The advantage of this projection is representation of the entire country on a single plan. The zero deformation circle has a 201.718 m radius and represents the intersection between the secant plan and ellipsoid.

The origin of the rectangular coordinate axes is the point Q_o, x-axis is directed northward and y-axis eastward. As is known, linear deformations are negative inside the zero deformation circle and positive outside in this projection.

Reduced distance formula in Stereographic projection plan 1970 has the form:

$$D_{ppr} = D_E + D_E \frac{x_m^2 + y_m^2}{4R_o^2} + D_E \frac{\Delta x^2 + \Delta y^2}{48R_o^2}$$

where:

- D_{ppr} is reduced distance to Stereographic projection plan 1970;
- D_E is reduced distance to ellipsoid;
- x_m, y_m is the average coordinates of base measuring heads in Stereographic system 1970;
- Δx, Δy is the difference between coordinates of the measuring base in 1970 Stereographic system;
- R_o is the average Earth radius.

x_m, y_m and Δx, Δy are calculated in the first stage approximately, based on reduced distances to ellipsoid. Influence of approximation is under a millimeter. (Paunescu C.et al., 2012)

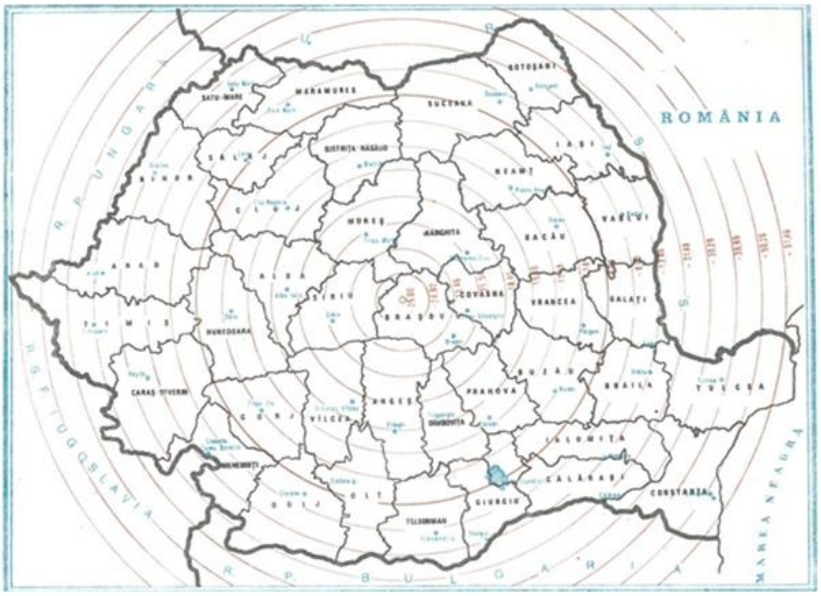

Figure 1. Distance deformations in Stereographic 1970 (Iosif Gh., 2012)

MATERIALS AND METHODS

In Romania the specialists used a lot planimetric total stations for determining the position of points of detail. GNSS receivers are usually used for topographic support grid points and coordinates determined on WGS′84 ellipsoid are later transformed to Krasovski ellipsoid and to Stereographic 1970 using TRANSDAT software provided free by the National Agency for Cadastre and Land Registration (NACLR). As I stated above, detailed points define the perimeter of properties.

At present, the property registration, with few exceptions, is made through sporadic cadastre. Thus, each property is separately measured, based on owners directions, plot plans, boundary elements (if any) and on documents of ownership.

The file is submitted to the Office of Cadastre and Land Registration and receives permission for registering or if some items do not match, they require clarification. Also, if the plan is not good, technical or juridical is rejected.

Over a period of time, the neighbor of the already registered parcel will want to register his own parcel. He will contact an authorized person and will go through the same steps. Most times, when submitting work to OCLR there is found an overlapping with the neighbor or between the 2 properties remains a free strip (they do not fit perfectly). Overlapping or distance has a certain value. When these values are in a tolerance or precision measuring existing old network, a meeting between parties takes place and the limit of the new registered property is aligned to the old one.

Often, the differences are great and then start problems regarding the drawing the technical documentation up.

The first issue brought up is how link the geodetic network to the Stereographic system 1970. Each specialists who carried out the technical work realised the link in a certain way. Either GNSS receivers and then transformed with TRANSDAT, either by direct binding to geodetic network points (retro-intersection, traverse, network compensated by the method of least squares, and so on).

The second problem is how as determined perimeter points. If these are materialized on ground (corner of fence, natural or artificial detail) it should be checked the location of the measurement. For example, a concrete wall, 40 centimeters thick, can be measured by each authorized specialist on the property measured. In this way creates a gap of at least 40 centimeters because it can be added the errors due to transmission network.

But the most serious problem is related to how reduce the distance to the projection plane. Most experts work with total station directly in coordinates. It is not wrong, but to obtain correct coordinates the reduced distance used by total station must be correctly calculated. Usually setting the Stereographic plan is considered sufficient. Or, even worse, a reducing coefficient of 0.99975 is inserted, which is totally wrong. This coefficient is valid only in central point of projection, as shown in Figure 1.
Another option is to insert a valid coefficient for the entire county. It is also wrong, because, as shown also in Figure 1, most counties have large differences in distance correction throughout the county.
Alternatively, also wrong, is to use simple formula to reduce the distance on the horizon:

$$D_0 = D_i \cos\alpha = D_i \sin z$$

Where:

- D_0 is the horizontal distance;
- D_i is the slope distance (measured);
- α is slope angle;
- z is the zenith angle. None of the above solutions is scientific valid.

The only one valid is formula 1 which takes into account the elements of Stereographic projection system 1970.

RESULTS AND DISCUSSIONS

Given the above, I selected from Figure 1 data related to gap distance / km for counties where using an improper formulation can lead to serious positioning errors.
Basically there is an error of principle, respectively the use of formulas that do not lead to a correct result.
Each expert pretends to respect the correct formula. Unfortunately, using formula 2 was possible on very small surfaces only topographic surveys.

No.	County	Reduced distance using formula (2.1) [m]	Reduced distance using formula (1.1) [m]	Difference /1000 m [cm]
1	Timis Est	1000	999.99	-0.1
	Timis Vest	1000	1000.615	+61.5
	Total difference county Timis			+61.6
2	Dolj Nord	1000	999.938	-6.2
	Dolj Sud	1000	1000.303	+30.3
	Total difference county Dolj			+36.5
3	Ialomita Vest	1000	999.92	-8.1
	Ialomita Est	1000	1000.318	+31.8
	Total difference county Ialomita			+39.9

The table presents an example of distance differences resulting from the application of incorrect formulas. Given the currently used tools, precision it offers, it is inexcusable to use formulas that provide solutions for measurements made with classic instruments. Using incorrect formulas leads to serious positioning errors and overlapping of parcels in cadastre.

CONCLUSIONS

We conclude from Table 1 that there is a 61.6 centimetres/100 meters difference between the 2 distances in Timis County. If measured distances is greater than 1000 meters, the error increases proportionally with distance. This situation is viable when large areas, spanning several kilometers, are measured.

Calculating errors induced in area could conclude that the minimum error per hectare is 246. 4 square meters. Minimum error occurs

when the hectare is a perfect square of sides of 100 meters. In the worst case, that is one side of 10 meters and one is 1000 meters, the error area is 622.16 square meters.

There are data that put a warning on how reduced distances are calculated to project plan. In fact, during data verification at OCLR, the expert should provide raw data measured, respectively the slope distance and vertical or zenith angle, height of the tool and the height at which to target. In this way, the distanced used for coordinate determination can be verified.

Long-time agreed that the total station and GNSS receivers replace both classic instruments and computer programs. If classic instruments replacement is valid there is not available the replacement of data processing programs. Without a carefully examination of how the total station reduces distances we cannot trust the resulting data, or the coordinates (positioning).

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