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CONSIDERATIONS CONCERNING THE TRANSCALCULUS OF THE COORDINATES IN STEREO 1970 PROJECTION FROM KRASOVSKI ELLIPSOID TO THE WGS 1984 ELLIPSOID

Mădălina AUGUSTIN[1], Andreia COSTACHE[1], Timea IZSAK[1], Ionuţ SILAGHI[1], Alexandru PORUMB[1]

Scientific Coordinators: Assist. PhD. Eng. Tudor SĂLĂGEAN[2], Lect. PhD. Eng. Sanda NAŞ[1]

[1]Technical University Cluj-Napoca, 28 Memorandumului Street, 400114, Cluj-Napoca, Romania, Phone: +40264.401.200, Fax: + 40264.592.055, Email: madeline_mcd@yahoo.com
[2] University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Calea Mănăştur 3-5, 400372, Cluj-Napoca, Romania | Tel: +40-264-596.384 | Fax: +40-264-593.792 Email: salagean_tudor@hotmail.com

Corresponding author email: madeline_mcd@yahoo.com

Abstract

The paper presents the transformation of the national system of reference coordinates, STEREO 1970, in the European reference system, WGS 1984, using constant coefficients method. It also presents the difference between the coordinates obtained by the method mentioned above and the results obtained by using TransDatRO program, authorized by ANCPI, application for converting coordinates of STEREO 1970 into ETRS 1989 system, currently used to the whole European continent for GPS measurements.

Key words*: transcalculus, coordinates, WGS 84, Krasovski.*

INTRODUCTION

Once with the adherence of Romania to the European Union, a problem has risen regarding the shift from the national system of projection to the european one, with the purpose of creating an unitary reference system for the whole european continent.
The projection system used in Romania is the STEREO 1970, which has the Krasovski ellipsoid as reference ellipsoid. The central point of this projection has the coordinates B=46°, L=25° and it is situated near Făgăraş city. In order for our country to have only positive coordinates, the reference ellipsoid is translated to SW such that the origin of the system has the coordinates x=500000 m, y=500000 m.

MATERIALS AND METHODS

The WGS 1984 reference system was created principally for navigation where precision is of 1 m or less. Because of the low precision of the system, ITRS was created, system used for international geodetic determinations, with a higher precision. In concordance with the permanent movement of the continents, which are approaching and moving away from each other with approximately 12 cm/year, the ETRS 1989 was created, standard system used for the GPS measurements in whole Europe. This system is based on the ITRS, the more precise version of WGS 1984, but it changes permanently the origin towards the reference system WGS 1984, that will result in the appearance of differences of the level of seconds.

RESULTS AND DISCUSSIONS

This case study was based on the points' CSA97 and B1 coordinates from Maramureş zone, coordinates obtained by GPS measurements in WGS 1984 reference system. The purpose of the paper is to verify these measurements with the method of transcalculus using constant coefficients, and also verification of the obtained results, with TransDatRO software, transcalculus software authorised by ANCPI.
The first part of the case study contains the transformation of plane coordinates STEREO

70 in geographic coordinates WGS 84, using the constant coefficient method.

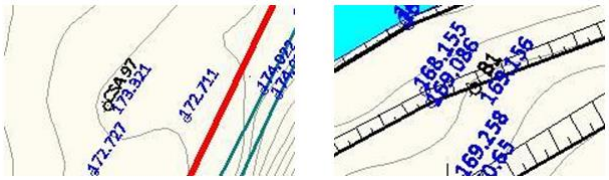

Figure 1. Points represented in plane

The first step, in order to do the transcalculus, consists in reducing the Stereographic coordinates to the origin of the coordinate system situated in the projection pole:

$$\Delta x_i = X_i - X_0$$

$$\Delta y_i = Y_i - Y_0$$

Second step consists in passing the stereographic coordinates from the secant plane to the tangent plane (Table 1).

$$x_{tan} = \Delta x_i \cdot c'$$

$$y_{tan} = \Delta y_i \cdot c'$$

where:

$$c' = \frac{1}{c} = \frac{1}{c} = 1.000250063$$

c' – transformation coefficient from tangent plane in secant plane.

Table 1. Transformation of coordinates from secant plane is tangent plane

Point	Stereographic coordinates		Coord. reduced to the origin of the coordinate system		Coord. in tangent plane	
	X	Y	Δ Xi	Δ Yi	Xtan	Ytan
CSA97	659525,955	373101,293	159525,955	-126898,707	159565,8465	-126930,4396
B1	659982,537	373383,766	159982,537	-126616,234	160022,5426	-126647,896

Then the coordinates transformation from tangent plane on the WGS84 ellipsoid with the help of the constant coefficients calculated by C. Moldoveanu.

$$f = x_{tan} \cdot 10^{-5}$$

$$l = y_{tan} \cdot 10^{-5}$$

It is determined first the values of f and l parameters, and then the value of vectors f and 1 is calculated.

Table 2. Vector f calculation

	Point CSA97	Point B1
f^0	1	1
f^1	1,595658465	1,600225426
f^2	2,546125936	2,560721415
f^3	4,062747401	4,097731518
f^4	6,48275728	6,557294166
f^5	10,34426653	10,49314885

Table 3. Vector l calculation

	Point CSA97	Point B1
l^0	1	1
l^2	1,61113365	1,603968955
l^4	2,595751638	2,57271641
l^6	4,182102811	4,126557253

Next step consists in summing the products of the elements of vector f with the elements of the first, second, third and the fourth column respectively from the first transformation coefficients table $(x, y)_{stereo1970} \rightarrow (B, L)_{WGS\ 1984}$ (Table 4).

Table 4. First transformation coefficients table $(x, y)_{stereo1970} \rightarrow (B, L)_{WGS\ 1984}$

A00	0	A02	-26,246618253	A04	0,003312513	A06	-0,0000002
A10	3238,8279765	A12	-0,620236752	A14	0,000173545		
A20	-0,256073492	A22	-0,009981972	A24	0,0000057		
A30	-0,066220292	A32	-0,000189282				
A40	0,0000312629	A42	-0,0000033				
A50	0,0000024216						

In order to obtain the latitude difference in sexagesimal seconds the following relationship is used:

$$\underset{(1,1)}{\Delta B} = \underset{(6,1)}{f^*} \cdot \underset{(6,4)}{A} \cdot \underset{(4,1)}{l}$$

The latitude of the point is obtained with the formula:

$$B = B_0 + \Delta B$$

$B_0 = 46°$ (the center of projection latitude for the STEREO 70 projection case).

Table 5. Calculation of latitude B

	Point CSA97	Point B1
R1	5167,142472	5181,928024
R2	-43,9235473	-43,73300784
R3	0,009354943	0,009274178
R4	-0,00000083642	-0,00000082531
ΔB=ΣR	5123,228279	5138,20429
$B_0''=B_0 \cdot 3600$	165600	165600
$B_0'' + \Delta B$	170723,2283	170738,2043
$B°=(B_0''+\Delta B)3600$	47,42311897	47,42727897
B	47.25.23,22827899	47.25.38,20428966

For the calculus of longitude, vector l has the following form:

$$l = \begin{vmatrix} l \\ l^3 \\ l^5 \end{vmatrix}$$

Table 6. Vector l calculation

	Point CSA97	Point B1
l^1	-1,269304396	-1,26647896
l^3	-2,045019025	-2,031392934
l^5	-3,294798965	-3,258291203

The products between the elements of vector f with elements of the first, second and third column recpectively from the second table and the transformation coefficients $(x, y)_{stereo1970} \rightarrow (B, L)_{WGS\ 1984}$ are summed up.

Table 7. The second table with the transformation coefficients $(x, y)_{stereo1970} \rightarrow (B, L)_{WGS\ 1984}$

B01	4647,362095	B03	-0,502105603	B05	0,0001124789
B11	75,322023692	B13	-0,0290014238	B15	0,0000112
B21	1,5063168091	B23	-0,0011247887		
B31	0,0290014238	B33	-0,0000365		
B41	0,0005623				
B51	0,000011				

The operations described before are used. The longitude of the point is obtained with the following relation:

$$L = L_0 + \Delta L$$

$$\underset{(1,1)}{\Delta L} = \underset{(6,1)}{f^*} \cdot \underset{(6,3)}{B} \cdot \underset{(3,1)}{l}$$

$L_0 = 25°$ (the longitude of the point at the center of projection, in STEREO 70 case).

Table 8. Calculation of L longitude

	Point CSA97	Point B1
$L_0''=L_0 \cdot 3600$	90000	90000
$L_0''+\Delta L$	83944,63215	83957,64169
$L°=(L_0''+\Delta L)3600$	23,31795337	23,32156714
L	23.19.04,632146862	23.19.17,64168915

The second part of the case study has the role of verifying the results obtained in the first part, using the reverse transformation method namely the geodetic coordinates transcalculus in plane coordinates.

The calculation method is analogue to the first part, just that for the calculus of coordinate x the following values are obtained first:

$$f = \Delta B' \cdot 10^{-4} = (B - B_0)' \cdot 10^{-4}$$

$$l = \Delta L' \cdot 10^{-4} = (L - L_0)' \cdot 10^{-4}$$

B, L- latitude respectively longitude of the point obtained in the first part;

B_0, L_0- latitude respectively longitude of the projection center.

Table 9. Calculation of f and l values

	Point CSA97	Point B1		Point CSA97	Point B1
$B''=B \cdot 3600$	170723,2283	170738,2043	$L''=L \cdot 3600$	83944,63215	83957,64169
$B_0''=B_0 \cdot 3600$	165600	165600	$L_0''=L_0 \cdot 3600$	90000	90000
$\Delta B''=B''-B_0''$	5123,228279	5138,20429	$\Delta L''=L''-L_0''$	-6055,367853	-6042,358311
$f=\Delta B'' \cdot 10^{-4}$	0,512322828	0,513820429	$l=\Delta L'' \cdot 10^{-4}$	-0,605536785	-0,604235831

Next, the calculation of f and l vectors (like in the case of latitude determination) and making the calculation which will lead to the obtaining of x coordinate in tangent plane. In

order to obtain the x coordinate in secant plane, the x coordinate is multiplied with the transformation coefficient c=0,99975. For y coordinate, the values of vectors f and l are calculated and then we proceed as in the case of x coordinate determination. In order to perform these verifications, the values from the constant coefficients tables are used for transforming geodetic coordinates in plane coordinates.

Table 10. Coefficients for $(B, L)_{WGS\ 1984} \rightarrow (x, y)_{Stereo1970}$ transfomation

a00	0	a02	3752,0831113	a04	0,3359081	a06	-0,0000576
a10	308753,6625	a12	-99,92634165	a14	-0,06222767		
a20	75,36803068	a22	-6,67476642	a24	0,0002361		
a30	60,21520616	a32	-0,07130343	a34			
a40	-0,014859	a42	-0,0025911				
a50	0,01426069						
a60	-0,0215834						

b01	215175,8308	b03	-23,2134706	b05	-0,00864536
b11	-10767,65395	b13	-1,92807416	b15	0,0004969
b21	-128,6581996	b23	0,13160763		
b31	-2,10605469	b33	0,0023711		
b41	-0,0495315	b43	-0,00083		
b51	0,0004263				

After the above verification the coordinates from which we started in the first part were obtained.

Table 11. Calculation of plane coordinates x, y

	Point CSA97	Point B1
$\Delta x=\Sigma R$	159525,954	159982,536
x_0	500000	500000
x	659525,954	659982,536
$\Delta y=\Sigma R$	-126898,7068	-126616,2338
y_0	500000	500000
y	373101,293	373383,766

The last part of the case study contains the transformation of CSA97 and B1coordinates obtained by GPS measurements, with the help of the transcalculus software, TransDatRO and the comparing of the results given by the software, with the data obtained from the above calculations.

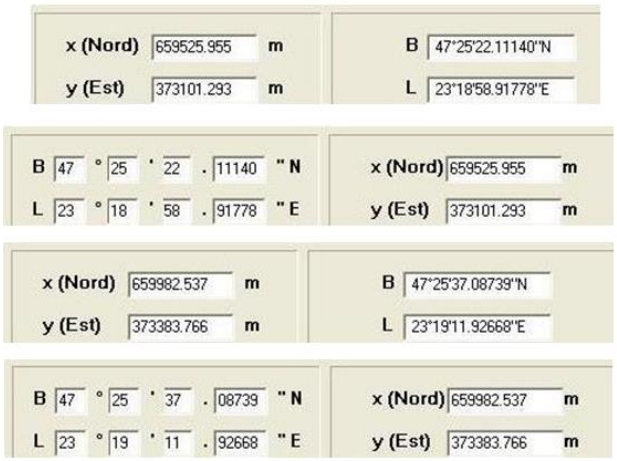

Figure 2. *Transformation of coordinates points CSA97 şi B1 with TransDatRO software*

CONCLUSIONS

In order to transform the coordinates in Stereo1970 projection from the Krasovski ellipsoid to the WGS ellipsoid and vice-versa, from the WGS ellipsoid to the Krasovski ellipsoid, the constant coefficients method can be used. Regarding the coordinates transcalculus from Stereo 1970 projection in the ETRS89 projection system, currently used in Europe, TransDatRO is used, transcalculus of coordinates software, created by ANCPI. The working principle of this software is based on transformation parameters that creates a link between the reference system and the coordinates (CRS-Coordinate Reference System) ETRS89 (European Terrestrial Reference System) with the afferent ellipsoid GRS80 and the national reference system S-42 with the afferent Krasovski 1940 ellipsoid.

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