About the use of the coordinate transfer from the local system to the official coordinate system and vice versa (Bulqiza mine as a case study)

Prof. Asoc. Dr. Gafur MUKA
European University of Tirana

Abstract

The chrome mine in Bulqiza has been exploited since 1948. The exploitation of the mine required the creation of a graphic documentation in which all the constructions of the mine are visualized. The visualization is created in three planes (horizontal, vertical and in profile) and initially referred to a local coordinate system. Although the Bulqiza mine was connected to the official coordinate system (Gauss-Kryger system at that time) in 1972, the application of the system continued due to the large amount of work required to convert from the local coordinate system to the official system (GK). This year (January 2022), due to the concession of the mine to a foreign company, the creation of a calculation model for the transformation of coordinates from the local to the official coordinate system was required. Since the official geodata portal ASIG (State Authority for Geospatial Information) provides the possibility to obtain coordinates in the three official coordinate systems used in our country (Gauss Kryger, UTM and KRGJSH), we deal with the creation and evaluation of the following model of transformation from local system to GK. Moreover, the georeferencing of images is produced in order to obtain, through digitization, geodata that allow to recreate all the graphic documentation in the official coordinate system.

Key words: *Chrome mine Bulqiza, graphic documentation, coordinate system, local coordinate system, official coordinate system, computational model, georeferencing of images.*

Presentation of the problem

Since 1948, when the exploitation of the Bulqiza chrome mine started, a very extensive graphic documentation (maps, vertical projections and profiles) has been created until today, referring to a local coordinate system [1]. This system is designed to be oriented to the magnetic meridian (X-axis). Normal to this axis is the Y-axis, obtained by rotating the X-axis 90 degrees counterclockwise in the horizontal plane, and normal to the XOY plane is the z-axis. The coordinates of the origin of this system are assumed to be Y = 5000,000 m, X = 5000,000 m in the plan while the magnetic declination, which is the angle between the direction of the magnetic meridian of the area (x-axis for the local system) and that of the mean meridian (x-axis for the official system), is 6'30 ". This is also the rotation angle of the local system, so the direction of the magnetic meridian coincides with the direction of the mean meridian. Figure 2 shows that the rotation is clockwise.

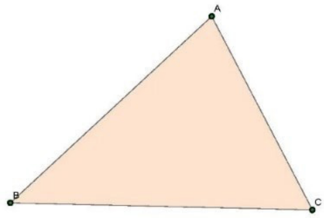
In 1972, the Bulqiza mining area was connected to the official coordinate system (at that time, the Gauss-Kryger system), but because of the large amount of work required to convert the coordinates from the local system to the Gauss-Kryger system, the preparation of documentation continued in the local system [1]. Since January 2022, the Bulqiza mine (North Zone) has been concessioned by a foreign company, which requires that all graphic documentation be referred to the GK system. We would like to point out that this system is one of the official coordinate systems that was used in the country until 2010 [6]. For the transformation of coordinates from the GK system to the UTM and KRGJSH coordinate systems, the program offered by the ASIG geoportal is used [6]. This situation requires the construction of a computational model for the transformation of coordinates from the local system to the GK system and vice versa.

In order to obtain all data in GK, UTM and KRGJSH coordinate systems during digitization, georeferencing of images in these systems is required [4]

Model building and evaluation

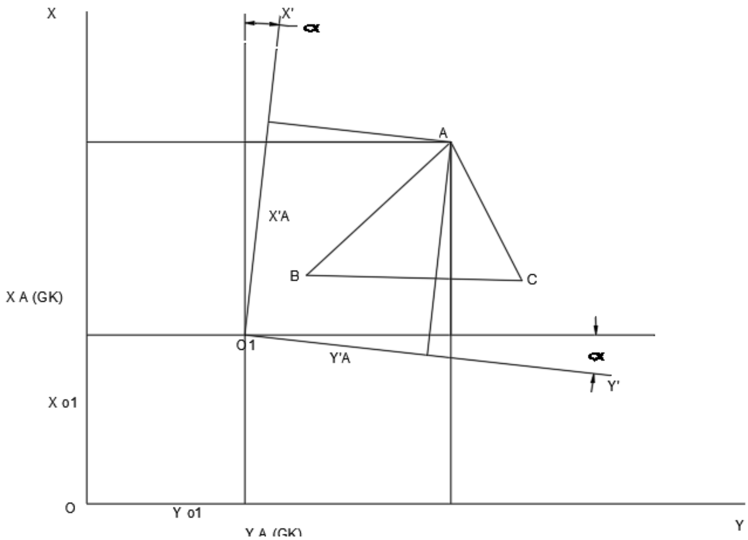
For the transformation of coordinates from the local system to the GK system and vice versa, the following formulas are derived, based on the existance of three points (A, B, C) that have coordinates in both systems (Fig. 1).[1]

FIG 1 The points with coordinates in both systems



The scheme implemented for deriving the formulas is shown in fig. 2

FIG 2 The scheme implemented for deriving the formulas (computational model)



The coordinates of points A, B, C are given in the table (tab 1):

Pont	Y Lok	X Lok	Y GK	X GK
A (Antena)	3978.323	5536.142	4434268.200	4594929.580
B	4690.52	5661.085	4434980.845	4595153.097
C	5375.941	5070.183	4435665.223	4594560.819

The derived formulas are:

a) For the transformation from the local system to the GK system

$$Y(GK) = Y(lok)^* \cos(\alpha) + X(lok)^* \sin(\alpha) + YO1 \quad (1)$$

$$X(GK) = X(lok)^* \cos(\alpha) - Y(lok)^* \sin(\alpha) + XO1$$

b) For the transformation from the GK system to the Local system

YO1 = YA-(Y'A* Cos(α)+X'A* Sin(α)) (2)

YO1 = XA-(X'A* Cos(α)+Y'A* Sin(α))

Using these formulas, the coordinates of the points are transformed as in the following tables (examples):

Transformation according to formula (1)

cos (α)	Y'	sin (α)	X'	Konst	Y (GK)	sin (α)	Y'	cos (α)	X'	Konst	X GK	Pika
0.999998205	4707.968	0.001894586	5885.16	4430279.624	4434998.733	0.001894586	4707.968	0.999998205	5885.16	4589500.874	4595377.104	P2
0.999998205	4856.27	0.001894586	5812.658	4430279.624	4435146.898	0.001894586	4856.27	0.999998205	5812.658	4589500.874	4595304.321	P3
0.999998205	4220	0.001894586	5805	4430279.624	4434510.614	0.001894586	4220	0.999998205	5805	4589500.874	4595297.868	3754

Transformation according to the formulas (2)

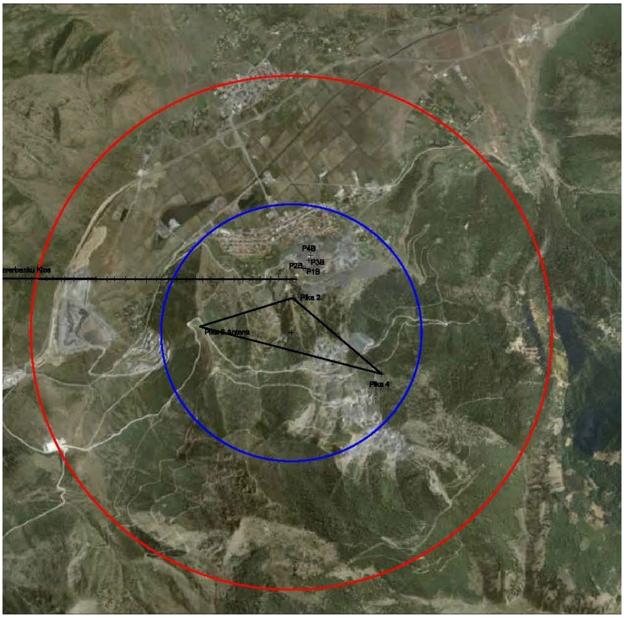
cos (α)	Y (GK)	sin (α)	X (GK)	Konst	Y'	sin (α)	Y (GK)	cos (α)	X (GK)	Konst	X'	Pika
0.999998205	4434998.733	0.001894586	4595377.104	4421576.468	**4707.968**	0.001894586	4434998.733	0.999998205	4595377.104	4597886.183	**5885.161**	P2
0.999998205	4435146.898	0.001894586	4595304.321	4421576.468	**4856.271**	0.001894586	4435146.898	0.999998205	4595304.321	4597886.183	**5812.658**	P3
0.999998205	4434510.614	0.001894586	4595297.868	4421576.468	**4220.000**	0.001894586	4434510.614	0.999998205	4595297.868	4597886.183	**5805.000**	3754
0.999998205	4434540.579	0.001894586	4595089.111	4421576.468	**4250.360**	0.001894586	4434540.579	0.999998205	4595089.111	4597886.183	**5596.300**	3575
0.999998205	4434540.579	0.001894586	4595089.111	4421576.468	**4250.360**	0.001894586	4434540.579	0.999998205	4595089.111	4597886.183	**5596.300**	3576/1

After determining the coordinates, the problem of calculating their accuracy arose.

To solve the problem, the location coordinates for 65 drilling holes were transformed in the GK, the location grid points of the 1: 2000 scale maps were transformed, the maps were geo-referenced, the 3754 drilling point was marked, and measurements were made in the Klos traverse bank.While the results of these activities were adequate, we did not consider them to be sufficient.

Therefore, based on these products, their accuracy was evaluated based on known points. From this assessment it emerged that the system is characterized by two levels of accuracy. The first plane includes the area of a circle of radius 1 km whose center corresponds to the intersection of the three medians of the sides of the triangle of the given points, while the second plane includes the area between the circumference of a circle of radius 2 km and the circumference of the previous circle of radius 1 km, that have the same center (Fig. 3). In the first case, the error is in the range of 10-25 mm, while in the second case the accuracy decreases and the error is in the range of 25-45 mm.

FIG 3 The levels of accuracy of the computational model



For creating new points and making measurements in the relative system, it is recommended to use the points P1, P2, P3 and P4 (local coordinate grid) near the shafts 2 and 3 (Fig. 4). [1]

In the same way as these points, other points can be defined inside the circle with a radius of 1 km or inside the area between the perimeter of the circle with a radius of 1 km and that with a radius of 2 km.

FIG 4 Local coordinate grid

Map georeferencing and create data with digitization

In the conditions of existence of a large amount of graphic documentation of Bulqiza mine, created with reference to the local coordinate system, it is necessary to create data in the official coordinate system. To solve this problem, georeferencing of maps (originally referenced in the local system) should be carried out in the official coordinate system. The georeferencing was done using the ArcGIS 10.7 program.

Fig. 5 shows the georeferencing of the map at a scale of 1:2000. After georeferencing, shapefiles can be created that contain the coordinates of the points in the official coordinate system.

Fig. 6 shows the digitized points on the georeferenced map. Fig. 7 shows the attribute table listing the coordinates of the points in the official Gauss-Kryger system.

FIG 5 Georeferenced Map

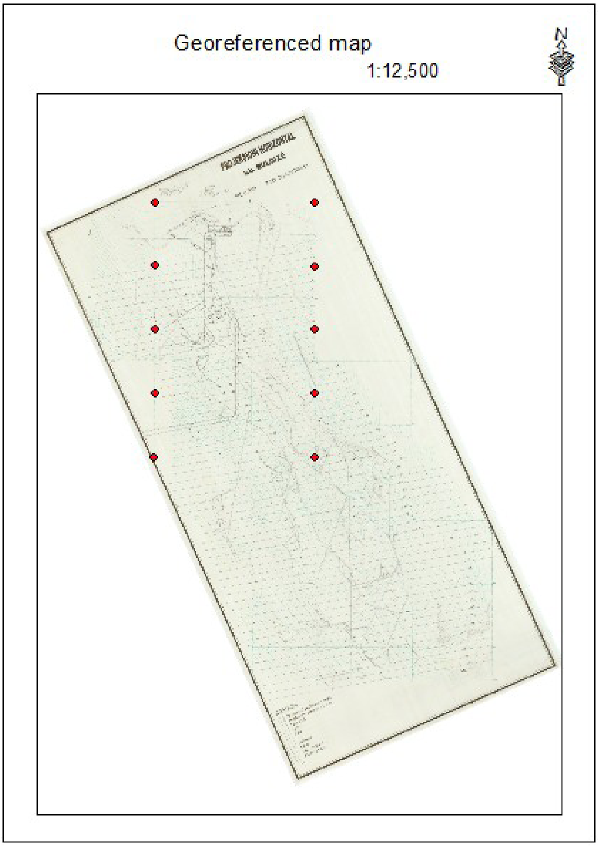


FIG. 6 Points, whose coordinates are determined by digitization

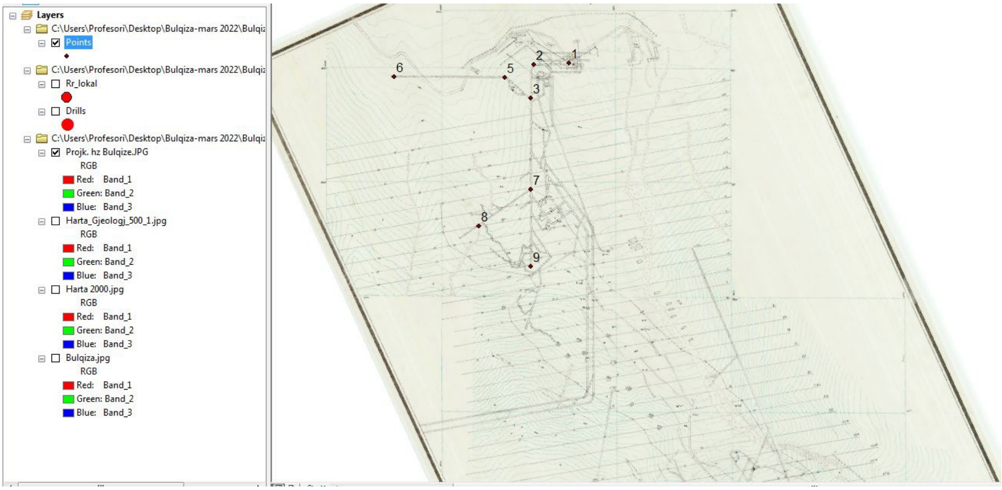


FIG. 7 Attribute table with coordinates of points in the official system (GK) created by digitization from the map, made with reference to the local coordinate system.

Table

Points

FID	Shape *	Id	Y	X
0	Point	1	4435129.541	4595309.871
1	Point	2	4435007.832	4595304.579
2	Point	3	4434997.249	4595188.162
3	Point	5	4434907.29	4595259.6
4	Point	6	4434523.644	4595262.245
5	Point	7	4434997.249	4594870.661
6	Point	8	4434817.332	4594743.661
7	Point	9	4434997.249	4594603.432

Conclusions & Recomandations

1. To create a coordinate transformation model, at least three points with known coordinates must be available in both systems.
2. It is recommended to use the constructed model only after its accuracy is evaluated.

3. From the assessment of the computational model for the transformation of coordinates from the local system to the GK system and vice versa.emerged that the system is characterized by two levels of accuracy
4. For all cases lying outside the circle with a radius of 2 km, it is recommended to derive the transformation formulas with reference to the three points known in both systems
5. To obtain more results confirming the formulas used, can measure the local coordinates of a lot of points starting from two points (inside the circle of radius 1 km) whose local coordinates were determined by the transformation formulas.
6. Georeferencing of maps in the official coordinate system allows data creation in this system by transformation models for only 4 points whose coordinates must be known in both coordinate systems.

References

[1]. G.MUKA (2022). Application of coordinate systems in Bulqiza mine (transformations and georeferences)

[2]. Muka G, Korini TH, etc. (2011): "The Use of GIS in identifying the abandoned workings to define the risk rate of earth's surface in Bulqiza chrome mine". IV Mining Congress, October 2011, Ljubljana, Slovenia.

[3]. Muka G "Geo-Risk Maps for Management of Abandoned Mine Workings Exploitations", Publisher: LAP LAMBERT Academic Publishing, 2018

[4]. G. MUKA, P. HOXHA, etc. (2015) "Regionalization and assessment of environmental risk based on the impacts of old mines". Section "Environment and Biodiversity", project funded by ARTI (2010-2015). (Project leader).

[5]. Liebig, W, et al.: ArcGIS-ArcView9, Band 1,2 2008, Pointsverlag, Norden-Halmstadt,

[6]. https://geoportal.asig.gov.al