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# APPLICATION OF 2D TRANSFORMATION MODELS FOR THE CONVERSION OF HISTORICAL TOPOGRAPHIC PLANS FROM SOROCA CITY, REPUBLIC OF MOLDOVA

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**Abstract.** The integration of historical geodetic data into the national spatial data infrastructure represents an essential step for valorizing cartographic heritage and ensuring the interoperability of modern reference systems. The present study has as its main objective the transformation of coordinates from the local Soroca system, historically used on the territory of the Republic of Moldova, into the national coordinate system MOLDREF99, compatible with European Terrestrial Reference System 1989 (ETRS89). The proposed methodology is based on the application of 2D mathematical transformation models — Helmert (4 parameters) and Affine (6 parameters) — for the conversion of topographic plans at scale 1:500 from Soroca city. Twelve common geodetic points were used, identified both on vectorized plans and in the national GeoData database, and the transformation parameters were calculated using the least squares method and validated on eight independent points. The comparative analysis demonstrated that both models offer similar precision, with mean square errors of approximately 0.002 m and RMSE (Root Mean Square Error) of 0.0226 m in the X direction and below 0.008 m in the Y direction, values that fall within acceptable limits for cadastral and topographic works at scale 1:500. The obtained results demonstrate the feasibility of coordinate transformation without direct field measurements, using exclusively existing cartographic resources and the national geodetic database, thus contributing to the development of the National Spatial Data Infrastructure (NSDI) and the valorization of cartographic heritage for cadastral applications, territorial planning, and urban development.

**Keywords:** *2D transformation, transformation parameters, least squares method, historical topographic plans, NSDI, Soroca local system, MOLDREF99.*

**Rezumat.** Integrarea datelor geodezice istorice în infrastructura națională de date spațiale reprezintă o etapă esențială pentru valorificarea patrimoniului cartografic și asigurarea interoperabilității sistemelor moderne de referință. Studiul de față are ca obiectiv principal transformarea coordonatelor din sistemul local Soroca, utilizat istoric pe teritoriul Republicii Moldova, în sistemul de coordonate național MOLDREF99, compatibil cu Sistemul European de Referință Terestră 1989 (ETRS89). Metodologia propusă se bazează pe aplicarea modelelor matematice de transformare 2D — Helmert (4 parametri) și Afină (6 parametri) — pentru conversia planșelor topografice la scara 1:500 din orașul Soroca. Au fost utilizate 12 puncte geodezice comune, identificate atât pe planșele vectorizate, cât și în baza de date națională GeoData, iar parametrii de transformare au fost calculați prin metoda celor mai mici pătrate și validați pe opt puncte independente. Analiza comparativă a demonstrat că ambele modele oferă precizie similară, cu erori medii pătratice de aproximativ 0.002 m și RMSE de 0.0226 m în direcția X și sub 0.008 m în direcția Y, valori care se încadrează în limitele acceptabile pentru lucrările cadastrale și topografice la scara 1:500. Rezultatele obținute demonstrează fezabilitatea transformării coordonatelor fără măsurători directe în teren, utilizând exclusiv resurse cartografice existente și baza de date geodezică națională, contribuind astfel la dezvoltarea Infrastructurii Naționale pentru Date Spațiale (INDS) și valorificarea patrimoniului cartografic pentru aplicații cadastrale, planificare teritorială și dezvoltare urbană.

**Cuvinte cheie:** *transformare 2D, parametri de transformare, metoda celor mai mici pătrate, planuri topografice istorice, INDS, sistem local Soroca, MOLDREF99.*

## 1. Introduction

The transformation of coordinates between different geodetic systems represents a fundamental necessity in the context of modernizing geospatial infrastructure and integrating historical cartographic data into contemporary reference systems [1,2]. With the evolution of Global Navigation Satellite System (GNSS) positioning technologies and the adoption of geocentric reference frames at national and international levels, the need has emerged to ensure the compatibility and interoperability of spatial databases created in traditional local systems with modern geospatial infrastructures [3,4].

In the Republic of Moldova, the transition from local coordinate systems, derived from the Soviet reference framework, to the national MOLDREF99 system, compatible with the European standard ETRS89, has generated significant challenges in the field of geodesy and cadastre [5,6]. Most of the technical works carried out previously were executed in local coordinate systems, adapted to regional specificities, which led to the formation of substantial databases that require transformation to be integrated into current GIS platforms and smart infrastructure projects [7,8]. A considerable part of this cartographic heritage is represented by topographic plans at scale 1:500, elaborated for numerous localities and districts of the republic, which are preserved in archives in analog form [9]. These plans contain valuable geodetic and topographic information, but remain insufficiently valorized due to the incompatibility of the coordinate systems in which they were created with the current national spatial data infrastructure [10,11].

The digitization, georeferencing, and integration of these historical cartographic materials into the National Spatial Data Infrastructure (NSDI) database represent a strategic objective for consolidating the informational capacity of the national geodetic system [10,12]. The process involves not only the scanning of plans and vectorization of graphic elements, but also the rigorous transformation of coordinates from local systems into the MOLDREF99 system, thus ensuring the continuity and coherence of spatial data at the national level [13-15]. This approach allows the recovery and reuse of a significant volume of detailed topographic information, essential for cadastral projects, territorial planning, and urban development [16,17]. In this context, national methodological guidelines regarding the analog-digital conversion of spatial data and their georeferencing offer a standardized procedural framework for processing historical cartographic materials [18,19].

The coordinate transformation process involves the application of rigorous two-dimensional mathematical models, capable of describing the geometric relationship between two reference systems through translation, rotation, and scaling parameters [20,21]. The 2D Helmert transformation method and Affine transformation, based on the least squares principle, have proven to be the most efficient and precise solutions for such conversions, allowing minimal deviations to be obtained and ensuring the spatial coherence of transformed data [22-24].

The present study aims to analyze the coordinate transformation process from the local Soroca system into the national MOLDREF99 system, using historical cartographic data and resources from the national geospatial database. Through the application of the Helmert method and Affine transformation in plane, as well as validation of results on a set of geodetic control points, the work demonstrates the feasibility and precision of 2D transformation models for the conversion of spatial data in the absence of direct field measurements [25]. The selected study area, Soroca city, located in the northeastern part of the Republic of Moldova, offers a representative framework for this analysis, due to its varied geomorphological characteristics, availability of topographic plans at scale 1:500 in the local system, and existence of data from the national geodetic infrastructure [26,27].

The results of this study contribute to the broader process of harmonizing geospatial data at the national level, while offering a methodology applicable in practical situations where verification of geodetic benchmarks is not possible, and the integration of historical data into modern systems must be carried out exclusively based on existing cartographic resources and official databases [28,29]. The proposed methodology can be extended and applied for the valorization of the entire fund of archived topographic plans, thus contributing to the completion and enrichment of the National Spatial Data Infrastructure of the Republic of Moldova.

## 2. Materials and Methods

### *2.1. Study Area*

The study area selected for the present research is Soroca municipality with an area of approximately 13.11 km$^2$, located in the northeastern part of the Republic of Moldova, on the right bank of the Dniester River, near the border with Ukraine (Figure 1). The municipality represents an important urban and administrative center of the region, with varied geomorphological characteristics that include Dniester terraces, steep slopes, and hilly areas [26]. These topographic particularities, together with the historical context and availability of a dense network of historical geodetic points, make Soroca an adequate framework for the study of geodetic transformations between different reference systems.

From an administrative perspective, Soroca municipality has a geodetic infrastructure developed during the soviet period, consisting of a network of geodetic and topographic points that were used in multiple local technical projects. These points were registered in local coordinate systems, derived from soviet reference frames, generating a topographic and cadastral database specific to the region.

The local coordinate system used in Soroca city belongs to the category of plane reference systems, adapted to the national triangulation and leveling network from the USSR period. In this system, the terrestrial surface was projected onto a plane using a transverse conformal projection, with an adjusted scale to reduce deformation errors at the regional level [3]. Although this system allowed efficient operation of local topographic projects in the long term, it presents significant limitations regarding integration with modern systems, especially concerning absolute positioning, interoperability, and precision [14].

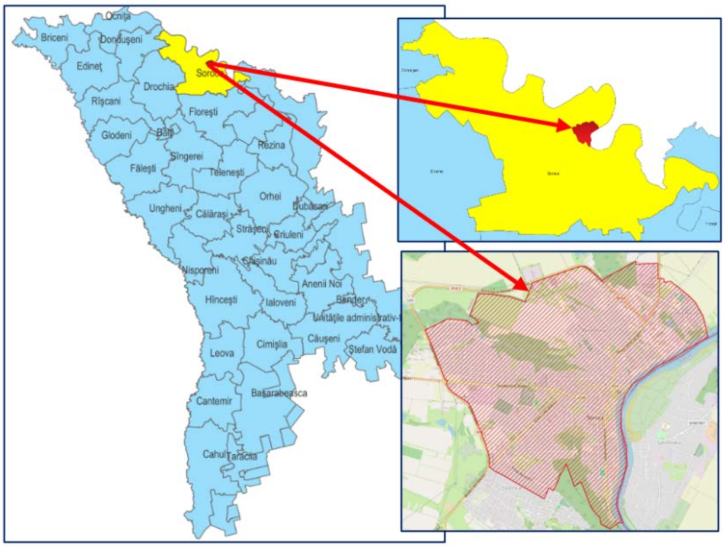



**Figure 1.** Study area – Soroca locality.

With the geodetic and cadastral reforms initiated in the Republic of Moldova starting in the 2000s, the MOLDREF99 system was officially adopted, which corresponds to the European framework ETRS89 [6]. The MOLDREF99 system allows precise three-dimensional positioning, and coordinates can be expressed in plane projection using a version of the Transverse Mercator projection, adapted to the national territory through the definition of an axial meridian at longitude 28°24′ E and a central scale factor of 0.9996 [6]. Thus, the system ensures optimal integration with European and international networks, offering centimeter-level precision when used together with modern GNSS technologies and permanent station networks. Therefore, it is necessary to perform the transformation of coordinates from the local Soroca system into MOLDREF99, which derives from the objective of harmonizing historical geodetic data with the national spatial data infrastructure (NSDI).

### *2.2. Data Sources*

The basic cartographic material used in this study consisted of topographic plans at scale 1:500 on paper support, elaborated in the local Soroca system, originating from the local cadastral documentation archive. Some plans are missing, the cause is unknown. These plans contain detailed information about the geodetic point network, topographic elements, and urban infrastructure of Soroca municipality. The plans were scanned at a resolution of 300 dpi in TIFF format to ensure the necessary quality for the subsequent vectorization process.

To obtain coordinates in the MOLDREF99 system, the GeoData platform was used, which provides access to the national geodetic coordinate database [27]. This platform allows the querying and extraction of official coordinates of geodetic points from the national network.

For processing the scanned topographic plans, GeoniCS software compatible with AutoCAD software was used [30], a specialized geospatial extension for vectorization and design work in the field of geodesy and cadastre [18,19]. This tool offers advanced functionalities for georeferencing rasters, vectorizing graphic elements, and extracting coordinates of geodetic points. For spatial analysis, results validation, and data visualization, open-source GIS applications were used, including QGIS [24], which allow the integration and processing of geospatial data from multiple sources and formats.

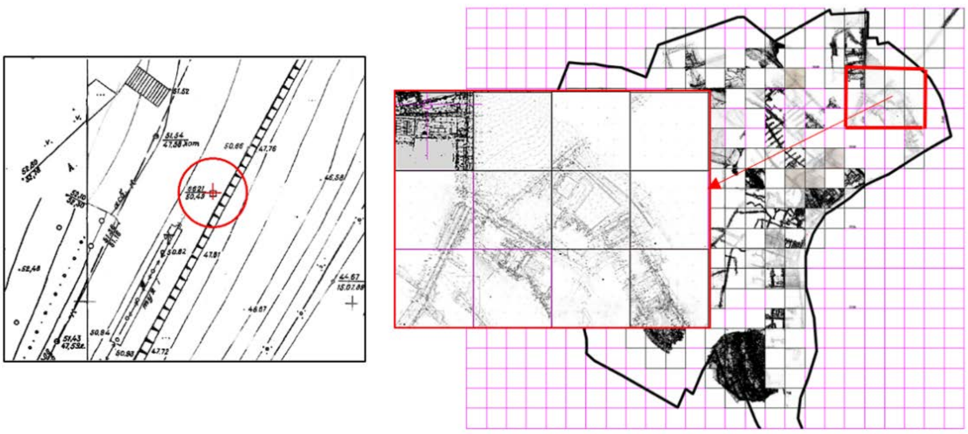
### *2.3. Methodology*

#### 2.3.1. Georeferencing and Unification of Topographic Plans

The processing of topographic plans followed a succession of standardized steps, according to national methodological guidelines regarding analog-digital conversion and georeferencing of spatial data [17,18]. The scanned plans were imported into the GeoniCS environment and preliminarily positioned on the local Soroca system grid, using grid intersections and corners of the graphic frame as references. To ensure precise positioning, the *Rubbersheet* function from GeoniCS was applied, which allows controlled deformation of the image through four control points, distributed at the corners of the plan's graphic frame, for which initial positions (source points) and desired positions (destination points) were defined according to the grid coordinate values.

Preliminary georeferencing was performed using the first-degree polynomial method. The georeferencing precision was evaluated through RMS error (root mean square), which was maintained below the limit of 0.05 m, according to technical standards for digital processing work of topographic plans. After georeferencing, the plans were clipped by eliminating exterior graphic elements and precise delimitation of the area of interest [31]. Relevant graphic elements (geodetic points, boundaries, infrastructure) were vectorized, and for each identified geodetic point, coordinates were extracted in the local Soroca system directly from the vectorized plan (Figure 2).

For each geodetic point identified in the vectorized plans, corresponding coordinates were searched in the MOLDREF99 system using the GeoData platform [27]. Identification criteria included the point name, identifier code, and approximate position on the map (Figure 3). Thus, a dataset was created consisting of coordinate pairs – one in the local Soroca system ($x_1$, $y_1$) and one in the MOLDREF99 system ($x_2$, $y_2$) – for each geodetic point.



a) b)

**Figure 2.** Topographic plans at scale 1:500: a) geodetic point; b) example of 12 unified aligned plans from the Soroca city area.

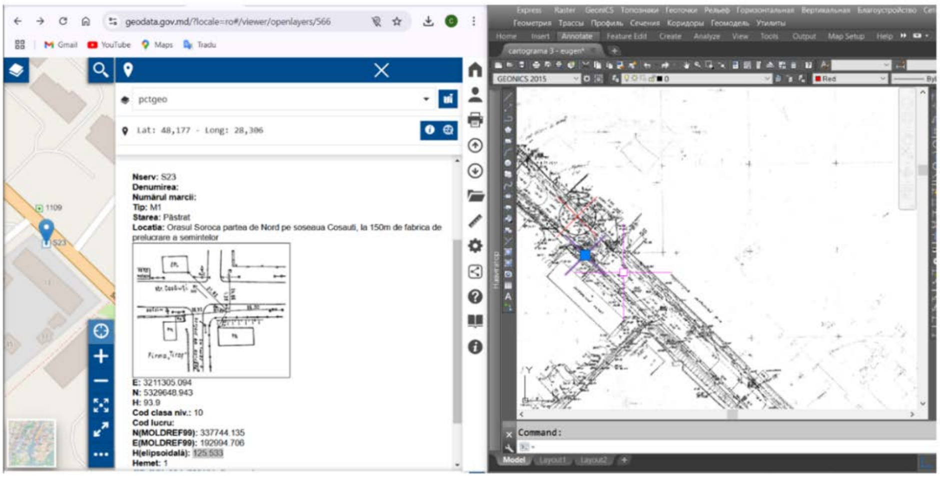


**Figure 3.** Correlation of points from the Local Soroca system to the MOLDREF99 system.

### 2.3.2. Mathematical Models of 2D Transformation

For the coordinate transformation between the local Soroca system and the national MOLDREF99 system, the 2D Helmert transformation with four parameters was applied, and for comparison, the 2D affine transformation with six parameters was used [22,23,32].

The 2D Helmert model is defined by the equation (1):

$$\begin{pmatrix} x_2 \\ y_2 \end{pmatrix} = \begin{pmatrix} x_0 \\ y_0 \end{pmatrix} + \begin{pmatrix} a & -b \\ b & a \end{pmatrix} \cdot \begin{pmatrix} x_1 \\ y_1 \end{pmatrix}, \quad (1)$$

where: $(x_0, y_0)$ represent the translation components between the origins of the local Soroca and MOLDREF99 coordinate systems; the coefficients $a$ and $b$ were replaced by the relations $a = k \cdot cos\alpha$ and $b = k \cdot sin\alpha$ ($k$ – scale factor, $\alpha$ – rotation angle between the coordinate systems); $(x_1, y_1)$ and $(x_2, y_2)$ are the coordinates of the point in the source system (local Soroca) and in the target system (MOLDREF99), respectively.

The determination of the parameters $x_0$, $y_0$, $a$, and $b$ was carried out using the least squares method, based on common points with known coordinates in both systems [23,24]. This process requires at least two common points, but in practice, a larger number of tie points is recommended [32]. The adjustment process was performed by constructing a system of linear equations expressed in matrix form:

$$L + V = A \cdot X, \quad (2)$$

where:

$$A = \begin{pmatrix} 1 & 0 & x_1^{LOC} & -y_1^{LOC} \\ 0 & 1 & y_1^{LOC} & x_1^{LOC} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ 1 & 0 & x_n^{LOC} & -y_n^{LOC} \\ 0 & 1 & y_n^{LOC} & x_n^{LOC} \end{pmatrix}; \; X = \begin{pmatrix} x_0 \\ y_0 \\ a \\ b \end{pmatrix}; \; L = \begin{pmatrix} x_2^{MOLDREF99} \\ y_2^{MOLDREF99} \\ \cdot \\ \cdot \\ x_2^{MOLDREF99} \\ y_2^{MOLDREF99} \end{pmatrix}; V = \begin{pmatrix} v_{x1} \\ v_{y1} \\ \cdot \\ \cdot \\ v_{xn} \\ v_{yn} \end{pmatrix}. \quad (3)$$

$n$ – the number of common points, with known coordinates in both systems.

The unknown transformation parameters X result from the relationship:

$$X = (A^T A)^{-1} A^T L. \quad (4)$$

The standard deviation of the Helmert transformation, $\sigma_0$, which can be used to compare the geometry of the two coordinate systems, is obtained using the following formula:

$$\sigma_0 = \pm\sqrt{\frac{V^T V}{2n-4}}. \tag{5}$$

The 2D Affine transformation, unlike the 2D Helmert linear transformation, introduces separate corrections for each of the two coordinate axes and is based on a total of six parameters [22,32]. The coordinates of the points in the transformed system are determined in matrix form using the following equation:

$$\begin{pmatrix} x_2 \\ y_2 \end{pmatrix} = \begin{pmatrix} x_0 \\ y_0 \end{pmatrix} + \begin{pmatrix} a & b \\ c & d \end{pmatrix} \cdot \begin{pmatrix} x_1 \\ y_1 \end{pmatrix}. \tag{6}$$

In this case, a minimum of three common points is required to solve the system using the least squares method for determining the six unknowns (*$x_0$, $y_0$, a, b, c, d*). The same steps as in the 2D linear Helmert transformation are followed to apply the least squares principle, with only the following modifications in the matrix formation:

$$A = \begin{pmatrix} x_1^{LOC} & y_1^{LOC} & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & x_1^{LOC} & x_1^{LOC} & 1 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ x_n^{LOC} & y_n^{LOC} & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & x_n^{LOC} & y_n^{LOC} & 1 \end{pmatrix}; \; X = \begin{pmatrix} a \\ b \\ x_0 \\ c \\ d \\ y_0 \end{pmatrix}. \tag{7}$$

The standard deviation of the transformation is calculated in a similar way, but with a modification in the denominator of the equation:

$$\sigma_0 = \pm\sqrt{\frac{V^T V}{2n-6}}. \tag{8}$$

In addition to the Helmert and Affine transformations, higher-order polynomial transformation models (degree 2, 3, or higher) are also described in the specialized literature [22]. However, the application of these methods to the available data from the Soroca area resulted in lower accuracy due to their increased sensitivity to the non-uniform distribution of control points.

### 3. Results and Discussion

For the determination of the transformation parameters, 12 common points (control points) were selected from the national geodetic network, where coordinates are known in both systems (the local Soroca system and the MOLDREF99 system) for the locality of Soroca (Figure 4).

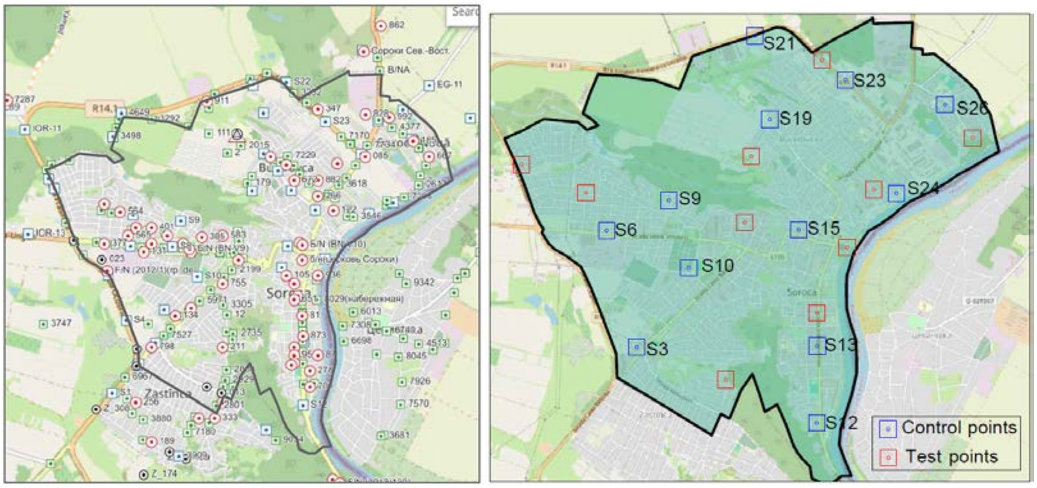
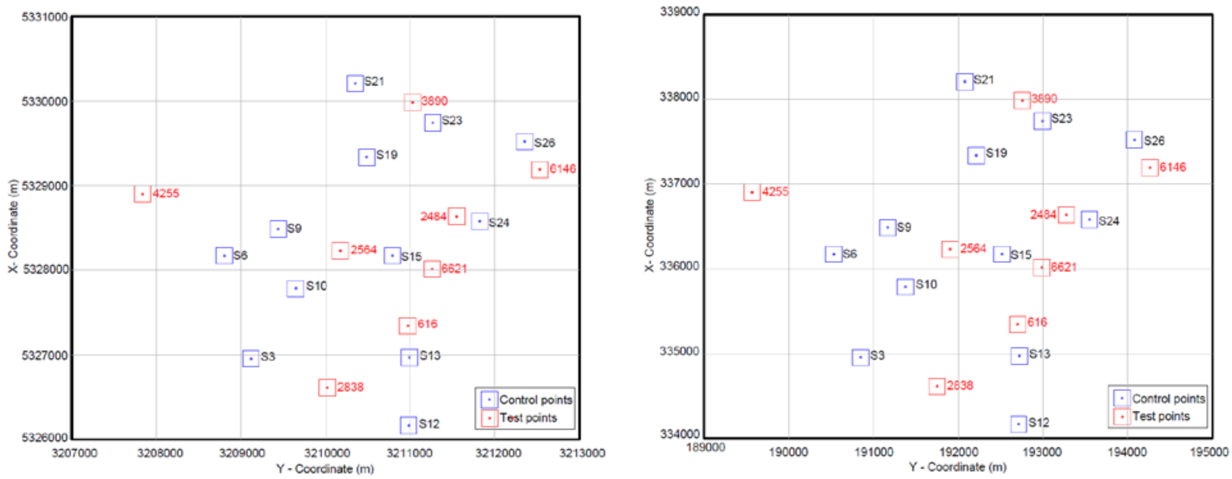



**Figure 4.** Selection of control and test points in both coordinate systems for the locality of Soroca.

The distribution of control and test points is presented in Figure 5, where blue squares indicate the control points (a total of 12), and red squares indicate the locations of the test points (a total of 8). Figure 5a shows the positions of the points in the local Soroca coordinate system, while Figure 5b shows their positions in the national MOLDREF99 coordinate system.




a) b)

**Figure 5.** Distribution of control and test points in both coordinate systems:
a) Local Soroca, b) MOLDREF99.

The control points were used to estimate the transformation parameters, while the test points were used to verify the validity of the estimated parameters by analyzing whether the obtained results are close to the original coordinates (from the registry). The eight test points were transformed into the second reference system (MOLDREF99) using the transformation parameters calculated by the two models – Helmert (4 parameters) and Affine (6 parameters). Table 1 lists the transformation parameters for converting coordinates from the local Soroca reference system to the national MOLDREF99 system, obtained by the least squares method based on common (control) points in both systems.

*Table 1*

**Estimated Transformation Parameters**

| Helmert transformation parameters | Affine transformation parameters |
|---|---|
| $x_0$, m = -5036471.608 | $x_0$, m = -5036474.323 |
| $y_0$, m = -2941065.247 | $y_0$, m = -2941064.688 |
| a = 0.999727971 | a = 0.999728445 |
| b = -0.014329569 | b = 0.014329628 |
| | c = -0.014329225 |
| | d = 0.999727227 |

The mean square error ($\sigma_0$), representing the accuracy of the transformation operation, and the average errors of the transformation parameters are presented in Table 2.

*Table 2*

**The Mean Square Error of Transformation ($\sigma_0$) and Average Errors of Transformation Parameters (meter)**

| Helmert transformation parameters | Affine transformation parameters |
|---|---|
| $\sigma_0$ = 0.002262 | $\sigma_0$ = 0.002298 |
| $\sigma_{x0}$ = 0.005832 | $\sigma_{x0}$ = 0.007470 |
| $\sigma_{y0}$ = 0.005832 | $\sigma_{y0}$ = 0.007470 |

*Continuation Table 2*

| | |
|---|---|
| $\sigma_a$ = $9.37\times10^{-10}$ | $\sigma_a$ = $1.34\times10^{-9}$ |
| $\sigma_b$ = $9.37\times10^{-10}$ | $\sigma_b$ = $1.52\times10^{-9}$ |
| | $\sigma_c$ = $1.34\times10^{-9}$ |
| | $\sigma_d$ = $1.52\times10^{-9}$ |

The coordinates of the test points from the local Soroca coordinate system were transformed into the national MOLDREF99 system using the transformation parameters determined by the two models. Subsequently, the differences between the transformed coordinates and the original coordinates (from the registry) in the MOLDREF99 system for the same test points were calculated (Table 3).

*Table 3*

**Differences between Local Soroca to MOLDREF99 Transformed Coordinates and Register MOLDREF99 Coordinates in Test Points**

| Point ID | Helmert transformation | | Affine transformation | |
|---|---|---|---|---|
| | ΔX (m) | ΔY (m) | ΔX (m) | ΔY (m) |
| 2838 | 0.0014 | -0.0020 | 0.0025 | -0.0029 |
| 2564 | -0.0012 | 0.0006 | -0.0009 | -0.0008 |
| 2484 | 0.0005 | 0.0014 | 0.0005 | 0.0009 |
| 616 | -0.0019 | -0.0001 | -0.0012 | -0.0005 |
| 4255 | -0.0535 | 0.0221 | -0.0535 | 0.0187 |
| 3890 | 0.0004 | -0.0019 | -0.0002 | -0.0032 |
| 6146 | 0.0028 | 0.0038 | 0.0025 | 0.0038 |
| 6621 | -0.0350 | -0.0002 | -0.0346 | -0.0007 |

Based on these differences, statistical indicators were evaluated, including the minimum and maximum errors, the root mean square error (RMSE), and the mean absolute error (MAE) [23].

The mean absolute error (MAE) is determined using the following equation:

$$MAE = \frac{1}{n}\left[\sum_{i=1}^{n} X_{MOLDREF99(register)} - X_{MOLDREFF99(transformed)}\right]. \tag{9}$$

The root mean square error (RMSE) is determined by the relationship:

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\left(\sum_{i=1}^{n}(X_{MOLDREF99(register)} - X_{MOLDREFF99(transformed)})^2\right)}. \tag{10}$$

The statistical indicators are presented in Table 4 for the Helmert transformation case and for the Affine transformation case.

*Table 4*

**Statistical Values for Differences between Local Soroca to MOLDREF99 Transformed Coordinates and Register MOLDREF99 Coordinates in Test Points**

| Statistical values | Helmert transformation | | Affine transformation | |
|---|---|---|---|---|
| | X - direction errors (ΔX) | Y - direction errors (ΔY) | X - direction errors (ΔX) | Y - direction errors (ΔY) |
| Min, m | -0.0535 | -0.0020 | -0.0535 | -0.0032 |
| Max, m | 0.0028 | 0.0221 | 0.0025 | 0.0187 |
| MAE, m | 0.0108 | 0.0030 | 0.0106 | 0.0019 |
| RMSE, m | 0.0226 | 0.0080 | 0.0226 | 0.0069 |

MAE - the mean absolute error, RMSE – the root mean square error.

If the coordinate differences (Δ*X*, Δ*Y*) between the transformed coordinates and the existing coordinates in the MOLDREF99 system are represented separately for the eight test points, the results shown in Figure 6 for the Helmert transformation model and in Figure 7 for the Affine transformation model are obtained.

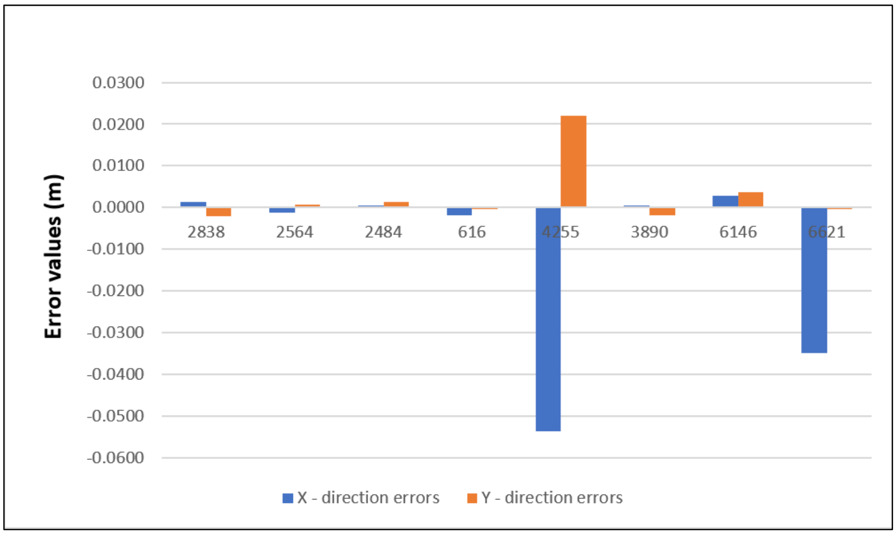



**Figure 6.** Coordinate differences of test points for the Helmert transformation model.

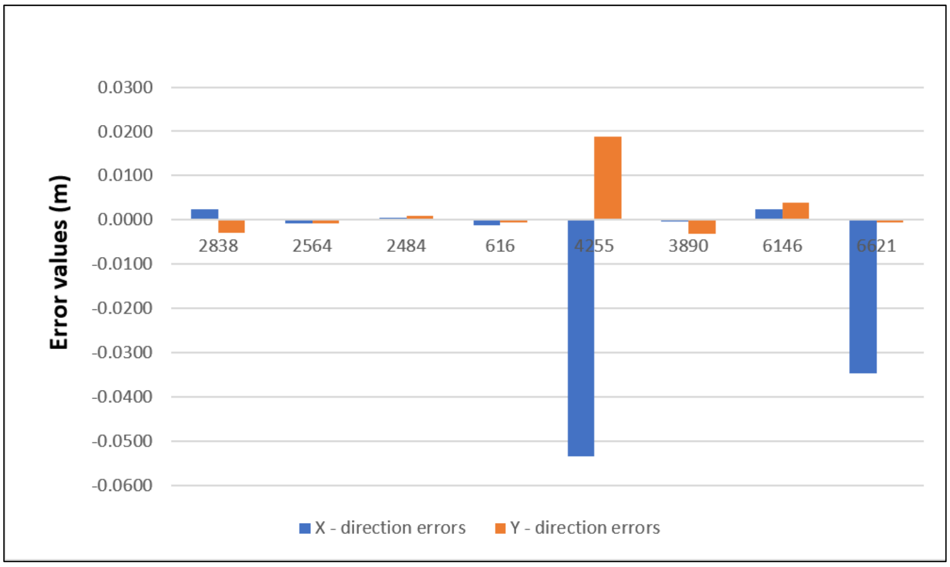



**Figure 7.** Coordinate differences of test points for the Affine transformation model.

If the deviations ΔS for each geodetic test point are represented for each transformation model, the situation shown in Figure 8 is obtained. The deviation ΔS represents the displacement vector at a point, which can be determined using the following equation:

$$\Delta S = \sqrt{\Delta X^2 + \Delta Y^2}, \tag{11}$$

where: $\Delta X = X_{MOLDREF99(register)} - X_{MOLDREFF99(transformed)}$,

$\Delta Y = Y_{MOLDREF99(register)} - Y_{MOLDREFF99(transformed)}$.

It can be observed that the histogram in Figure 6 is approximately identical to that in Figure 7, indicating that the coordinate differences of the points are the same, whether determined using the Helmert model or the Affine transformation model. The same situation can be seen in Figure 8 for the ΔS deviations of the test points.

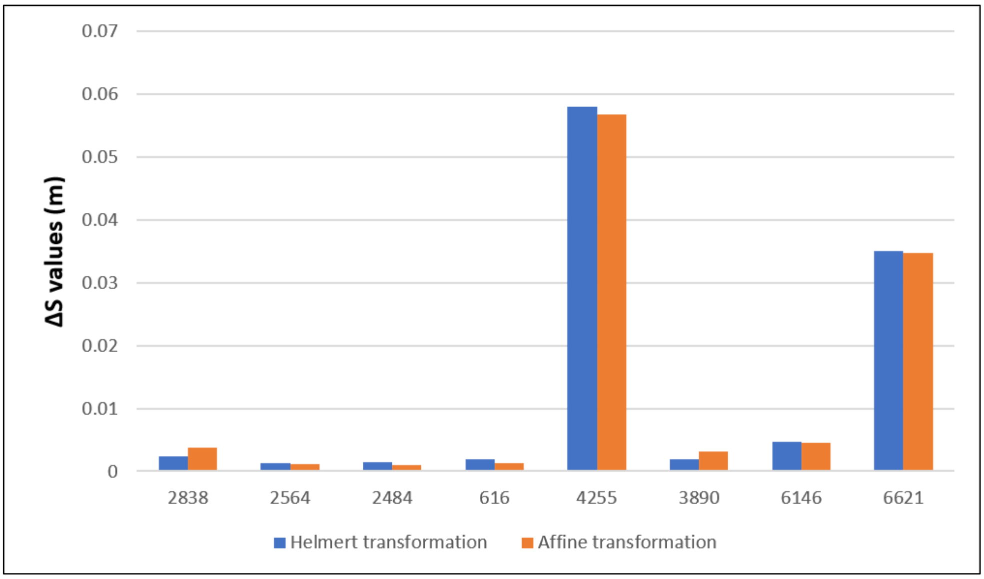



**Figure 8.** ΔS deviations of test points for the Helmert transformation and Affine transformation models.

It can be concluded that, for the 2D coordinate transformations from the local Soroca system to the MOLDREF99 system, both the Helmert and Affine transformation model parameters can be used, since the obtained error values are approximately equal in both cases.

## 4. Conclusions

The present study demonstrated the feasibility and efficiency of two-dimensional transformation methods for converting coordinates from the local Soroca system to the national MOLDREF99 system, using exclusively existing cartographic resources and the national geodetic database, without the need for direct field measurements.

The comparative analysis of the 2D Helmert transformation (with four parameters) and the 2D Affine transformation (with six parameters) highlighted that both mathematical models provide similar results in terms of accuracy. The mean square error obtained for both methods is approximately 0.002 m, confirming the reliability of the transformation process. Validation on the eight test points showed RMSE values of 0.0226 m in the X direction and 0.0080 m in the Y direction for the Helmert transformation, and 0.0226 m and 0.0069 m respectively for the Affine transformation. These results fall within the acceptable accuracy limits for cadastral and topographic works at the 1:500 scale.

The obtained results confirm that, in the absence of the possibility to directly verify geodetic benchmarks in the field, coordinate transformation can be successfully performed by utilizing archived topographic plans and the official GeoData database. The minimal differences between the results of the two transformation models indicate good geometric compatibility between the local Soroca system and the national MOLDREF99 system within the study area.

The methodology developed in this study can be extended and applied to process the entire collection of topographic plans preserved in national archives, thus contributing to the enhancement and enrichment of the National Spatial Data Infrastructure (NSDI) of the Republic of Moldova. The process of digitizing, georeferencing, and transforming historical cartographic materials represents a strategic investment in preserving and capitalizing on the national geodetic heritage and ensuring the continuity of spatial data necessary for cadastral, territorial planning, and urban development projects.

Future research could focus on a comparative analysis of transformation accuracy across different geographic regions of the country, characterized by diverse relief conditions and varying geodetic network densities, as well as on the development of automated procedures for large-scale processing of archived topographic plans.

**Conflicts of interest:** The authors declare no conflict of interest.

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