

Studies of the Linear and Surface Deformations of Cartographical Projections Used in Introduction Works of General Survey in Iasi City

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Abstract: *In works of introduction of general survey and urban survey within the built up area of town or city residence, it is recommended to adopt some local system projection, derived from 1970 stereographical projection, where relative linear deformation will not exceed ± 5 cm/km.*

For the elaboration of base survey plan at 1:1000 scale of Iasi city, we have analyzed the value and the distribution of linear and surface deformations using the following cartographical projections: the Gauss-Krüger cylindrical transversal projection, local projection with central point at Golia ($X_0 = 10\ 000$ m; $Y_0 = 10\ 000$ m), 1970 stereographical projection on unique secant plan and stereographical projection on Iasi local secant plan.

Through the adoption of stereographical projection on Iasi local secant plan derived from 1970 stereographical projection on unique secant plan have been realised the significant distinct decreasing of linear and surface deformations towards other analysed projection systems. For the relative linear deformations have been recorded values between $+ 0,12$ cm/ km to $+1,62$ cm/km, in the north and east extremity area of the Iasi municipality cadastral territory and between $-0,27$ cm/km to $-1,76$ cm/km in extreme south and west areas. When is used stereographical projection on Iasi local secant plan results that surface relative deformations doesn't influence the accuracy of surfaces determination.

1. Introduction

The achievement of general survey and data base make-up is done on administrative units according to the stipulations of Law no. 7/1996 concerning to the survey and building advertising [8], taking into considerations the further changes and supplements. For this purpose it was performed by authorized judicial and physical person's new geodesic, photogrammetric and topographical - survey measurements down to the level of portions / property corps. With these could be identified and mapped rigorously, all buildings from the base administrative territory: villages, towns and cities [1, 2, 3]. Concomitently it is done after introduction the survey works and the graphical or textual data base at the level of administrative territory, on those two essential components, (within the built up area or outside built-over area) in official system of cartographical representation of 1970 stereographical projection [9,10].

Graphical data base of urban survey is distinguished on base survey plan, draw up and elaborating at the following cartographical scale: 1:5000 for a density over 50 lots/ha (cities); scale 1:1000 for a density 30-50 lots/ha (cities and towns); scale 1: 2000 for a density less than 20 lots/ha for the small town and rural localities [10].

Geodesic, photogrammetric and topographical works necessary for the detail elevations and for the introduction of general survey have been realised, in the case of administrative territory of Iasi city, in the same coordination systems, in accordance with cartographical projections used on different periods. From the geodesic triangulations works, made among 1950-2005, could be mentioned chronologically the most representative:

➤ **Local triangulation of Iasi city, with the central point at Golia**, which represent the origin of the plan coordination axes ($X_O = 10\,000.000\text{ m}$; $Y_O = 10\,000.000\text{ m}$), with OY axis orientated on the north-south direction, and axis OX orientated on east-west direction, calculated in local azimuthally projection stereographical perspective on Golia secant plan, Baltic Sea mark system, among 1950-1952, then between 1969-1970 being extended and completed with new points.

➤ **Geodesic triangulation of superior and lower order of Iasi city**, determined in coordination system of the Gauss-Krüger cylindrical transversal projection, 1962 system, with Baltic Sea reference plan, on geographical meantime of 3° longitude, for the first time in 1956 for Ist, IInd, IIIrd order, then in 1967 for IVth and Vth order.

➤ **Geodesic triangulation of superior and lower order of Iasi city** from azimuthally projection slanting stereographical perspective identical on unique secant plan - 1970, having at the base the elements of Krasowski ellipsoid – 1940 and Black Sea reference plan, 1962 system. The plan rectangular coordinates of help for geodesic network from stereographical projection – 1970, have been obtained trough the transformations of Gauss-Krüger coordinates, 1962 system, through the methods of formula with constant coefficients, which assure a ± 1 cm precision. This help network have been completed later in different stages among 1980-2005, according to the requirement of different types of topographical – survey measurements, through adequate rendering more frequent.

Cartographical and topographical-survey documentations existing at the level of Iasi city include plans and maps elaborating in the projection systems previously mentioned, in analogical form and at standard scale, like:

➤ **Base survey plan, scale 1:1,000**, draw up and elaborating in local azimuthally projection stereographical perspective on Golia secant plan, Baltic Sea system, first of all in 1950-1970, then putting up-to-date after implementation of „Survey in Iasi city among 1988-1991”, by I.C.P.R.O.M. Iasi

➤ **Base topographical plan, scale 1:2,000 and 1: 5,000**, elaborating in local azimuthally projection stereographical perspective on Golia secant plan, Black Sea reference plan, between 1980-1983, through aerophotogrammetrical methods, by I.G.F.C.O.T.

➤ **Base topographical plan, scale 1:5,000 and 1: 10,000**, draw up and elaborated in the Gauss –Krüger cylindrical transversal projection, 1962 system and Baltic Sea reference plan between 1964-1966 and 1977-1979, through aerophotographic methods by D.T.M.

➤ **Base topographical map, scale 1:25,000 and 1: 50,000** draw up and elaborated in the Gauss-Krüger cylindrical transversal projection, 1962 system and Baltic Sea reference plan, through aerophotographic methods by D.T.M.

➤ **Base survey map scale 1:50,000**, draw up and elaborated in the azimuthally projection slanting stereographical perspective identical on unique secant plan 1970, by I.G.F.C.O.T.

2. Calculation of cartographical base of survey plans

The survey territory of Iasi city is situated between the extreme parallels $47^\circ 06' 45''$ at south and $47^\circ 13' 30''$ at north, respective between marginal meridians $27^\circ 28' 45''$ at west and $27^\circ 41' 50''$ at east. The cartographical base of survey plans necessary for the implementation of new general survey for the built up area or outside built-over area of Iasi city, will be realised in 1970 stereographical projection, on trapezes adequate to the scale representation: 1:5,000, 1: 2,000; 1: 1,000. For this reason is impressive the correlation of present documentation, elaborated in local projection Golia-Iasi with the database of the new general survey [5].

2.1. The geodesic network of rendering of planimetric elevations and survey delimitation of Iasi city

The general survey of Iasi city, must be realised among 2005-2008, by a consortium coordinated by “GeoTop 2001” Company. The cost, estimated by the Iasi City hall is around 77 billions lei. Through ensemble and execution technical project was established according to the technical standards, the volume of the works on stages, the following stages being realised:

➤ The geodesic network of rendering and elevation, was determined by GPS technologies, which into a first stage has 84 main points, and after made the next stages of the rendering with point necessary to detail topographical measurements must be extended until 5000 points, in the coordination projection system STEREO – 1970.

The survey delimitation of the border of the territory of Iasi city, was made in the field through 200 border points, determinate through X,Y,Z, in 1970 stereographical projection and in the 1975 Black Sea reference mark system. The territory of the Iasi city has a total area of 9,396.22 ha, obtained after the last survey delimitation from 2005, being neighboured by the following nine sections border: Popricani-Aroneanu-Holboca-Tomești-Bârnova-Ciurea-Miroslava-Valea Lupului-Rediu (*figure 1*).

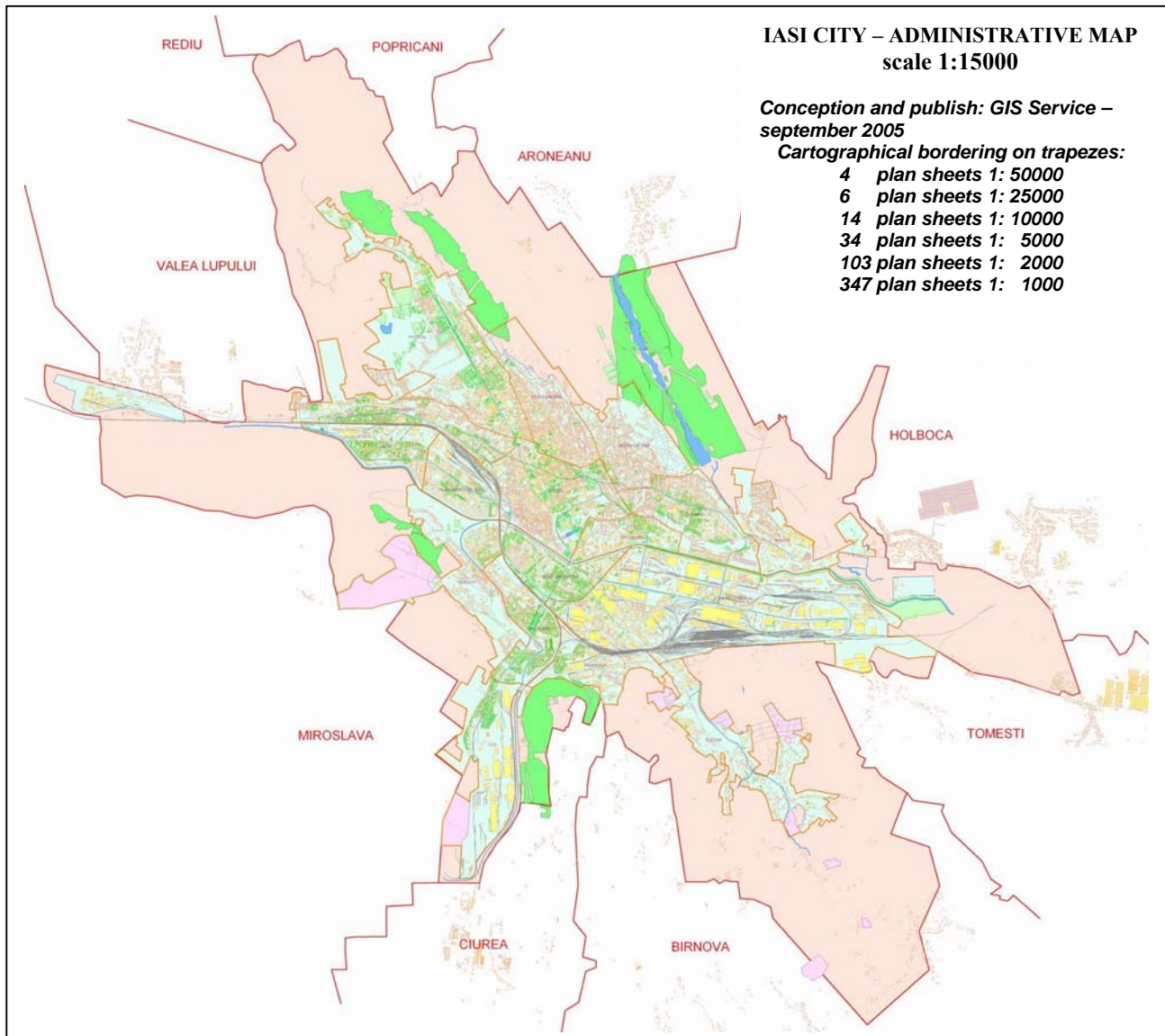


Figure 1 - General outline of the border of administrative-cadastral territory of Iasi city

2.2. Cartographical base of survey plan at scale 1:5000 in stereographical projection on unique secant plan - 1970

The survey territory of Iasi city is frame fully-empty on the following official trapezes: 4 plan sheets 1: 50,000; 6 plan sheets 1: 25,000; 14 plan sheets 1: 10,000 ; 34 plan sheets 1: 5,000; 103 plan sheets 1: 2,000; 347 plan sheets 1: 1,000. The calculation of mathematical base of survey plan, at scale 1: 5,000, in the stereographical projection system 1970, include the following cartographical elements (figure 2):

- Plan –stereo rectangular coordinations – 70 (Y,Y), calculated according to the ellipsoid geographical coordinations of the corner of geodesic trapezes;

- the dimensions of the sides and areas of the trapezes, on Krasowski ellipsoid – 1940, according to the geographical coordinations (φ, λ) of the corner of the geodesic trapezes, and on the stereographical projection plan -1970, according to the plan stereographical coordination – (X, Y);

- The relative linear deformations (D) on length unit (1Km) and surface deformation, from the central point of extreme delimitation trapezes of the outside built-over area: L-35-32-A-c-1-IV, at north; L-35-32-C-b-2-III, at east; L-35-32-C-b-3-III, at south; L-35-31-B-d-4-IV, at west and from the central trapeze of within the built up area of Iasi city, L-35-32-C-a-2-I.

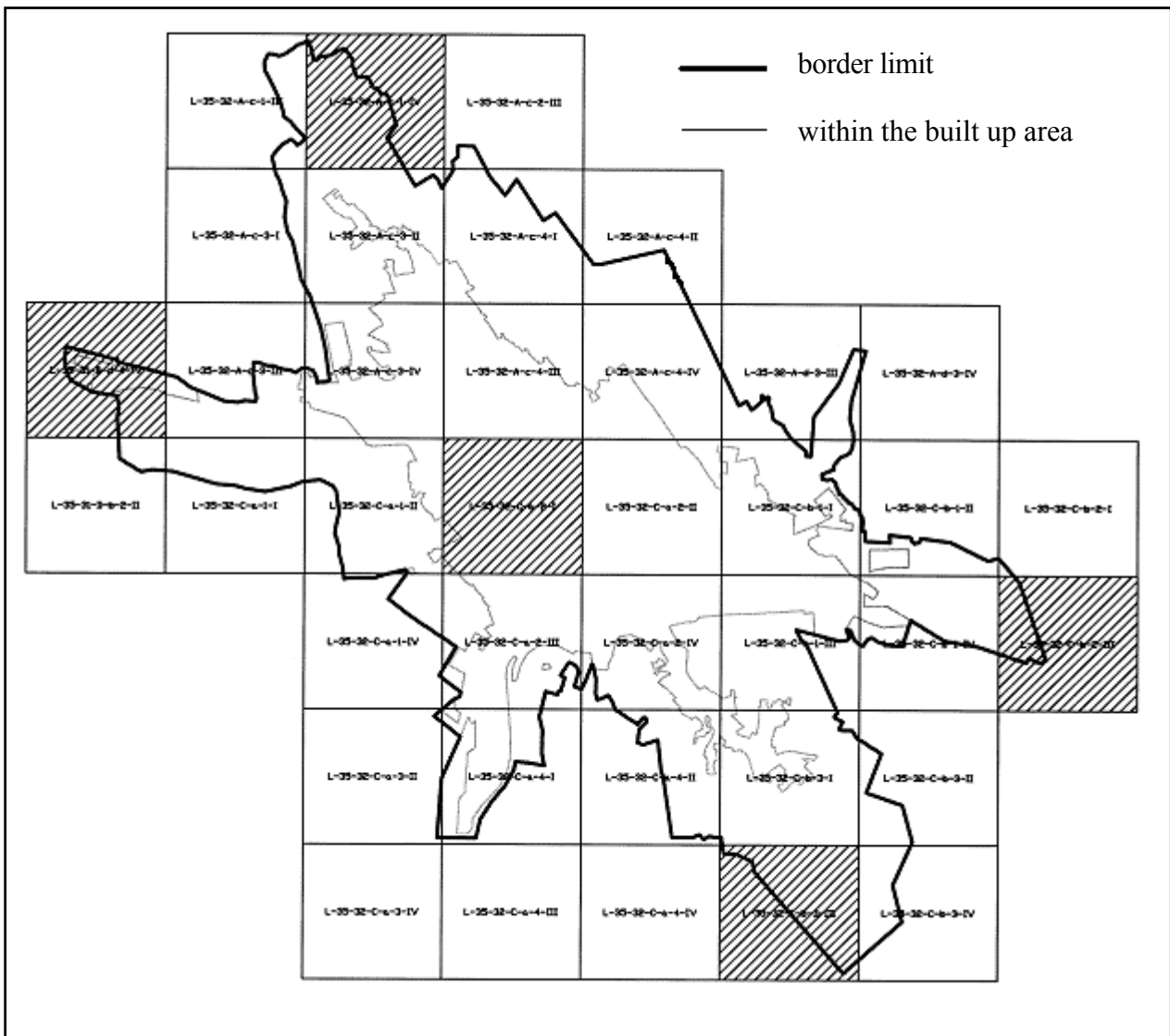


Figure 2 – Plan of bordering and connection trapezes in plan rising at scale 1: 5,000 from administrative-cadastral territory of Iasi city

2.3. The regional deformations of the length and areas, in projection STEREO – 1970 on the cartographical trapezes of Iasi territory at scale 1:5000

The survey territory of Iasi city is located in the outside of the null deformation circle with radius $r_0 = 201,718 \text{ km}$ toward the central point of 1970 stereographical projection, situated at the north of Fagaras city, with geographical coordinations: $\varphi_0 = 46^\circ 00' 00''$ and $\lambda_0 = 25^\circ 00' 00''$. In the case of the geographical position of Iasi territory have been obtained only positive deformations as well as for lengths and also for areas, which records increases cut out for distance of trapezes toward the central point of 1970 stereographical projection and null deformation circle, to the outside (table 1).

Table 1

Regional deformations of the lengths and areas, in 1970 STEREO- projection on the trapezes of cartographical framed of Iasi territory at the scale 1:5,000

Name of the trapeze at scale 1:5000	Position and the location zone	Relative linear deformations (D)		Relative surface deformations (P)	
		cm/km	m/km	m ² /ha	m ² /km ²
L-35-32-A-c-1-IV	North-outside city	9.65	0.096	1.93	193
L-35-32-C-b-2-III	East- outside city	11.16	0.112	2.23	223
L-35-32-C-b-3-III	South- outside city	9.26	0.093	1.85	185
L-35-31-B-d-4-IV	West- outside city	7.77	0.088	1.55	155
L-35-32-C-a-2-I	Downtown- inside city	9.51	0.095	1.83	183

The regional deformation at the lengths from the 1970 unique secant plan, from the delimitation trapezes of the Iasi territory have been between 7.77 cm/km in the west and 11.16cm/km in the east. Similar have been characterised the distribution of the surface deformations, situated between **1.55 m² / ha**, in west **2. 23 m² / ha**, in east.

2.4. Cartographical base of survey plan at scale 1:1000 in 1970 stereographical projection on unique secant plan

For the introduction of the general survey in the administrative territory of Iasi city, and of the building – town survey on the plan elevation trapezes at scale 1:1,000, according to the official nomenclature of 1970 STEREO projection, have been determined also the mathematical base of cartographical representation at large and largest scale 1:2,000. 1:1,000, 1:500. In the case study have been determined the cartographical base of survey plan at scale 1:1,000 for the 128 trapezes full-empty of the Iasi downtown within the built up area which include the following elements: 70-STEREO plan coordinations, the dimensions and the areas of the reference ellipsoid in the projection plan, length and area deformations from 1970 secant plan (figure 3).

2.5. Cartographical base of survey plan at scale 1:1000 in Iasi –Golia local stereographical projection

The survey documentation from Iasi territory including: base survey plan at scale 1:1,000, the survey registers on owners and lots, documentations made between 1950-1990 and 1990-2005, for the concede the property title, in view to join temporary in land charter, have been draw up and elaborating in Iasi local stereographical projection, with Golia central point. After realization of new survey and generalization digital plan at scale 1:1000 in 70 STEREO projections, become impressive the renunciation of Iasi-Golia local stereographical projection. For this reason, was calculated the cartographical base of projection used in Iasi city on 128 trapezes, scale 1:1,000 from Iasi-Golia local stereographical projection, as well as those corresponding to the stereographical projection on local secant plan, derived from 70 STEREO projection (figure 4).

LEGEND

- Scale 1:5000 - 8 trapezes
 Scale 1:2000 - 32 trapezes
 Scale 1:1000 - 128 trapezes
- L-35-32-A-c-3-IV
 L-35-32-A-c-3-IV-1
 ① = L-35-32-A-c-3-IV-1-a
 ② = L-35-32-A-c-3-IV-1-b
 ③ = L-35-32-A-c-3-IV-1-c
 ④ = L-35-32-A-c-3-IV-1-d

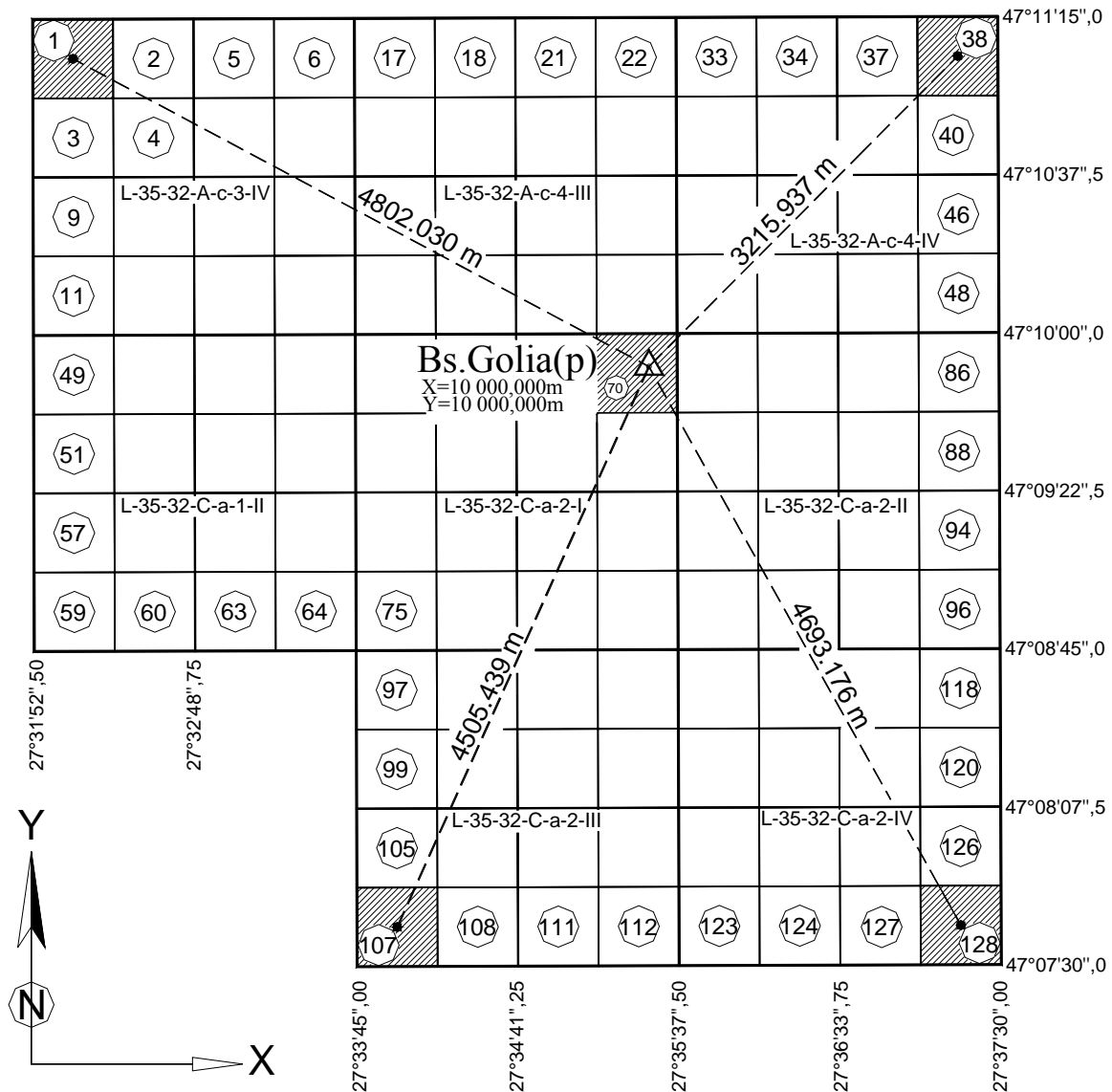


Figure 3 - Partitioning and numbering of the sheets of base cadastral plan, scale 1:1,000 in local stereographical projection and rectangular coordinations system with central point at Golia, Black Sea

LEGEND

Scale 1:5000 - 8 trapezes
 Scale 1:2000 - 32 trapezes
 Scale 1:1000 - 128 trapezes

L-35-32-A-c-3-IV

L-35-32-A-c-3-IV-1

- ① = L-35-32-A-c-3-IV-1-a
- ② = L-35-32-A-c-3-IV-1-b
- ③ = L-35-32-A-c-3-IV-1-c
- ④ = L-35-32-A-c-3-IV-1-d

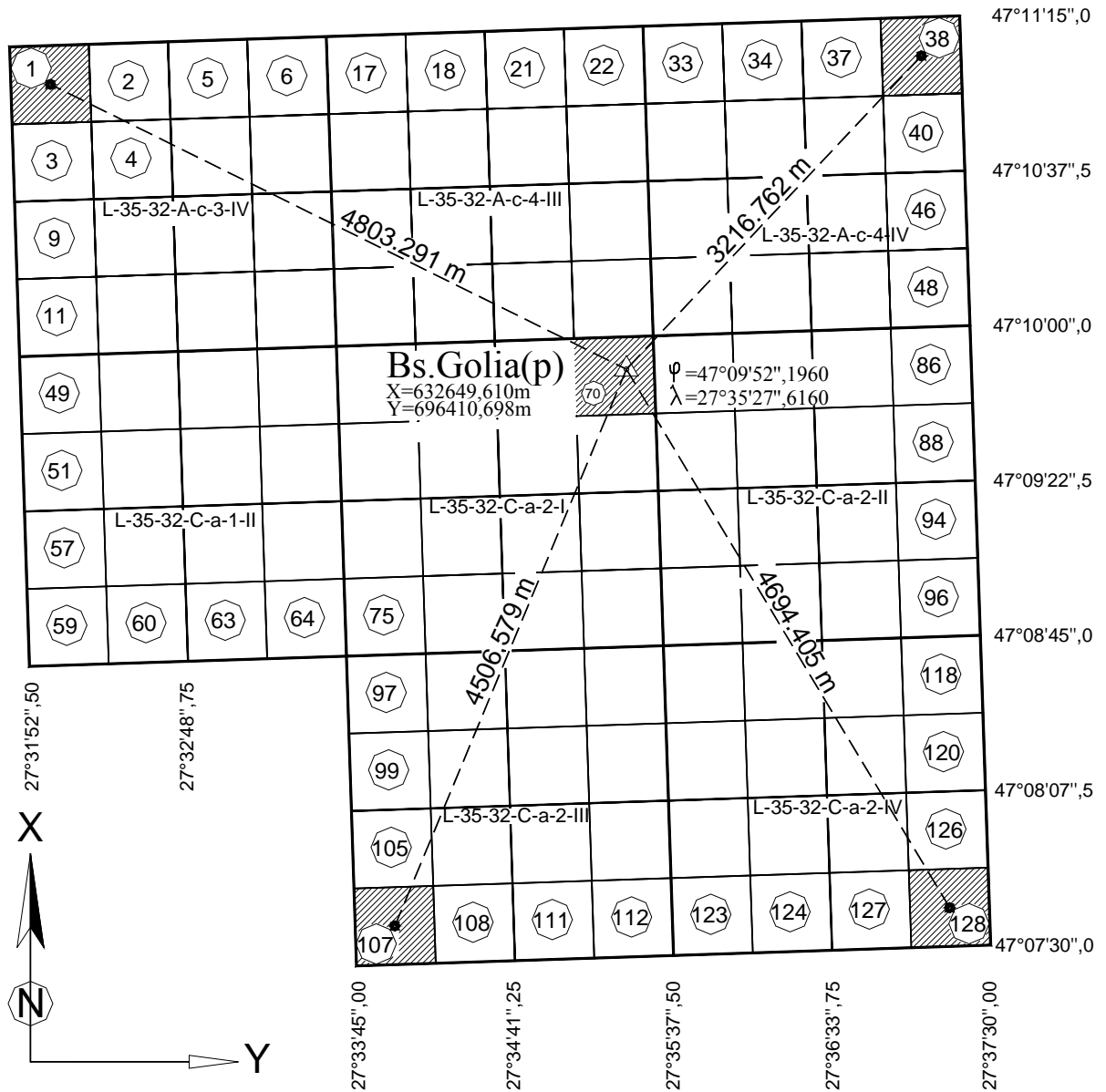


Figure 4 - Partitioning and numbering of the sheets of base cadastral plan, scale 1:1,000 in stereographical projection azimuthally oblique view conformal on 1970 - unique secant plan, 1975 Black Sea mark system, from within the built up area of Iasi city

3. Calculation of the parameters of Iasi local secant stereographical projection system – derived from 1970 stereographical projection

To reduce the length deformations from secant plan of 1970 stereographical projection, covered between -0.250 m/km , in central point to $+0.637 \text{ m/km}$, in extreme zone of Romania territory, was recommended to apply obligatory some local stereographical systems- derived from 70 STEREO projection in all localities where the length deformations are higher then $\pm 5 \text{ cm/km}$ through norms of introduction of building-town survey [4, 5, 7, 9].

The secant plan stereo-local Iasi was obtained through parallel translation of secant plan 70-STEREO from the depth H_{70} at depth H_L which assure the transition of secant circle of null deformation through central point of the locality. For this reason was used the Golia point defined by 1970 stereographical coordinations ($X_G = 632\ 649.610 \text{ m}$ and $Y_G = 696\ 410.698 \text{ m}$) and on 1940 Krasowski ellipsoid through geographical coordinations ($\varphi_G = 47^\circ\ 09'\ 52''.1960$ and $\lambda_G = 27^\circ\ 35'\ 27''.6160$). The geometrical element of LOCAL –STEREO system and the transformation factor (K) of coordinations from official system in local system and reversed are represented in figure 5:

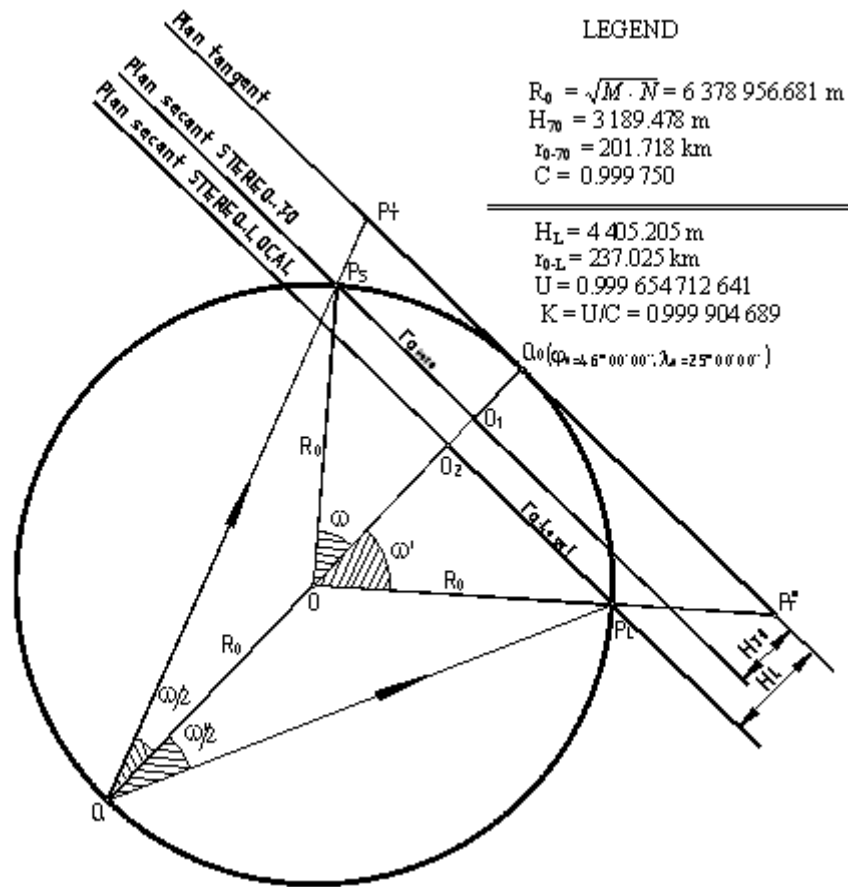


Figure 5 – Geometrical elements of the representation of stereographical projection on secant unique plan – 1970 (H_{70} , r_{0-70}) and on stereographical Golia – Iasi secant local plan (H_L , $r_{0-Local}$)

4. The evaluations of linear and surface deformations in the case of projections adopted in Iasi territory

Through the adoption of stereographical projection on local secant plan, derived from the stereographical projection on 1970 unique secant plan, was obtained the significant reduction of the linear and surface deformations. In the case study was calculated the relative linear and surface deformations on cartographical framed trapezes at scale 1:5,000, (table 2).

Table 2

Regional deformations of the lengths and areas, in 70 STEREO and local -STEREO projection on the trapezes of Iasi territory at the scale 1:5,000

Trapeze name at scale 1: 5,000	Position and location zone	70 STEREO- projection		Local STEREO projection	
		D, cm/km	P, mp/ha	D, cm/km	P, mp/ha
L-35-32-A-c-1-IV	North-outside city	9.65	1.93	0.12	0.02
L-35-32-C-b-2-III	East- outside city	11.16	2.23	1.62	0.33
L-35-32-C-b-3-III	South- outside city	9.26	1.85	-0.27	-0.05
L-35-31-B-d-4-IV	West- outside city	7.77	1.55	-1.76	-0.35
L-35-32-C-a-2-I	Downtown- inside city	9.51	1.83	0.00	-0.08

Relative linear and surface deformations from LOCAL-SECANT plan on those 4 extreme framed trapezes of Iasi territory, have been record negligible values under the aspect of determination precision of surfaces for the works of introduction of building-town survey in localities, being between -0.05 and -0.35 mp/ha, respective -0.02 and -0.33 mp/ha.

For the evaluation of the deformations from the zone of the within the built up area of Iasi city was calculated similarly the distributions of the deformations from cartographical framed trapezes at scale 1:1,000 and from the central trapeze which include Golia point, considered the origin of Iasi local projection, of known coordination in local system and in 1970 stereographical system(table 3).

Table 3

Regional deformations determined by projections adopted in Iasi within the built up area on the trapezes of cartographical representation, at the scale 1:1,000

Trapeze name at scale 1: 1 000	Position and location zone	Relative linear deformations (D), cm/km		Modulus (μ)	Relative surface deformations (P), m ² /ha		
		70 stereo-projection	Local - stereo projection	Iasi local projection	70 stereo-projection	Local - stereo projection	Iasi local projection
L-35-32-A-c-3-IV-1-a	N – V	8.8	-0.70	0.999822	1.76	-0.14	-3.82
L-35-32-A-c-4-IV-2-b	N – E	10.4	0.89	0.999838	2.08	0.18	-3.30
L-35-32-C-a-2-III-3-c	S – V	8.4	-1.11	0.999817	1.68	-0.22	-3.60
L-35-32-C-a-2-IV-4-d	S – E	9.5	0.08	0.999825	1.90	0.02	-3.52
L-35-32-C-a-2-I-2-b	Golia	9.5	0.00	0.999824	1.90	0.00	-3.50

In accordance with the total area calculated on the surface of 1940 Krasowski reference ellipsoid and from the cartographical projection plan adopted in Iasi within the built up area, have been estimated the total surface deformation for all 128 trapezes, which totalized an ellipsoidal area of **4 390.9560 ha**. For those three cartographical projections studied, arise a total surface deformation about **+ 0.8121 ha** for the stereographical projection on 1970 unique secant plan, **-0.0251 ha**, in the hypothesis of adoption stereographical projection on Iasi local secant plan derived from 70 stereo projection and about **-1.2804 ha**, for the local stereographical projection with central point at Golia, used in Iasi territory.

Conclusions

1. For the achievement of works of introduction general survey and to made up the urban data bases, is impressive the adoption some local projection systems derived from 1970 stereographical projection, which will assure the annihilation or reduction of relative linear deformations under the

value of $\pm 5 \text{ cm/km}$, establish according to the technical norms for the implementation of building – town survey.

2. The works of the general survey from Iasi city, will be realised between 2005-2008, on a total surface of **9 396.22 ha** and was estimated at the investment values of approximates 77 billions ROL, the 84 main points of rendering planimetric geodesic network and the survey border delimitation in 1970 stereo projection being already executed.

3. Through adoption the stereographical projection on Iasi-Golia local secant plan, derived from stereographical projection on 1970 unique secant plan, was realised the significant and distinct decrease of linear deformations, being recorded values between **+ 0.12 cm/km** and **+ 1.62 cm/km**, in the north and east extremities and between **-0.27 cm/km** and **-1.76 cm/km**, in south and west extremities zones of Iasi city territory.

4. The relative surface deformations from secant plan of Iasi –Golia local stereographical projection, determined on extreme trapezes of framed Iasi territory, at scale 1:5,000 register negligible values, which from the practical point of view doesn't influence the precision of surface calculation, considering the size situated between **-0.05 mp/ha** and **0.33 mp/ha**.

5. The evaluation of total surface deformation on all 128 trapezes at scale 1:1,000, depending the total undistorted area from Krasowski ellipsoid, which cover the area of **4 390.9560 ha**, lead in the case of those three studied projections at the following values: **+0.8121 ha**, in 70 STEREO system, **-0.0251 ha**, in LOCAL-STEREO system and **-1.2804 ha**, in Iasi LOCAL system.

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