# MAKING A GEOGRAPHIC INFORMATION SYSTEM FOR THE SOCOLA-NICOLINA NEIGHBORHOOD IN IASI COUNTY

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***Abstract**: The main purpose of the article aims in creating a GIS for an urban area with an eye to efficient management of this. Also, the application includes an inventory of all the component elements for an urban area. Other undertaken and proposed objectives are represented by creating an attribute database, relationing that database with graphic entities, making analysis, queries, thematic maps and basic notions of spatial modeling.*

***Keywords:** Square, GIS, efficient management, AutoCAD Map3D 2020, Microsoft Office Access 2016, inventory, 3D model, thematic maps, queries, SQL*

## 1. Introduction

Once with the demographic growth, the diversification of social-economical-cultural activities and the beginning of the industrialization process in Romania, the urban development has been manifested too through a larger number of cities or expanding territorial of existing ones.

The industrialization process and urban development bring with them a set of "side-effects" represented by a large number of: buildings, municipal technical networks, infrastructure and different public places, which generate the problem of an efficient management for all of those. So, in the current article I have considered for studying an urban area from Iasi County, represented by the Socola-Nicolina neighborhood, for making a GIS through the concept of efficient management has been approached.

## 2. Materials and methods

The support of the input data of the project is represented by 2 sheets of a topographic plan at a scale of 1:500. The acquisition of data was made through digitization "on-screen" process. It has to be made the mention that has been necessary a preliminary stage before the georeferencing and vectorization process because the sheets of topographic plan was drawn up early in 1974, projected in Local Iasi coordinate system, due to reason of enshrining a high-precision of data. So, I've been made the conversion of coordinates between Local Iasi System and National Stereographic 1970 System. The method that we have been used is called "**linear transformation in two-dimensional space - the method of least squares**".

The linear transformation in the two-dimensional space between two plane rectangular coordinate systems is based on the following parameters: two translation constants ($\Delta x$, $\Delta y$), a rotation angle ($\alpha$) and a scale factor (k). Note: in the current paper the rotation angle ($\alpha$) is considered negative for the counterclockwise direction and the scale factor (k) is constant for both directions of the coordination axes.

$$\begin{pmatrix} x \\ y \end{pmatrix}_2 = \begin{pmatrix} \Delta x \\ \Delta y \end{pmatrix}_{1\to 2} + k\begin{pmatrix} cos\alpha & -sin\alpha \\ sin\alpha & cos\alpha \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix}_1$$

Where: 1 = Local Iasi Coordinate System; 2 = National Stereographic 1970 Coordinate System.

By entering the scale factor (k) into the rotation matrix and replacing the terms:

$a = k\ cos\alpha$

$b = k\ sin\alpha$

The formula can be written as:

$$\begin{pmatrix} x \\ y \end{pmatrix}_2 = \begin{pmatrix} \Delta x \\ \Delta y \end{pmatrix}_{1\to 2} + \begin{pmatrix} a & -b \\ b & a \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix}_1$$

A minimum of two common points between the two coordinate systems is considered necessary to solve the system of 4 unknowns (Δx, Δy, a, b), but for the application of the least squares method an additional number of common points is needed [2].

For the present paper, within the topographic plan, a number of 272 points were identified in the Local - Iasi Coordinate System, based on the intersection of the kilometer grid lines drawn up at a scale of 1: 500.

If the errors specific to the coordinates of system 1, respectively Local - Iasi, are neglected, then the system of correction equations for the coordinates of system 2, respectively National Stereographic - 1970, is written in his linearized form [2]:

$$V = AX + L,$$

Where:

$$A_{2n,4} = \begin{pmatrix} x_1 & -y_1 & 1 & 0 \\ y_1 & x_1 & 0 & 1 \\ \dots & \dots & \dots & \dots \\ x_n & -y_n & 1 & 0 \\ y_n & x_n & 0 & 1 \end{pmatrix}_1 ;\ X_{4,1} = \begin{pmatrix} \mathrm{a} \\ \mathrm{b} \\ \Delta x \\ \Delta y \end{pmatrix};\ L_{2n,1} = \begin{pmatrix} -x_1 \\ -y_1 \\ \cdots \\ -x_n \\ -y_n \end{pmatrix}_2 ;V_{2n,1} = \begin{pmatrix} v_{x_1} \\ v_{y_1} \\ \cdots \\ v_{x_n} \\ v_{y_n} \end{pmatrix}.$$

Where **n** – common points number, $n = 6$.

The unknown parameters result according to the functional matrix model, applying the relation:

$$X = -(A^T A)^{-1} A^T L$$

Next, we return to the relation stated in matrix form and rewrite it, analytically [2]:

$$X_{i_{(2)}} = \Delta x_{1\to 2} + a x_{i_{(1)}} - b y_{i_{(1)}}$$

$$Y_{i_{(2)}} = \Delta y_{1\to 2} + b x_{i_{(1)}} - a y_{i_{(1)}}$$

In this way we have got rectangular plane coordinates in **National Stereographic-1970 System**.

The next step consists in preparation of graphic information for topographic plane.

Designing a graphic database for the current topographic plane represent a very important stage, so we have treated that in a special way because, starting from idea that "every action has a purpose", the vectorization of graphic information provides input data of the project and this accuracy and precision influences the quality of the final product.

Next step, we defined the parameters of project; this process consists in setting the units of measuring (decimals, north direction) and attaching the system of projection (Stereo-1970); After that, those 2 sheets of topographic plane had been georeferenced through the inserting of raster images on working environment of AutoCAD Map3D 2020 platform and generating network grid (figure 1).

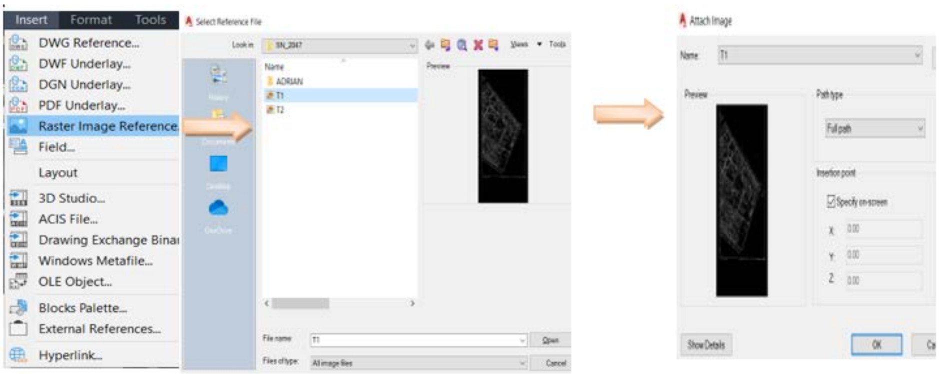


Fig. 1 – Inserting sheets of topographic plane in AutoCAD Map3D 2020

The actual georeferencing was performed by punctuating the intersection of the grid network of node 1 in the raster image, respectively the punctuation at the intersection of the grid network 1 'of the vector data (similar procedure was performed for all 272 points - intersections of the grid lines).

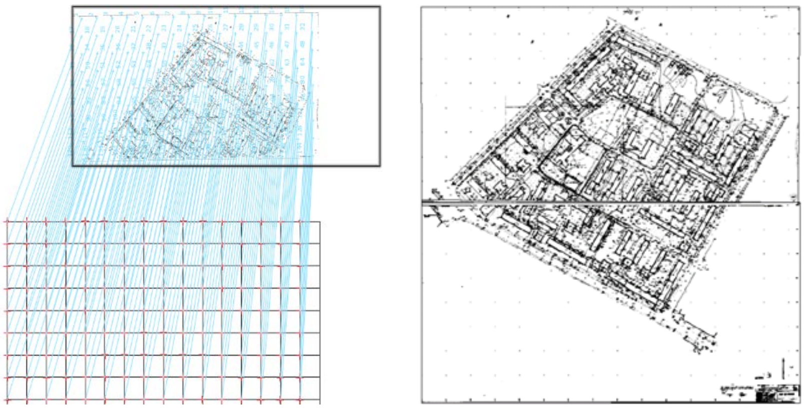

Fig. 2 – The georeferencing of the first sheet of topographic plane and viewing the results

Once that both images were brought to their spatial position, we were able to move on to the data acquisition stage, namely digitization “on-screen”. For that, we organized the graphical information on working layers related to the horizontal and vertical elements found in the plans, we set the digitization environment, finally obtaining the project data in vector format.

During the digitization process, a series of errors occur, such as: line intersections, overlapping lines, elements of very short length, non-closing of polygonal contours, etc. In order to eliminate the errors that occur on the graphical data vectorized during the digitization process and to create topologies, we proceed to access the editing and cleaning functions provided by the AutoCAD Map3D 2020 work platform.

A previous stage of creating the topologies of the current design is the stage of assigning the labels to the polygonal contours, respectively to the punctual elements.

The main purpose is to provide a key to link graphic information with textual information from an external database.

In order to solve this problem, we conventionally established a series of notations for each class and we placed them inside the polygonal contour of the respective class (example in figure 3).

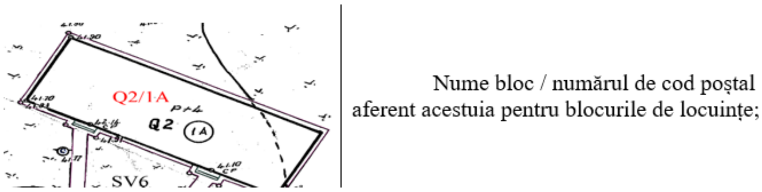

Fig. 3 - Example of a label assigned to a polygonal outline

For the punctual elements, we created block with attributes (according to the Atlas of Conventional Signs - 1978 Edition). Thus, we made blocks with the attributes: for water heaters "Capa1, Capa2, Capan", for sewers "Ccn1, Ccn2, ..., Ccnn", for gas fireplaces "Cgaz1, Cgaz2, ..., Cgazn", for telephone booths, Ctel1, Ctel2, ..., Cteln", for district heating "Ctermo1, Ctermo2, Ctermon", for electric lighting poles, S1, S2, Sn", for floor lamps "L1, L2, ..., Ln", for "H1, H2, Hn" for hydrants and "Vapa1, Vapa2, Vapan" for water valves" (Figure 4).

Fig. 4 - Example of a label assigned to point entities

Next, another stage approached was the creation of topologies. For this paper, we created all three types of topologies, by accessing the specialized functions available on the AutoCAD Map3D 2020 work platform. Thus, a number of 10 node topologies were created for point-type graphic primitives, for lines - a number of 7 network topologies and for polygon type primitives (closed contours), a single polygonal topology.

In the next step, we proceeded to design the attribute databases, which are related to the previously vectorized graphical information. We created 2 databases, as follows: designing the internal Object Data database in the working environment of the AutoCAD Map3D 2020 platform and designing the external database in the working environment of the Microsoft Office Access 2016 platform.

For the internal database we designed a number of 6 tables, which were loaded with attribute data (example in figure 5).

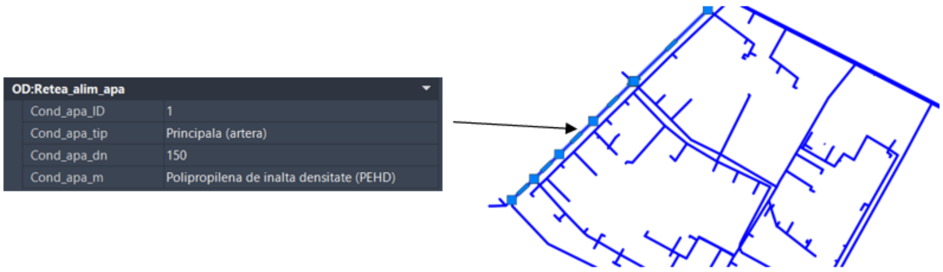

Fig. 5 - Example of a table for one of the 6 technical-municipal networks

To design the external database in the working environment of the Microsoft Office Access 2016 platform, we went through the following steps: designing tables and structuring data on tables, relating the tables, creating forms and loading data into tables. Thus, in the external database "Socola_Nicolina_2047" were designed a number of 32 tables, which contain information specific to the urban area delimited in the neighborhood Socola – Nicolina, Cantemir, Iasi (example in figure 6).

Hidrant

| Field Name | Data Type | Description (Option |
|---|---|---|
| Hidrant_ID | AutoNumber | Numărul de identificare corespondent fiecărui hidrant. |
| Hidrant_m | Long Text | Materialul din care corpul hidrantului este confecționat. |
| Hidrant_d | Number | Diametrul nominal al capacității de evacuare apă cu care hidrantul în cauză este pr |
| Hidrant_sup/subt | Short Text | Specificarea amplasamentului hidrantului (dacă acesta este situat la suprafață sau |
| Hidrant_cod | Short Text | Etichetă folosită pentru relaționarea bazei de date alfa-numerice cu cea grafică. |
| Hidrant_cond_apa_id | Number | Câmpul de legătură pentru identificarea conductei de apă la care hidrantul este rac |

Fig. 6 - Example of a table designed for the hydrant class

In the context of ensuring the interoperability of the data loaded into the tables, they must meet a relational condition. The type of relationship used for the current paper is one to many, so, a record in table no. 1 (example: countries) corresponds to many entries in table no. 2 (example: counties), thus defining the relationship from one to many (example: a country has many counties) [4]. To load the data without errors or overwriting in the database tables, we defined a form for each table (figure 7).

Acoperis

Acoperis_ID: 1
Acoperis_cod: TC
Acoperis_descr: Terasa circulabila

Acoperis

| Acoperis_ID | Acoperis_coc | Acoperis_descr |
|---|---|---|
| 1 | TC | Terasa circulabila |
| 2 | TN | Terasa necirculabila |
| 3 | TCER | Tigle ceramice |
| 4 | TBET | Tigle din beton |
| 5 | ADZ | Placi din ardezie |
| 6 | T | Tabla |
| 7 | PB | Panouri bituminoase |
| 8 | L | Lemn |

Fig. 7 - Example of form and data for the roof class

In the external database, a series of queries can be made with through some help tools, called reports. Reports provide a way to view, format, and summarize information uploaded in tables in the Access environment database [4]. In other words, a report is a tool in the database through which certain details in a database are highlighted and provided, depending on the needs established. For example, for the current application, a report can solve questions such as: "What is the number of green spaces in the Socola - Nicolina neighborhood?", "How many buildings are built in the Socola - Nicolina neighborhood?", "Which is the number of undergrounds, but above-ground hydrants in the Socola - Nicolina neighborhood?"

For example, we executed a number of 3 reports from which data on green spaces could be identified: no. green spaces = 214, where 177 with decorative role and 37 with recreational role; Statistical data on constructions, a no. of 97 constructions, where 63 are residential constructions, 10 annexes, 8 administrative and socio-cultural, and the rest of 16 industrial and urban constructions. Also, data on hydrants were identified, so there was a no. of 24 hydrants, where for one the positioning was not specified, 2 are with positioning in the underground, and the remaining 21 are positioned above ground.

Before proceeding with the operation of the created GIS application, the connection between the graphic entities of the project and the attribute data related to them must be ensured. This is done by attaching the external database to the AutoCAD Map3D 2020 work platform, defining the specific links (labels and attributes exemplified in the previous points), respectively the actual generation of the defined links.

Once this criterion is met, the data from the labels are also transferred to the polygonal contour of buildings, roads, green spaces and other polygonal elements. In addition to creating a geographical information system, we also approached 3D elements of the studied area, thus offering the possibility to view in the screen-space the entire studied area, which leads to more intelligent and efficient decisions.

In order to make the 3D model for the study area, Socola-Nicolina, Iasi, we proceeded, after vectorizing the point elements, to define the elevation of the points raised on the topographic plan at a scale of 1: 500 (where the elevation of the land was shown on the raster image);

Due to the fact that in the urban space we work with shapes and dimensions as accurate and well delimited (curbs, squares, level differences of a few centimeters), we tried to render a 3D model of the terrain with the best possible accuracy. This procedure took place in two stages: in a first stage, we thickened the “network” of dimensioned points already existing following the vectorization and allocation of dimensions, by linear interpolation on long alignments as possible (streets, sidewalks, decorative squares of spaces green) based on some end points, and in the second stage, we gave up the elevation points 0, respectively the elevation of the floor at the construction level to eliminate the possibility of anomalies in 3D model. We also moved a characteristic set of points from horizontal (2D) positioning to spatial (3D) positioning. The characteristic set of points refers to the points located on the roadside, on the border of green spaces and sidewalks.

Adapting the control set points to the practical situation for our case, will have the following shape: for the road edges, we specified the height of the respective curb at a height of ± 10 cm, and for sidewalks and green spaces, height = ± 5 cm.

Finally, a 3D model of the terrain for the study area resulted - the Socola-Nicolina neighborhood, which we distinguished with the help of the Z-scale factor in order to highlight the minimum and maximum elevations (figure 8).

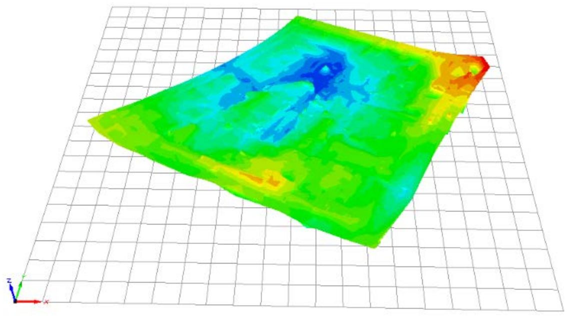

Fig. 8 - Visualization of 3D model for Socola-Nicolina urban space

Spatial modeling can continue through the actual modeling of the characteristic elements of the urban environment. For 2 of them (buildings and a pipe segment from the water supply network) we considered the realization of an example (figure 9 a, b).

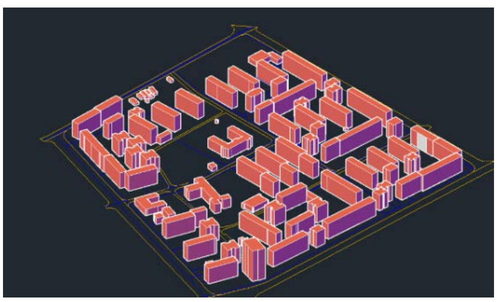

Fig. 9-a – The extruding of buildings

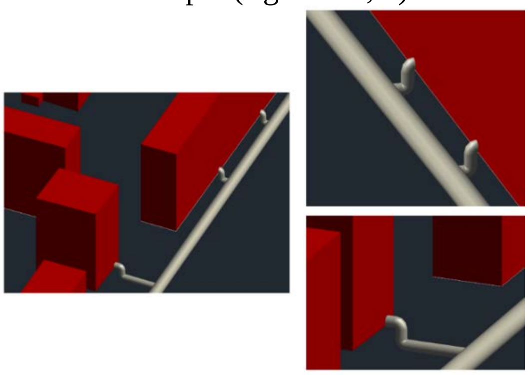

Fig. 9-b- The modeling a segment of the water supply network

## 3. Results

Finally, the geographical information system related to the Socola-Nicolina neighborhood in Iasi, Iasi County can be exploited. The operating stage of a GIS application involves visualization, analysis and query functions through thematic maps are obtained. Therefore, the current application was exploited by 3 methods: specific queries (by location, by properties or by SQL type), thematic maps and inventories;

Queries are mechanisms for selecting, according to a series of pre-established criteria, graphic and alpha-numeric data in order to find and display them (figure 10 a, b, c, d) [4]

Fig. 10 - All elements with an area of less than 500 $m^2$

Fig. 10-b - All green spaces in the Socola-Nicolina neighborhood

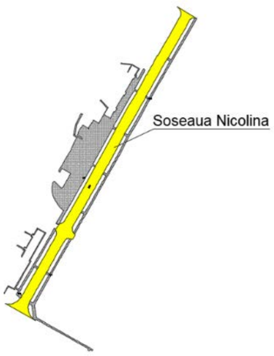


Fig. 10-c - All sidewalks and alleys belonging to Nicolina Road

Fig. 10-d - All buildings and the water supply network, respectively the sewerage network in the Socola-Nicolina neighborhood

Thematic maps are characteristics of mapped objects and provide information on data found in a given territory [4].

A thematic map is represented by characteristic colors according to each class of objects, contains a legend in which is explained the explanation of the colors used and is executed on several criteria (figure 11 a, b)

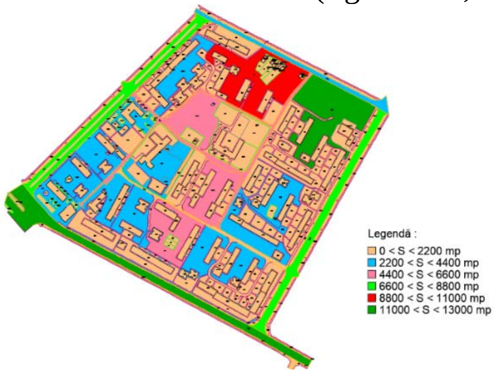


Fig. 11 - Thematic map by surface intervals

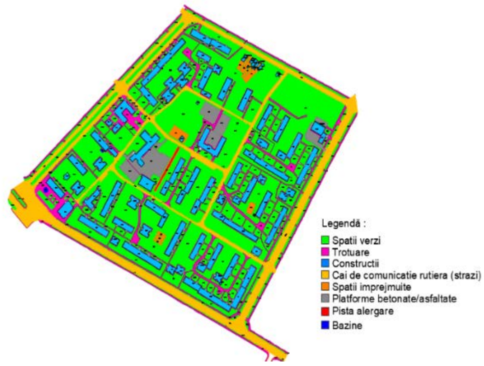


Fig. 11-b - Thematic map by the elements in an urban area

By exploiting a GIS application, not only information and spatial analysis of phenomena and certain characteristics of a system can be provided, but also qualitative and quantitative information or statistical data on the elements found, for the present situation, in the topographic plan at scale 1: 500. A number of **1869 punctual elements** were thus inventoried, among which: C.E.T. = 34, electrical terminals = 4, water manholes = 28, sewer manholes = 510, gas manholes = 438, telephone manholes = 32, district heating manholes = 13, water taps = 2, shafts = 391, artesian wells = 4, vents for sewerage = 5, hydrants = 24, lighting floor lamps = 86, historical monuments = 1, bounded point = 13, geodetic points = 89, drainage ditches = 80, electric lighting poles = 81, cathode stations = 2, water valves = 32.

Regarding the graphic primitives of line type (networks), it resulted in a length of **36,530 meters (36.53 km),** as follows: 6532 meters of level curves, 7084 meters of water pipes, 9276 meters of sewer pipes, 4858 meters of pipes gas, 2177 meters of telephone lines, 403 meters of district heating pipes, 6190 meters of overhead / underground electrical network lines.

For the polygonal contours resulted an area of **253,624,230 $m^2$ (25.36 ha)**, related to water basins, constructions, runways, concrete platforms, asphalt platforms, green spaces, sidewalks, respectively road communication routes.

## 4. Conclusions

In the article entitled "Making a Geographic Information System for the Socola-Nicolina neighborhood in Iasi, Iasi County" were approached the following issues: location of the study area, vectorization of information of those 2 sheets of topographic plan at a scale of 1: 500 , editing and cleaning data in order to eliminate errors that occurred during the digitization process, creating topologies, creating attribute databases, ensuring links between alpha-numeric information and graphical information by establishing link labels and blocks, exploitation of the created GIS application, generation of the three-dimensional model and a brief approach to the notions of 3D spatial modeling for some elements raised in a topographic plan.

In conclusion, a complete and correct GIS application has resulted, that offers the ability to meet the requirements for which it was designed, thus providing a clearer perspective on more efficient management and more rational decisions regarding the management of the urban space considered.

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